This course supports the assessments for Earth and Space Science. The course covers 4 competencies and represents 3 competency units.

Introduction

Overview
The Earth and Space Science Course involves the study of astronomy, geology, meteorology, and oceanography. As a science teacher, you will want to convey the excitement of careers related to earth science to your students and help them connect the concepts to their own lives.

While working through this course, connect your new knowledge with your current base. Sometimes new knowledge contradicts your current understanding. You will need to pay close attention during these times so that you can properly reframe your understanding. Your goal is to become the best teacher you can be.

Please watch the following video:

Note: To download this video, right-click the following link and choose "Save as...": download video.

Competencies
This course provides guidance to help you demonstrate the following 4 competencies:

- **Competency 204.5.2: Geology**
  The graduate has a broad understanding of the principles of geology.
- **Competency 204.5.4: Oceanography**
  The graduate has a broad understanding of the basic concepts of oceanography.
- **Competency 204.5.3: Meteorology**
  The graduate has a broad understanding of the concepts of meteorology.
- **Competency 204.5.1: Astronomy**
  The graduate has a broad understanding of the basic concepts of astronomy.

Teaching Dispositions Statement
Please review the Statement of Teaching Dispositions.

Course Mentor Assistance
As you prepare to successfully demonstrate competency in this subject, remember that course mentors stand ready to help you reach your educational goals. As subject matter experts, mentors enjoy and take pride in helping students become reflective learners, problem solvers, and critical thinkers. Course mentors are excited to hear from you and eager to work with you.

Successful students report that working with a course mentor is the key to their success. Course mentors are able to share tips on approaches, tools, and skills that can help you apply the content you’re studying. They also provide guidance in assessment preparation strategies and
troubleshoot areas of deficiency. Even if things don’t work out on your first try, course mentors act as a support system to guide you through the revision process. You should expect to work with course mentors for the duration of your coursework, so you are welcome to contact them as soon as you begin. Course mentors are fully committed to your success!

Preparing for Success

The information in this section is provided to help you become ready to complete this course of study. As you proceed, you will need to be organized in your studies, competent in the indicated areas, and ready to pass the final assessments

Learning Resources

The learning resources listed in this section are required to complete the activities in this course. For many resources, WGU has provided automatic access through the course. However, you may need to manually enroll in or independently acquire other resources. Read the full instructions provided to ensure that you have access to all of your resources in a timely manner.

Enroll in Learning Resources

You will need to enroll in or subscribe to learning resources as a part of this course. You may already have enrolled in these resources for other courses. Please check the “Learning Resources” tab and verify that you have access to the following learning resources. If you do not currently have access, please enroll or renew your enrollment at this time.

Note: For instructions on how to enroll in or subscribe to learning resources through the “Learning Resources” tab, please see the "Acquiring Your Learning Resources" page.

AMNH Seminars (Optional)

Online seminars offered by the American Museum of Natural History (AMNH) use multimedia and discussions to connect teachers and future teachers from around the world to cutting-edge research, classroom resources, and each other. Participating in the seminars develops your understanding of the content, models an appropriate teaching technique, and exposes you to an array of resources that can be used in your classroom. While this is an optional learning resource, you are strongly encouraged to take advantage of this opportunity.

The following seminars are related to this course:

- "Earth Inside and Out"
- "The Solar System"

Each six-week seminar requires about eight hours per week of your time. Review the AMNH Calendar to determine when the course is offered and consult your mentor to coordinate this seminar with your schedule. Discuss the AMNH-WGU FAQ document with your mentor to better understand how to successfully use the AMNH course as a WGU learning resource.

LabPaq

The "Science Methods" LabPaq from Hands-On Labs is a physical shipment. This lab kit (LabPaq) is covered by your program lab fee and is required to complete the performance
assessment. You may have already enrolled for this resource through a different course. This kit includes a lab manual along with the science equipment, specimens, supplies, and chemicals necessary to complete college laboratory experiments at home. The experiments reinforce science content and teach laboratory techniques.

**Automatically Enrolled Learning Resources**

You can access the learning resources listed in this section by clicking on the links provided throughout the course. You may be prompted to log in to the WGU student portal to access the resources.

**VitalSource E-Texts**

The following textbook is available to you as an e-text within this course of study. You will be directly linked to the specific readings required within the activities that follow.


**Composition of Earth**

After completing this section's activities, you will be able to

- describe the layered structure of Earth,
- use latitude and longitude to find a point on Earth,
- identify minerals and rocks,
- describe the rock cycle, and
- describe Earth's geological resources.

**Makeup of the Earth**

When people dig into the earth to build structures, they are only scratching the surface of the earth's crust. This section covers what is underneath this crust humanity walks upon.

This topic addresses the following competency:

- **Competency 204.5.2: Geology**
  The graduate has a broad understanding of the principles of geology.

This topic highlights the following concepts:

- describe the layered structure of Earth.
- use latitude and longitude to find a point on Earth
- identify minerals and rocks,
- describe the rock cycle, and
- describe Earth's geological resources

**Earth's Internal Structure**

In your notebook, draw a cross section of the earth. Label and color code each layer. Add information about the earth's size, general composition, and layered structure.
Answer the following questions:

- If you were to dig a hole through the center of the earth to the other side, how long would your tunnel be?
- How many layers would you need to dig through?
- What materials would you dig through?

Reference the following section in Chapter 1 of *Earth Science* to help you complete this task:

- Section 1.5 A Closer Look at the Geosphere

**Earth's Grid System**

Watch this 3 minute video to learn more about Earth's latitude and longitude grid system.

;  

Make note of where zero latitude and zero longitude are located in your notebook. How are positions recorded using these references?

**Minerals**

Identifying minerals can be challenging. With the knowledge gained in this topic, you will be able to identify the rocks you pick up outside.

This topic addresses the following competency:

- **Competency 204.5.2: Geology**
  The graduate has a broad understanding of the principles of geology.

**What is a Mineral?**

As you read the materials below, write down a definition of mineral in your notebook.

Read the beginning of the following chapter in *Earth Science*:

- **chapter 2 (Matter and Minerals)**

**Properties of Minerals**

As you read through the materials below, memorize the Mineral Identification chart and, without using any notes, practice identifying samples using the links to specific minerals at the bottom of the web page.

At the completion of this activity, you should be able to identify hand samples of common rock-forming and ore minerals by their properties (e.g., color, luster, streak, density, cleavage).

Review the following sections in **chapter 2 (Matter and Minerals)** in *Earth Science*:

- Properties of a Mineral
Mineral Groups

Review the following figures in chapter 2 (Matter and Minerals) in Earth Science:

- Figure 2.16, which shows the hardness scale
- Figure 2.18, which shows the common cleavage directions
- Figure 2.24, which shows common silicate minerals (note that there are two different feldspars mentioned in figure 2.24)

Read through the following web page:

- Mineral Physical Properties and Identification

Mineral Activity

The Science Methods LabPaq contains 18 minerals and a list of 18 mineral names. Using what you have learned in the previous activity, match the 18 minerals with their appropriate names.

Use the following websites as necessary to help you better understand how to use the streak test and hardness test to identify minerals:

- Mineral Properties: Streak
- Mineral Properties: Hardness

Once you have identified the minerals, list two common uses of each mineral and send your results to the course mentor for feedback.

Mineral Groups

While reading in chapter 2 (Matter and Minerals) in Earth Science, take note on the conditions (temperature and pressure) in which the specific minerals were formed.

The Rock Cycle

Varying degrees of temperature, pressure, and weathering are needed to change the form of rocks. What processes created the marble used as tile in a building or the granite used for a countertop in a kitchen?

This topic addresses the following competency:

- Competency 204.5.2: Geology
  The graduate has a broad understanding of the principles of geology.

Earth as a System

As you read through the materials below, explain in your notebook the general details of the processes involved when one type of rock (i.e., igneous, metamorphic, or sedimentary) is transformed into any other kind of rock.
Review the beginning of the following chapter in *Earth Science*:

- chapter 3 ("Rocks: Materials of the Solid Earth")

Focus specifically on the following section:

- "Earth as a System: The Rock Cycle"

**Igneous Rocks**

As you read materials below, write down in your notebook how these rocks can be identified by their texture and composition. For example, granite has a course-grained texture. How is this related to its appearance, and where it was made?

Read the following section in chapter 3 ("Rocks: Materials of the Solid Earth") of *Earth Science*:

- "Igneous Rocks: Formed by Fire"

You should be able to identify six common igneous rocks found in the following figure in *Earth Science*:

- figure 3.7 Classification of Igneous Rocks, Based on their Mineral Composition and Texture

**Sedimentary Rocks**

As you read the following materials, write down in your notebook how these rocks can be identified by their texture and composition. The size of the sediment particles helps with sedimentary rock classification. For example, sandstone is made from sand sediment.

