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

Greenhouse Effect:
Measuring Temperature Inside and Outside a Greenhouse
(Teacher's Guide)

© 2012 WARD'S Science. v.11/12
All Rights Reserved

For technical assistance,
call WARD'S at 1-800-962-2660

OVERVIEW

Students will reproduce a greenhouse on a small scale and measure the temperature both inside and outside. They will make observations to relate their results with the information provided in the teacher background. Finally, they will create a graph displaying their results in order to analyze them.

MATERIALS NEEDED

Ward's DataHub
USB connector cable*
13 sticks (180 mm x 6 mm x 6 mm)
4 sticks (140 mm x 6 mm x 6 mm)
Plastic (clear plastic sheet)
Liquid silicone glue
Masking 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 but only one greenhouse can be built with the materials listed above.

© 2012 WARD'S Science. v.11/12
All Rights Reserved

For technical assistance,
call WARD'S at 1-800-962-2660

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		

Dimension 3 Core Concepts	Discipline	Core Idea Focus
	Life Science	LS2: Ecosystems: Interactions, Energy, and Dynamics
		LS2.B: Cycles of Matter and Energy Transfer in Ecosystems
	Physical Science	PS3: Energy
		PS3.B: Conservation of Energy and Energy Transfer
		PS3.D: Energy in Chemical Processes and Everyday Life
	Earth and Space Sciences	ESS2: Earth's Systems
		ESS2.A: Earth Materials and Systems
		ESS2.D: Weather and Climate
		ESS3: Earth and Human Activity
		ESS3.C: Human Impacts on Earth Systems
		ESS3.D: Global Climate Change
	Engineering, Technology, and Applications of Science	ETS2: Links Among Engineering, Technology, Science and Society
		ETS2.A: Interdependence of Science, Engineering, and Technology
		ETS2.B: Influence of Engineering, Technology and Science on Society and the Natural World

NGSS Standards	Middle School Standards Covered	High School Standards Covered
	MS.LS-MEOE: Matter and Energy in Organisms and Ecosystems	HS.LS-MEOE: Matter and Energy in Organisms and Ecosystems
	MS.PS-E: Energy	HS.PS-E: Energy
	MS.ESS-WC: Weather and Climate Systems	HS.ESS-CC: Climate Change
	MS.ESS-HI: Human Impacts	HS.ESS-HS: Human Sustainability

✓ Indicates Standards Covered in Activity

(Standards continued on next page)

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		

Earth Science Standards Middle School		Earth Science Standards High School	
✓	Structure of the Earth System		Energy in the Earth System
	Earth's History	✓	Geochemical Cycles
	Earth in the Solar System		Origin and Evolution of the Earth System
			Origin and Evolution of the Universe

✓ 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 the differences in temperature inside and outside a greenhouse, and to create a hypothesis which will be tested during the experimental activity using the Ward's DataHub external temperature sensor.

Time Requirement:

60-90 minutes

© 2012 WARD'S Science. v.11/12
All Rights Reserved

VOCABULARY

Absorb: Take in or soak up by chemical or physical action.

Agronomist: A person that studies the science of soil management and the production of crops.

Atmosphere: The envelope of gases that surround Earth.

CO_2: Carbon Dioxide. A heavy odorless, colorless gas formed during respiration and by the decomposition of organic substances; absorbed from the air by plants in photosynthesis.

Global Warming: The gradual increase in the temperature of the Earth's atmosphere believed to be due to the greenhouse effect, caused by increased levels of carbon dioxide and other pollutants.

Greenhouse: A structure, primarily made of glass or plastic, in which temperature and humidity can be controlled for the cultivation and protection of plants.

Greenhouse Effect: Warming that results when solar radiation is trapped by the atmosphere; caused by atmospheric gases that allow sunshine to pass through but absorb heat that is radiated back from the warmed surface of the Earth.

Greenhouse Gases: Gases in the atmosphere that trap energy.

Infrared Radiation: Electromagnetic radiation with wavelengths longer than visible light but shorter than radio waves. Long wavelengths of light that heat objects instantly.

Precipitation: Rain, hail, mist, sleet, snow or any other moisture that falls to the Earth.

