

PBIS

Planetary Forecaster

AS A STUDENT SCIENTIST, YOU WILL...

Ask
QUESTIONS

APPLY
MEANING

Pursue
ANSWERS

Make
MEANING

Share
ANSWERS



Teacher's Planning Guide

UNIT OVERVIEW

Content

In this curriculum, students explore the major factors affecting temperature on Earth and then use what they learn to make temperature predictions, and consequently, predictions for habitable areas, on a fictional, “newly discovered” planet. In order to make their temperature predictions for the new planet, students must answer the following driving questions:

- What are the major factors that affect surface temperature?
- How do each of these factors affect surface temperature?
- Why does each of these factors have the effect that they do?
- How much of an effect does each factor have on surface temperature?

These questions motivate a series of investigations consisting of both hands-on labs and software-based activities in which students examine the different factors affecting temperatures. The curriculum concludes with students’ final presentations, in which they describe their findings and make a recommendation for where colonists should settle on the new planet.

Investigations

Student groups have experiences that lead them to answer the Unit’s *Big Question*. In *Learning Set 1*, students are given the *Big Question* and they will be investigating the causes of temperature variation on Earth in order to make predictions for the newly-discovered planet. They are asked to draw on their preexisting knowledge to predict surface temperatures on Earth in July and then compare an electronic version of their maps to real temperatures in a data visualization program called *My World*. In *Learning Set 2*, students receive more details about their mission and learn about the four factors identified by the Cooperative Space Agency (CSA) as having the greatest influence on surface temperature. They also investigate the first factor in predicting *Planet X*’s surface temperatures: How the shape of the planet changes the directness with which incoming solar energy strikes the planet’s surface. Students investigate the second factor in *Learning Set 3*: The tilt of a planet’s axis as it revolves around its sun. Students investigate how incoming solar energy varies on different parts of Earth as it moves to different positions relative to our own Sun. In *Learning Set 4*, students investigate how the differences in air temperature over land and water affect surface temperatures. They learn how the specific heat capacities of land and water create different temperature patterns and use this information to modify their predictions about the habitability of *Planet X*. Students explore the fourth and final factor, elevation, in *Learning Set 5*. Students apply information from readings and their own

*A class period is considered to be one 40 to 50 minute class.

analyses of data from labs to understand surface temperatures of different places on Earth at different elevations. They then modify their predictions about the habitability of *Planet X* based on their new knowledge. In *Learning Set 6*, students put together all of the information they have learned about the four factors that affect surface temperature on a planet. They have been told throughout the Unit that they will be making a recommendation to the CSA for the location best suited for a new colony, and this is their opportunity to complete that task.

Nature of Science

This Unit addresses a variety of inquiry skill and Earth Science content standards. Of the inquiry skill standards, it is perhaps most important that students improve their abilities to monitor and revise their own understanding of particular concepts. Many students come into this curriculum with an assortment of Earth Science misconceptions, and it is important for them to not only correct these misconceptions, but to reflect on how these misconceptions change due to their own investigations. Students also practice the skills of making observations, recording and analyzing data, utilizing print resources, utilizing visual representations and symbols, and using information about one situation to make generalizations about another.

Of the Earth Science content standards, students focus especially on learning objectives relating to the heating of Earth's surface by the Sun. In the first three content lessons, students study how the shape of Earth's surface causes incoming solar energy to strike less directly farther from the Equator and how the tilt of the Earth's axis causes different parts of Earth's surface to receive the most direct incoming solar energy as Earth revolves around the Sun. While studying these specific concepts, students also study in detail latitude and longitude, curvature, angles, tangent lines, season, solstices, and equinoxes. In the fourth content lesson, students study how differential heating of land and water result in temperature variations due to differences in specific heat capacity and reflectivity. Students learn how and why Earth's surface temperatures change with increasing elevation in the fifth content lesson. The specific concepts studied in this lesson are atmospheric pressure and heat energy transfer via radiation, conduction, and convection. Differential heating of Earth's surface is the driving force behind weather on the planet. Therefore, weather is a natural add-on to this curriculum. Weather and climate readings are included as the sixth content lesson.

