Lab Handout

Lab 2. Seasons: What Causes the Differences in Average Temperature and the Changes in Day Length That We Associate With the Change in Seasons on Earth?

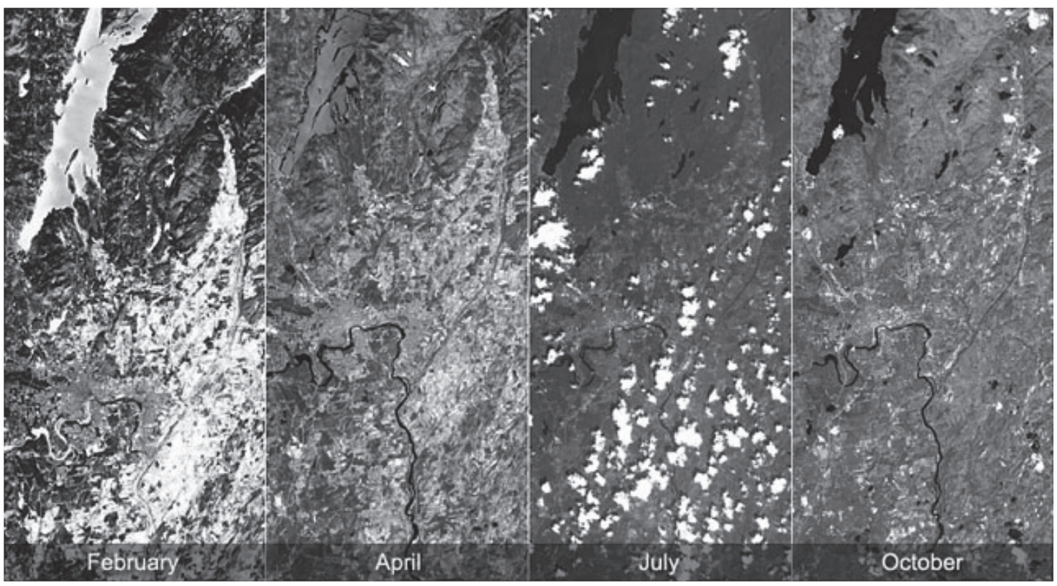
Introduction

A season is a subdivision of a year, which is often marked by changes in average daily temperature, amount of precipitation, and hours of daylight. People who live in temperate and subpolar regions around the globe experience four calendar-based seasons: spring, summer, fall, and winter. People who live in regions near the equator, in contrast, only experience two seasons: a rainy (or monsoon) season and a dry season.

Figure L2.1 shows four satellite images of Lake George in New York in February, April, July, and October. These images illustrate how the surface of the Earth looks different during different seasons.

FIGURE L2.1

The change of seasons as seen in four satellite images of Lake George, New York, from the Advanced Spaceborne Thermal Emission and Reflection Radiometer instrument on NASA's Terra spacecraft



Note: A full-color version of this figure is available on the book's Extras page at *www.nsta.org/adi-ess*.

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To understand why we experience different seasons in different locations on Earth, we must first think about the objects that are found in our solar system and how all these objects move over time in relation to each other. The Sun is at the center of our solar system. All the other objects in the solar system, which include planets, dwarf plants, asteroids, and comets, revolve (orbit) around it. All the planets in our solar system travel around the Sun in a counterclockwise direction (when looking down from above the Sun's north pole).

