WARD'S™
DataHub
The Power of Twelve
The Convenience of One

Sweat Production:
Measurement of Temperature and Humidity Changes Relative to Perspiration
(Teacher's Guide)

OVERVIEW

During this activity, we will isolate a system, consisting of a student's hand and the Ward's DataHub, from the environment using a plastic bag and adhesive tape. For 10 minutes, we will monitor the environmental temperature and humidity inside the bag with the Ward's Datahub software, observing a graph showing the variations of the parameters mentioned earlier. Students should relate the physiological response, indicated by the perspiration process, to the environmental humidity and temperature variations. They should understand the importance of water as a natural temperature regulator between two different environments.

MATERIALS NEEDED

Ward's DataHub
USB connector cable*
Ward's DataHub external temperature probe
Plastic bag
Adhesive tape

** – The USB connector cable is not needed if you are using a Bluetooth enabled device.*

NUMBER OF USES

This demonstration can be performed repeatedly.

FRAMEWORK FOR K-12 SCIENCE EDUCATION © 2012

* The Dimension I practices listed below are called out as **bold** words throughout the activity.

Dimension 1 Science and Engineering Practices	✓	Asking questions (for science) and defining problems (for engineering)	✓	Use mathematics and computational thinking
	✓	Developing and using models	✓	Constructing explanations (for science) and designing solutions (for engineering)
	✓	Planning and carrying out investigations	✓	Engaging in argument from evidence
	✓	Analyzing and interpreting data	✓	Obtaining, evaluating, and communicating information

Dimension 2 Cross Cutting Concepts		Patterns	✓	Energy and matter: Flows, cycles, and conservation
	✓	Cause and effect: Mechanism and explanation		Structure and function
		Scale, proportion, and quantity	✓	Stability and change
	✓	Systems and system models		

	Discipline	Core Idea Focus
Dimension 3 Core Concepts	Life Science	LS1: From Molecules to Organisms: Structures and Processes
		LS1.A: Structure and Function
		LS1.C: Organization of Matter and Energy Flow in Organisms
	Physical Science	PS2: Motion and Stability: Forces and Interactions
		PS2.C: Stability and Instability in Physical Systems
	Earth and Space Science	ESS2: Earth's Systems
		ESS2.D: Weather and Climate

	Middle School Standards Covered	High School Standards Covered
NGSS Standards	MS.LS-SFIP: Structure, Function, and Information Processing	HS.LS-SFIP: Structure, Function, and Information Processing
	MS.LS-MEOE: Matter and Energy in Organisms and Ecosystems	HS.LS-MEOE: Matter ad Energy in Organisms and Ecosystems
	MS.PS-IF: Interactions of Forces	HS.PS-IF: Interactions of Forces
	MS.ESS-WC: Weather and Climate Systems	HS.ESS-CC: Climate Change

NATIONAL SCIENCE EDUCATION STANDARDS © 2002

Content Standards (K-12)			
✓	Systems, order, and organization	✓	Evolution and equilibrium
✓	Evidence, models, and explanation	✓	Form and Function
✓	Constancy, change, and measurement		

Life Science Standards Middle School		Life Science Standards High School	
✓	Structure and Function in Living Systems	✓	The Cell
	Reproduction and Heredity	✓	Molecular Basis of Heredity
✓	Regulation and Behavior		Biological Evolution
	Populations and Ecosystems		Interdependence of Organisms
	Diversity and Adaptations of Organisms	✓	Matter, Energy, and Organization in Living Systems
			Behavior of Organisms

✓ Indicates Standards Covered in Activity

LEARNING OBJECTIVES

Core Objectives (National Standards):

- Develop the ability to refine ill-defined questions and direct to phenomena that can be described, explained, or predicted through scientific means.
- Develop the ability to observe, measure accurately, identify and control variables.
- Decide what evidence can be used to support or refute a hypothesis.
- Gather, store, retrieve, and analyze data.
- Become confident at communicating methods, instructions, observations, and results with others.

Activity Objectives:

The purpose of this activity is to study our body's cooling system while measuring skin temperature and sweat production. We will create a hypothesis and proceed to test it using the Ward's DataHub humidity and temperature sensors.