Read the following section in chapter 3 ("Rocks: Materials of the Solid Earth") of *Earth Science*:

- "Sedimentary Rocks: Compacted and Cemented"

Mechanical weathering creates the detrital group of sedimentary rocks, while chemical weathering creates the chemical group of sedimentary rocks (chapter 4 of *Earth Science* discusses weathering in more detail).

**Metamorphic Rocks**

As you read the materials below, write down in your notebook how these rocks can be identified by texture and composition. For example, slate is made from very fine grains, whereas marble is made from larger grains. When looking at marble, you can typically see the grains, whereas in slate you cannot distinguish individual grains.

Read the following section in chapter 3 ("Rocks: Materials of the Solid Earth") of *Earth Science*:

- "Metamorphic Rocks: New Rock from Old"
You should be able to identify five common metamorphic rocks shown in the following figure of *Earth Science*:

- figure 3.29 Classification of Common Metamorphic Rocks

**Experiment 12: Crystal Growing and the Rock Cycle**

Complete the following experiment in the Science Methods LabPaq:

- experiment 12 ("Crystal Growing and the Rock Cycle")

After completing the lab, send your lab report to the course mentor to receive feedback.

**Geological Resources**

Humans use many geological resources for building materials as well as for energy sources.

This topic addresses the following competency:

- **Competency 204.5.2: Geology**
  The graduate has a broad understanding of the principles of geology.

**Environmental Impact of Resource Extraction**

Read the following section in chapter 3 of *Earth Science*:

- Energy Resources: Fossil Fuels

Use the following pages found on the Pollution Issues website to take notes on the impact of the following substances:

- "Petroleum"
- "Coal"

**Movement on Earth**

Although Earth has a rocky base, there is much movement on its surface. Air, water, and the earth itself are constantly moving. Due to the water cycle, water is continuously moving, which causes wear and tear on the earth's surface.

Gravity causes boulders and mud to move downhill. Convection currents keep the earth's inner materials moving, which in turn moves the earth's plates. What observations can you make that verify these movements on the earth?

**Effects of Wind, Water, and Ice on the Landscape**

Weathering is part of the rock cycle. Erosion occurs because of the effects of wind, water, or ice.

This topic addresses the following competency:
• **Competency 204.5.2: Geology**
  The graduate has a broad understanding of the principles of geology.

**Weathering and Erosion**

Read these sections from *chapter 6* in *Earth Science*:

- Section 6.3 Glacial Erosion
- Section 6.3 Wind Erosion

In your notebook, describe the features created by these actions.

**Mass Wasting**

Mass wasting, or movement, is due to the effects of gravity. Rocks naturally want to roll downhill. Moving water can transport sediment, creating large deposits downstream. Earth is wasting away, or, more appropriately, Earth is moving due to gravity.

This topic addresses the following competency:

- **Competency 204.5.2: Geology**
  The graduate has a broad understanding of the principles of geology.

**The Work of Gravity**

As you read the materials below, describe in your notebook the types and mechanics of mass wasting, including the bold-faced terms used. Drawings may help with your learning.

Read the following section in *chapter 4* ("Weathering, Soil, and Mass Wasting") of *Earth Science*:

- Section 4.9 Mass Wasting: The Work of Gravity

**Human Activity**

In your notes on mass wasting, write your thoughts on the following question:

- How might the destruction caused by mass wasting be prevented?

**Streams**

Review the water cycle and the benefits of running water. In this topic, you will learn what humans can do to slow down the erosion caused by streams.

This topic addresses the following competency:

- **Competency 204.5.2: Geology**
  The graduate has a broad understanding of the principles of geology.

**The Work of Running Water**

As you read the materials below, describe in your notebook the stages of stream development.
Begin reading the following chapter of *Earth Science*:

- chapter 5 ("Running Water and Groundwater")

Notice the movement of water through the hydrologic cycle in the following figure in *Earth Science*:

- figure 5.2 The Hydrologic Cycle

To help you better understand the process by which streams erode and deposit sediments, read the following section in *Earth Science*:

- Section 5.6 "Shaping Stream Valleys"

**Stream Channels**

Read the following section in chapter 5 ("Running Water and Groundwater") of *Earth Science*:

- Section 5.5 "Stream Channels"

In your notebook, write down the processes by which streams change their course.

**Floods and Flood Control**

As you read the material below, write down in your notebook the motivations for and consequences of human attempts to alter stream processes.

Read the following section in chapter 5 ("Running Water and Groundwater") of *Earth Science*:

- Section 5.8 "Floods and Flood Control"

**Plate Tectonics**

In the early 1900s, there were no planes to circumnavigate the earth, no satellite imagery, and no submersibles to view ocean ridges. Despite lacking these technological advances, Alfred Wegener was able to propose the idea of continental drift.

This topic addresses the following competency:

- **Competency 204.5.2: Geology**
  The graduate has a broad understanding of the principles of geology.

**Supporting Evidence of Continental Drift**

As you read the material below, write down in your notebook the evidence Wegener used to support his ideas.

Read the following section in chapter 7 ("Plate Tectonics: A Scientific Theory Unfolds") of *Earth Science*: 
Plate Boundaries

As you read the material below, write down what is occurring at each type. Answer the following questions:

- When do volcanoes occur at divergent boundaries?
- When do volcanoes occur at convergent boundaries?
- How are earthquakes related to plate boundaries?

Read about the types of plate boundaries (i.e., divergent, convergent, and transform) in the following chapter of Earth Science:

- chapter 7 ("Plate Tectonics: A Scientific Revolution Unfolds")

Make a chart in your notebook to help you organize this information. As you read about each type of boundary, add to your chart.

In your notes, answer the following question:

- Which type of boundary created the Hawaiian Islands?

Modern Evidence of Plate Tectonics

As you read the material below, write down in your notebook the modern evidence that can now be measured because of technological advances.

Read the following sections in chapter 7 ("Plate Tectonics: A Scientific Theory Unfolds") of Earth Science:

- Section 7.9 "Testing the Plate Tectonics Model"
- Section 7.10 "How is Plate Motion Measured?"

Experiment 14: Plate Tectonics

Complete the following experiment in the Science Methods LabPaq:

- experiment 14 ("Plate Tectonics")

After completing the lab, send your lab report to the course mentor to receive feedback.

Earthquakes

As the theory of plate tectonics describes, Earth's crust is moving. Occasionally, the movement is quick enough for you to feel.

This topic addresses the following competency:
The Production of Earthquakes

As you read through the materials below, explain in your notebook why earthquakes occur along faults and describe the waves that earthquakes generate.

Read the first three sections in the following chapter of *Earth Science*:

- chapter 8 ("Earthquakes and Earth's Interior")

Earthquakes create P- and S-waves. You can remember these waves by their types. P-waves push and pull (note that both words begin with p). Also, P-waves are considered the primary waves (another p word to associate with P-waves), since they move faster than S-waves, arriving ahead of the S-waves. S-waves actually create an s curve in the surface of land.

Describe in your notebook the three scales used to measure earthquakes (i.e., modified Mercalli, Richter, and moment magnitude) and how these scales are used and calculated.

The different levels of the Mercalli intensity scale are clearly described in the following table in chapter 8 in *Earth Science*:

- table 8.1

Isoseismal lines can be drawn on a map to connect areas with similar earthquake experiences.

Destruction From Earthquakes

As you read through the materials below, describe in your notebook the hazardous effects of an earthquake. If the ground is saturated with water, what can occur during an earthquake?

Read the following section in chapter 8 ("Earthquakes and Earth's Interior") in *Earth Science*:

- Section 8.4 "Earthquake Destruction"

Volcanoes

The mantle is one layer of Earth's structure. This material, which is partly molten, occasionally makes its way to Earth's surface.

This topic addresses the following competency:

- Competency 204.5.2: Geology
  The graduate has a broad understanding of the principles of geology.

Types

As you read through the material below, explain in your notebook why some volcanoes have explosive eruptions, while others are quiet. Create a table comparing the conditions for an
explosive volcano versus a quiet volcano.

Begin reading the following chapter in *Earth Science*:

- chapter 9 ("Volcanoes and Other Igneous Activity").

**The Hazards of Volcanoes**

As you read the materials below, describe in your notebook the hazards associated with volcanoes.

**Topographic Maps**

The Earth’s surface is constantly changing.

This topic addresses the following competency:

- **Competency 204.5.2: Geology**
  The graduate has a broad understanding of the principles of geology.

**Topographic Maps**

The Earth’s surface is constantly changing. Topography is the study of landform elevation. How high above sea level is a geologic feature? How low below sea level is that oceanic trench? Topographic maps are used to measure and record these changes.