Artifacts

Each *Learning Set* in this curriculum contains four to six activities geared towards developing understanding of a particular concept. The four content *Learning Sets* focus on one of the particular "factors" students are studying to predict temperatures for their final products. Almost every lesson has a

product students will create that can be used to assess student learning. At the end of each content *Learning Set*, students will create maps representing their hypotheses about the surface temperatures on *Planet X*. These maps will show an increasing degree of complexity as students study more factors that affect their temperature predictions.

Targeted Concepts, Skills, and Nature of Science	Section
Students should be able to use a thermometer to record the temperature outside their school.	1.1, 1.2
The surface temperatures on Earth fall into patterns that can be anticipated and predicted.	1.3, 1.4, 1.5
Surface temperatures on Earth are predictable to a certain extent, in that there are specific ranges found in different locations.	1.4, 1.5
Surface temperatures on Earth fall into distinct patterns, with respect to latitude. The warmest temperatures are found on or near the equator. Average temperatures decline as you move farther away from the equator toward the poles.	1.5
Some locations on Earth are habitable, based on the range of temperatures that are experienced during different seasons of the year.	1.5
Temperature is a measurement of energy. Temperature readings can vary, even in the same location, depending on several factors.	1.1, 1.2
Scientists measure surface temperature a short distance above the ground in order to measure the temperature of the environment.	1.2
Temperatures around Earth’s surface vary widely, but can be predicted somewhat by location and season.	1.3, 1.4
Habitable areas of Earth are determined by average temperatures suitable for humans.	1.5
Students should update the <i>Project Board</i> after completing their temperature readings.	1.1
The spherical shape of the planet changes the way that solar energy strikes its surface as compared to the way the energy would strike a flat surface. As the curvature of the surface increases and the angle at which the energy strikes increases, the intensity of solar energy decreases.	2.1, 2.2, 2.3

Targeted Concepts, Skills, and Nature of Science	Section
The amount of solar energy that strikes Earth's surface is highest at the Equator and the intensity of the solar energy that strikes the surface decreases as you move further away from the Equator, whether you are moving north or south.	2.4, 2.5
The intensity of solar energy is affected by the angle at which it strikes Earth's surface.	2.2
The more directly that light strikes the surface, the more intense the light is. When light strikes less directly, it covers a larger area and is less intense.	2.2
The shape of a planet affects the intensity of solar energy received in different locations and therefore, temperature at different areas.	2.3
A scientific explanation should be backed up by evidence that supports the claim.	2.3
The intensity of solar energy can be measured at different latitudes on Earth's surface. This data reveals a pattern, showing that light energy is most intense nearest the Equator and less intense as you move away from the Equator, toward the poles.	2.4
The amount of solar energy varies by latitude. The highest intensity of solar energy is received at the Equator, with lower intensities being recorded as you move farther away from the Equator.	2.4
Scientists use new information and ideas to revise their learning process.	2.5
The shape of a planet directly affects its surface temperatures.	2.5, LS 2 Back to the Big Challenge

NOTES

.....

.....

.....

Unit Material List

Quantities based on 28 students in 7 groups		
Unit 6 - Durable Kit	Section	Quantity
<i>My World</i> software	All	1
<i>Big World Map</i>	1.3	1
flashlight, bright penlight	3.2, 4.2	7
overhead protractor	3.2	8
globe, inflateable plastic	3.2, 4.2	7
scissors	3.2	7
large test tubes	5.2	14
single-hole rubber stoppers for test tubes	5.2	14
thermometers, glass, alcohol	5.2	14
100 watt light bulb	5.2	7
lamp stand, clamp w/ shield	5.2	7
ring stand	5.2	7
clamps to hold test tubes on ring stand	5.2	7
ruler, metric 30 cm	5.2, 6.4	28
soda bottle pressure pump	6.3	14
temperature strips, 55 - 88 degrees F	6.3	14
goggles, splashproof	6.3	28