Radiate: Emit in the form of rays or waves.

Reflect: Throw back (heat, light or sound) without absorbing it.

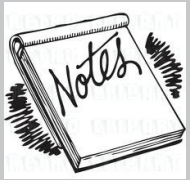
Temperature: A measure of how hot or cold something is.

Thermal: Thermal properties are dependent on temperature; they are related to, or caused by, heat.

Thermometer: An instrument used to measure temperature.

© 2012 WARD'S Science. v.11/12
All Rights Reserved

For technical assistance,
call WARD'S at 1-800-962-2660



Teacher Notes

INTRODUCTION

In some places of the world, it is common to build plastic or glass buildings to protect vegetables or flowers during cold seasons. These buildings, called greenhouses, cause a rise in the internal temperature, which is good for the different species of plants that grow there. The increase in temperature is caused because sun radiation enters the greenhouse, but only a small part of that radiation can leave after it has been reflected and absorbed. This is similar to the process that occurs on Earth causing the atmosphere to warm-up and enabling the existence of life on our planet.

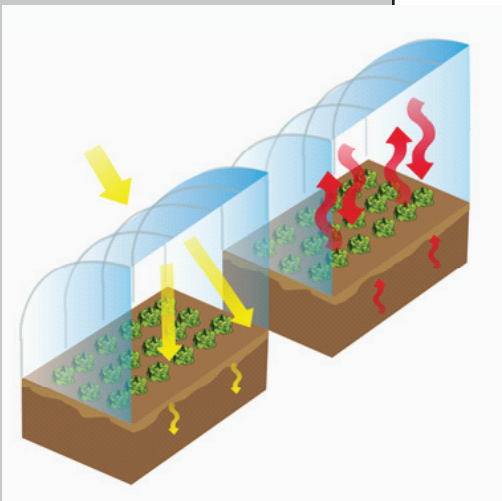
- **In which places of the world do you think greenhouses are used?**
- **Do you think there is a relationship between what happens in a greenhouse and global warming?**

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

- **Why do agronomists use greenhouses?**

BACKGROUND

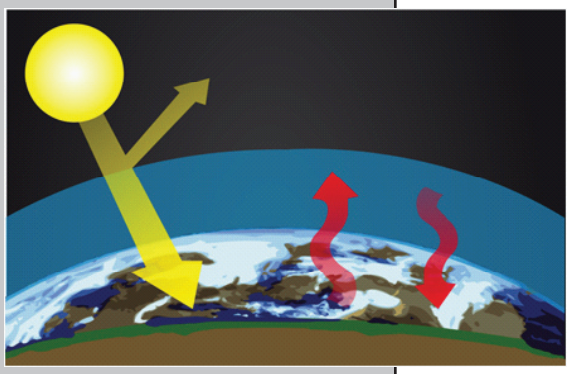
A greenhouse is a metal or wooden structure covered with different types of translucent material, like plastic or glass. This kind of material is used because sun radiation is able to pass through it but cannot easily leave once it is inside. This process causes a rise in air temperature inside the greenhouse, because infrared radiation (the part of the light spectrum with the most thermal energy) coming from the sun reflects off the floor and sides of the greenhouse and stays inside. This phenomenon is called the greenhouse effect.



On the Earth's surface, the same phenomenon occurs at greater magnitude. The natural greenhouse effect keeps the Earth's climate warm, allowing the existence of life, in a similar way to a greenhouse. In our atmosphere, the greenhouse effect is caused by greenhouse gases, like methane (CH_4), carbon dioxide (CO_2) and water vapor (H_2O).

Sun radiation comes into contact with the surface of the Earth, warming it. Heat is then radiated towards the

© 2012 WARD'S Science. v.11/12
All Rights Reserved

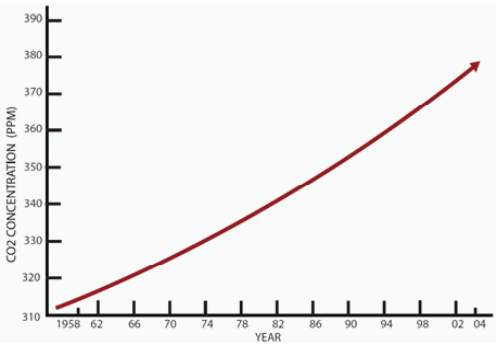


atmosphere, where it is stopped by greenhouse gases preventing it from leaving again and going into outer space. Heat then flows between the external atmosphere layer and the Earth's surface, keeping peak temperature conditions for life existence.

