Activity A Student Guide

Building a Simple Physical Model

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Activity A

Building Simple a Physical Model

Overview

Studying ecosystems is a way to explore the diverse conditions within Earth's biosphere. The arctic tundra consists of cold ecosystems populated by organisms adapted to these conditions. In contrast, the tropical rain forests have ecosystems which receive abundant rainfall with consistently warm temperatures throughout the year. As ecologists and earth scientists, you have studied examples of this abiotic and biotic diversity in characterizing the many biomes that make up Earth's biosphere.

But what about other important characteristics that allow life to flourish on Earth? Scientists who study the planetary bodies within our solar system might suggest that Earth's ecosystems are really not as varied as you may think. Through their research they have determined that one specific abiotic factor varies among the planets more significantly than any of the others. Can you surmise which one of the abiotic factors that you have used to characterize Earth's biomes that this could be?

The abiotic factor that varies the most among the planets in our solar system is temperature. Extreme temperature differences exist between planets in our solar system. On Mars, one of Earth's closest neighboring planets, the average surface temperature is -45°C. This is too cold to support the diversity of life that exists on Earth. On Venus, the average surface temperature is 430°C. This is too hot for Earth's diversity of life to live. On Earth, the average surface temperature is 15°C. As Goldilocks would say, "This is just right!" It is both warm enough and cool enough to produce the habitable and diverse condition of our planet, Earth. So, how is it that the temperatures on 3 nearby planets can be so different? The surface temperature on a planet is influenced by many factors including its atmosphere and surface features.

A planet's atmosphere consists of a variety of gases. Some of these gases are able trap heat. By doing do, the atmosphere helps to retain some heat that is generated from the sun's energy. As sunlight strikes Earth, some of that energy is absorbed by the planet, as well as re-radiated back to space as heat. These heat-trapping gases that radiate heat energy are known as greenhouse gases because they produce what is called the Greenhouse Effect. The Greenhouse Effect is the retention of heat energy by atmospheric gases.

When comparing different planets, scientists sometimes refer to the thickness of the atmosphere. The thickness of an atmosphere refers to the amount of greenhouse gases present in an atmosphere. If the atmosphere were too thin (without or with few greenhouse gases) the planet would be too cold to sustain life. A good example of this type of planetary condition is Mars. Too thick an atmosphere (with many greenhouse gases and the planet would be too hot to sustain life. Venus is such a planet. Our atmosphere contains a mixture of gases that retain just the right amount of heat to gives Earth habitable temperature.

It is also important to understand that if the sun's energy were blocked from reaching the surface of the

planet, this would also produce a planet that was too cold for Earth's life to exist. Likewise, a planet's surface features play important roles in influencing surface temperature. Some surface features absorb more energy and produce a warming effect. Other surface features reflect that energy and cool the planet.

Earth's unique atmospheric and surface characteristics allow light or solar energy to pass through and reach the planetary region where we live, absorbing and reflecting it in just the right amounts to achieve planetary energy balance ideal to sustain life.

Studying the factors that affect a planet's surface temperature can lead to important understandings related to potential changes in Earth's temperature. If humans modify the relative concentrations of greenhouse gases in Earth's atmosphere as may be happening with increased fossil fuel burning, it would be helpful to understand how this might affect global temperature. In addition, if we change the features of Earth's surface (e.g. land and water), this might also affect temperature. The question is how can we conduct experiments that will help us understand the consequences of these changes?

One way to study the influence of atmosphere and Earth's absorption of light on temperature is to design and construct small-scale physical models to simulate these processes. By using simple models researchers can run experiments to infer how a system that is much larger, like Earth, works. The experiments can isolate different factors that influence temperature and reveal their significance in warming and cooling the planet. In this activity, teams will design experiments using small-scale models to test two questions: 1) Does an atmosphere influence the temperature of a planet system? 2) How do the surface features of different biomes influence the temperature of the planet system?

