Unit Map

Archaeologists discovered part of an ancient artifact that depicts the sun and other stars. How can we figure out what would have appeared on the missing piece?

Taking on the role of astronomers, students help a team of archaeologists at the fictional Museum of Archaeology figure out what the missing piece of a recently discovered artifact might have depicted. As they learn about the sun and other stars and the movement of Earth, students can explain what is shown on the artifact and what might be on the missing piece.

Chapter 1: Why don't we see a lot of stars in the daytime?

Students figure out: The stars are all around Earth in every direction. Because the sun is much closer to Earth than all other stars, it appears bigger and brighter. During daytime, the sun's brightness overwhelms the brightness of other stars, and that is why we can only see the sun during the daytime. This is why the artifact depicts the sky in different scenes: the sun in the sky is distinct from depictions showing all other stars in the sky.

How they figure it out: Through reading and investigating in the *Patterns of Earth and Sky* Simulation, students gather data about the size and distance of objects in space relative to Earth. Students create a physical model demonstrating the distances of various stars and the sun from Earth and conclude that it is the immense distance of Earth from other stars and the sun's proximity to Earth that creates the illusion of other stars being much smaller than the sun. By gathering additional evidence in text and photos and a video, students come to understand why they can't see other stars in the daytime.

Chapter 2: Why is the sun up sometimes, but not other times?

Students figure out: The sun is only up sometimes and not at other times because Earth spins once per day. Since gravity pulls us down toward Earth, we are carried with Earth as it spins. What we see up above us changes as we spin. When the side of Earth we are on faces the sun, the sun is up in the sky. When Earth spins to face away from the sun, the sun is not up, and we can see other stars. This is why each artifact panel shows a repeating pattern: the sun is in the sky, then other stars are in the sky, and so on.

How they figure it out: Through a series of observations in the Simulation, participation in a kinesthetic model, and video evidence, students investigate what causes the daily pattern of sun and stars that can be seen from Earth. Students read and model to investigate Earth's gravitational pull and conclude which way is *up*.

Chapter 3: Why do we see different stars at different times of year?

Students figure out: As Earth spins, it also orbits around the sun once a year. Since Earth is moving, this means that throughout the year, Earth is in different places in its path around the sun. Our view of the stars in the nighttime sky changes in a pattern that repeats each year because Earth is traveling along its orbital path. This is why the artifact shows different constellations in the different nighttime panels.

How they figure it out: Using the Simulation and a kinesthetic classroom model, students investigate what constellations can be seen over the course of a year and across multiple years. They carefully plan a systematic investigation with the Simulation and look for patterns in the data. Students read about Earth's orbit around the sun and apply their new ideas to the classroom model in order to understand the yearly pattern of star visibility.

Chapter 4: How can we investigate why we see different stars on different nights?

Students figure out: We can investigate many different questions about the stars using systematic observations.

How they figure it out: Students are presented with a list of possible questions about patterns of when and where certain constellations can be seen. Students choose a question to investigate and apply what they have learned to carefully plan their own investigations in the Simulation. Through peer feedback and iteration, students refine their investigation plans. They then conduct their investigations in the Simulation and share results with peers.

Unit Map

What happens when two substances are mixed together?

In the role of food scientists working for Good Food Production, Inc., students are introduced to the ideas that all matter is made of particles too small to see and that each different substance is made of particles (molecules) that are unique. Students are then challenged to solve two problems: One problem requires them to separate a mixture, and the other problem requires them to make unmixable substances mix. Students are challenged to use the particulate model of matter to explain their work to the president of the company. In so doing, students figure out that the properties of materials are related to the properties of the nanoparticles that make up those materials.

Chapter 1: Why did the food coloring separate into different dyes?

Students figure out: The different dyes that are mixed together have different properties (colors), so they are made of different molecules. The molecules in the mixture that are carried up the paper by the water are attracted to the water and mix with it. As the water travels up the paper, different kinds of molecules travel different distances because their molecules are different sizes or have a different attraction to the paper.

