

Topic

1

**Temperature
Variations
and Habitability**

**Activity A Observing, Describing, and Adapting to
Environmental Variations**

**Activity B Relating Factors that Influence Planetary
Temperature and Habitability**

Topic 1

Temperature Variations and Habitability

Overview

To understand why Earth is hospitable to life, it is important to study the conditions that contribute to a planet's habitability. We can begin by looking at the kinds of adjustments humans make to produce more comfortable living environments. Temperature is one of the most basic conditions that we adjust. Topic 1 is an introduction to the module, providing an appreciation of temperature variations that exist on Earth and our neighboring planets, and a sense of some factors that influence average planetary temperatures.

Science Content

Temperature variations on Earth and our neighboring planets

An initial idea of the importance of temperature in planetary habitability can be gained by identifying the magnitude and range of temperature differences found on neighboring planets, Mars and Venus, as well as in diverse geographic locations on our own planet. By comparing images of planetary surface and atmospheric features, we can begin to formulate hypotheses for factors that produce an average planetary temperature that is habitable. Evaluating the relative importance of these factors helps in identifying variable ranges needed for habitability. Relationships between these system variables and ways humans and nature influence planetary temperature have positive or negative consequences on Earth's habitability.

Science Skills

Measurement and experimental design

To appreciate how humans can modify the environment, students participate in an exercise to describe and compare differences between conditions inside and outside the school building. Students will propose measurements needed to quantify their statements and a plan for collecting data. In making observations of indoor and outdoor environments using science instruments, the value and limitations of these tools can be appreciated.

Data analysis and magnitude and scale

Data analysis of temperature and environmental conditions is conducted on various planetary-level spatial scales. First, students study environmental conditions in their own local environment. Next, they look at the temperature and surface features in the Sahara Desert and Antarctica. Their final task is to study the average planetary temperatures of Venus, Mars, and Earth, and images of their planetary and surface features. A comparison of these data leads students to assess the magnitude and range of temperature variations that influence habitability.

Teacher Notes

Knowledge mapping, systems thinking, and hypothesis development

With an initial idea about the factors that determine a planet's habitability students can hypothesize about relationships among these system variables. By connecting the variables where they believe a relationship exists and preparing justifications for these connections, students can develop a "knowledge map" that diagrams "inputs", "variables," and "outputs" in the earth system that help determine average planetary temperature.

Considering a Real World Problem

Searching for Life in Extreme Environments

A wide range of environmental conditions characterizes regions around the globe. In Topic 1, students offer their ideas on the factors or conditions that make our planet habitable and explore the range of temperatures that exist on Earth and neighboring planets in our solar system. The real world problem asks them to apply their initial understandings to consider the most extreme environments on Earth where life forms exist, such as the geysers and hot springs in Yellowstone National Park where microorganisms live and grow.

Students offer their perspectives on the magnitude of differences in environmental conditions where humans can exist, as well as the types of *negative* and *positive* consequences that may occur if adjustments or changes are made to the essential factors or conditions that make Earth a habitable planet. The ideas they formulate provide the basis for hypotheses and experiments students will develop in Topic 2 to test the influence of various factors on planetary temperature.

Activity A

Observing, Describing, and Adapting to Environmental Variations



1 class period

What do students understand about the range of temperatures found on the Earth and within the solar system? Begin by asking students, “What would we have to do to make areas with extreme temperatures more comfortable for humans?” The first activity is to compare indoor and outdoor conditions where students live. After some discussion, they hypothesize about what kind of adjustments would have to be made in order for a classroom to be comfortable in the Antarctic and in the Sahara. A variety of answers are proposed. The References at the end of the activity provide visuals of regions on Earth and in our solar system that can be used to stimulate discussion.

Learning Objectives

By the end of this activity, students should be able to:

- ✓ Identify a minimum of five factors useful for describing local environmental conditions.
- ✓ State the range of temperature variability on the earth.
- ✓ State the range of temperature variability within our solar system.
- ✓ Explain the connections among quality of life on Earth, temperature variability, and the environment.