Time Requirement:

60-90 minutes

VOCABULARY

Air Saturation: The concept or measure of air being able to "hold" or suspend molecules.

Heat Transfer: The exchange of thermal energy being passed from one substance to another.

Humidity: A quantity representing the amount of water vapor in the atmosphere or a gas.

Latent Heat: The heat required to convert a solid into a liquid or vapor, or a liquid into a vapor, without change of temperature.

Perspiration: The process of sweating.

Stoma: Any of the minute pores in the epidermis of the leaf or steam of a plant, forming a slit of variable width that allows movement of gases in and out of the intercellular spaces.

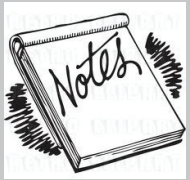
Sweat: Moisture exuded through the pores of the skin, typically in profuse quantities as a reaction to heat, physical exertion, fever, or fear.

Temperature: The degree or intensity of heat present in a substance or object.

Thermal Equilibrium: The point at which the rate of cooling becomes equal to the rate of heat generation. Also called heat balance.

Thermal Inertia: Volumetric heat capacity (VHC), also termed volume-specific heat capacity, describes the ability of a given volume of a substance to store internal energy while undergoing a given temperature change, but without undergoing a phase change.

Transpiration: The loss of water molecules from pores in the leaves of plants.



Teacher Notes

INTRODUCTION

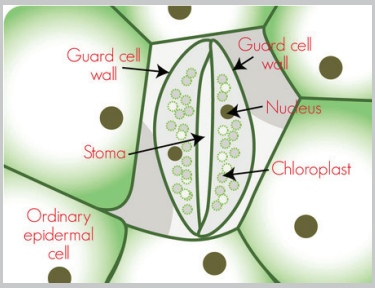
Have you ever experienced very high temperatures or felt extreme stress? Your body would have responded by exuding little drops of water through the pores of your skin. Usually we think of this as unpleasant or irritating because it makes our clothes wet and can even make us smell bad. However, perspiration is a very important physiological process that is vital in maintaining our body temperature via the evaporation of water for thermo-regulation.

- **In what types of situations do we usually produce a lot of sweat?**
- **How does it feel when the sweat evaporates on your skin?**

Carry out the experiment with your class so that at the end students will be able to answer the following question:

- **During the process of perspiration, what is the relationship between the humidity of a body and environmental temperature?**

BACKGROUND



Perspiration is a physiological mechanism used by plants and animals for various functions like excretion of salts, toxins, and other waste products. In plants, the process of excess water disposal produced after photosynthesis or in a hot environment is called transpiration. Plants are able to control transpiration by blocking the stomata (microscopic pores on the epidermis of land plants, which allow the gas exchange process). This way, plants are able to avoid water losses due to evapotranspiration. In some animals, such as humans, this moisture is called sweat. Sweat is exuded through the pores of the skin, eliminating toxins through a body reflex that maintains body temperature, in order to keep stable the normal metabolic functions of the cells.

DID YOU KNOW?

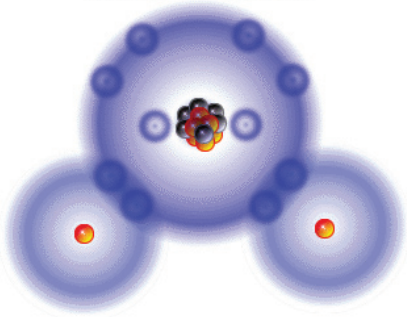
Some animals do not have sweat glands like we humans do, and therefore they cool their body down by other methods. Dogs are one such animal. They cool their bodies down by panting.

DID YOU KNOW?

Absolute humidity is a measure of the actual amount of water vapor present in a particular sample of air. Warm air has the ability to hold up to 25 grams of water vapor. This is why the air in the tropics feels so damp and heavy. The air in the cold polar regions can not hold any water vapor.

The molecular structure of water has very unique chemical and physical properties. One of them is the high specific heat index, where water can absorb a lot of heat before it raises its temperature (this property is called thermal inertia). To increase or decrease only one degree centigrade of temperature, water has to absorb or liberate a lot of thermal energy. To change the physical phase from liquid to gas, it liberates another quantity of energy (latent heat) without changing its temperature.

