Lesson 8: Conclusion and Summarizing

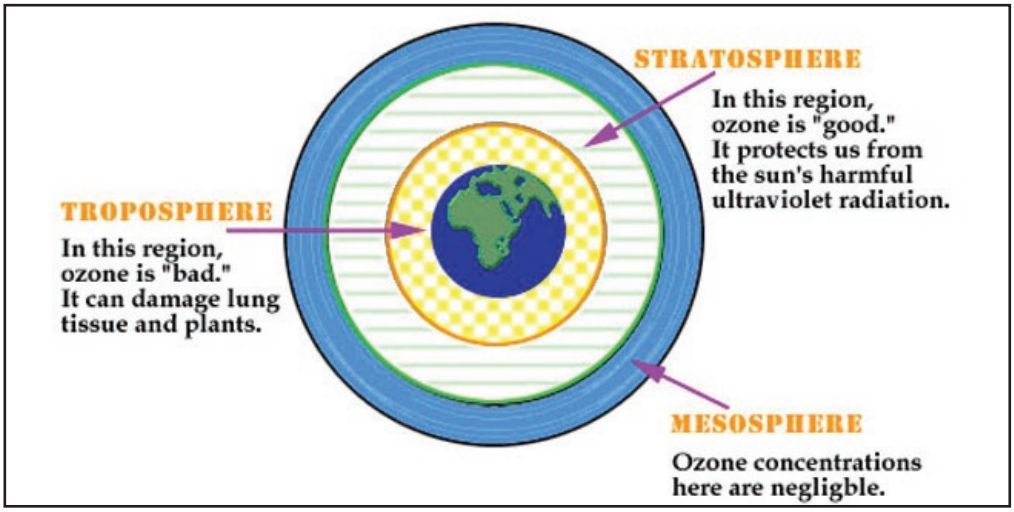


Illustration showing ozone concentration in Earth atmosphere; NASA

Students review astronomy and atmosphere systems and draw connections to geological processes and structures. They then summarize their learning from this unit in a final project.

Main Lesson Concept:
The Earth's structure is an important part of the Earth's system, which is composed of several layers. The movement of these layers affects the atmosphere and biosphere.

Scientific Question:
How are the Earth's structure and processes important to the Earth system, especially as it supports habitability to humans?

Objectives	Standards
• Students will draw and explain concept maps that show how the Earth's interior characteristics and processes interact with many different systems to support human habitability. • Students will write a guided tour for the Earth's structure and processes explaining how these processes contribute to a habitable planet for humans.	**Partially meets:** 2061: 4C (6-8) #1 **Addresses:** 2061 4B (6-8) #2 2061 11A (3-5) #1 2061 11A (3-5) #2 2061 11A (6-8) #2 2061 11A (6-8) #3 NSES D (5-8) #1.8

Assessment	Abstract of Lesson
Concept maps and guided tours.	Students review the characteristics of systems, the planetary temperature system, human body system, and the connections between the atmospheric and astronomical characteristics that support the human body system. They then draw concept maps that show the interaction of geologic structure and processes with important systems that support human survival. Finally, students write a guided tour of the Earth's interior and processes that describes the importance of each to help maintain the habitability of Earth.

Prerequisite Concepts

- Humans need water, oxygen, food, gravity, a moderate temperature, and protection from poisonous gases and high levels of radiation to survive. (Astronomy Lesson 1)
- Systems consist of many parts that usually influence each other. A system may not work as well (or at all) if a part of it is missing, broken, worn out, mismatched or misconnected. Thinking about things as systems means looking for how every part relates to other parts. Any system is usually connected to other systems. (Astronomy Lesson 7)
- The type of star, the orbital distance of a planet and the mass of the planet are the major components of the planetary temperature system that determine the surface temperature of the planet. (Astronomy Lessons 9 and 11)
- A large object, such as a Jupiter-size planet, orbiting near an Earth-size planet, could disrupt the planetary temperature system. (Astronomy Lesson 12)
- Carbon dioxide and water vapor are greenhouse gases that absorb energy radiated from Earth's surface and reradiate some of it back towards the Earth, increasing the surface temperature. (Atmosphere Lesson 3)
- Oxygen is important to humans because it helps to generate energy in the cells from sugars. (Atmosphere Lesson 5)
- The creation and destruction of ozone in the stratosphere protects life on Earth from harmful ultraviolet radiation. (Atmosphere Lesson 6)
- Nitrogen, like other substances, can have an effect on life because of its unique properties and because of the amount of it in the environment, which contributes to air pressure necessary for life functions. (Atmosphere Lesson 7)
- Humans need the following geologic conditions (Geology Lesson 1):
  - Liquid outer core (coupled with the planet's rotation) and a thick atmosphere
  - Viscous mantle (slow motion)
  - Slow motion of crust and upper mantle (lithosphere) of 3 to 5 centimeters/year
- Temperature and pressure are key factors that determine geologic conditions. (Geology Lesson 2)
- Density determines whether a substance will float on another substance and thus affects the composition of Earth's layers. (Geology Lesson 3)
- The interior of the Earth is hot. The heating and cooling of the mantle results in convection cells and movement inside the Earth. (Geology Lesson 4)
- The Earth's solid crust is composed of separate sections that constantly move on a partially molten layer of the upper mantle. Major geologic events such as volcanic eruptions result from these plate motions. (Geology Lesson 5)
- The movement of the crust and mantle allows carbon to be cycled in and out of the atmosphere, stabilizing the surface temperature. (Geology Lesson 6)
- The rotation of the Earth and its liquid outer core generate a magnetic field that, with the atmosphere, helps protect us from cosmic rays from exploding stars and harmful solar wind produced by our star, the Sun. (Geology Lesson 7)