Materials

Access to the outdoors, instruments to measure weather phenomena (thermometers, barometers, anemometers, etc.), images of Earth and other planets that represent temperature extremes.

Engagement

The teacher asks class how they would describe what kind of day it is. After a variety of responses, ask how students would make measurements to quantify their statements. What tools would they need? How long would it take? The class makes a plan to describe the day.

Procedure

Once the plan is formulated, students are provided with the equipment they have requested. This should include thermometers, barometers, and anemometers. The class is divided into teams, half the teams will evaluate conditions outside the building and the other half will evaluate conditions inside the classroom. Students spend about 15 minutes making observations and specific measurements. Observations are recorded on the Data Sheet provided for the activity.

Consensus

Students are asked to compare interior and exterior conditions. How are they different or similar? Discuss why these differences and similarities occur. Look at the magnitude of the differences. Answers will depend upon the season and geographic location.

How do humans modify their own environment to make it more livable? Place some emphasis upon heating and sources of energy so these concepts can be referred to later. What are alternate sources of energy? Is this done for comfort or necessity? How would these answers differ if it were some other season or another place on the earth? The teacher displays the Reference viewgraphs of sites in the Sahara and the Antarctic to elicit student responses.

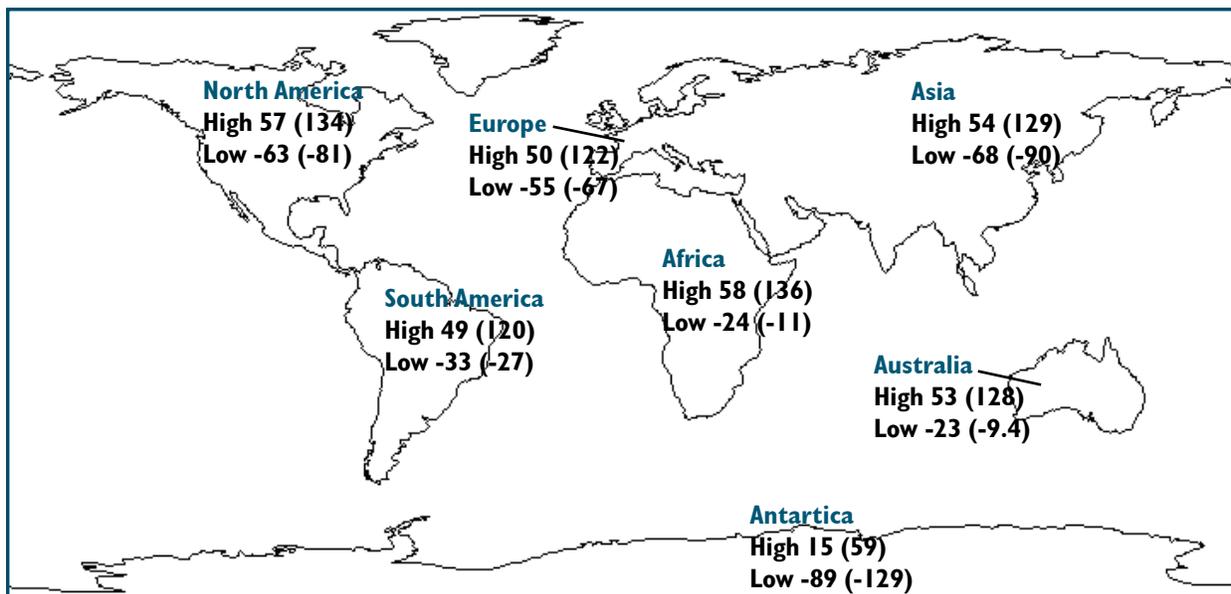


Figure 1.1. Global Measured Temperature Extremes [in ° Celsius (° Fahrenheit)].

