ADVENTURE 6

Animal Skin

Time:
1 class period

Suggested grade levels: 7-8

Math Objectives:
Graph temperature as a function of time, Interpret and analyze graphs of data, Understand slope and rate of change

Science Objectives:
Model the cooling rate of different sizes of animals, Collect, record, and analyze information using tools including graduated cylinders, calculators, probes, and computers

Materials:
TI-73 Explorer™, Calculator-Based Laboratory™ (CBL 2™), DataMate™, Temperature sensor
Large beaker or container, 2 surgical gloves, Water (ice water and warm water)

OVERVIEW

Those who have been caught outside in a blizzard have had to take heroic measures to survive. The difference between life and death is only a matter of a few degrees. Normal human body temperature is around 98.6°F. Hyperthermia begins to set in at 95°F, and becomes critical at 90°F.

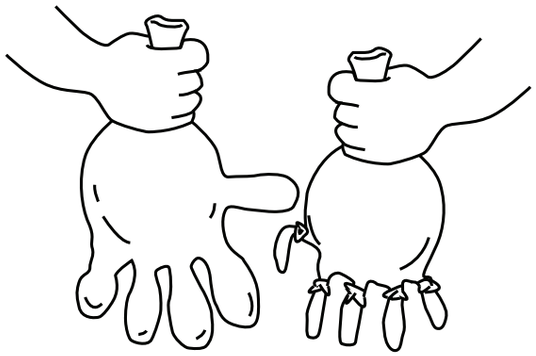
An animal's skin surface is the site of a large amount of heat transfer between the animal's body and the environment. If the temperature of the environment is warmer than the animal's body, heat is transferred *into* the body through the skin surface.

If the temperature of the environment is cooler than the animal's body, heat is transferred *out* of the body through the animal's skin surface. This is especially the case with *ectothermic* (cold-blooded) animals. Many *endothermic* (warm-blooded) animals have adaptations to conserve body temperature, such as fur, feathers, circulatory patterns, and perspiration. However, the skin of endotherms still serves as a site of heat exchange.

The shape and size of an animal's body is also a factor in heat exchange. Smaller animals have a larger skin surface area to body volume ratio while large animals have a smaller skin surface area to body volume ratio.

In this adventure, students will make two models to simulate the cooling rate of different skin surface areas and determine the effect of skin surface area on the results.

NOTE Demo the activity using the overhead calculator so the entire class can see the process. If you have only one CBL 2, have each group individually perform this activity. If you have enough CBL 2 units, have students work in small groups.



SET UP

1. Fill the large beaker or container with ice and water.
2. Tie off the figures of one glove. (Tying the fingers in a knot will do the trick.)
3. Connect the CBL 2 to the calculator using the I/O unit-to-unit cable.
4. Plug the TI temperature sensor into Channel 1 (CH 1) on the CBL 2.
5. To launch the DATAMATE program, press the [APPS] key, select **DataMate** and then press [ENTER] to view the DataMate screen. **See Figure 1.**

Figure 1

NOTE: DataMate may be listed under Programs (Press [PRGM]).

NOTE: For help with transferring DataMate to the CBL 2, see Appendix D.

NOTE: DataMate moves slowly between screens. As you make selections, be patient as the program executes the command.

6. The DataMate screen changes to the Main Screen. Select **1:SETUP.** Then, select **CH1**. Select **1:TEMPERATURE** and **4:STAINLESS TEMP(C).** If you are using a different temperature sensor, select the appropriate item from the menu. Last, select **1:OK** to return to the Main Screen. **See Figures 2a-b.**

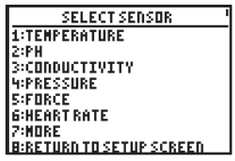


Figure 2a

Figure 2b

NOTE: The calculator may identify the temperature probe for you.

NOTE: The flexible TI temperature sensor is the same as the stainless steel.