How they figure it out: Students conduct a chromatography test on the dye mixture and observe as it separates. The class explores and critiques a variety of physical models before creating their own models of what might be happening at the nanoscale. Students share, critique, and revise their diagram models and write scientific explanations.

Chapter 2: Why do some salad dressings have sediments, and others do not?

Students figure out: Salad dressings with sediments contain solids that are not soluble; salad dressings without sediments contain soluble solids. The molecules of water and the molecules of different solids are different from one another. When a solid dissolves in water (it is soluble), it means that the molecules of the solid are attracted to water molecules. When a solid does not dissolve in water, it means that the molecules of the solid are not attracted to water molecules.

How they figure it out: Students get hands-on experience with solids that dissolve and solids that do not dissolve. They then explore the phenomenon of a solid dissolving at the nanoscale in the *Modeling Matter* Simulation. Students create their own diagram models and write scientific explanations of dissolving.

Chapter 3: Why can salad-dressing ingredients separate again after being mixed?

Students figure out: When liquids do not mix together, they form layers. The A molecules and the B molecules are not attracted to one another, so they do not mix together. In addition to the level of attraction between A molecules and B molecules, A molecules have a level of attraction to other A molecules, and B molecules have a level of attraction to other B molecules. Liquid ingredients in a salad dressing separate after being mixed if the attraction between molecules of one liquid is greater than the attraction between molecules of different liquids. However, if an emulsifier is added, the liquids can mix because the molecules of the emulsifier are strongly attracted to both A molecules and B molecules.

How they figure it out: Students observe real liquids that don't mix, and then they use the Simulation to figure out what the phenomenon might look like at the nanoscale. Students create their own models of mixing and non-mixing liquids and write scientific explanations about the phenomenon. In order to try to get liquids to mix, students then experiment with food additives that act as emulsifiers, and some that do not. The Simulation enables them to explore and observe how emulsifiers work at the nanoscale and create their own models that explain how emulsifiers work.

Unit Map

What can determine how much water is available for human use?

The cities of East Ferris and West Ferris are located on different sides of a mountain on the fictional Ferris Island. East Ferris is having a water shortage while West Ferris is not. As water resource engineers, students learn about the Earth system so they can help figure out what is causing the water shortage on one part of the island. They also design ways to alleviate the effects of water shortages, including freshwater collection systems and proposals for using chemical reactions to treat wastewater.

Chapter 1: Why is East Ferris running out of water while West Ferris is not?

Students figure out: Ferris Island is surrounded by ocean, but salt water is unusable for most human purposes. East Ferris's growing population is using up their only freshwater source, a groundwater reservoir, whereas West Ferris has an additional source of freshwater—rain.

How they figure it out: Students define the problem in East Ferris by analyzing graphs of global water distribution and reading about water shortages. They discuss how the biosphere and hydrosphere interact and write a scientific explanation about why East Ferris is experiencing a water shortage.

Chapter 2: Why does more rain form over West Ferris than East Ferris?

Students figure out: More rain forms over West Ferris because more water vapor condenses there. During condensation, water vapor gets colder and turns into liquid water. There is a lot of water getting cold in West Ferris, so a lot of rain forms. There is not a lot of rain forming over East Ferris, so there is not a lot of water vapor getting colder and condensing into liquid water there.

How they figure it out: Students gather information from hands-on investigations, *The Earth System* Simulation, and texts that help them understand condensation and evaporation at two scales: the observable and the nanoscopic. They apply this to a discussion of how the atmosphere and hydrosphere interact. They also design and build freshwater collection systems.

Chapter 3: Why is more water vapor getting cold over West Ferris than East Ferris?

Students figure out: There is more water vapor getting cold over West Ferris because on that side of the island more water vapor moves upward in the atmosphere where it is colder. This means that more water vapor can condense and fall as rain.

How they figure it out: Students synthesize information from text, physical models, and the Simulation to determine that at higher elevations in the atmosphere where it is colder, water vapor can condense. They also evaluate and iterate on their freshwater collection system designs.

Chapter 4: Why is there more water vapor high up over West Ferris than East Ferris?