Teacher Proposes

What if this activity were to be moved to another planet? What would we have to do to duplicate this activity on another planet? Would it be as easy as going to the South Pole? The Sahara? Show the Reference viewgraph of the earth and ask the class to think about the following question: What makes the earth so special to humans? Teacher elicits answers from students to obtain a general answer.

Synthesis

The Reference viewgraphs of other planets are shown to emphasize the hostile environments present in the solar system. A summary of these comparisons would be the last Reference viewgraph shown. Students complete the investigation's Questions prior to discussing conclusions about the range of temperatures that exist on Earth and within our solar system, and ideas about the relationship to the habitability of these environments.

Activity B

Relating Factors that Influence Planetary Temperature and Habitability



2 class periods

This activity enables the teacher to ascertain students' understanding of factors that determine the average temperature and habitability of planets in general and the earth in particular. By developing diagrams called "Knowledge Maps," students convey their ideas about the essential factors needed to produce a habitable temperature, including links between related factors. Knowledge Maps are tools to help students formulate testable hypotheses. Explaining and defending the maps is a key part of this activity. The hypotheses developed will drive the process for students to design experiments in Topic 2 concerning the relative significance of their factors.

Learning Objectives

By the end of this activity, students should be able to:

- ✓ Give three examples of how humans modify the environment to improve livability.
- ✓ Identify three factors that may determine the average temperature of a planet.
- ✓ Identify a minimum of five factors that may determine the habitability of a planet.
- ✓ State the importance of maintaining habitable temperature on a planet.
- ✓ Briefly describe the links between two sets of factors of their choosing.

Materials

Post-it (or similar) notes, colored linking strips made by cutting index cards lengthwise, large sheets of poster paper, and markers.

Engagement

Class Period 1

Present an example of a knowledge map dealing with a familiar topic, such as factors influencing a flower's growth. This will help students produce a *Habitable Planetary Temperature Knowledge Map*.

Procedure

Students work on teams of about five members each. The initial task is to construct a Knowledge Map of the essential ingredients or factors for a habitable planetary temperature. Each team selects a recorder. A list of approximately 10 essential factors is prepared, with each factor written on a separate Post-it note. On poster paper, students group the most closely related factors, using colored linking strips to show strong relationships. They should be prepared to explain why they chose their factors, how they are related, and how they contribute to planetary habitability. These ideas should be discussed within the team and brief summaries of explanations recorded. The teacher circulates to ensure student efforts

Teacher Notes

in this direction.

Habitable Planetary Temperature Knowledge Maps are presented. Questioners and Presenters are selected among the students. Each designated Questioner selects one Knowledge Map team to examine. A team will be given time to present and explain their map and defend it in response to questions. Questioners will fill out the Knowledge Map Assessment Form for the Presenters. This process introduces different perspectives about factors needed for a habitable planetary temperature and relationships between them.