Major Concepts

- The structure, composition, and mass of the Earth determine its structure and processes, all of which affect Earth's atmosphere and ability to support human survival.
- Like all systems, the Earth's structure is made up of parts that influence each other and can be part of other systems.
- The structure and composition of Earth's layers can affect the survival of humans.
- The amount of carbon dioxide in the atmosphere is an important factor in maintaining a moderate surface temperature.
- The amount of carbon dioxide in the atmosphere is determined by the carbon cycle, in which carbon is trapped in rocks and shells and then broken down and released through volcanoes and living processes.
- The slow movement of the crust and upper mantle results in volcanoes at plate boundaries. Movement in the mantle occurs as a result of convection. As mantle material increases in temperature, it becomes less dense and rises. When the temperature of the mantle material decreases, the density of the material increases and it sinks down.
- The lower part of Earth's upper mantle is partially molten. Earth's lithospheric plates float upon this layer.
- Earth's lower mantle is solid, but capable of flow due to the extreme pressures inside the Earth. The extreme pressure comes from the Earth's mass, which plays a role in making the inside of the Earth hot.
- The Earth's liquid outer core generates a magnetic field that, with the atmosphere, helps protect us from cosmic rays produced by exploding stars and harmful solar wind produced by our star, the Sun.

Suggested Timeline (45-minute periods):

Day 1: Engage and Explore sections
Day 2: Explain and Extend sections
Day 3: Evaluate Sections

Materials and Equipment:

- A class set of System Concept Map and Final Geology Project
- Concept Map of the interaction of the atmospheric gases with the planetary system and human body system from Atmosphere Lesson 8 (optional)
- Chart paper for class concept maps, chart of the importance of Earth's structure to humans, and lesson main concept
- Construction paper or blank white paper for students to draw their concept maps
- Different colored pens or colored pencils (for student concept maps)
- Earth's Structure Transparency (optional)
- Computers with "PowerPoint," "Hyperstudio," "Kid Pix," or other multimedia software for Final Geology Project (optional)
- Optional: Computers and concept map software such as freely available Cmap Tools at: http://cmap.ihmc.us

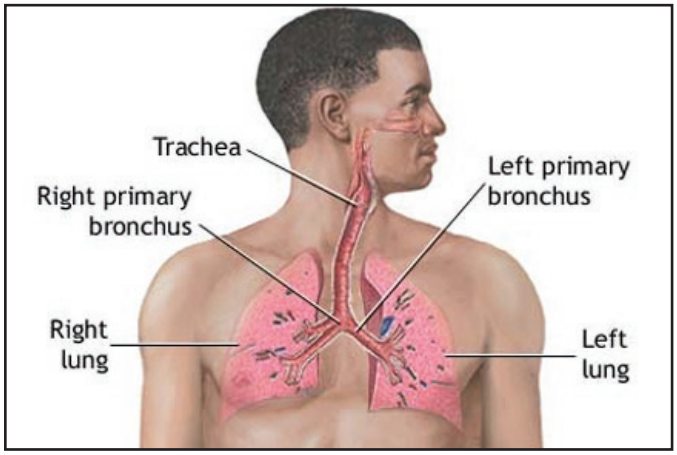
Preparation

- Prepare chart to record Earth's structure and its importance to humans.
- Gather materials.
- Duplicate System Concept Map and Final Geology Project.
- Prepare Earth's Structure Transparency (optional).
- Prepare chart paper with the major concept of the lesson to post at the end of the lesson.

Differentiation
Accommodations For students who may have special needs: Have them report orally to the teacher to explain their concept maps and guided tour or have them act out their guided tour with a partner.
Advanced Extensions For students who have mastered this concept: Write a guided tour of another planet or moon in our solar system describing why the structure and processes do not meet human habitability requirements and what changes would need to take place to meet human habitability requirements. Be sure to include the astronomical and atmospheric changes that would also be required to make the planet or moon habitable to humans.