7. Select **1:SETUP.** Select **MODE**, and then select **2:TIME GRAPH.** Select **2:CHANGE TIME SETTINGS.** For **ENTER TIME BETWEEN SAMPLES IN SECONDS,** enter **30**. Press [ENTER]. For **ENTER NUMBER OF SAMPLES,** enter **20. See Figure 3.** Press [ENTER]. The **TIME GRAPH SETTINGS** screen reappears, showing the new settings. Select **1:OK** twice to return to the Main Screen.

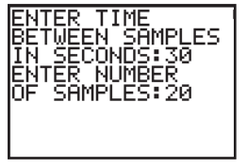


Figure 3

DATA COLLECTION

1. Fill the glove that has the fingers tied with 200 ml of warm water.
2. Insert the temperature sensor into the water inside the glove.
3. Holding the end of the glove closed, put the glove into the beaker or container of ice and water.
4. 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 corner.

5. Continue to hold the glove in the beaker of ice and water. The CBL 2 beeps twice when it has finished collecting the data. It will take 10 minutes.
6. The graph is displayed showing the data that was collected. Use the arrow keys (▶ and ◀) to move the cursor to each data point. Record the temperature for each 30 second interval in the table on the Data Collection worksheet and sketch the graph.
7. Press ENTER to return to the Main Screen and select **5:TOOLS**. Select **1:STORE LATEST RUN.**
8. Repeat steps 1 through 7, refilling the beaker with ice and water and using the warm water in the glove that does not have the fingers tied. Record the temperature for each 30 second interval in the table on the Data Collection worksheet and sketch the graph.
9. To see the two graphs on the same set of axes, select GRAPH from the Main Screen. After the graph displays, press ENTER to return to the Graph menu. Select **4:MORE.** Select **6: L2 AND L3 VS L1. See Figure 4.**
10. To exit the DATAMATE program, press ENTER to return to the Main Screen. Select **6:QUIT** and press ENTER. A screen appears once you quit the program that allows you to see where your data is stored. S**ee Figure 5.**
11. The times are stored in $\mathbf{L_1}$. The temperature for the second glove is stored in $\mathbf{L_2}$. The temperature from the first glove with the tied fingers is stored in $\mathbf{L_3}$.

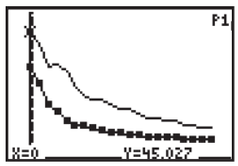


Figure 4

Figure 5

EXTENSION ACTIVITY

Calculate your own skin surface area to volume ratio.

a. To find the approximate skin surface area of the human body, there are three different methods:
- Three-fifths times your height squared
- 100 times the surface area of your hand print
- Twice your height times the circumference of your thigh

b. To find your approximate volume, multiply your body weight in kg by 0.9.

DISCUSSION NOTES

To help students understand surface to body area ratios for different animals, use a fixed number of 1 cm cubes to build animals with different body plans and calculate the surface area.

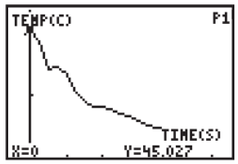
Example: Using 48 cm cubes, construct one animal with no appendages (4 x 3 x 4 cm) and calculate the volume (48 cm^3) and surface area (80 cm^2). Then build an animal with 4 legs and a head (4 x 3 x 3 body, 4 legs 2 blocks tall, and a head 2 x 1 x 2). Again calculate the volume (48 cm^3) and surface area (106 cm^2). Calculate the ratios.

Lead a discussion and help students form conclusions about the effect of body design on cooling rates based on their data.

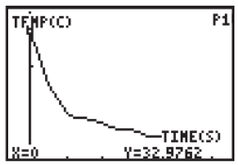
WORKSHEET ANSWERS

NOTE: The data in these tables is simulated. Actual data will be slightly different.

