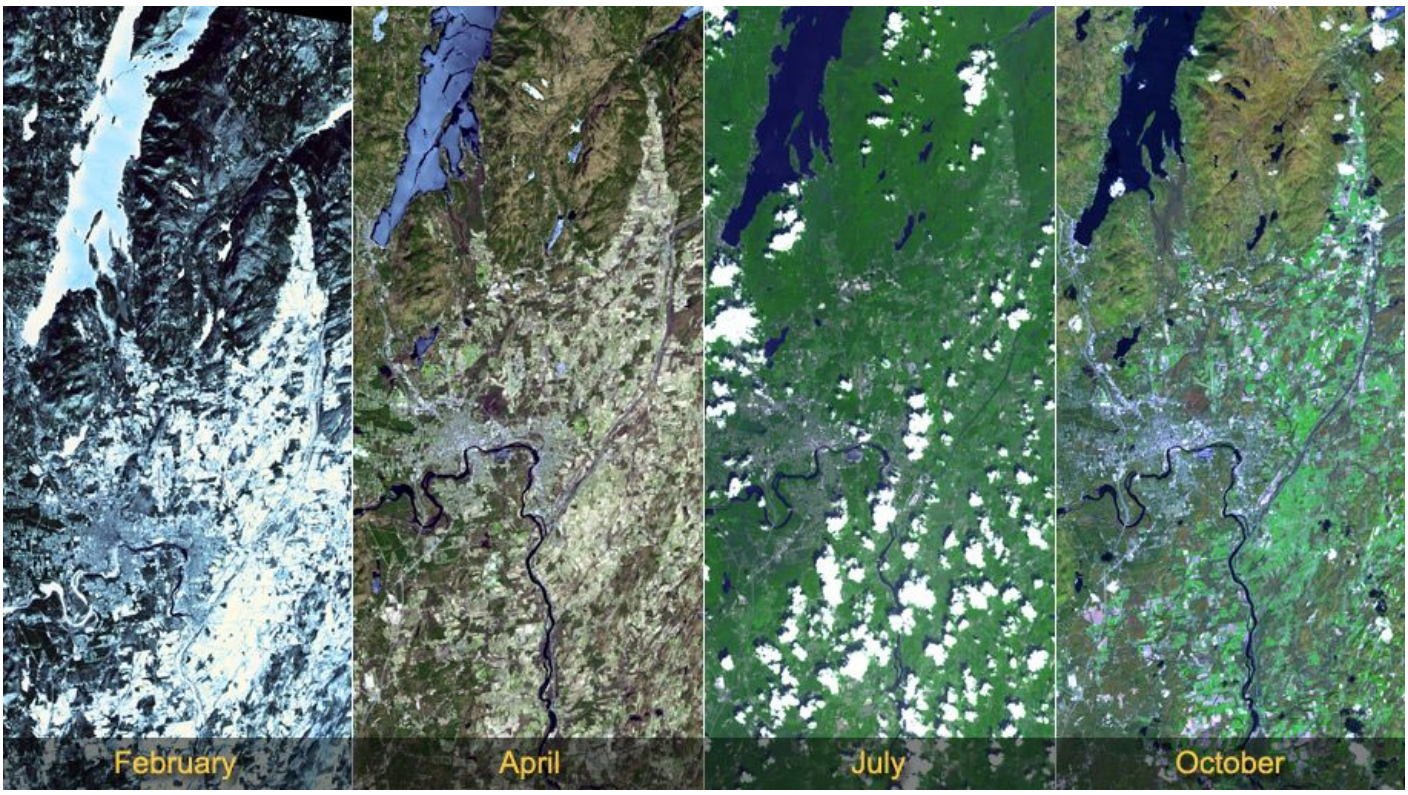
Seasons: What Causes the Differences in Average Temperature and the Changes in Day Length That We Associate With the Change of Seasons on Earth?

<u>NO LAB REPORT FOR THIS LAB</u>! Instead you will be collecting data, drawing a model, and explaining why the average temperature and day length changes with the seasons.

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. The figure below 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.