*Note: To download this video, right-click the following link and choose "Save as...":* [download video].

**Earth’s History**

Scientists collect data from around the world to better understand what has happened in Earth’s history.

**Fossils**

There are many types of fossils. Footprints left in mud and preserved over many years are considered fossil evidence. This section covers types of fossils.

This topic addresses the following competency:

- **Competency 204.5.2: Geology**
  The graduate has a broad understanding of the principles of geology.

**Fossils in the Making**

As you read through the materials below, explain in your notes how fossils are formed.

Read the section on fossils in chapter 11 ("Geologic Time") of *Earth Science*:

- Section 11.3 "Fossils: Evidence of Past Life"

**Diversity of Life**
As you read through the materials below, explain in your notebook how fossils provide evidence of the diversity and complexity of life over time. For example, the fossils in the Burgess Shale provide evidence that complex life-forms existed during the Cambrian period that do not exist today and did not exist before the Cambrian period.

Read about how fossils are used to better understand past events in the following section in chapter 11 ("Geologic Time") of Earth Science:

- Section 11.4 "Correlation of Rock Layers"

**Dating**

Knowing the order of events helps to put a timeline in place. Scientists use the chemical properties of rocks to help them determine a rock's age.

This topic addresses the following competency:

- **Competency 204.5.2: Geology**
  The graduate has a broad understanding of the principles of geology.

**Introduction of Chapter 11**

Read the first two sections of the following chapter in Earth Science to help you better understand how studying rocks helps people understand the past:

- chapter 11 ("Geologic Time")

**Relative Dating**

As you read the materials below, describe in your notebook the methods used for relative dating.

Read the following section of chapter 11 ("Geologic Time") in Earth Science:

- "Relative Date"

**Absolute Dating**

Read the following section in chapter 11 of Earth Science:

- "Dating With Radioactivity"

Go through the review questions at the end of the following chapter in Earth Science to solve simple half-life problems involving radiogenic isotopes and their daughter products:

**Experiment 13: Radioactive Decay**

Complete the following experiment in the Science Methods LabPaq:

- experiment 13 ("Radioactive Decay")
After completing the lab, send your lab report to the course mentor to receive feedback.
Geologic Timeline
Based on the evidence collected, a geologic timeline for Earth has been put together. In this timescale, a hundred or even a thousand years is a relatively short time span.

This topic addresses the following competency:

- **Competency 204.5.2: Geology**
  - The graduate has a broad understanding of the principles of geology.

Geologic Timescale

Identify the principal divisions of geologic time.

Read the following section in chapter 11 ("Geologic Time") of *Earth Science*:

- "The Geologic Time Scale"

Earth's History

In your notes, identify the approximate time period for important events in Earth's physical and biological history.

Read the following chapter in *Earth Science*, which describes each era in further detail:

- chapter 12 ("Earth's Evolution Through Geologic Time")

Geologic Time Task

Now that you have completed the activities so far, you are ready to complete the Geologic Time performance task. Review your notes and contact the course mentor if you have any questions as you work on the task.

This topic addresses the following competency:

- **Competency 204.5.2: Geology**
  - The graduate has a broad understanding of the principles of geology.

Geologic Maps

The Geologic Time Task asks you to provide a geologic map. Please watch the video below to ensure you are using the correct kind of map in your task submission.

*Note: To download this video, right-click the following link and choose “Save as...”: [download video]*

Geological Time Performance Task

Complete the following task in TaskStream:

- Earth & Space Science: Geological Time
For details about this performance assessment, see the "Assessment" tab in this course.

**The Importance of Earth's Placement**

One thing you should appreciate is Earth's placement in the solar system, which is not too close to the sun (where all water would vaporize), or too far from the sun (where all water would freeze). Earth also has enough gravity to hold an atmosphere.

This topic addresses the following competency:

- **Competency 204.5.2: Geology**
  The graduate has a broad understanding of the principles of geology.

**Conditions on Earth**

Read the following sections from Chapter 1 in *Earth Science*:

- Section 1.4 "Earth's Spheres"

These spheres are continuously interacting, which creates a system. This complex system is unique to planet Earth. Read about the system those spheres create in the following section of *Earth Science*:

- Section 1.7 "Earth as a System"

**Earth's Unique Characteristics**

As you read the material below, write down the important factors that allow life to exist here.

- Why is Earth considered the right size?
- Why is Earth's place in the solar system important?
- Why is timing important?

Read the following chapter in *Earth Science*:

- **chapter 12 ("Earth's Evolution Through Geologic Time")**

Compare Earth's surface temperatures to its neighboring planets Mars and Venus. How much hotter does Venus get than Earth? How much colder than Earth does Mars get? How does Earth's placement in the solar system help to create the conditions that enable organisms to survive?

**Origin of the Atmosphere and Oceans**

As you read the materials below, describe in your notebook the stages in the early formation and evolution of the atmosphere.

To help you appreciate the beginnings of the atmosphere and oceans, continue reading the following chapter in *Earth Science*:
The Bottom of the Ocean

From the earth's surface, only the ocean's top layer, exposed to the sun, can be seen. Using instruments such as sonar, scientists can detect the structures that are at the bottom of the ocean. Sea level is always the starting point for elevation measurements, whether measuring the height of a mountain or the depth of an abyss.

The Ocean Floor

The ocean floor has a varied terrain, just as land's surface does. Boundaries between continental plates are seen as ridges where new crust can be forming.

This topic addresses the following competency:

- **Competency 204.5.4: Oceanography**
  - The graduate has a broad understanding of the basic concepts of oceanography.

Bathymetric Chart

As you read the materials below, write down descriptions of the tools scientists use to collect oceanic data.

A map showing the contours of the ocean floor is called a bathymetric chart.

Begin reading the following chapter of *Earth Science* to learn how bathymetric charts are made:

- **chapter 13 (“The Ocean Floor”)** through page 419

Contour lines are often drawn on bathymetric charts to show areas at the same depth. These chapters show several examples of different charts depicting the ocean floor. Take the time to interpret these bathymetric charts. Keep in mind that sea level is the starting point for all measurements.

Ocean Basins

To better understand continental margins and ocean basins, continue reading the following chapter of *Earth Science*:

- **chapter 13 (“The Ocean Floor”)** starting at section 13.4 on page 419

The center of the basin has an oceanic ridge, which is where new seabed is formed. In your notebook, write a physical description of Earth's oceanic ridges.

There are four main ocean basins: the

- Pacific,
- Atlantic,
- Indian, and
Arctic.

Become familiar with the terms describing the features found on the ocean basins.

**Ocean Sediment**

Sediment includes particles of debris that accumulate in the oceans. This debris can include particles that wash from land and the shells of once-living organisms.

This topic addresses the following competency:

- **Competency 204.5.4: Oceanography**
  The graduate has a broad understanding of the basic concepts of oceanography.

**Types of Sediment**

Read the following section in chapter 13 ("The Ocean Floor") of Earth Science:

- Section 13.6 "Seafloor Sediments"

While reading about sediments, write down the different types by comparing their source, properties, and distribution.

**Properties of Oceans**

The chemical properties of ocean water contribute to its movement and its ability to sustain living organisms.

**Properties of Seawater**

The composition of seawater can change, which then can change seawater's behavior. For example, when icebergs are created, the excess salts are left dissolved in the ocean. Consequently, the seawater left after an iceberg freezes is denser and therefore sinks. Where do dissolved substances come from that are found in seawater?

This topic addresses the following competency:

- **Competency 204.5.4: Oceanography**
  The graduate has a broad understanding of the basic concepts of oceanography.

**Composition of Seawater**

As you read the materials below, describe in your notebook the chemical composition of seawater (i.e., the dissolved substances).

Begin reading the following chapter of Earth Science:

- chapter 14 ("Ocean Water and Ocean Life")

**Properties of Seawater Performance Task**

**Properties of Seawater Performance Task**
Complete the following performance task in TaskStream:

- Earth & Space Science: Properties of Seawater

For this task, you will be performing the following simple experiments, and you will need to plan extra time to complete them:

- "Water Experiments 1 and 2"
- "Sinking Water Activity"

**Temperature and Density Variations**

The temperature of water affects its density. The more particles in a given amount of water, the denser the water is. In cold water, the water molecules are closer together, and, consequently, cold water is denser than hot water. The temperature and density of water impacts its movement.

This topic addresses the following competency:

- **Competency 204.5.4: Oceanography**
  The graduate has a broad understanding of the basic concepts of oceanography.

**Processes Affecting Seawater Salinity**

As you read the material below, explain in your notebook how temperature and salinity affect the density of seawater.

- chapter 14 ("Ocean Water and Ocean Life")

Ocean water masses organize themselves by density. Add to your notes how and where water masses of varying density are produced.