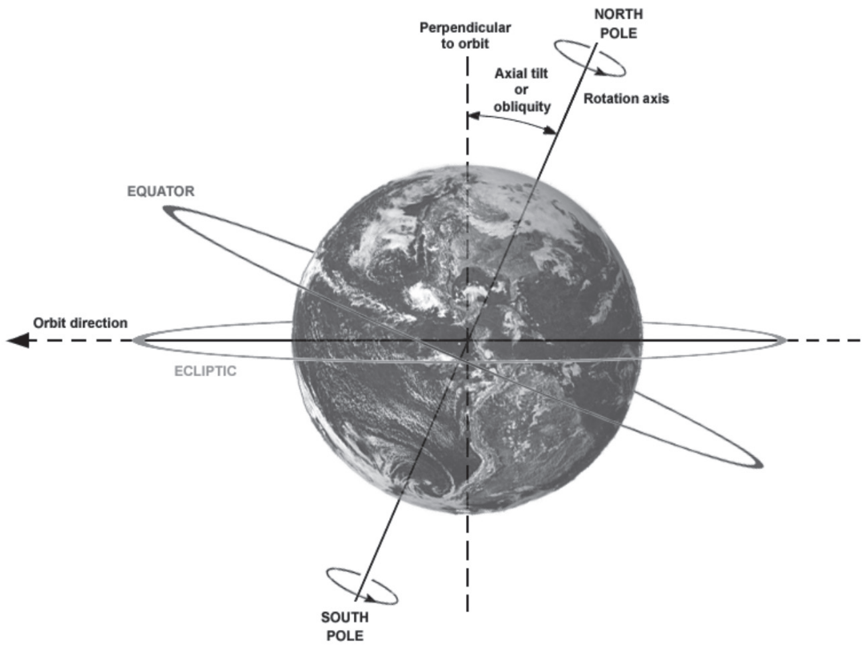
Earth takes 365.25 days to orbit the Sun. The distance that Earth must travel to complete one full revolution around the Sun is 940 million km. Earth, as a result, travels around the Sun at a speed of about 30 km/s. Earth is closest to the Sun in early January due to its slightly elliptical orbit. At this time, the Earth is about 146 million km away from the Sun. Earth is farthest from the Sun in early July, when the distance between Earth and the Sun is about 152 million km.

Earth also spins (or rotates) on its axis as it travels around the Sun. Earth spins on its axis in a counterclockwise direction (when looking down from above Earth's North Pole; see Figure L2.2). It takes 23 hours and 56 minutes for Earth to complete one full rotation. The rotation of Earth on its axis is what gives us day and night. During the day, we are facing the Sun and during the night we are facing away from it. Earth's axis, however, is not perpendicular to its orbit (or straight up if we were able to look down at it from above the solar system). Earth currently has an axial tilt of 23.4° (see Figure L2.2). Earth remains tilted in the same direction regardless of where it is in its orbit. This means that Earth's North Pole is directed toward the Sun in June but directed away from the Sun in December. In contrast, Earth's South Pole is directed toward the Sun in December and is directed away from the Sun in June.

These facts are useful and can help us understand the change in seasons. Yet, these facts do not provide us with all the information that we need to develop a complete conceptual model that explains the cause of the seasons. You will therefore need to learn more about how the average temperature and the hours of daylight change over the course of year at different locations on Earth. Next, you will need to use an online simulation called the Seasons and Ecliptic Simulator to explore how the tilt of Earth affects the amount of sunlight and the angle that sunlight strikes Earth at various locations over time. Finally, you will have an opportunity to put all these pieces of information together to develop a conceptual model that explains the cause of the seasons.

FIGURE L2.2

The axial tilt is the angle between a planet's rotational axis at its north pole and a line perpendicular to the orbital plane of the planet. Earth's axial tilt is currently 23.4°



Your Task

Develop a conceptual model that you can use to explain the cause of the seasons. You must base your conceptual model on what we know about how Earth revolves around the Sun and spins on its axis. You will also need to use what you know about systems and system models and the importance of looking for patterns in nature to develop your conceptual model. To be considered valid or acceptable, your conceptual model should not only explain the underlying cause of the seasons but also predict the changes in average daily temperature and hours of daylight at several different locations on Earth.

The guiding question of this investigation is, ***What causes the differences in average temperature and the changes in day length that we associate with the change in seasons on Earth?***

Materials

You will use an online simulation called Seasons and Ecliptic Simulator to conduct your investigation; the simulation is available at *http://astro.unl.edu/naap/motion1/animations/seasons_ecliptic.html.*

Information about the location (latitude and longitude), weather, and hours of daylight for most major cities around the world can be found at *www.climate-charts.com/world-index.html*.