Water Molecule



These unique properties of water are crucial in impacting environmental temperature and environmental humidity. Environmental humidity pertains to the amount of water molecules that are suspended in the air. Once this property reaches a certain value on the steam saturation curve, water will begin to condense and water droplets will form. This occurs without any change in temperature.

We can therefore conclude that water acts as a temperature regulator between the liquid and the gas phase, transferring slowly the heat from one to the other, until it reaches a thermal equilibrium.

At this point, encourage students to formulate a hypothesis to test as part of this activity. Students may find it helpful to formulate their hypothesis as an answer to the following question:

- **What do you think happens to the humidity and the temperature of the air surrounding a body that sweats profusely?**

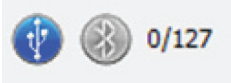
CONNECTING THE WARD'S DATAHUB TO A COMPUTER

If you are using a Bluetooth communication device:

Right-click on the Bluetooth icon in the lower right corner of the screen and select the Ward's DataHub you are using. The icon will change from gray to blue, as shown at right, indicating that the Ward's DataHub and the computer are now connected via Bluetooth.

If you are using a USB communication device:

In order to use USB communication, connect the Ward's DataHub and the computer with the USB cable supplied. Click on the USB icon at the lower right corner of the screen. This icon will change from gray to blue, as shown at right, indicating that the Ward's DataHub is connected to the computer via USB.



USING THE WARD'S DATAHUB

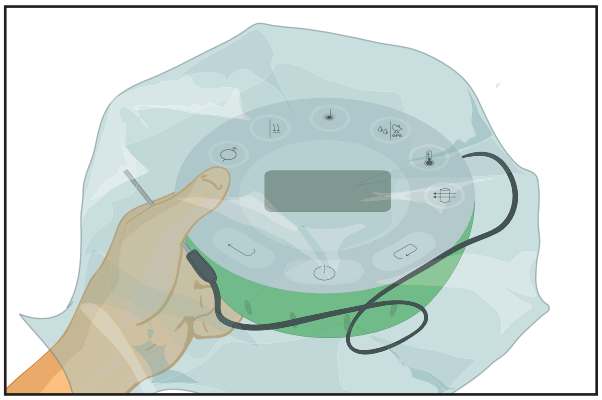
= Select key = On/Off and Escape key = Scroll key

To collect measurements with the Ward's DataHub, it must first be configured as follows:

1. Turn on the Ward's DataHub by pressing the On/Off/Esc key.	
2. Go to Setup by using the Scroll key then select Setup by pressing the Select key.	then
3. Select the Set Sensors option by pressing the Select key.	
4. If any sensor(s) appear on the screen, press the key representing that sensor to deactivate it. Press the **Relative Humidity/GPS Sensor** key. Also press the **Temperature Sensor** key Twice for the External Temperature.	x 2
5. Press the On/Off/Esc key once to return to the Setup menu.	
6. Press the Scroll key then press the Select key to set the Sampling Rate.	then
7. Use the Scroll key to highlight a Sampling Rate of "**1/sec**", then press the Select key.	then
8. Press the On/Off/Esc key to return to the Setup menu.	
9. Press the Scroll key then the Select key to set the Number of Samples to be collected.	then
10. Use the Scroll key to highlight "**10,000**" as the Number of Samples to be collected then press the Select key.	then
11. Press the On/Off/Esc key three times to return to the main operating screen.	x 3
12. **Press the Select key to start measuring.** (You are collecting data when there is an icon of a Runner in the upper left hand corner of the screen.)	
13. Once you have finished measuring, stop the Ward's DataHub by pressing the Select key, followed by the Scroll key.	then

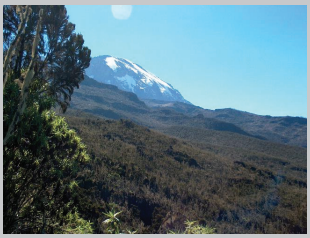
ACTIVITY

1. Hold the Ward's DataHub in one hand and the external temperature probe tip between two fingers.
2. Start measuring and cover your hand and the Ward's DataHub with the plastic bag.
3. Seal the system with the adhesive tape.
4. Record your sensations and observations during the experiment.
5. Wait 10 minutes to remove the bag and then stop the Ward's DataHub.