The greenhouse effect happens at a given concentration of greenhouse gases. In recent years, the amount of greenhouse gases has strongly increased due to human industrial activity. For example, carbon dioxide emanation from industrial processes enhances the natural greenhouse effect, causing further temperature increases. This phenomenon is called global warming.

Global warming is a concept that refers to the rise in average global atmospheric and sea temperatures. Scientists are aware of the periodic return of high-temperature cycles on Earth.

At the beginning of the 19th century, a significant increase in the amount of greenhouse gas in the atmosphere occurred. This was elevated by the industrial revolution. During this period, the combustion of fossil fuel, like coal and oil, were used as an energy source and this caused a vast increase in the amount of greenhouse gas that was released.



Due to the increase in greenhouse gases in the atmosphere, the temperature of the Earth's surface has continuously risen over the last 50 years. Each year the average daily temperature increases by approximately 8 °C. Some consequences of this are the melting of the ice caps at the poles, the rise in sea level and other problems like an increase in hurricane, tornado, and storm frequency, hotter summers and colder and longer winter seasons.

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:

- **If we expose a small greenhouse to the sun, how many degrees will the variation in temperature be inside?**

© 2012 WARD'S Science. v.11/12
All Rights Reserved

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. Once you have a blank window, press the **Temperature Sensor** key **3 times**.	x 3
5. Press the On/Off/Esc key once to return to the setup menu.	
6. Press the Scroll key to highlight the Sampling Rate and then press the Select Key	then
7. Press the Scroll key until "**1/min**" is highlighted, then press the Select key.	then

8. Press the On/Off/Esc key to return to the setup menu.	
9. Press the Scroll key to highlight the Number of Samples and then press the Select Key.	then
10. Press the Scroll key until "**100**" is highlighted, 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

© 2012 WARD'S Science. v.11/12
All Rights Reserved

DID YOU KNOW?

Over the last 100 years, the global temperature has increased by 0.74 °C and the global sea levels have risen by 17 cm. This rise in sea level is partly due to the melting of snow and ice from the mountains and polar regions.

ACTIVITY

Set Up

If using a scale model to build a house structure:

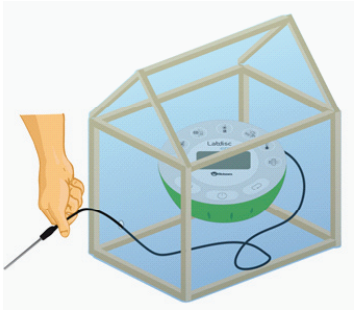
Use the sticks as shown in the figure below, left. Use the four shorter sticks to angle/pitch the roof. Cover the structure with a clear plastic sheet and fix it with masking tape. After that, setup the Ward's DataHub configuration, connecting the temperature probe to the Ward's DataHub and place it **inside** the greenhouse.

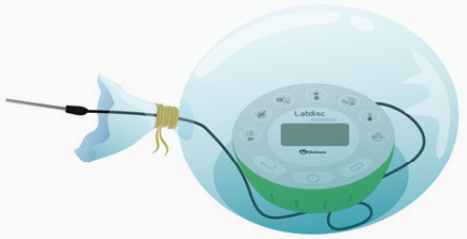
If using a small plastic chamber:

Inflate a clear nylon bag with the DataHub **inside**. Set up the Ward's DataHub configuration with the temperature probe connected, then, close the bag with the temperature probe **inside** and be sure the air remains inside.

Procedure

1. Place your greenhouse model in direct sunlight.
2. Record temperature data for 30 minutes. Once you have finished, stop measuring.
3. Bring the temperature probe **outside** of your greenhouse and repeat steps 1 and 2 to record temperature data **outside** of the greenhouse.