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

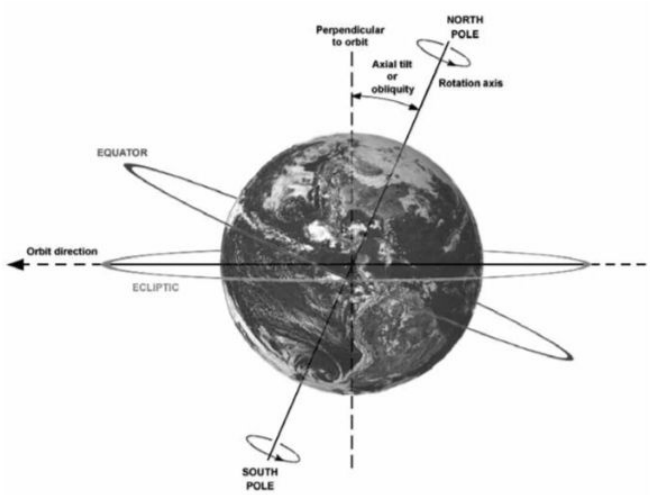
To understand why we experience different seasons in different locations on Earth, we must first think about the objects that are found in our solar system and how all these objects move over time in relation to each other. The Sun is at the center of our solar system. All the other objects in the solar system, which include planets, dwarf planets, 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 below). 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 below). 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.



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 be able to 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

- Information about the location (latitude and longitude), weather, and hours of daylight for most major cities around the world can be found at the ***World Climate Charts website*** at https://www.climate-charts.com/
- You will use two online simulations to conduct your investigation:
    - *https://www.pbslearningmedia.org/resource/npls13.sci.ess.seasons/why-seasons/support-materials/*
    - *http://highered.mheducation.com/sites/007299181x/student_view0/chapter2/seasons_interactive.html*

Getting Started

The first step in developing your conceptual model (labeled diagram) 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. Choose at least five cities (at least one near the equator, one each in the northern and southern hemispheres, and one each in the eastern and western hemispheres) and make a data table for this information. Once you collect this information, look for any patterns that you can use to help develop your conceptual model. Here is an example data table:

City Climate Data

Name of City					
Latitude					
Longitude					
High/Low Temp in Jan (℃)					
High/Low Temp in April (℃)					
High/Low Temp in July (℃)					
High/Low Temp in Oct (℃)					
Hours of Daylight in Jan					
Hours of Daylight in April					
Hours of Daylight in July					
Hours of Daylight in Oct					

Next, you can use the two seasons simulators to learn more about how light from the Sun strikes Earth over the course of the year. Each simulation will show you something different: different latitudes on Earth, the Sun's altitude in the sky throughout the year, and the sunlight angle over the course of the year for that latitude. In the first simulation, be sure to look at each of the four cities and how the seasons are different depending on where they are on the Earth. In the second simulation, be sure to play around with Earth's inclination, as well as that of Venus and Uranus. Use these simulations to learn more about how Earth's tilt affects the amount of sunlight and the angle at which sunlight strikes Earth over time.

Once you have finished exploring the simulations, you can develop a conceptual model (labeled diagram) that can be used to explain the cause of the seasons. To be valid or acceptable, your conceptual model must be able to explain (1) why the length of day changes by different amounts in different locations and (2) 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. Be sure to include at least three new cities, one in the northern hemisphere, one in the southern hemisphere, and one near the equator. Make a data table of your predictions as well as the actual data. 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.

Rubric

Data Tables:

- ❑ City climate data: Include a data table and/or graph to show the city climate data for at least five cities. Be sure to include a title for your table or graph with labels for the variables. (10 points)
- ❑ City climate data predictions: Include a second data table and/or graph to show the city climate data predictions as well as the actual data for at least three additional cities. Be sure to include a title for your table or graph with labels for the variables. (6 points)

Your model includes:

- ❑ A diagram of the Earth orbiting the sun, showing the Earth's axial tilt of 23.4° and how the Earth is positioned at each of the major seasons (summer, fall, winter, and spring) (5 points)
- ❑ Summer: A labeled diagram showing what happens to the angle of the sunlight in the summer (June) in the northern hemisphere, the southern hemisphere, and at the equator (3 points)
- ❑ Fall: A labeled diagram showing what happens to the angle of the sunlight in the fall (September) in the northern hemisphere, the southern hemisphere, and at the equator (3 points)
- ❑ Winter: A labeled diagram showing what happens to the angle of the sunlight in the winter (December) in the northern hemisphere, the southern hemisphere, and at the equator (3 points)
- ❑ Spring: A labeled diagram showing what happens to the angle of the sunlight in the spring (March) in the northern hemisphere, the southern hemisphere, and at the equator (3 points)

A written summary:

- ❑ A written summary explaining what causes the seasons (at least 5-7 sentences), including the amount and angle of the sunlight hitting the Earth at the poles and at the equator. Be sure to answer the lab's guiding question: ***What causes the differences in average temperature and the changes in day length that we associate with the change in seasons on Earth?*** (5 points)

You can draw your labeled diagram on paper, then take a picture and upload it to your Google Doc or you can make your diagram using the drawing tools on Google Docs. You may NOT just upload a diagram from the Internet.

If you would prefer to upload a video of you explaining the seasons using props or pictures and giving examples, that would work, too!