Learning Objectives

- ✓ Design an experiment to answer a specific question and test a hypothesis
- ✓ Differentiate independent and dependant variables
- ✓ Evaluate the results and suggest modifications to an experiment
- ✓ Prepare a synthesis of the experimental results to prioritize a set of parameters
- ✓ Explain a conceptual relationship between temperature, energy inputs and surface features
- ✓ Describe strengths and limitations of physical models

Relevance

People all around the globe are concerned with current events and the impact they have on our daily lives. We are also interested in how events will change and affect our future lives and generations. This is especially true for events related to the earth system that is our shared habitat. In order to make predictions about such a complicated system, we have to develop models. Only if we can improve what we know about the relative importance of specific factors/variables, can we understand the delicate balance that regulates earth's habitable temperature.

Materials (per group)

2 small plastic containers (to hold the model)
light source (150 Watt light bulb)
2 digital thermometers
transparency grid sheets
bag of aquarium moss
Global Vegetation Map
water and sand
rolls of cotton
various colors of aquarium gravel
rolls of clear plastic wrap
various colors of modeling clay

Period 1 – Designing Biome Models and Writing Experimental Proposals

In this activity you will be working with a specific biome to understand the effects that biome might have on global temperature. Design an experiment using different colored materials to differentiate between the biomes and make inferences about its effect on global temperature. It is important to remember that white light consists of all of the colors of the rainbow. The color that an object appears is because the object is reflecting that color of light. Therefore, different colored materials will reflect different colors and amount of light energy. In this activity you will be researching the effects that different surface colors have on surface temperature.

Preliminary Activity – Engagement

You have been assigned ONE specific terrestrial biome. This will be yours to build a model that represents its unique characteristics. Before you can do that you must contemplate what it is that you are creating. As a group, think about the characteristics of the ONE biome that you have been assigned. In particular think about where the biome is found on surface of Earth. Use the global vegetation map and your knowledge of the biome to identify the major areas on Earth where this particular biome can be found. Place a transparent sheet over the global vegetation map and carefully outline with a marker the locations of your biome on Earth's surface. Be prepared to present and justify your locations to the class.

Methods

In this experiment you should only be testing ONE experimental variable at a time. Therefore, all of the possible experimental variables that you are not testing should be kept the same throughout your experiments. One of the materials for your experiment, a light source, should remain at a constant height throughout the experiment. In addition, experiments designed to answer both questions should run simultaneously in order to save on time.

Preliminary Discussion and Planning

Consider the following question and then carry out the investigation tasks below: How much of each colored material should be used to represent our biome?

1. Overlay the outline you made from the global vegetation map with the transparent grid boxes sheet.
2. Trace the outline onto the grid boxes sheet.
3. Count the total number of boxes in the circled areas (combine/estimate box parts as whole boxes). This is an estimate of the total area of Earth that represents your biome. This number is 100% of your biome's Earth surface.
4. Within your biome there are probably more than one color represented. You can see this by looking at colors on the world vegetation map. Count the numbers of boxes of each different color within your outlines.
5. Calculate the percentage of each color by separately dividing the number of boxes of each color by the total number of boxes you counted and then multiplying this number by 100. This number estimates the amount of surface in your model that will be covered by each material.

Experimental Design

A good experiment is guided by a well thought out plan. What is your plan?

1. Organize your investigative team by discussing and determining the role each team member will take in order to contribute to the overall project. Complete and submit Data Sheet 1: Team Member Roles.
2. Prepare your team's research proposal by completing Data Sheet 2: Experimental Design Proposal.

Period 2: Model Experiments: The Influence of World's Biomes on Temperature

Teams will conduct experiments to test these two questions: 1) Does an atmosphere influence the temperature of a planet system? 2) How do the different biomes influence the temperature of a planet system? You will create a physical model for your biome, one with an atmosphere and one without on which to conduct your experiment.