Class Period 2

Consensus

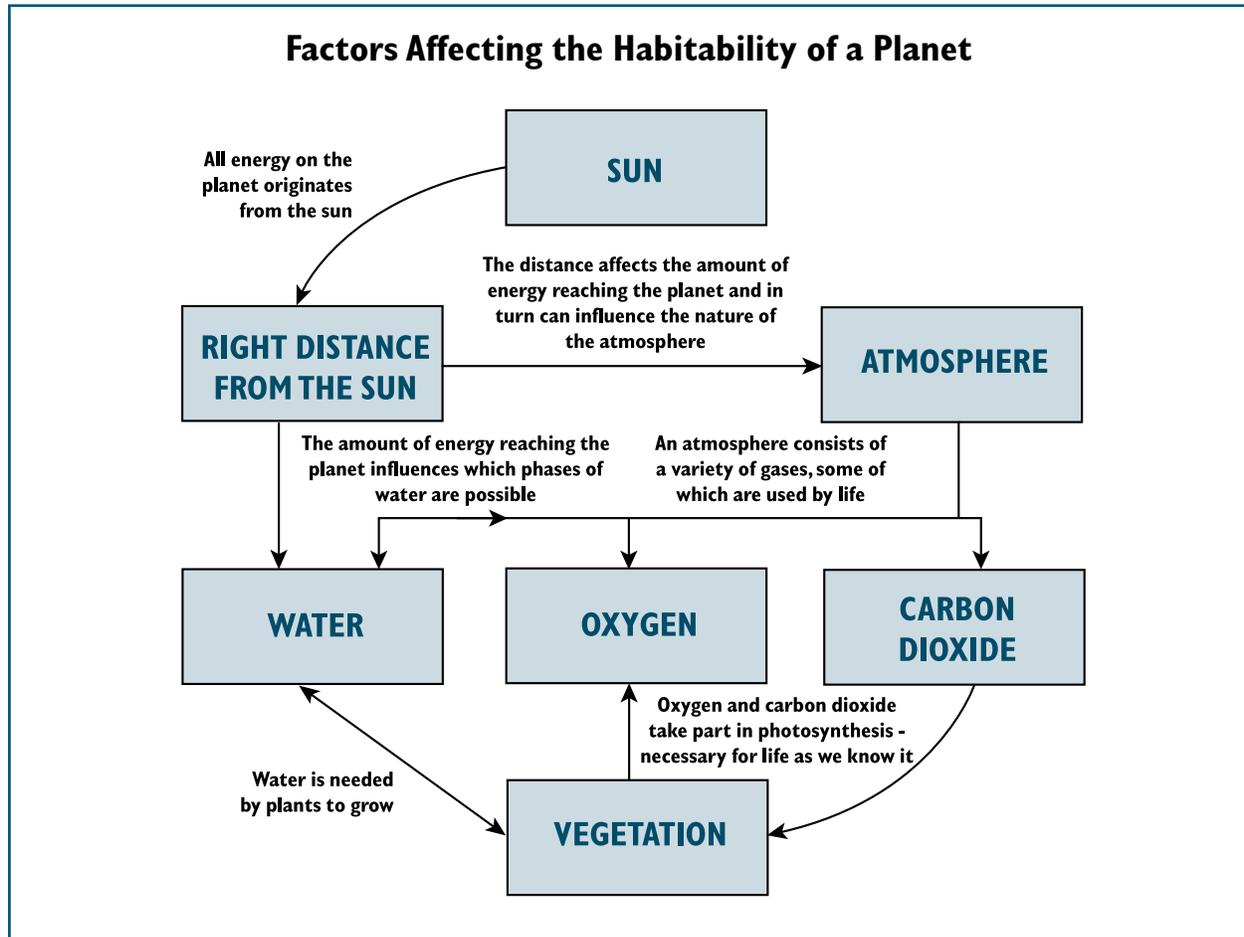


Figure 1.2. Sample Knowledge Map.

The concept of a *system* is introduced. An aquarium can be used to illustrate this idea. Ask students to identify the *inputs* (light, food, heat, air, etc.), the *variables* (amount of water, number of fish, clarity of water, etc.) and the *outputs* (reflected light, odors, sound, etc.). Students define these three concepts. A planet can be viewed as a system, albeit a large one. Students then return to their Maps and identify factors as inputs, system variables, or outputs. Each student submits a Data Sheet with their team's system diagram, including factors, links, and explanations. The Investigation Questions are also handed in to the teacher.

Teacher Notes

Synthesis

A class discussion of how all the ingredients can be classified is held, producing a class list of the inputs, system variables, and outputs of the planet as a system. Students are informed that they will use this list as a set of hypotheses to investigate the planet as a system during the next learning activities. Their final assignment is to prepare a short essay that addresses the Real World Problem: Searching for Life in Extreme Environments.