How does the formation of sea ice increase seawater salinity?

**Ocean Temperature Variation**

As you read the materials below, describe in your notebook the thermal layering of the ocean.

The following figure in chapter 14 ("Ocean Water and Ocean Life") of Earth Science shows the variation in ocean water temperature at different latitudes:

- figure 14.46

Below the surface layer of the ocean is the thermocline layer, where the temperature changes dramatically. Notice that near the earth's poles, there is not much of a thermocline, since the surface water is cold as well.

**Ocean Life**

There are many organisms that live in oceans. Most organisms are adapted to a particular subset of the ocean.
This topic addresses the following competency:

- **Competency 204.5.4: Oceanography**  
The graduate has a broad understanding of the basic concepts of oceanography.

### Oceanic Lifestyles

Read the following section in *chapter 14* of *Earth Science*:

- Section 14.3 "The Diversity of Ocean Life"

In this section, you will learn that organisms are classified by where they live. If you know the prefixes and suffixes for terms, you will be able to decipher the terminology used to name organisms. You will also compare and contrast the three oceanic lifestyles by using examples of each (e.g., pelagic [planktonic], swimming [nektonic], and attached [benthic]).

Write down some examples of pelagic organisms in your notebook.

Various oceanographic factors influence where marine organisms live. In your notebook, describe the characteristics of marine-life zones.

### Ocean Productivity

Organisms live where they can find the nutrients they need to survive.

Review the following chapter of *Earth Science*:

- *chapter 14* ("Ocean Water and Ocean Life")

Explain how the concentrations of the elements of life within the oceans affect the amount of living material the oceans can support.

Read the following section in Earth Science and take notes on what limits the productivity of oceans:

- Section 14.4 "Ocean Productivity"

### The Movement of Oceans

Waves are just one example of the movement of oceans. Currents move water great distances on the surface as well as deep in the ocean.

#### Surface Currents

Surface currents are driven by wind.

This topic addresses the following competency:

- **Competency 204.5.4: Oceanography**  
The graduate has a broad understanding of the basic concepts of oceanography.
Patterns

Begin reading the following chapter in *Earth Science* to help you understand surface circulation (e.g., the Coriolis Effect and Ekman transport):

- *chapter 15* ("The Dynamic Ocean")

Ocean currents affect the climate. As the diagrams in this chapter illustrate, a general pattern in the Northern Hemisphere is for the currents to move clockwise. This pattern occurs because of the Coriolis Effect and Ekman transport.

In the North Atlantic, the Gulf Stream brings the warmer water from the south along the eastern United States to northern Europe, which provides more temperate climates to these areas. Without this current, these areas would have colder temperatures, which are more common for the areas located at these latitudes. In contrast, along the California coast, currents bring colder arctic water south, which means water temperatures are much colder along this coast than along the East Coast.

In the Southern Hemisphere, the currents between the continents move counter clockwise. Note that the Southern Hemisphere has less land to block moving currents. The Antarctic current is able to move freely around the globe.

**Upwelling**

As you read the materials below, explain in your notebook the process and importance of coastal upwelling. What causes upwelling?

**Deep Ocean Circulation**

The cause for deep ocean circulation is primarily due to the vertical movement of water that is created as dense water moves downward.

This topic addresses the following competency:

- **Competency 204.5.4: Oceanography**
  The graduate has a broad understanding of the basic concepts of oceanography.

**Circulation**

As you read the materials below, describe in your notebook the formation and importance of deep water masses and the deep ocean circulation that depends on them. What are the names of these water masses? In which direction do they flow?

Read the following section in *chapter 15* of *Earth Science*:

- Section 15.2 "Upwelling and Deep-Ocean Circulation"

**Ocean Waves**

Ocean waves are a form of energy moving through the water.
This topic addresses the following competency:

- **Competency 204.5.4: Oceanography**
  The graduate has a broad understanding of the basic concepts of oceanography.

### Cause of Ocean Waves

As you read the materials below, write down the following in your notebook:

- the three factors that determine a wave's size
- an explanation for the cause and behavior of ocean waves
- where large waves are likely to be found

Read the section on waves in chapter 15 in *Earth Science*:

- Section 15.4 "Ocean Waves"

### Impact of Ocean Waves

As you read the materials below, explain in your notebook the impact of ocean waves on coastal topography.

Waves change the coastal topography over time.

Continue reading the following chapter in chapter 15 of *Earth Science*:

- Section 15.5 "The Work of Waves"

### Beaches

Sand is easily moved and will move in a fairly predictable manner.

This topic addresses the following competency:

- **Competency 204.5.4: Oceanography**
  The graduate has a broad understanding of the basic concepts of oceanography.

### Longshore Transport

As you read the materials below, describe in your notebook the process of the longshore transport of sand and sandbars.

Review the following section in chapter 15 ("The Dynamic Ocean") of *Earth Science*:

- Section 15.5 "The Work of Waves"

The movement of sand creates various coastal conditions. Read the following section in chapter 15 ("The Dynamic Ocean") of *Earth Science*:

- Section 15.6 "Shoreline Features"
Tides
Gravitational forces create changing tides.

This topic addresses the following competency:

- **Competency 204.5.4: Oceanography**
  The graduate has a broad understanding of the basic concepts of oceanography.

Tidal Patterns

Read the following section in chapter 15 ("The Dynamic Ocean") of *Earth Science*:

- Section 15.9 "Tides"

In your notebook, describe how the sun and the moon influence tides.

Heating Earth

Earth's atmosphere allows life to exist on this planet. After completing this section's activities, you will be able to

- describe Earth's atmosphere,
- explain the differential heating of the earth's surface,
- explain why there are seasons, and
- explain the greenhouse effect.

Atmosphere

Humans breathe to bring oxygen into their lungs, but air is made of more than just oxygen.

This topic addresses the following competency:

- **Competency 204.5.3: Meteorology**
  The graduate has a broad understanding of the concepts of meteorology.

Composition of the Atmosphere

As you read the material below, state in your notebook the chemical composition of Earth's atmosphere.

Begin reading the following chapter in *Earth Science*:

- chapter 16 ("The Atmosphere: Composition, Structure, and Temperature")

Temperature Gradient

As you read the material below, describe in your notebook the structure of the atmosphere in terms of the temperature gradient. In this case, the term *gradient* is referring to the change in temperature as the elevation changes.
Ozone

Based on what you have read in chapter 16 (“The Atmosphere: Composition, Structure, and Temperature”) of Earth Science, describe the ozone layer in the stratosphere. How does the ozone shield the earth from ultraviolet (UV) rays?

Earth-Sun Relationships

This sections covers the reasons why the hemispheres have seasons at opposite times of the year.

This topic addresses the following competency:

- **Competency 204.5.3: Meteorology**
  The graduate has a broad understanding of the concepts of meteorology.

Reasons for the Seasons

Read the following section of chapter 16 of Earth Science to help you understand the reason for day lengths and seasons:

- Section 16.4 "Earth-Sun Relationships"

Temperature, Heat, and Climate

Proper use of terminology is important. In this topic, you will learn to distinguish between the terms temperature, heat, and climate.

This topic addresses the following competency:

- **Competency 204.5.3: Meteorology**
  The graduate has a broad understanding of the concepts of meteorology.

Weather and Climate

Weather changes daily, and even with today's technology, it is often difficult to predict. The first few pages in the following chapter of Earth Science distinguish between weather and climate:

- chapter 16 (“The Atmosphere: Composition, Structure, and Temperature”)

Write definitions for weather and climate in your notebook.

Heat and Temperature

A thermometer is used to measure temperature. When two objects meet, heat will flow from the object with the higher temperature to the object with the lower temperature. Heat can be transferred between objects by radiation, conduction, and convection. For example, the sun's radiation increases the temperature on Earth.

Conduction occurs when two materials are touching. Most wind is generated by convection, which is the movement of the air due to the differences in density.

Air is warmed near Earth's surface, causing its molecules to move and the air to become less
dense. The rising of warmer air allows cooler air to take its place.

As you read the materials below, write in your notebook a formal definition for **heat** and **temperature**.

Read about temperature, heat, and conduction in chapter 16 ("The Atmosphere: Composition, Structure, and Temperature") of *Earth Science*:

- **Section 16.5 Energy, Heat and Temperature**

**Greenhouse Effect**

Planet Earth acts somewhat similarly to a greenhouse.

This topic addresses the following competency:

- **Competency 204.5.3: Meteorology**
  The graduate has a broad understanding of the concepts of meteorology.

**Incoming Solar Radiation**

What happens to all the incoming solar radiation on Earth? Some of it is reflected back into space. The albedo, or reflective power, of Earth is about 30%. What does this mean?