DID YOU KNOW?

In the summer months, trees have many leaves on them. This means that there are millions of stomatas open to the environment transpiring water to cool the tree. A large maple tree can transpire 50-60 gallons of water per hour into the atmosphere. This greatly increases the humidity, and can often create super-saturated clouds. These clouds result in snow or rain. If the trees were not present to produce this water vapor, precipitation would not occur. On Mt. Kilimanjaro, in Tanzania, the snows have disappeared due to the deforestation that has taken place in their area. It has resulted in a net loss of local transpiration and thus less (or no) snowfall.



DID YOU KNOW?

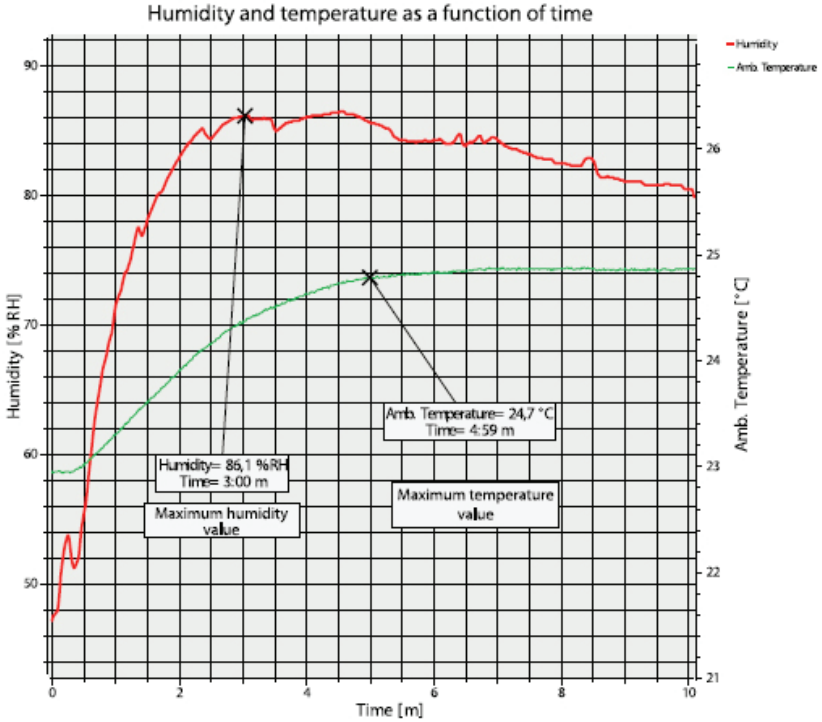
Perspiration all over your body is usually due to exertion or hot external temperatures, while perspiration just on the palms, soles of the feet and forehead is usually the result of nerves or excitement.

RESULTS AND ANALYSIS

1. Connect the Ward's DataHub to the computer using the Bluetooth wireless communication channel or USB connector.
2. In the top menu, click on the  button and select the  button.
3. Select the last experiment on the list.
4. Observe the graph displayed on the screen.
5. Identify the maximum value and the stabilization value of the humidity and temperature curves, respectively.
6. Activate the markers  and select the points on each curve. If you want, label each one by pressing  .

- **What similarities did you find between the temperature and humidity curves? Explain.**
- **How would you explain the time delay between the maximum values of both curves?**
- **How did the results of the graph relate to the sensations your hand felt during the experiment?**

The graph below should be similar to the one the students come up with.



CONCLUSIONS AND ASSESSMENTS

1. How does the humidity vary inside the plastic bag from the moment the temperature starts to rise?

   Students should recognize the moment at which the temperature starts to rise (around 30 seconds) by observing the graph. In this moment, the humidity curve suddenly starts to elevate, meaning the amount of water molecules in the air begin to rise inside the bag.

2. What happens to the environmental temperature from the moment at which the relative humidity reaches its maximum value? **Explain.**

   Students should recognize that starting from the moment at which humidity reaches its maximum point (around 3 minutes), the temperature curve changes its variation rate. The temperature continues rising but the slope decreases with time, i.e., it gets hotter, but at a lower rate.

3. Why do you think the temperature rises in the same time period in which the humidity reached the maximum value? **Argue** your answer with data from the experiment.