© 2012 WARD'S Science. v.11/12
All Rights Reserved

DID YOU KNOW?

Cornwall UK has the largest greenhouse in the world. It is called the Eden Project and was constructed at a cost of 128 million dollars. It is 150 feet tall and half a mile wide. The domes that make up the sides and roof of the greenhouse consist of hundreds of hexagonal and pentagonal inflated plastic cells which are supported by steel frames so that it can withstand the wind conditions in the area.

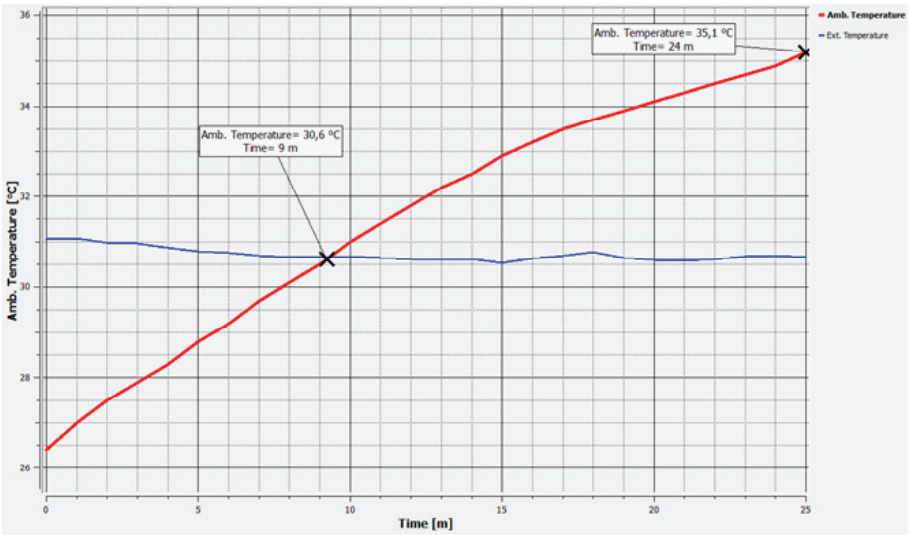
RESULTS AND ANALYSIS

The following steps explain how to analyze the experiment results.

1. Connect the DataHub to the computer using the USB communication cable or via the Bluetooth wireless communication channel.
2. On the upper menu, press 
3. Observe the graph displayed on the screen.
4. Press the  button and write notes on the graph specifying initial and final temperature.
5. Press  to select points on the graph and pick representative points.

- **How do the results relate to your initial hypothesis? Explain.**
- **Did you record a higher variation in temperature inside or outside the greenhouse?**

The graph below should be similar to what the students obtained.



© 2012 WARD'S Science. v.11/12
All Rights Reserved

CONCLUSIONS AND ASSESSMENTS

1. How would you **explain** the rise in temperature inside the greenhouse?

   Students should point out that the rise in temperature is caused because of the Sun's radiation trapped inside. The Sun's radiation is reflected by the sides and roof of the greenhouse, and therefore heats the air inside.

2. How could you **conclude** the sun's radiation indeed passed through the plastic sheet but didn't come out after?

   Students should explain that by observing an increase in temperature inside the greenhouse, we can infer that the air was heated by the radiation "trapped" inside the greenhouse. The rise in temperature was quantified by the sensor.

3. How could you **explain** that after the initial rise in temperature, it remained quite constant inside the greenhouse?

   Students should point out that the structure and the plastic sheet protect the inside from sudden changes in environmental conditions. Therefore, temperature keeps quite constant inside when compared with the outside.

4. What is the **quantitative** difference between the maximum temperatures measured inside and outside the greenhouse? If we extrapolate this result to the biosphere, what **consequences** would you expect? **Argue** why.

   After students select the representative points on each graph they should report the magnitude of the difference and link the Global Warming phenomenon to this result. Based on the theoretical background the students will be able to enrich their answers to mention different consequences due to climate change (poles melting and the increase of water, more intense hurricanes and tsunamis, longer winters and summers, floods and scarcity of water and all the negative effects on biodiversity and human well being).