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Safety Precautions

Follow all normal lab safety rules.

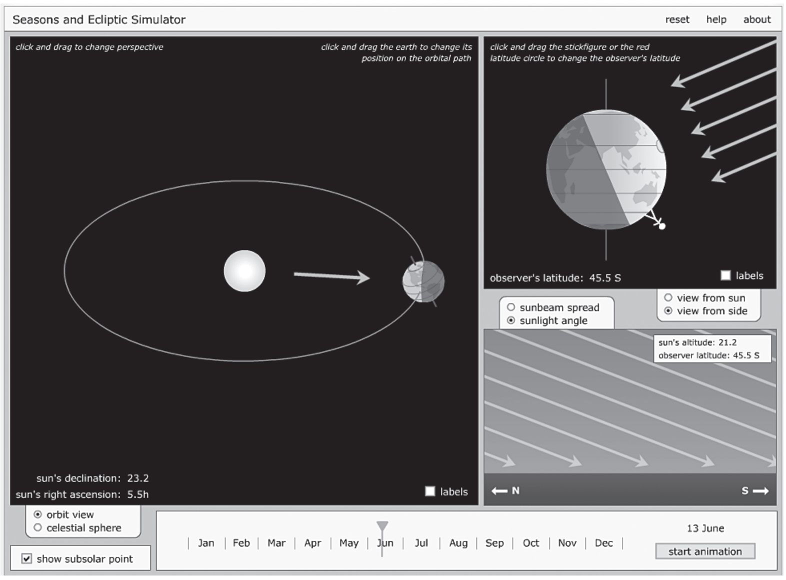
Investigation Proposal Required? ☐ Yes ☐ No

Getting Started

The first step in developing a conceptual model that explains the cause of the seasons is to collect information about the changes in average daily temperature and hours of daylight over a year at several different locations on Earth. This information can be found for cities in 149 countries at the World Climate website, which contains the largest set of accessible climate data on the web. Be sure to collect information from cities at a wide range of latitudes and longitudes. Once you collect this information, look for any patterns that you can use to help develop your conceptual model.

FIGURE L2.3

A screenshot from the Seasons and Ecliptic Simulator simulation



Next, you can use the *Seasons and Ecliptic Simulato*r to learn more about how light from the Sun strikes Earth over the course of the year (see Figure L2.3). This simulation allows you to move an observer to different latitudes on Earth and to track the Sun's altitude in the sky and the sunlight angle over the course of the year for that observer. Given the nature of the simulation, you must determine what type of data you need to collect, how you will collect it, and how you will analyze it to learn more about how Earth's tilt affects the amount of sunlight and the angle at which sunlight strikes Earth over time.

To determine *what type of data you need to collect,* think about the following questions:

- What are the boundaries and components of the system you are studying?
- How do the components of the system interact with each other?
- What type of measurements or observations will you need to record to determine how Earth's tilt affects the amount of sunlight that strikes Earth over time?
- What type of measurements or observations will you need to record to determine how Earth's tilt affects the angle that sunlight strikes Earth over time?

To determine *how you will collect the data,* think about the following questions:

- How often will you need to make the measurements or observations?
- What scale or scales should you use when you take your measurements?
- What types of comparisons will you need to make?

To determine *how you will analyze the data,* think about the following questions:

- What types of calculations will you need to make?
- What types of patterns could you look for as you analyze your data?
- How could you use mathematics to describe a change over time?
- How could you use mathematics to describe a relationship between variables?

Once you have finished using the *Seasons and Ecliptic Simulator*, your group can develop a conceptual model that can be used to explain the cause of the seasons. Be sure to incorporate the information you collected from the World Climate website. To be valid or acceptable, your conceptual model must be able to explain (a) why the length of day changes by different amounts in different locations and (b) why the average temperature for each month changes by different amounts in different locations.