Preliminary Activity: Engagement

Let's hypothesize! In today's activity you will test how the presence of a simulated atmosphere affects planet surface temperature for an area with the characteristics of your biome. Before you get started, think about the following question. Does is matter if a planet has an atmosphere or has no atmosphere. What kind of effect might an atmosphere have on surface temperature? Why? Write it down. Once you have written your thoughts down discuss them with a partner. Be prepared to discuss your thoughts with the class.

Methods

Experimentation and Observations

1. Construct your physical small-scale model, but do it twice. Since you are testing the effect of an atmosphere on surface temperature, you will need to have two models. One of the models will have an atmosphere and one will not have an atmosphere. Use your experimental protocol that you wrote during last class as methods to construct your biome model and set up the experiment.
2. Use clear plastic wrapping to represent an atmosphere. After you have built your biome models you can simply place the plastic wrapping over the top of your box. Be sure that you have placed all material, including a thermometer inside the model before placing the plastic wrapping on.

Experiment: Atmosphere/No Atmosphere… that is the question.

1. Each team will follow a common measurement protocol. You will take temperature measurements of the atmospheric and non-atmospheric biome models every minute for a 20-minute period. Don't forget the importance of standardized procedures.
2. Record your measurements on Data Sheet 3: Box Model Temperature Data.
3. A second round of experiments can be conducted, if after all results are analyzed and discussed and researchers determine that modifications can be made to their experiment to achieve a greater degree in accuracy. Just repeat the steps for data collection. Check with your teacher to be sure there is time for a repeat of the experiment.

Data Analysis, Comparisons and Consensus

1. Analyze the temperature data by completing Data Sheet 4: Experimental Results, the section titled Your Biome Conditions. (only complete this first section of Data Sheet 4)

Period 3 – Sharing and Critiquing Results

This activity is an opportunity for peer review of each group's research protocol. Throughout the presentations everyone should take notes on the results from each biome.

Preliminary Activity – Engagement

Observe the two graphs that your teacher has provide you. These represent the data for an experiment. Compare the data for the two model situations (atmosphere/no atmosphere). How does an atmosphere seem to have affected the temperature in the models? Are the results similar to yours? Explain. Do you have any questions about the experiment? Do you think it is important to repeat experiments many times? Why? Be prepared to discuss these questions.

Data Analysis, Comparisons and Consensus (continued)

1. Prepare your team presentation to the class. Be sure you are able to discuss your research question, your hypothesis, and the general methods you followed in order to complete the experiment. In addition, present your results and conclusion to your research question. Finally present any improvements that you think would be helpful.
2. As each other group is presenting take notes on the class results using Data Sheet 4: Class Biome Conditions Table.
3. Use Data Sheet 5: Graph Data to draw a histogram of the class results showing temperature differences from each of the different biomes.
4. Answer the Individual Assessment Questions. Use the ideas you have learned as well as your table and graph to answer the questions

Data Sheet 1 Activity A

Team Member Roles

Before planning and carrying out an experiment, you must first decide who will play each role on your research team. Look over the responsibilities of each position and decide among yourselves who will take on each one.

Lead Researcher: _____

Responsibilities:

- ✓ Organize activities of team
- ✓ Make sure that all members are contributing productively
- ✓ Criticize the results of your experiments
- ✓ Make suggestions to improve your experimental procedure
- ✓ Initiate the repetition of an experiment if necessary
- ✓ Keep notes on the following:
  a) How could your experimental procedure be improved?
  b) What materials do you lack in order to make this a more effective experiment?