5. How is the phenomenon of the experiment similar to the artificial greenhouse effect that is present on Earth?

   Students should analyze the information and point out that the greenhouse effect inside the actual greenhouse that they built and the one in the Earth's atmosphere are alike. In both cases, the Sun's radiation passes through the atmosphere and reflects on the ground, however on the Earth's surface only a small part of it returns to outer space because of the greenhouse gases. These gases form a layer that prevents the radiation from escaping out towards the atmosphere, increasing the average temperature on our planet's surface.

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

   Students should reach the following conclusions: *Greenhouse effect is a phenomenon that caused a rise and stabilization of temperature inside a closed system, because of a given amount of radiation flowing inside it. This radiation comes from the sun and passes through the atmosphere. It then flows between the outer atmospheric layers and the surface of the Earth, warming the air. The outer barriers isolate the internal medium from changes that may happen in the environment.*

© 2012 WARD'S Science. v.11/12
All Rights Reserved

For technical assistance,
call WARD'S at 1-800-962-2660

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. Why do some agronomists use greenhouses to grow certain species of vegetables?

   Students should explain that greenhouses are useful to make the most of sun radiation in places where there is not a lot of it; for example, in countries next to the poles. Besides, greenhouses protect the vegetables from adverse environmental conditions.

2. If you wanted to maximize the greenhouse effect of a system, which variables do you need to manipulate at a structural level?

   Students should point out that to minimize the radiation lost through the sides and the walls of the greenhouse, they had to use a thicker plastic sheet to cover it. They could also change the color of the plastic, and replace it with one that absorbs more radiation.

3. How could we minimize greenhouse gas emissions?

   Students should think of some actions that could decrease greenhouse gas emissions. For example, use green transportation like bicycles, reforestation and/or reduce carbon emissions (control carbon footprint).

4. Why is reforestation a way to reduce greenhouse gas concentration, particularly carbon dioxide (CO_2) concentration?

   Students should explain that reforestation reduces CO_2 concentration because plants use it for photosynthesis, by capturing it from the environment and releasing oxygen in return.

5. Imagine a greenhouse on the Earth's surface and plants growing inside, protected from environmental changes. Now consider the Earth-atmosphere system as a second, greater greenhouse, limited with greenhouse gases. Which other factors are protecting the plants inside the Earth-atmosphere system?

   Students should identify Earth as a planet inside the solar atmosphere, with a roof (formed by greenhouse gases) protecting the surface from changes in the hemisphere. For further experimentation, students can investigate which other conditions are protecting Earth from the effects of solar atmosphere.

DID YOU KNOW?

Things you can do to slow global warming:

1. "Reduce, Reuse, Recycle".

2. Replace incandescent bulbs with energy-efficient ones.

3. Save water by shutting it off while brushing teeth, shaving or washing dishes.

4. Green your daily commute by walking, biking, taking public transportation or carpooling to work or school instead of driving.

5. Replace old appliances with Energy-Star rated appliances.

© 2012 WARD'S Science. v.11/12
All Rights Reserved

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

Greenhouse Effect:
Measuring Temperature Inside and Outside a Greenhouse
(Student Guide)

INTRODUCTION

In some places of the world, it is common to build plastic or glass buildings to protect vegetables or flowers during cold seasons. These buildings, called greenhouses, cause a rise in the internal temperature, which is good for the different species of plants that grow there. The increase in temperature is caused because sun radiation enters the greenhouse, but only a small part of that radiation can leave after it has been reflected and absorbed. This is similar to the process that occurs on Earth causing the atmosphere to warm-up and enabling the existence of life on our planet.