Some of the sun's energy reaches the surface of the earth. Of the light that reaches the earth's surface and that is the correct wave length for photosynthesis, only about 0.4% is actually converted to carbohydrates by plants.

Read the following section of chapter 16 of *Earth Science* to help you understand what happens to incoming solar radiation:

- **Section 16.6 "Heating the Atmosphere"**

**The Greenhouse Effect**

Read the following section in chapter 16 ("The Atmosphere: Composition, Structure, and Temperature") of *Earth Science* to help you better understand the greenhouse effect:

- **Section 16.6 "Heating the Atmosphere"**

How is this effect related to a car's interior warming up in a parking lot?

Draw a picture describing the greenhouse effect process in your notebook. The greenhouse effect and global warming are separate concepts. Life on this planet would not exist without the greenhouse effect to provide a warm environment. **Global warming** refers to the excessive heating of the earth.

**Differential Heating**

When provided with the same amount of sunlight, land, and water change temperatures differently.
This topic addresses the following competency:

- **Competency 204.5.3: Meteorology**
  The graduate has a broad understanding of the concepts of meteorology.

**Temperature Variations**

As you read the materials below, write down in your notebook reasons for the differential heating of land and water. Also, write down the weather implications caused by the differential heating of land and oceans.

Finish reading the following chapter of *Earth Science* to analyze the temperature gradients within the continental United States:

- chapter 16 ("The Atmosphere: Composition, Structure, and Temperature")

Although the entire earth is warmed by the greenhouse effect, there are great temperature variations on the earth. Part of this is due to land and water heating up at different rates.

The Midwest cities, such as Fargo, are colder than the more coastal cities, such as Boston. Water has a higher specific heat than land does, which means that water is slower to warm up and slower to cool down than land is. The land near Fargo will cool down faster than water, leading to cooler temperatures in Fargo than in Boston.

**Measuring Temperature**

There are three scales for measuring temperature. Celsius (C) marks zero as the freezing temperature of water and 100 as the boiling point of water. Kelvin (K) marks zero as much colder than the freezing point of water-the temperature at which molecules stop their movement, or the absence of all thermal energy. In the Fahrenheit (F) scale, water freezes at 32 degrees and boils at 212 degrees.

To convert from Fahrenheit to Celsius, you need to subtract 32 from the temperature and then multiply by 5/9ths. Each degree Fahrenheit is 5/9ths of a degree Celsius. In your notebook, practice converting between Fahrenheit and Celsius.

**Greenhouse Effect Task**

Now that you have completed the activities so far, you are ready to complete the Greenhouse Effect performance task. Review your notes and contact the course mentor if you have any questions as you work on the task.

This topic addresses the following competency:

- **Competency 204.5.3: Meteorology**
  The graduate has a broad understanding of the concepts of meteorology.

**Greenhouse Effect Performance Task**

Complete the following task in [TaskStream]:

""
Earth & Space Science: The Greenhouse Effect

For details about this performance assessment, see the "Assessment" tab in this course.

Clouds

When air has reached its saturation level, meaning it cannot hold any more water, clouds, fog, or dew can develop. After completing this section's activities, you will be able to

- define relative humidity,
- describe the effects of air moving upward, and
- describe the weather associated with different types of clouds.

Collecting Weather Data

In this topic, you will learn about what causes people to comment that it is a "hot, sticky day" or that there is a "dry heat."

This topic addresses the following competency:

- Competency 204.5.3: Meteorology
  The graduate has a broad understanding of the concepts of meteorology.

Humidity

Begin reading the following chapter in Earth Science to learn more about water and humidity, which refers to the amount of water in the air:

- chapter 17 ("Moisture, Clouds, and Precipitation")

Warmer air can hold more water than colder air can. Relative humidity is a measure of air's actual water content compared to what it can potentially hold at that particular temperature and pressure. If the relative humidity is 30%, then the air is holding 30% of the water vapor that it could potentially hold at that particular temperature and pressure.

You feel the effects of high humidity in the summer because your body sweats to release body heat, but your sweat does not evaporate since the air is already saturated. After reading about humidity in chapter 17, write a definition for relative humidity in your notebook as well as how humidity is measured.

Instruments Used to Collect Weather Data

To collect weather data, scientists use a variety of tools: a barometer for measuring air pressure, a hygrometer for measuring relative humidity, a weather vane for determining wind direction, etc.

As you read the materials below, keep a list in your notebook of the instruments used to collect weather data (e.g., barometer, hygrometer, weather vane, etc.).
Read the following section of chapter 17 of Earth Science to help you better understand how a psychrometer with wet and dry bulbs is used:

- Section 17.2 “Humidity: Water Vapor in the Air”

**Adiabatic Cooling and Lapse Rate**

This section covers the reasons why air cools as it rises.

This topic addresses the following competency:

- **Competency 204.5.3: Meteorology**
  The graduate has a broad understanding of the concepts of meteorology.

**The Basis of Cloud Formation**

As air rises, it expands and cools. This temperature change, which is due to the air's expansion, is considered an adiabatic temperature change.

As you read the materials below, write in your notebook the adiabatic rate for wet and dry air. There are different reasons air might rise, causing adiabatic cooling. *Lapse rate* refers to the rate at which temperature decreases as elevation increases.

Read the following section in chapter 17 of *Earth Science* to learn about adiabatic temperature change:

- Section 17.3 "The Basis of Cloud Formation: Adiabatic Cooling"

**Clouds**

When air reaches its dew point, clouds can form.

This topic addresses the following competency:

- **Competency 204.5.3: Meteorology**
  The graduate has a broad understanding of the concepts of meteorology.

**Formation**

To help you better understand what is needed for clouds and fog to form, begin reading the following section in chapter 17 of *Earth Science*:

- Section 17.6 "Condensation and Cloud Formation"

In addition to the air being saturated with water, water vapor needs a surface to condense on. In your notebook, write down what can serve as surfaces for condensation.

**Types of Clouds**

There are three main cloud forms that blanket the sky: high thin cirrus clouds, puffy cumulus clouds, and stratus clouds.
Continue reading the following chapter in *Earth Science*:

- *chapter 17 ("Moisture, Clouds, and Precipitation")*

The following table in this chapter describes the 10 basic cloud types that you should know:

- *table 17.2*

**Weather Associated With Clouds**

In your notebook, for each of the 10 cloud types (listed in table 17.2 in *Earth Science*), draw a picture of the cloud.

For each of your cloud pictures, write down the weather associated with it.

**Moving Air**

Air moves from high pressure to low pressure. After completing this section's activities, you will be able to

- explain air pressure and how it is used to predict upcoming weather,
- describe the global patterns of moving air, and
- describe local weather patterns.

**Air Pressure**

Although air is not visible, its weight still exerts pressure on Earth. Air will move from areas of high pressure to areas of low pressure. This movement of air is felt as wind.

This topic addresses the following competency:

- **Competency 204.5.3: Meteorology**
  The graduate has a broad understanding of the concepts of meteorology.

**Understanding Air Pressure**

As you read the materials below, define air pressure in your notebook. Also, answer the following questions:

- What is the average air pressure at sea level?
- Does that seem like a lot of pressure per square inch?
- How is air pressure measured?

Begin reading the following chapter in *Earth Science*:

- *chapter 18 ("Air Pressure and Wind")*

**Highs and Lows**

Continue reading the following chapter in *Earth Science* through the "Highs and Lows" section:
The Coriolis Effect determines the wind patterns associated with high and low pressure.

High pressure in the United States moves winds clockwise, away from the high's center. In your notebook, describe the mechanics and weather effects of centers of high and low air pressure.

Predicting Weather

Now you can piece together the information from chapter 18 ("Air Pressure and Wind") to explain how changes in air pressure help people predict upcoming weather.

Fair weather is associated with high pressure and air moving down. In contrast, rising air (low pressure) often results in cloud formation and precipitation. Think about the process of precipitation. Water changes from a previous gaseous state to liquid precipitation. The liquid state requires less energy than the gaseous state. Consequently, heat is given off when water goes from a gaseous to a liquid state. This is one reason that lowering pressure can have warmer weather.

Global Wind Circulation

The general circulation of air is complex. Forces caused by air pressure, the Coriolis effect, and solar radiation all need to be taken into account.

This topic addresses the following competency:

- **Competency 204.5.3: Meteorology**
  The graduate has a broad understanding of the concepts of meteorology.

Jet Stream

The polar cells are related to jet streams. The colder arctic air at the poles travels toward the equator and then rises at around 60 degrees latitude before reaching the midlatitude cell. Because of the Coriolis Effect, this air movement is angled, which causes the jet stream.

As you read the materials below, draw in your notebook a simple picture of Earth. Draw an arrow to indicate the jet stream. Label the air north of the jet stream as cold arctic air. When watching weather forecasts, take note of jet stream movement.