Time (in seconds)	Temperature of Water In Glove with Tied Fingers	Temperature of Water In Glove with Untied Fingers
0	45.03	32.98
30	41.13	26.98
60	38.98	20.37
90	35.36	17.43
120	33.65	14.23
150	32.33	13.23
180	29.74	12.83
210	28.60	12.33
240	27.52	11.72
270	25.47	10.80
300	24.95	10.28
330	24.38	10.08
360	23.75	9.87
390	23.69	8.92
420	22.98	8.81
450	14.93	8.59
480	14.33	8.81
510	13.33	8.38
540	12.73	8.16
570	12.33	8.05
600	11.82	8.05



Sketch the graph from Trial 1: Glove with tied fingers



Sketch the graph from Trial 2: Glove with untied fingers

1. Answers will vary. The graph of the glove with the untied fingers will be "steeper."
2. The steeper graph of the glove with fingers indicates that the rate of cooling is faster than in the glove without fingers which has a less steep graph.
3. The glove without fingers has less surface area per body volume so it cools more slowly. The glove with fingers has more surface area per body volume so it cools more quickly.
4. The *y*-intercept is the initial temperature of the water in the gloves.
5. The glove with fingers cooled more quickly. Data points will vary.
6. less quickly
7. The greater the surface area of the glove, the more quickly the water inside cools.
8. Animals such as whales, seals, and penguins live in cold environments. Their shortened appendages decrease their skin surface area and assist in decreasing body heat loss.

TI-NAVIGATOR™ EXTENSION ACTIVITY

1. Assign each student a whole number, starting with 1.
2. Have them calculate the surface area and volume of a sphere whose radius is the length of their assigned number. For a sphere, $SA = 4\pi r^2$ and $V = \frac{4}{3}\pi r^3$.
3. Tell students to find the surface area to volume ratio by dividing.
4. Load the **SphereRatio.act** activity settings file. Start the activity. The activity settings files can be found on the CD located in the back of the book.
5. Have students enter the value of the radius they used in L1 and the resulting ratio in L2.
6. View the graph of the collected points. Explain that this shows an inverse relationship because as the radius increases, the ratio decreases.
7. For those students who understand the algebra, divide the formula for the surface area of a sphere, $4\pi r^2$, by the formula for the volume of a sphere, $\frac{4}{3}\pi r^3$, and simplify. The result is $\frac{3}{r}$. Enter the equation $y = \frac{3}{x}$ in Activity Center and watch the graph overlap the points. Substitute a few *x*-values from the list into the equation.

Name _____

ADVENTURE 6

Animal Skin Worksheet

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Model the cooling rate of different sizes of animals, Collect, record, and analyze information using tools including graduated cylinders, calculators, probes, and computers

Materials:

TI-73 Explorer™, Calculator-Based Laboratory™ (CBL 2™), DataMate™, Temperature sensor
Large beaker or container, 2 surgical gloves, Water (ice water and warm water)

In this adventure, you will make two models to simulate the cooling rate of different skin surface areas and determine the effect of skin surface area on the results.

1. Describe the shape of each graph.

2. What do the differences in the "steepness" of the two graphs indicate about the cooling rates of the two gloves?

3. Explain why the graphs of the two gloves differ.

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

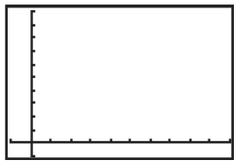
5. Refer to the table and compare the change in the temperatures of the two gloves at the same time intervals. Which glove changes temperatures more quickly? List some data points from both gloves to support your answer.

6. An animal with less skin surface area will cool off _____ than an animal with more skin surface area.
7. Compare the surface area of both gloves. Does the surface area of the glove seem to affect the rate of temperature change?

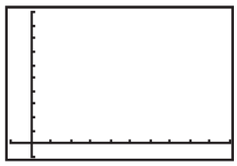
8. How does this phenomenon affect animals in extremely cold or hot environments? Why don't whales, seals, and penguins have long legs and necks?

DATA COLLECTION

Time (in seconds)	Temperature of Water In Glove with Tied Fingers	Temperature of Water In Glove with Untied Fingers
0		
30		
60		
90		
120		
150		
180		
210		
240		
270		
300		
330		
360		
390		
420		
450		
480		
510		
540		
570		
600		



Sketch the graph from Trial 1: Glove with tied fingers



Sketch the graph from Trial 2: Glove with untied fingers