The last step in your investigation will be to generate the evidence that you need to convince others that your conceptual model is valid or acceptable. To accomplish this goal, you can use your model to predict the length of day and average temperature at different times of the year in several additional cities. These cities should be ones that you have not looked up before. You can also attempt to show how using a different version of your model or making a specific change to a portion of your model will make your model inconsistent with data you have or the facts we know about seasons. Scientists often make comparisons between different versions of a model in this manner to show that a model is valid or acceptable. If you are able to use your conceptual model to make accurate predictions about the changes in average daily temperature and hours of daylight at several locations on Earth or you are able show how your conceptual model explains the cause of the seasons better than other models, then you should be able to convince others that it is valid or acceptable.

Connections to the Nature of Scientific Knowledge and Scientific Inquiry

As you work through your investigation, be sure to think about

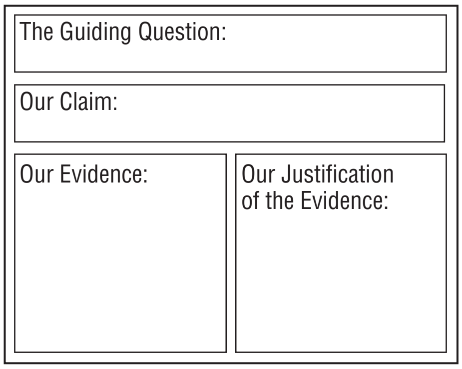
- the use of models as tools for reasoning about natural phenomena, and
- how scientists use different methods to answer different types of questions.

Initial Argument

Once your group has finished collecting and analyzing your data, your group will need to develop an initial argument. Your initial argument needs to include a claim, evidence to support your claim, and a justification of the evidence. The *claim* is your group's answer to the guiding question. The *evidence* is an analysis and interpretation of your data. Finally, the *justification* of the evidence is why your group thinks the evidence matters. The justification of the evidence is important because scientists can use different kinds of evidence to support their claims. Your group will create your initial argument on a whiteboard. Your whiteboard should include all the information shown in Figure L2.4.

FIGURE L2.4

Argument presentation on a whiteboard



Argumentation Session

The argumentation session allows all of the groups to share their arguments. One or two members of each group will stay at the lab station to share that group's argument, while the other members of the group go to the other lab stations to listen to and critique the other arguments. This is similar to what scientists do when they propose, support, evaluate, and refine new ideas during a poster session at a conference. If you are presenting your group's argument, your goal is to share your ideas and answer questions. You should also keep a record of the critiques and suggestions made by your classmates so you can use this feedback to make your initial argument stronger. You can keep track of specific critiques and suggestions for improvement that your classmates mention in the space below.

Critiques of our initial argument and suggestions for improvement:

If you are critiquing your classmates' arguments, your goal is to look for mistakes in their arguments and offer suggestions for improvement so these mistakes can be fixed. You should look for ways to make your initial argument stronger by looking for things that the other groups did well. You can keep track of interesting ideas that you see and hear during the argumentation in the space below. You can also use this space to keep track of any questions that you will need to discuss with your team.

Interesting ideas from other groups or questions to take back to my group:

Once the argumentation session is complete, you will have a chance to meet with your group and revise your initial argument. Your group might need to gather more data or design a way to test one or more alternative claims as part of this process. Remember, your goal at this stage of the investigation is to develop the best argument possible.

Report

Once you have completed your research, you will need to prepare an *investigation report* that consists of three sections. Each section should provide an answer for the following questions:

1. What question were you trying to answer and why?
2. What did you do to answer your question and why?
3. What is your argument?

Your report should answer these questions in two pages or less. You should write your report using a word processing application (such as Word, Pages, or Google Docs), if possible, to make it easier for you to edit and revise it later. You should embed any diagrams, figures, or tables into the document. Be sure to write in a persuasive style; you are trying to convince others that your claim is acceptable or valid.