Re-read the following section within chapter 18 ("Air Pressure and Wind") of Earth Science to better understand jet streams, which are situated over the polar front:

- **Section 18.2 "Factors Affecting Wind"**

In the Northern Hemisphere, the jet stream blows west to east. This wind circulation of the jet stream separates the colder polar air from the warmer air just southward. On typical weather maps of North America, the jet stream is shown. As the cooler polar air moves south, so does the jet stream.

Hadley Cells
As you read the materials below, describe in your notebook global wind circulation, which includes the Hadley cells.

Continue reading the following sections from chapter 18 ("Air Pressure and Wind") in Earth Science:

- Section 18.4 "General Circulation of the Atmosphere"

In the following figure in Earth Science, notice that the Hadley cells near the equator cause trade winds:

- figure 18.17

The Coriolis Effect causes the wind to angle along the earth's surface.

The higher blue arrows all point away from the equator. The air moves down only at the subtropical 30 degree latitudes.

Practice drawing the Hadley cells while not looking in the book, and then check your accuracy.

**El Niño**

Read the following section on El Niño in chapter 18 ("Air Pressure and Wind") of Earth Science:

- Section 18.7 "El Niño and La Niña and the Southern Oscillation"

The strong trade winds cause an equatorial current which flows from east to west in the Pacific Ocean under normal conditions. For reasons that are still unclear, this current can change directions, giving rise to the El Niño weather pattern. In your notebook, describe the cause of El Niño and its effects on regional conditions.

**Local Winds**

Global wind patterns show general trends. At the local level, wind direction can change for a variety of reasons.

This topic addresses the following competency:

- **Competency 204.5.3: Meteorology**
  
The graduate has a broad understanding of the concepts of meteorology.

**Monsoon**

As you read the materials below, describe in your notebook the causes and effects of Indian monsoons.

Review the following page in Earth Science as an introduction to monsoons:

- section 18.4 "General Circulation of the Atmosphere"
Land and Sea Breezes

As you read the materials below, describe in your notebook the causes and effects of the breezes described in this section.

Read the section on land and sea breezes in chapter 18 of Earth Science:

- Section 18.5 "Local Winds"

Review your notes from chapter 16 ("The Atmosphere: Composition, Structure, and Temperature") of Earth Science on the differential heating of land and water. How does the differential heating of land and water affect land and sea breezes?

Draw pictures of land and sea breezes in your notebook. If you were living at the beach, when would you feel an on-shore breeze blowing from the ocean to your house?

Mountain and Valley Breezes

As you read the materials below, describe in your notebook the causes and effects of mountain and valley breezes. Relate these concepts to those from chapter 17 describing the processes that lift air.

Mountains and valleys alter wind patterns.

Read the section on mountain and valley breezes in chapter 18 of Earth Science:

- Section 18.5 "Local Winds"

Chinook and Santa Ana Winds

As you read the materials below, describe in your notebook the causes and effects of Chinook and Santa Ana winds.

Read the section on Chinook and Santa Ana winds from chapter 18 of Earth Science:

- Section 18.5 "Local Winds"

Major Wind Systems Task

Now that you have completed the activities so far, you are ready to complete the Major Wind Systems performance task. Review your notes and contact the course mentor if you have any questions as you work on the task.

This topic addresses the following competency:

- Competency 204.5.3: Meteorology
  The graduate has a broad understanding of the concepts of meteorology.

Major Wind Systems Performance Task
Complete the following task in TaskStream:

- Earth & Space Science: Major Wind Systems

For details about this performance assessment, see the "Assessment" tab in this course.

**Fronts**

Fronts are boundaries between air masses.

This topic addresses the following competency:

- **Competency 204.5.3: Meteorology**
  The graduate has a broad understanding of the concepts of meteorology.

**Moving Air Masses**

Begin reading the following chapter in *Earth Science* to learn about moving air masses and fronts:

- chapter 19 ("Weather Patterns and Severe Storms")

Cold fronts move cold air, whereas warm fronts move warm air. In your notebook, compare and contrast cold and warm fronts in terms of the motion of air masses and describe the weather these fronts bring.

**Warm Front**

Draw a picture of a warm front in your notebook with the associated cloud formations. Notice the gentle wedge of air masses as the warm air gradually passes over the cold air. At a warm front, the cirrostratus clouds give a warning that precipitation is coming. Nimbostratus clouds eventually form, which bring steady rain.

**Cold Fronts**

Draw a picture of a cold front in your notebook with the associated cloud formations. Notice the steeper grade between the air masses as the cold air pushes the warm air up. At a cold front, cumulonimbus clouds form, bringing heavy downpours, thunderstorms, and vigorous wind gusts.

**Weather Map**

Watching the news on the television usually includes a view of a weather map.

This topic addresses the following competency:

- **Competency 204.5.3: Meteorology**
  The graduate has a broad understanding of the concepts of meteorology.

**Interpreting a Weather Map**

During your readings so far, there have been many examples of weather maps. Be sure you can interpret a weather map.
Warm fronts are shown with red semicircles, and cold fronts are shown with blue triangles. The air mass is moving in the direction the shapes are pointed. Make note of this as you look at the maps.

Examine the following figure in chapter 19 of Earth Science to see how a developing front has alternating shapes. Notice how the air masses are moving in relation to the lines of the map:

- figure 19.11

You can visit the following website to see the national weather map and practice interpreting a weather map:

- The Weather Channel

The leading edge of a cold front has the most severe weather. Examine the following figure in Earth Science and note which city would have the most severe weather:

- figure 19.12

Notice that city D has the most severe weather because it is located at the leading edge of the cold front. Cold fronts move faster than warm fronts. Afternoon summer thunderstorms can develop fairly quickly as a cold front moves through the area.

**Electrical Storms**

Thunderstorms can generate lightning.

This topic addresses the following competency:

- Competency 204.5.3: Meteorology
  The graduate has a broad understanding of the concepts of meteorology.

**Thunderstorms**

Continue reading the following chapter in Earth Science to help you better understand thunderstorms that generate lightning and thunder:

- chapter 19 ("Weather Patterns and Severe Storms")

Warm humid air needs to rise, which could occur near cold fronts as described in the previous section. In your notebook, answer the following question:

- What other conditions might cause warm humid air to rise?

**Tornadoes and Hurricanes**

Tornadoes and hurricanes are weather systems that can have devastating effects.

This topic addresses the following competency:
• Competency 204.5.3: Meteorology
  The graduate has a broad understanding of the concepts of meteorology.

Hurricanes

Read the following section in chapter 19 of *Earth Science*:

• Section 19.6 "Hurricanes"

By definition, a hurricane has winds of 74 mph or more. For a hurricane to form, the ocean temperature must be at least 80 degrees F. In your notes, write down the requirements for a *hurricane*, *tropical depression*, and *tropical storm*. Describe how hurricanes and other large cyclonic weather systems form, move, and dissipate.

**Human Impact on Global Climate**

Climates on Earth were changing long before humans were prevalent on Earth. Human activity, however, can influence climate change.

This topic addresses the following competency:

• Competency 204.5.3: Meteorology
  The graduate has a broad understanding of the concepts of meteorology.

**Anthropogenic Climate Change**

Read about human impact on global climate from chapter 20 ("World Climates and Global Climate Change") of *Earth Science*:

• Section 20.8 "Human Impact on Global Climate"

**The Solar System**

As technology improves, so does the information that people can gather on the solar system. For example, Galileo was able to observe Jupiter's moons by using a telescope. Earth's solar system includes four dense inner terrestrial planets orbiting the sun, and four large outer Jovian planets that are less dense. Other objects rotate around the sun, as well. After completing this section's activities, you will be able to

• describe Earth's solar system and
• explain how the sun, moon, and earth are positioned during eclipses.

**The Heliocentric Model**

In Greek, *helios* means sun and *kentron* means center. The heliocentric model has the sun in the center of Earth’s solar system.

This topic addresses the following competency:

• Competency 204.5.1: Astronomy
  The graduate has a broad understanding of the basic concepts of astronomy.

**Ancient Astronomy**
Begin reading the following chapter in *Earth Science* to help you appreciate the many ideas that different cultures had to explain their observations of the sky:

- **chapter 21 ("Origin of Modern Astronomy")**

**The Elliptical Orbit of Planets**

Kepler helped with the current understanding of the elliptical path that planets take around the sun. Today, his discoveries are referenced as three laws.

Continue reading in the following chapter of *Earth Science* to learn about the current understanding of Earth's solar system:

- **chapter 21 ("Origin of Modern Astronomy")**

Make flash cards listing Kepler's laws. To help with your learning, find a willing participant and explain Kepler's findings to them. Use your flash cards to reinforce your knowledge of Kepler's laws.