Evaluating Student Work

Topic 1. Temperature Variations and Habitability

Activity A – Investigation Questions

1. What are the differences and similarities between environmental conditions in the classroom and outdoors? What is the magnitude of the difference?
2. How do humans modify the environment to make it more livable?
3. Discuss whether or not you think it would be practical to build large cities in the Sahara and/or the Antarctic?
4. Consider the temperature differences that exist between Earth and Mars, and Earth and Venus. Do regions exist on Earth that can experience similar high or low temperature differences? Use the map in figure 1.1 to answer this question. If yes, identify these regions and the temperature ranges. Calculate the magnitude of these temperature differences. For example: Region X's highest recorded temperature was 40 degrees higher than Region Y's lowest recorded temperature. Relate these differences to the temperature differences found between the planets.
5. What makes Earth special to humans?

Answer Guide – Questions 1 through 4

Students should discuss the fact that energy must be consumed in order to create comfortable conditions for everyday human activities, and that the amount and type of energy is different for the different regions of the globe. They should also indicate that even the largest differences between Earth regions are small compared to differences between Earth and other planets.

Answers to these questions should show that students understand that temperature is one measure of habitability, but by no means the only one. They should also make some connection with the magnitude of the temperature extremes at a point and the amount of energy or cost necessary to maintain habitable conditions.

Activity B – Investigation Questions

1. What are some of the essential factors that determine the habitability of a place located anywhere in our solar system?
2. How are these factors related to one another to produce a habitable climate?
3. Do you think there is anywhere on Earth that is so inhospitable that human beings cannot physically visit it? Would your answer change if you were to consider the whole solar system?

Answer Guide – Questions 1 through 3

This is a knowledge assessment exercise; most logical answers are acceptable. The emphasis should be on the ability of the students to build logical links between factors and to distinguish between inputs to a system like sunlight, system properties like color of the surface, and outputs like surface temperature.

Answers should refer back to the concept diagrams that the students developed during Activity B. Acceptable answers should include direct references to the relationships discussed in the concept diagrams.

Essay: Real World Problem – Searching for Life in Extreme Environments

A wide range of environmental conditions characterizes regions around the globe. What factors or conditions do you think are essential to sustain human life and how do they interact to produce a habitable temperature? What locations on Earth do you think represent the most extreme environmental conditions in which human life can survive? Based on what you have learned and discussed with your classmates, indicate the magnitude of the differences in these environmental conditions.

Consider the extremely high temperatures inhabited by microorganisms in Yellowstone National Park. Are there other extreme environments on Earth where scientists can search for life forms other than human? Based on the ideas discussed in this topic, what are the implications for the existence of life on other planets?

From this initial study of some of the extreme temperatures that exist on Earth and other planets in our solar system, offer your perspective on the types of negative and positive consequences that may occur if adjustments or changes are made to the essential factors or conditions that make Earth a habitable planet.

Assignment: Write a 300 word essay that responds to the questions in this topic's Real World Problem. You should use at least one reference in your essay. Consider the following: encyclo-

pedia, science magazines, textbooks, the Internet. Be sure to cite the reference(s) you decide to use.

Minimum Expectations for this Essay

- ✓ State at least three conditions or factors essential to maintaining human life.
- ✓ Provide a short discussion on how these factors interact.
- ✓ Give at least two examples of extreme environments on Earth (preferably not the Sahara or the Antarctic).
- ✓ Give an example of the range of values for the above factors for these environments.
- ✓ Give two examples of life in extreme environments on Earth (e.g. black smokers in the Atlantic Ridge).
- ✓ Discuss the implications of the existence of these life forms upon the possible existence of life on other planets.
- ✓ Discuss the effect changes in at least one of these factors has on the habitability of Earth.

In the essay, students should exhibit their knowledge of the factors leading to habitable temperatures on a planet and that these factors are logically linked to one another. They should also indicate that they understand that while habitable conditions for humans exist in a somewhat narrow range of values, other life forms can exist in conditions too extreme for humans.