Engage

(approximately 25 minutes)



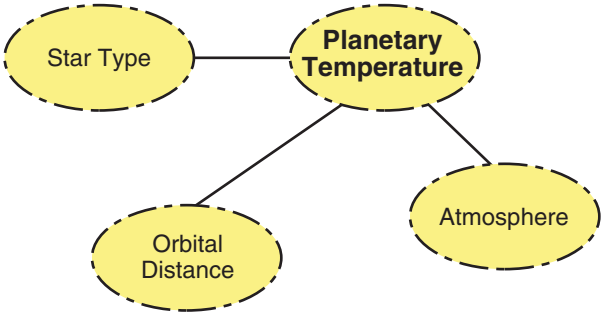
Air breathed in through the nasal passageways, travels through the trachea and bronchi to the lungs; U.S. National Library of Medicine, NIH

1. Review systems, the human body systems (Astronomy Lesson 7), and the planetary temperature system (Astronomy Lessons 9, 11, and 12).

- Question: What are the characteristics of a system?
- *Answer: Systems consist of many parts that usually influence each other. A system may not work as well (or at all) if a part of it is missing, broken, worn out, mismatched, or misconnected. Thinking about things as systems means looking for how every part relates to other parts. Any system is usually connected to other systems.*

- Question: What system is largely based on the astronomical characteristics of our solar system?
- *Answer: The planetary temperature system.*

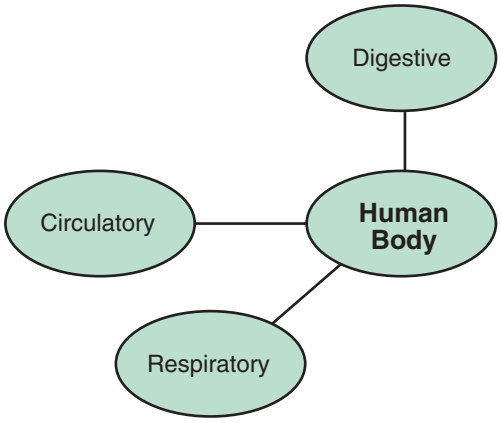
- Question: How is this system important to human survival?
- *Answer: The planetary temperature system is important to human survival because we need a moderate temperature that allows water to be a liquid and a temperature that is comfortable for our bodies to function.*



- Question: What are the parts of the planetary temperature system?
- *Answer: (As you discuss, begin to draw this as a concept map on the board.) The three main parts that determine the surface temperature of a planet are: star type, orbital distance, and atmosphere.*

Note to Teacher: If you have completed the concept map activity with the class in Atmosphere Lesson 8, simply review it at this time.

- Question: What are some of the important systems that make up the human body and help to keep us alive?
- *Answer: (As you discuss, begin to draw this as another concept map on the board.) Some of the systems that make up the human body are the respiratory system, the circulatory system, and the digestive system.*



- Question: What are these systems? How do they work? How do they relate to each other?
- *Answer: They have parts that usually relate to each other or work together. If one part is missing or broken, the whole system can be affected. For example, if the star type is very hot, the planet will need to orbit at a further distance in order to maintain a temperature that is habitable for humans.*