**Astronomical Units**

When measuring distances between planets and stars, measuring in meters or kilometers is cumbersome. Therefore, larger units are used. The average distance from the earth to the sun is called one astronomical unit, or AU. When measuring length within the solar system, AUs are used.

Examine the following table in **chapter 21** of *Earth Science* to see the distance of the planets from the sun:

- **table 21.1 "Period of Revolution and Solar Distances of Planets"**

You should know the order of the planets in the solar system. You should also know the units used to measure distances within the solar system (i.e., astronomical units) and when measuring distances beyond the solar system (i.e., light years).

**The Heliocentric Solar System**

In your notebook, write down Galileo's observations and how they influenced the establishment of the heliocentric model. Newton built upon this model by describing the forces involved in this model.

Notice the picture of the heliocentric solar system on the following page of *Earth Science* in **chapter 22 ("Touring Our Solar System")**:

- **Figure 22.1 "Orbits of the Planets"**

Look at how the sun is in the center surrounded by orbiting planets. This arrangement has been deduced after hundreds of years of scientific observations and is now commonly taught in
school.

Draw a diagram of the heliocentric model. The four dense rocky planets orbit closer to the sun, and the four large planets are much farther from the sun.

**Galileo Performance Task**

Now that you have completed the activities associated with the "The Heliocentric Model," you are ready to complete the Galileo performance task. Review your notes and contact the course mentor if you have any questions as you work on the task.

This topic addresses the following competency:

- **Competency 204.5.1: Astronomy**
  The graduate has a broad understanding of the basic concepts of astronomy.

**Galileo Performance Task**

Complete the following task in [TaskStream]:

- Earth & Space Science: Galileo

For details about this performance assessment, see the "Assessment" tab in this course.

**Observing the Night Sky**

Understanding the solar system began by observing the night sky.

This topic addresses the following competency:

- **Competency 204.5.1: Astronomy**
  The graduate has a broad understanding of the basic concepts of astronomy.

**Celestial Sphere**

Read the following section in chapter 21 of *Earth Science*:

- Section 21.3 "Positions in the Sky"

Using a grid system allows viewers to observe and discuss objects in the sky. Share what you enjoy about studying the night sky on the message board.

**Retrograde Motion**

Review the following section in chapter 21 of Earth Science, which shows why Mars might appear to be traveling backwards in the sky at times:

- Section 21.1 "Ancient Astronomy"

Earth passes Mars on the inside of Mars’s orbit, creating this illusion.

**Identifying Objects**
Stars appear to be fixed objects in space and can be used as reference points in the sky. For example, the Big Dipper has maintained the same configuration over time. As the Earth rotates, a person has a different viewing angle of the sky.

Planets can be identified because they move in relation to fixed stars' locations. You can see man-made satellites moving relatively quickly across the night sky because they are much closer than neighboring planets.

A planisphere is a portable star chart, or map, that can help you locate constellations in the sky. To use it, you match its two attached disks to your date and time, allowing you to see which stars should be visible. Planispheres are designed for specific latitude zones, so you need to be sure that you are using one appropriate for your latitude.

There are a few online planispheres that you can use to view the night sky from various positions. OpenLearn's Virtual Planisphere provides a virtual planisphere with interactive controls allowing you to view the night sky at any time of the year. Ernie Wright's online Planisphere Applet provides a traditional planisphere that is programmable to your own location.

The Motions of Earth

Earth can act like a spinning top.

This topic addresses the following competency:

- **Competency 204.5.1: Astronomy**
  The graduate has a broad understanding of the basic concepts of astronomy.

Earth's Orbital Parameters

Read the following section in chapter 21 ("Touring Our Solar System") of Earth Science:

- Section 21.4 "The Motions of Earth"

Notice the ecliptic plane, which is the plane created as the earth revolves around the sun. This figure also depicts the plane of the equator, which cuts through Earth's equator. This is also referred to as the celestial equator or celestial plane.

In your notebook, write down a description of earth's precession. Recall the importance of Earth's tilt in creating the seasons and how the motions of Earth affect global climates.

Elliptical Movement

Earth moves around the sun in a slightly elliptical pattern. Kepler investigated the idea that planets have an elliptical path, versus a circular path.

To review this shape, refer to the following figure in chapter 21 of Earth Science, which depicts two different ellipses:
Figure 21.10 "Drawing Ellipses with Various Eccentricities"

The eccentricity of an ellipse is dependent on the distance between the foci. Answer the following question in your notes:

- If the distance between the foci were zero, what shape would the ellipse have?

Earth's path around the sun is almost a circle, but not quite. Asteroids and comets have more eccentric paths around the sun than the earth does.

Look at the following figure in chapter 21 of Earth Science to review Kepler's law of equal areas:

- figure 21.11 Kepler's Law of Equal Areas

A comet far from the sun at aphelion moves slowly. Conversely, when the comet is close to the sun at perihelion, it moves quickly and also has a tail as the sun burns off some of the comet's ice.

**Changes in Earth's Movement**

There are three types of variations in Earth's orbit that have been recorded.

Read the following section in chapter 6 ("Glaciers, Deserts, and Wind") of Earth Science:

- Section 6.7 "Causes of Ice Ages"

This section describes the following changes:

- Earth's orbit around the sun (changes on a 100,000-year cycle)
- Earth's axis of rotation (changes on a 41,000-year cycle)
- Earth's precession (changes on a 26,000-year cycle)

These cyclical events are thought to explain major climatic changes that have occurred over thousands of years.

**Motions of the Earth-Moon System**

As the moon orbits the earth and the earth orbits the sun, the lineup of these three bodies can cause some interesting effects.

This topic addresses the following competency:

- **Competency 204.5.1: Astronomy**
  The graduate has a broad understanding of the basic concepts of astronomy.

**Phases of the Moon**

Read the following section in chapter 21 ("Origin of Modern Astronomy") of Earth Science:
"Phases of the Moon"

Where is the moon in relation to the earth and sun during a full moon? Where is it during a new moon? The sun is always lighting up half of the moon and the earth. It is the perspective from earth that produces the phases of the moon.

**Eclipses**

Read the following section in chapter 21 ("Origin of Modern Astronomy") of *Earth Science*:

- Section 21.5 "Motions of the Earth-Moon System"

Where is the moon in relation to the earth and sun during a lunar eclipse? Where is it during a solar eclipse? In your notebook, draw a diagram of each eclipse and label the umbra and penumbra.

Using common household materials such as a flashlight and balls, create a demonstration to depict lunar and solar eclipses. Be sure you can demonstrate how each occurs and the results of each.

**Earth’s Motion Performance Task**

Now that you have completed activities associated with Earth's motion, you are ready to complete the Earth's Motion performance task. Review your notes and contact the course mentor if you have any questions as you work on the task.

This topic addresses the following competency:

- **Competency 204.5.1: Astronomy**
  The graduate has a broad understanding of the basic concepts of astronomy.

**Earth’s Motion Task**

Complete the following task in TaskStream:

- Earth & Space Science: Earth's Motion

For details about this performance assessment, see the "Assessment" tab in this course.

All diagrams must be original. You can draw your diagrams on paper and scan to submit, or you can create diagrams electronically. Some diagrams require many concepts to be illustrated at once, and therefore require planning to make sure that everything required is included.

**Planets and Moons**

There are eight planets, and some of these planets have moons.

**Formation of the Solar System**

The solar system formed from rotating interstellar dust and gas.

This topic addresses the following competency:
Competency 204.5.1: Astronomy
The graduate has a broad understanding of the basic concepts of astronomy.

Early Evolution of Earth

As you read the materials below, write in your notebook down the importance of gravity in the formation of stars and planets from interstellar dust and in determining whether a body will be a star or a planet.

Take a moment to review the following section in chapter 1 ("Introduction to Earth Science") of Earth Science:

- Section 1.3 "Early Evolution of the Earth"

During the evolution of the solar system, rotating matter condensed and clumped together to form larger and larger pieces. This accretion (sticking together) continued as matter revolved around what would become the sun.

Objects close to the sun were hotter than those far from the sun and therefore became more dense as gases burned off, leaving behind only metallic and rocky substances.

In your notebook, describe the scientific explanation for the formation of the solar system.

Understanding Gravity

The effects of gravity are dependent on the distance between the objects involved and the mass of each object. The closer the objects and the higher their masses, the greater the gravitational effects will be between the objects.

Review the following section from chapter 21 ("Origin of Modern Astronomy") in Earth Science:

- "Sir Isaac Newton" within Section 21.2 "The Birth of Modern Astronomy"

Be sure to understand Newton's law of universal gravitation. Newton described objects in motion in general, whereas Kepler's laws were specific to the path of planets in motion.

Draw a picture of an object orbiting another object. Draw another picture with the object now orbiting a little farther away. In which of these two models is the gravitational force between the objects greater?