- **In which places of the world do you think greenhouses are used?**
- **Do you think there is a relationship between what happens in a greenhouse and global warming?**

After carrying out this experiment, you should be able to answer the following question:

- **Why do agronomists use greenhouses?**

© 2012 WARD'S Science. v.11/12
All Rights Reserved

For technical assistance,
call WARD'S at 1-800-962-2660

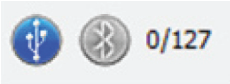
CONNECTING THE WARD'S DATAHUB TO A COMPUTER

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. Once you have a blank window, press the **Temperature Sensor** key **3 times**.	x 3
5. Press the On/Off/Esc key once to return to the setup menu.	
6. Press the Scroll key to highlight the Sampling Rate and then press the Select Key	then
7. Press the Scroll key until "**1/min**" is highlighted, then press the Select key.	then
8. Press the On/Off/Esc key to return to the setup menu.	
9. Press the Scroll key to highlight the Number of Samples and then press the Select Key.	then
10. Press the Scroll key until "**100**" is highlighted, 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

© 2012 WARD'S Science. v.11/12
All Rights Reserved

For technical assistance,
call WARD'S at 1-800-962-2660

ACTIVITY

Set Up

If using a scale model to build a house structure:

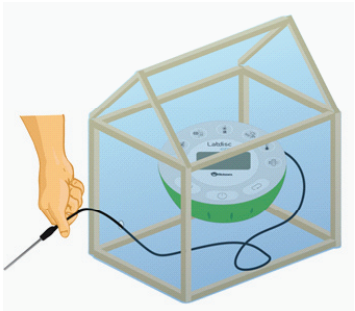
Use the sticks as shown in the figure below, left. Use the four shorter sticks to angle/pitch the roof. Cover the structure with a clear plastic sheet and fix it with masking tape. After that, setup the Ward's DataHub configuration, connecting the temperature probe to the Ward's DataHub and place it **inside** the greenhouse.

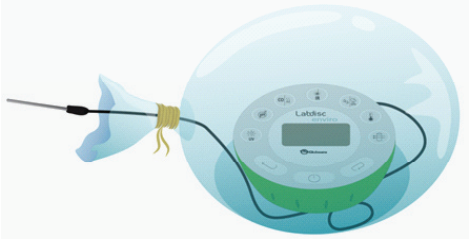
If using a small plastic chamber:

Inflate a clear nylon bag with the DataHub **inside**. Set up the Ward's DataHub configuration with the temperature probe connected, then, close the bag with the temperature probe **inside** and be sure the air remains inside.

Procedure

1. Place your greenhouse model in direct sunlight.
2. Record temperature data for 30 minutes. Once you have finished, stop measuring.
3. Bring the temperature probe **outside** of your greenhouse and repeat steps 1 and 2 to record temperature data **outside** of the greenhouse.





© 2012 WARD'S Science. v.11/12
All Rights Reserved

RESULTS AND ANALYSIS

1. Connect the DataHub to the computer using the USB communication cable or via the Bluetooth wireless communication channel.
2. On the upper menu, press 
3. Observe the graph displayed on the screen.
4. Press the 

button and write notes on the graph specifying initial and final temperature.
5. Press  to select points on the graph and pick representative points.

- **How do the results relate to your initial hypothesis? Explain.**

  _____

  _____

  _____

- **Did you record a higher variation in temperature inside or outside the greenhouse?**

  _____

  _____

  _____

© 2012 WARD'S Science. v.11/12
All Rights Reserved

For technical assistance,
call WARD'S at 1-800-962-2660

CONCLUSIONS AND ASSESSMENTS

1. How would you **explain** the rise in temperature inside the greenhouse?

_____

_____

_____

_____

2. How could you **conclude** the sun's radiation indeed passed through the plastic sheet but didn't come out after?

_____

_____

_____

_____

3. How could you **explain** that after the initial rise in temperature, it remained quite constant inside the greenhouse?

_____

_____

_____

_____

4. What is the **quantitative** difference between the maximum temperatures measured inside and outside the greenhouse? If we extrapolate this result to the biosphere, what **consequences** would you expect? **Argue** why.

_____

_____

_____

_____

(continued on next page)

© 2012 WARD'S Science. v.11/12
All Rights Reserved

For technical assistance,
call WARD'S at 1-800-962-2660

CONCLUSIONS AND ASSESSMENTS

(continued)

5. How is the phenomenon of the experiment similar to the artificial greenhouse effect that is present on Earth?

_____

_____

_____

_____

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

_____

_____

_____

_____

© 2012 WARD'S Science. v.11/12
All Rights Reserved

For technical assistance,
call WARD'S at 1-800-962-2660