Students figure out: More water vapor moves up in the atmosphere over West Ferris because a mountain directs the wind blowing from the ocean upward. This causes water vapor in the air to cool, condense, and fall as rain over West Ferris. Air that continues on over the mountain does not have enough water vapor left to condense and fall as rain over East Ferris.

How they figure it out: Students investigate using the Simulation and a hands-on activity to observe that water vapor gets directed upward when it blows toward a mountain. They synthesize this with their knowledge of where and why water vapor condenses in order to explain how Earth system interactions create rain shadows. They also iterate once more on their freshwater collection system designs.

Chapter 5: How can East Ferris turn wastewater into clean freshwater?

Students figure out: East Ferris can add substances to wastewater that react with harmful substances in the water. The reaction creates new substances that are easier to remove from the water, so East Ferris can get clean freshwater.

How they figure it out: Students observe a chemical reaction and read about everyday chemical reactions. They use a digital model to discover that matter is not created or destroyed in chemical reactions. They write a scientific explanation about how wastewater treatment, using chemical reactions, could be another solution to the water shortage in East Ferris.

Unit Map

Why aren't the jaguars and sloths in a reforested part of the Costa Rican rain forest ecosystem growing and thriving?

Working as ecologists, students figure out why the organisms in a part of a Costa Rican rain forest ecosystem aren't growing and thriving. As they solve this problem, students learn more generally how organisms in an ecosystem get the matter and energy they need to survive. Along the way, students write a series of restoration plans that include arguments about why the rain forest ecosystem is not thriving and recommend actions to restore its health.

Chapter 1: Why aren't the jaguars and sloths growing and thriving?

Students figure out: Jaguars eat the body matter of sloths as food so they can grow. They change the food molecules from the sloth into molecules that build their body matter or release energy for movement and growth. The sloths eat the body matter of cecropia trees as food so they can grow. They change the food molecules from the cecropia trees into molecules that build their body matter or release energy for movement and growth. Because there weren't enough cecropia trees in the failing rain forest ecosystem, the sloths and jaguars did not have enough food.

How they figure it out: Students learn that everything in an ecosystem is made of matter. They use the *Ecosystem Restoration* Simulation as well as physical models to show how animals get the food molecules they need to grow their bodies. They analyze data about the animals and plants in the project area and use the data to write an argument about why the animals are not growing and thriving. They also make recommendations for improving the health of this area of the rain forest.

Chapter 2: Why aren't the cecropia trees growing and thriving?

Students figure out: Cecropia trees in the rain forest ecosystem make their own food. Like all plants, they use energy from the sun to turn carbon dioxide and water into food molecules. They change these food molecules into molecules that build their bodies or release energy. The cecropia trees must not be getting the sunlight, water molecules, or air molecules that they need to grow and thrive.

How they figure it out: Students use and create models to investigate how plants get food and how energy enters and flows through the ecosystem. They read about the role of energy and conduct investigations in the Simulation in order to figure out that all energy in an ecosystem can eventually be traced back to the sun. They demonstrate their understanding by making a model of the relationships between the sun, plants, and animals in an ecosystem. Students write a data-based argument about why the cecropia trees are not growing and thriving and include new recommendations for improving the health of this area of the rain forest.

Chapter 3: Why aren't the cecropia trees growing and thriving in the soil?

Students figure out: Decomposers live in the soil in the rain forest ecosystem and use matter from dead organisms as food. Decomposers change the food molecules into molecules that build their own body matter or release energy for movement and growth, and decomposers also release nutrients into the soil. Nutrients in the soil are important for cecropia trees because they help the plants make food and body matter. Because there are not enough decomposers in the soil, there are not enough nutrients. This is the reason the cecropia trees are not growing and thriving, which affects the health of the whole ecosystem.

How they figure it out: Students gather data from the Simulation, hands-on investigations with soil, and a close-up look at soil and decomposition in a forest ecosystem in *Walk in the Woods*. They figure out that the soil in the project area lacks decomposers. Students use data about the decomposers and the soil in the project area to write their final Restoration Plan, an argument about why the cecropia trees are not growing and thriving in the soil.