The majority of mass is in the center of the solar system: the sun. The gravitational force of the sun keeps materials rotating around this center. Earth's moon is attracted to Earth due to the force of gravity. There is also a force propelling the moon forward that was created during the solar system's early beginnings. Gravity determines the orbit of a body in motion around another body.

Creating the Giant Planets
Read the following section at the beginning of chapter 22 ("Touring Our Solar System") in Earth Science:

- Section 22.1 "Our Solar System: An Overview"

Describe why the Jovian planets are much larger than the four interior planets in the solar system:

This increase in mass then increased the gravitational pull of the forming planet, thereby attracting even more mass. The increase in gravitational pull allowed the forming planet to hold gases even closer, causing the gaseous molecules to come closer together. Jupiter, for example, has hydrogen in its atmosphere and liquid hydrogen at its surface.

In your notebook, draw a picture of a planet with air molecules in its atmosphere. Then draw a second picture depicting how those same air molecules would behave if that same planet had a higher gravity. In this second picture, the air molecules should be drawn closer together. You should understand the effects of gravity on a planet's atmosphere.

**Holding an Atmosphere**

Gravity is important in determining whether a planet will be able to hold an atmosphere. A planet's atmosphere depends on its mass and its temperature. The moon has one-sixth the gravity of Earth and consequently does not hold an atmosphere as Earth does. Conversely, Jupiter's huge gravitational forces create enormous pressures and cause hydrogen to be a liquid at its surface.

Earth has enough gravity to hold an atmosphere and yet allow gasses to persist, allowing for the existence of life.

Review the following section in chapter 22 of Earth Science to further your understanding:

- Section 22.1 "Our Solar System: An Overview"

The outer planets are colder and much more massive than Earth, which explains the existence of an atmosphere on these outer planets. Review this section in the text to further your understanding.

**Earth's Moon**

With a simple telescope, or even binoculars, you can see surface features of the moon. What caused these features?

This topic addresses the following competency:

- **Competency 204.5.1: Astronomy**
  The graduate has a broad understanding of the basic concepts of astronomy.
Describing the Moon

As you read the materials below, write in your notebook the description of the moon in terms of its relative size, mass, volume, density, general surface features, and general history.

Read the following section in chapter 22 ("Touring Our Solar System") of Earth Science:

- Section 22.2 "Earth's Moon: A Chip off the Old Block"

Planets

The greatest density of the solar system is at its center with the sun and the four rocky planets.

This topic addresses the following competency:

- Competency 204.5.1: Astronomy
  The graduate has a broad understanding of the basic concepts of astronomy.

Earth in Perspective

As you read the materials below, for each planet, describe its type (rocky or gaseous), relative size, relative distance from the sun, general surface features, gravity, and special features (e.g., rings of Saturn, moons of Jupiter, etc.) in your notebook.

Also answer the following questions in your notebook:

- Which planets are the dense, rocky planets?
- How far away is the farthest planet from the sun?

Review the following section in chapter 22 of Earth Science:

- "Our Solar System: An Overview"

Review the following PDF, which shows the relative sizes of the planets with each other:

- "Earth in Perspective"

The following in chapter 22 of Earth Science show differences between the planets along with their order from the sun:

- figure 22.2 Comparing Internal Structures of the Planets
- table 22.1 Planetary Data

Composition and Motion of Galaxies, Asteroids, Comets, and Meteors

This section covers the composition of galaxies, as well as the asteroids, comets, and meteors that move within them.

This topic addresses the following competency:
Objects in Space

As you read the materials below, answer the following questions in your notebook:

- What are asteroids and comets made of?
- What path do they take?
- What is found in the Kuiper Belt?
- What is found in the Oort Cloud?

To better understand the terms asteroids and comets, read the following pages in chapter 22 ("Touring Our Solar System") of Earth Science:

- Section 22.5 "Small Solar System Bodies"

**Compare Asteroids, Comets, and Meteoroids**

In your notes, compare asteroids, comets, and meteoroids. Make a three-circle Venn diagram to show similarities and differences between these things. Describe to a friend asteroids, comets, and meteoroids.

**Galaxies**

A galaxy is a massive system of stars. Use the following section in chapter 24 ("Beyond Our Solar System") of Earth Science to understand the composition and movement of galaxies:

- Section 24.6 "Galaxies and Galactic Clusters"

In what galaxy is Earth located?

**Beyond Earth’s Solar System**

The sun is just one star in the Milky Way galaxy. Young stars behave differently than old stars. When a star's fuel begins to be exhausted, heavier elements can be created.

**Properties of Light and the Sun**

By analyzing the light given off by stars, scientists can determine a star's properties.

This topic addresses the following competency:

- **Competency 204.5.1: Astronomy**
  The graduate has a broad understanding of the basic concepts of astronomy.

**Spectroscopy**

Scientists use spectroscopy to understand the composition of stars. Each gas atom has electrons at different energy levels. If an electron moves from a high energy level to a lower
energy level, light waves are given off.

When light is projected onto an atom, light waves are absorbed if the light’s energy matches with the atom’s difference in electron energy levels.

As you read the materials below, write down in your notebook all the information on stars that can be gathered by studying the wavelength of light and spectroscopy.

Read the following section in chapter 23 (“Light, Astronomical Observations, and the Sun”) of Earth Science, which describe the concept of using spectroscopy to study astronomical bodies:

- Section 23.2 "Spectroscopy"

Doppler Effect and Spectroscopy

Scientists use the Doppler effect of light rays to determine the radial velocity of stars in relation to the earth. Light travels in waves. Different wavelengths determine the different colors of light. If a star is moving away from the earth, the waves will be stretched and the appearance of the color of the star will be modified accordingly. If a star is moving toward the earth, the light waves will be compressed and the appearance of the color of the star will be modified accordingly. Therefore, scientists can use the colors of stars to determine the stars’ movements in relation to the earth.

Review the following section in chapter 23 (“Light, Astronomical Observations, and the Sun”) of Earth Science to learn about how scientists use the Doppler effect of light rays to determine the radial velocity of stars in relation to the earth:

- Section 23.2 "Spectroscopy"

As you read, add to your list of information on stars that can be gathered by studying the wavelength of light and spectroscopy. Why is the Doppler Effect not used to measure transverse velocity?

The Sun

notebook you read the materials below, describe in your notebook the sun’s process for moving energy. It is important to understand how scientists make observations of the sun. Sunspots can be seen by projecting the sun's image through telescopes. Impressive details of the sun's surface (such as spicules and filaments) can be seen only by using photographic filters.

Read the following section in chapter 23 (“Light, Astronomical Observations, and the Sun”) of the Earth Science:

- Section 23.5 "The Sun"

Make a labeled drawing describing the sun's structure and its surface, including sunspots
(whose number cycles every 11 years). Include six layers of the sun in your drawing (i.e., inner core, radiative zone, convection zone, photosphere, chromosphere, and corona).

**Stars**
Stars evolve differently, depending on their size.

This topic addresses the following competency:

- **Competency 204.5.1: Astronomy**
  The graduate has a broad understanding of the basic concepts of astronomy.

**Observing Stars**

Begin reading the following chapter in *Earth Science* to better understand how scientists collect data on stars:

- chapter 24 ("Beyond Our Solar System")

**Hertzsprung-Russell Diagrams**

In 1912, Hertzsprung and Russell plotted attributes of stars and noted patterns. Hertzsprung and Russell's organization of collected data is referred to as the H-R diagram.

Read the following section in chapter 24 ("Beyond Our Solar System") of *Earth Science* so that you are able to interpret information on the H-R diagram:

- Section 24.3 "Classifying Stars: Hertzsprung and Russell Diagrams"

Notice that the numbers on the axis do not necessarily go in the traditional direction. When interpreting an H-R diagram, you need to pay attention to the numbers on the axis.

**Stellar Evolution**

Read the following section in chapter 24 ("Beyond Our Solar System") of *Earth Science* to help you understand stellar evolution:

- Section 24.4 Stellar Evolution

Notice that medium- and high-mass stars go through a red-giant phase, which starts after all usable hydrogen fuel is consumed. During this phase, heavier elements, such as carbon, are created. Be sure you understand the red-giant phase. All the elements on the periodic table up to iron are made during the red-giant phase.

**Black Holes**

Only high-mass stars can eventually form black holes. During a supernova, the star’s core condenses.

Read the section on black holes in chapter 24 of *Earth Science*:
- Section 24.5 Stellar Remnants

What is emitted that helps scientists detect black holes?

**Final Steps**

Congratulations on completing the activities in this course! This course has prepared you to complete the assessments associated with this course. If you have not already been directed to complete the assessments, schedule and complete your assessments now.

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The WGU Library

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