Unit Material List

Quantities for 5 classes of 28 students		
Unit 2 - Consumable Kit	Section	Quantity
small sticky notes, 0.5" X 1.75" (Page Markers)	1.2	14
restickable easel pad	1.5, 2.3	1
markers, set of 8 colors	2.3, 3.2	7
graph paper, Pk/50	3.2, 3.3, 5.2	1
index cards, 5" x 8"	4.2	200
overhead marker (black)	4.5	1
overhead marker (blue)	4.5	1
overhead marker (green)	4.5	1
overhead marker (red)	4.5	1
Additional Items Needed Not Supplied		
clipboard, lunch tray, or stiff cardboard to hold graph paper	3.2	7
colored pencils or crayons, 8 colors	1.2, 1.4, 5.2, 6.4	28
soil, small sample, student supplied	5.2	7
mass scale option 1 (Strongly Preferred): electronic mass scale, ≥ 1000 gram capacity, ≤ 0.1 g readability & precision	5.2, 6.3	7
mass scale option 2: triple beam mass balance w/ attachment weights, ≥ 1000 gram capacity, ≤ 0.1 g readability & precision	5.2, 6.3	7
glycerine, 25 mL dropper bottle, to lubricate rubber stopper hole	5.2	7
2 liter plastic bottles, soda, student supplied	6.3	7
cabinet, sanitizer for goggles	6.3	1

UNIT INTRODUCTION

What's the Big Challenge?

1 class period 

Which regions of a newly discovered planet have appropriate surface temperatures for a human colony?

Overview

Students are introduced to the *Big Challenge of Planetary Forecaster: Which regions of a newly discovered planet have appropriate surface temperatures for a human colony?* As part of the *Big Challenge*, students learn that they have the opportunity to work as part of a research team that will be investigating the causes of temperature variation on Earth to make predictions for the surface temperature of the newly discovered *Planet X*. They will explore the four factors presented by the Cooperative Space Agency that are key in determining surface temperature: Shape of the planet, tilt of the planet's axis, land/water differences, and surface elevation. The class will create a *Project Board* to post ideas and track what they learn. After each investigation, the class will update the *Project Board*. The students will also create a prediction map of *Planet X* using computer software called *My World*. They will also update their prediction maps as they learn more about the factors that affect surface temperature.

*A class period is considered to be one 40 to 50 minute class.

Targeted Concepts, Skills, and Nature of Science	Performance Expectations
<p>Some locations on Earth's surface are more habitable than others. One of the main factors in determining habitability is surface temperature. Surface temperatures can vary greatly across Earth's surface.</p>	<p>Students should be able to observe the pictures of different Earth environments and recognize that surface temperatures can vary widely in different locations. Students should think about what factors affect surface temperatures and share their ideas with the class.</p>

Materials**1 per class**class *Project Board*

Activity Setup and Preparation

Select groups of three to four students to discuss the *Big Challenge* in discussion groups and work together during this Unit.

Learn About the *Big Challenge*

- If possible, prepare an overhead of the letter from the Cooperative Space Agency describing the *Big Challenge*. This will allow you to read and discuss the challenge as a class. If this is not possible, you can have the students read the material out loud as a class.

Homework Options

Reflection

- **Science Process:** What types of things can you tell about an environment from looking at a picture? What types of things can you not observe from a picture? (*Students should be able to identify things such as plant and animal life, presence of water, and indications of relative temperature such as snow or sun. Things not identifiable are actual temperature, amount of wind, etc.*)
- **Science Content:** Describe some of the things that make the environment you live in different from other places on Earth. (*Students should be able to identify the temperature or environmental conditions in their location that make it different from other places on Earth.*)

Preparation for 1.1

- **Science Process:** Describe the different ways that you learn about the temperature in your environment every day. (*Answers will vary. Students may describe using weather forecasts on TV, radio, or newspapers. They may also describe looking for clues to the temperature when they look outside.*)

UNIT INTRODUCTION IMPLEMENTATION

† 1 class period

What's the Big Challenge?

Which regions of a newly discovered planet have appropriate surface temperatures for a human colony?