   Students should think about the heat increase as the hand is covered with a plastic bag, preventing the sweat vapors from releasing into the air. This stops the evaporation process, which is the mechanism that cools our hand.

4. Why do you think the humidity falls compared to temperature, during the last period of time?

   In the last period of time, the water molecule concentration inside the plastic bag falls. This happens because it reaches a steam saturation point, and starts to condense water back to the liquid phase. It is important to mention that the temperature keeps constant because it has already achieved a thermal equilibrium with the steam, before starting the condensation process.

Students should reach the following conclusions:

The skin of the hand reaches a thermal equilibrium with the surrounding air, by the following processes:

Heat Transfer: The transfer of heat in the form of radiation, from the hand to the air. Because of this process, the air temperature rises, triggering sweat production.

Sweat evaporation inside the bag: The space inside the bag gets full of steam.

Heat Transfer: The transfer of heat between the steam and the air, reaching a thermal equilibrium, raising the temperature in the bag.

Air Saturation: Once the air reaches maximum saturation, the process of condensation causes a decrease in humidity, without causing a drop in environmental temperature.

ACTIVITIES FOR FURTHER APPLICATION

The aim of this section is for students to extrapolate the knowledge acquired during this class and apply it to different contexts and situations. Furthermore, it is intended that students question and present possible explanations for the experimentally observed phenomena.

1. What would you do to cool down the road surface on a sunny day?

   Students should suggest wetting the road surface with cold water, so that both materials may achieve a thermal equilibrium. This way, the water would absorb a great amount of thermal energy without significantly raising its temperature.

2. How would you explain that the water in the pool feels warmer at night than during the afternoon?

   Students should relate this question to the thermal inertia of water. According to this concept, the pool will absorb heat all day from the sun to achieve a thermal equilibrium. During the night, it will lose the heat very slowly to reach a thermal equilibrium with the cold night air.

3. Why is it dangerous for us to submerge in very cold water for an extended period of time? Explain.

   Students should point out that our body is composed mainly of water, being able to absorb or emit a lot of heat without changing its temperature very much. The danger of submerging completely in cold water for an extended period of time is that a person will get hypothermia. A person's body heat would be transferred to the cold water as the "system" attempts to reach thermal equilibrium.

4. How would you explain the low temperature variations in coastal areas?

   Students should mention the great concentration of water particles in the coastal atmospheres due to the proximity to the sea. This acts as a temperature buffer because of the water's ability to absorb or emit heat.

DID YOU KNOW?

The human body has approximately 4 million sweat glands, and 6 or 7 times a minute those sweat glands release sweat or perspiration containing water, salt, potassium and waste materials. A hard working adult can lose up to 4 gallons (15 liters) of sweat a day. An average person during an average day sweats up to 1.5 gallons (6 liters) per day. Half a pint or more of this sweat is usually produced by the sweat glands on our feet!

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- **In what types of situations do we usually produce a lot of sweat?**
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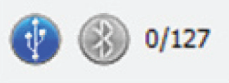

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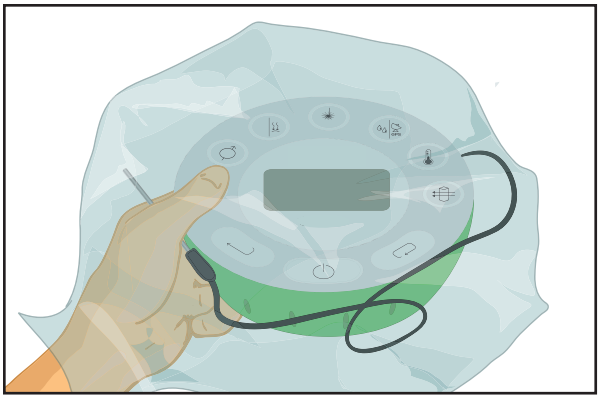

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2. What happens to the environmental temperature from the moment at which the relative humidity reaches its maximum value? **Explain.**

3. Why do you think the temperature rises in the same time period in which the humidity reached the maximum value? **Argue** your answer with data from the experiment.

4. Why do you think the humidity falls compared to temperature, during the last period of time?

5. Write a concluding paragraph describing what you observed during the experiment.