Materials and Data Managers: _____

Responsibilities:

- ✓ Acquire materials for setting up experiment
- ✓ Coordinate team effort to set up the experimental model
- ✓ Keep organized records of all experimental measurements
- ✓ Return and organize all equipment at the end of class period
- ✓ Organize all written materials for group and return at end of class period

Experimental Communication: _____

Responsibilities:

- ✓ Carefully note all steps of experimental procedures
- ✓ Construct diagrams of experimental set-up
- ✓ Construct graphs of experimental results
- ✓ Coordinate team presentation of results and analysis

Data Sheet 2 Activity A

Experimental Design Proposal – Part 1

Before getting into the details of your experiment, you need to propose a hypothesis and realize the limitations of your experiment.

Hypotheses

How do you expect the atmosphere will affect the surface temperature of your physical model systems?

How do you expect the biome differences will affect the surface temperatures of the physical model systems?

How large of a temperature difference do you expect between your TWO physical models?

Experimental Limitations

How do the lab materials used in this experiment differ from the objects they are simulating?

Laboratory Materials	**Simulated Object**
Light source	Sun
Plastic Container	Planet
Gravel, water, clay, sand, other textured materials	Surface of the planet (Biome Type)
Additional Materials: meter sticks, thermometers	

Data Sheet 2 Activity A

Analysis of Experimental Factors

Variables

List all the factors or materials you can change in this experiment.

Experimental Independent Variable: What variable can the experimenter purposely change?

Experimental Dependent Variable: What variable will respond to the change in the independent variable?

Experimental Control: What factors or materials will not change during the experiment?

Methodology for Controlled Experiments

Design an experiment that addresses the 2 guiding scientific questions: : 1) Does an atmosphere influence the temperature of a planet system? 2) How do the different biomes influence the temperature of a planet system?

Experimental Procedure

Data Sheet 3 Activity A

Box Model Temperature Data

Record your data (every minute for 20 minutes) in the table. Report the temperature at 20 minutes and your estimated final temperature. The columns "Round Two" will only be used if researchers decide to modify their experiments and repeat the procedures.

Biome: _____

Time (min)	Round One		Round Two	
	Atmosphere	w/o Atmosphere	Atmosphere	w/o Atmosphere
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

Data Sheet 4 Activity A

Experimental Results: Biome Conditions

Report your experimental results based on the data you collected for your biome's physical models. First note the temperature conditions achieved by both physical models. Next, note the temperature difference for your models. Compare these results with the biome results from all class models. Create a histogram showing these results. Explain what you have learned about your original hypothesis.

Experimental Results: Your Biome Conditions

To answer the first question – Does an atmosphere influence a planet's temperature?

a) Independent variable: _____

b) Dependent variable: _____

Name of Biome	Final Temperature with Atmosphere	Final Temperature without Atmosphere	Temperature Difference

Experimental Results: Class Biome Conditions

To answer the second question – How much of an effect does a biome have on temperature?

a) Independent variable: _____

b) Dependent variable: _____

Name of Biome	Final Temperature with Atmosphere	Final Temperature without Atmosphere	Temperature Difference

Data Sheet 5 Activity A

Graph Data

- ✓ Draw a histogram (or bar graph) below to illustrate the class results
- ✓ Be sure to label the x-axis with the independent variable from your experiment
- ✓ Be sure to label the y- axis with the dependent variable from your experiment
- ✓ Use appropriate scales on both axes

Describe how the results compared with your original hypothesis.

If you were to repeat the experiment, what changes could you implement to be more accurate?

Individual Assessment Questions Activity A

Answer the following questions using the ideas you have learned as well as your table and graph.

1. How did the presence of an atmosphere on the models influence the temperature of the biomes represented?

2. In what ways for the world's biome s effect the Earth's temperature

3. Why is the use of physical models a helpful introduction to studying the earth system and environment?

4. Why not solely rely on physical models to understand a certain aspect of the environment?

5. How could you modify the experiment to make it even more realistic?

6. In what ways does a thick atmosphere affect the Earth system?

7. Why is it called the Greenhouse Effect?

8. Research the types of gases/molecules found in the Earth's atmosphere and list 5 of the most common. Two of these are considered greenhouse gases. Circle the two greenhouse gases.