Weather is an important part of your daily life. What you wear and do outside depends on the weather. Weather describes what the atmosphere is like at a given time and place. It includes things like temperature, precipitation, wind, air pressure, and humidity. Over a long period of time, these factors determine the **climate** of an area. Though humans have figured how to survive in a variety of climates, some climates require more energy to survive

climate:
the average condition of the weather of a place.



TO: All Potential Research Scientists
FROM: The Cooperative Space Agency
SUBJECT: Request for researchers

The Cooperative Space Agency (CSA) has been searching outside the solar system for new planets. CSA is looking for planets that could support human life. The goal of CSA is to some day establish human colonies on other planets. CSA has found a new planet very similar to Earth that revolves around a star very similar to our Sun. For now, it is called *Planet X*. This planet is the same distance from its star as Earth is from the Sun. There appears to be water on the planet. It also has an atmosphere with enough oxygen to support humans.

However, CSA has not yet found the temperature ranges on *Planet X*. This information is needed to know if the planet is appropriate for a colony. CSA is putting together a team of research scientists to find out this information. You have been selected as a possible member of this team.

Please expect another bulletin with more details at a later date.



Advances in technology have helped scientists find several Earth-like planets. These planets are outside our solar system.

in than others. How do people who live in the Arctic stay warm in the winter? How do people in Texas stay cool? A group of human colonists traveling to a newly discovered planet would want to find a place to live where the temperatures never get too hot or cold.

Scientists have recently discovered several planets that they think may

Welcome to Planetary Forecaster. Enjoy the challenge of being a student research scientist.

PF 3

PLANETARY FORECASTER

Unit Introduction

What's the Big Challenge?

5 min.

Introduce the Big Challenge to the class.

△ Guide

After the class has learned the *Big Challenge*, have the students look over the pictures of different climates in their textbooks and think about what makes these locations different from each other with respect to climate and habitability.

◇ Get Going

Have the students read through the *Get Started* questions individually. Ask them to answer the questions as completely as possible. Tell them that there are no correct or incorrect answers to the questions.

*A class period is considered to be one 40 to 50 minute class.

Think about the Big Challenge

5 min.

Introduce students to the concept of the Big Challenge of Planetary Forecaster.

Get Started

15 min.

Have the students read through the Get Started questions and discuss their concepts of temperature and habitability.

PBIS

be a lot like Earth. These planets are outside our solar system, so it is not possible for humans to travel to them, but imagine if they could travel to one... Scientists would want to know where the best place for people to live on that planet would be. Scientists understand a lot about the weather and climate of Earth and the advantages and disadvantages of living in these different climates. They could use what they know about Earth to predict what the climate of this other planet would be like. This is what you will be doing. Read the bulletin on the previous page.

Think about the Big Challenge

Your challenge for this Unit is to research one climate factor on *Planet X*. That factor is temperature. The temperature ranges on the planet will determine if it is suitable for a human colony.

Before you get started on any challenge, it is a good idea to organize your thinking. You will start this Unit by thinking about what areas here on Earth are habitable for humans and what makes them that way.

Get Started

1. What would make a place suitable for a human colony? Make a list of what you think is needed and why you think it is needed to sustain a colony.
2. As you know, people live all over the world. Carefully observe the pictures on the right. They show different regions of the world. As you look at the pictures, think about the following questions:
 - What factors do you think affect the temperatures of the different regions?
 - How much do you think the temperatures change in the different regions at different times of year?
 - Which areas do you think would be best suited for a human colony? Why?

TEACHER TALK

“What do we mean when we call a place habitable? What do humans need in order to live? How does the location and environment affect these needs?”



Tundra in the Arctic.



Desert in Africa.



Deciduous forest in New York State.



Tropical rainforest in Costa Rica.



Grassland in Wyoming.

PF 5

PLANETARY FORECASTER

Conference

15 min.

Ask the students to discuss their answers to the Get Started questions in small groups. Have the students take turns sharing and encourage them to ask each other questions during the conference.

META NOTES

Many students will give responses indicating habitability often depends on the presence of food or water. Make sure to follow up these responses with questions asking them to describe the conditions necessary for food or water to be present.

Conference

Share your ideas with the rest of your group. Discuss the factors you thought affected the temperature of each region. Also, make sure that you understand why each group member thought an area was suitable for a human colony. You may disagree, but listen carefully to each group member's ideas.

Decide as a group what are the most important things you'll need to know about the temperature of a planet to figure out which areas are suitable for a human colony. What questions are important to investigate in order to successfully complete your challenge?

Create a Project Board

It is useful, when you are working on a challenge, to keep track of your progress. It is also useful to keep track of what you still need to do. Throughout this Unit, you will be using a *Project Board* to do that. During classroom discussions, your teacher or one of the students will record the class's ideas on a class *Project Board*. At the same time, you will keep track of what has been discussed on your own *Project Board* page.

Which regions of a newly discovered planet have appropriate surface temperatures for a human colony?				
What do we think we know?	What do we need to investigate?	What are we learning?	What is our evidence?	What does it mean for the challenge or question?

PF 6

Project-Based Inquiry Science

△ Guide

Ask students to form small groups and share their responses to the *Get Started* questions. Assign one of the students in each group the task of reading the questions and then have the students answer each question in a discussion format.

Create a Project Board

It is useful, when you are working on a challenge, to keep track of your progress. It is also useful to keep track of what you still need to do. Throughout this Unit, you will be using a *Project Board* to do that. During classroom discussions, your teacher or one of the students will record the class's ideas on a class *Project Board*. At the same time, you will keep track of what has been discussed on your own *Project Board* page.

Which regions of a newly discovered planet have appropriate surface temperatures for a human colony?				
What do we think we know?	What do we need to investigate?	What are we learning?	What is our evidence?	What does it mean for the challenge or question?

Project-Based Inquiry Science

PF 6

Create a Project Board

15 min.

Create a Project Board and start to fill it out.

META NOTES

The *Big Challenge* will involve learning about the various factors that affect surface temperatures on Earth. The *Planetary Forecaster* program will highlight four main factors: Shape, tilt, land/air differences, and elevation. In the beginning, students may be unfamiliar with these concepts. At this point, they need only to begin thinking about their concepts of temperature itself. The four factors will be introduced at the end of *Learning Set 1*.

Get Going

Transition students by telling them that now that they have thought about the *Big Challenge* and the concepts of temperature, climate, and habitability, they are going to need a way to keep track of their progress. Introduce the students to the idea of a *Project Board* by having them read the selection in their text. Go over the five headings used in the *Project Board* and fill it out with the responses.

Guide

Try to respond to the answers that the students give with follow-up questions. This will encourage the students to follow their train of thought and provide support for their thoughts in the form of logic or experiences.

Recall that a *Project Board* has space for answering five guiding questions:

- What do we think we know?
- What do we need to investigate?
- What are we learning?
- What is our evidence?
- What does it mean for the challenge or question?

To get started on this *Project Board*, you need to identify and record the important science challenge you need to address: *Which regions of a newly discovered planet have appropriate surface temperatures for a human colony?*

What do we think we know?

In this column of the *Project Board*, you will record what you think you know about surface temperature and temperatures suitable for a colony. Discuss and post the things you and your classmates think you know. Have you studied these concepts before? What did you learn then? Even if it is a small fact or idea, talk about it. Discuss any factors that you might think affect the temperature of a region.

What do we need to investigate?

In this column, you will record the things you need to investigate. During your group conference, you may have found that you and others in your group disagreed with some of your ideas. You may not know exactly what determines the temperature of a region. This second column is designed to help you keep track of things that are debatable, unknown, and need to be investigated.

Later in this Unit, you will return to the *Project Board*. For now, work with your classmates as you begin filling in the first two columns.

PF 7

PLANETARY FORECASTER

△ Guide

It may be helpful to review the *Big Challenge* again at this point. If possible, post the letter from the CSA as an overhead during the creation of the *Project Board*. This will help stimulate ideas on what must be investigated.

□ Assess

It is not important for the students to come up with correct responses. It is not even essential that they attempt to answer the questions completely