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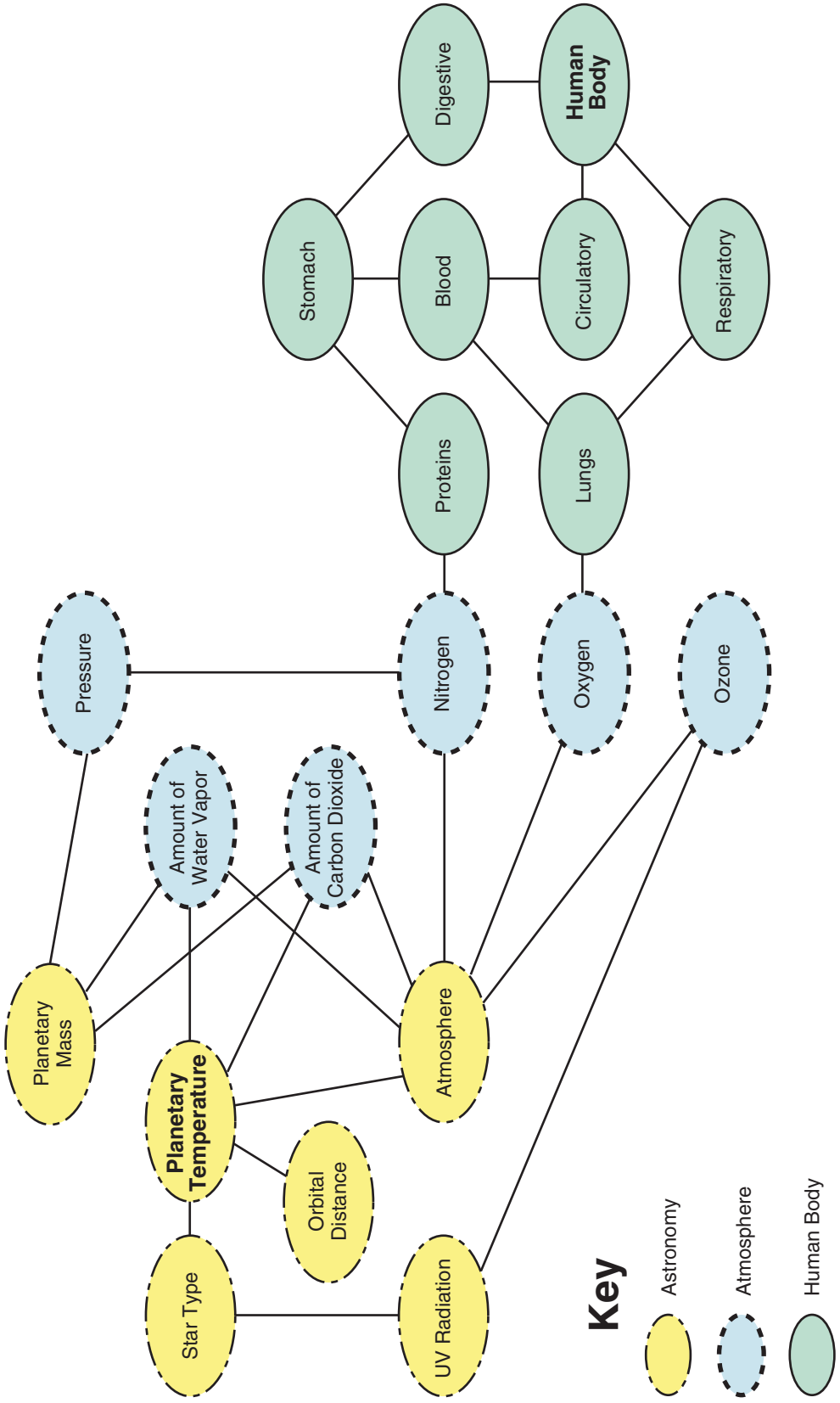
2. Review the interaction of the atmospheric gases with the planetary temperature system and human body system (Atmosphere Lesson 8).

- Question: How do the gases in our atmosphere interact with these two systems to support human habitability?
- *Answer: (Add to the concept map as students identify each of these. See the concept map on the next page as a guide to the types of connections to include.) Answers should include:*
  - *Carbon dioxide and water vapor are greenhouse gases that absorb radiation that bounces off Earth's surface and reradiate it back to Earth, playing an important role in the surface temperature of a planet. The amount of an atmosphere (including greenhouse gases) that a planet has is related to the force of gravity of that planet, which in turn depends on its mass.*
  - *The strength of gravity of a planet, along with its atmosphere, determines the surface pressure. We need the right amount of pressure to keep gases inside our body and to keep water a liquid on Earth's surface.*
  - *Nitrogen is an inert gas that makes up the bulk of our atmosphere contributing to the necessary pressure we need. Nitrogen is also a building block of proteins, which make up important parts of our bodies. Nitrogen is brought into our bodies through the digestive system.*

Sample Concept Map



– *Oxygen is highly reactive and reacts with sugars to give us energy. We breathe oxygen in through the respiratory system. It is circulated to the cells through the circulatory system, where it reacts with sugars that are brought in through the digestive system.*
– *Ozone absorbs harmful ultraviolet radiation in the upper atmosphere and prevents much of it from reaching the Earth's surface where it can kill us. (You could connect ozone to the atmosphere part of the Planetary Temperature System. You could also connect ultraviolet radiation to the star type of the planetary temperature system, since most stars put out ultraviolet light.)*

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3. Bridge to this lesson and introduce the purpose and Scientific Question.

- Say: Today, we are going to look at the Earth's structure and processes to see how they also connect to parts of the planetary temperature system and support the human body system. The scientific question we will explore is:
  – How are the Earth's structure and processes important to the Earth system, especially as it supports habitability to humans?

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4. Review the Earth's structure and importance. (Geology lessons 2, 3, 4, 5, 6, and 7)

- Question: What are important characteristics and processes of the Earth's interior and how is each characteristic important to human survival?
- *Answer: (You may want to record these on a chart as seen below.)*

Note to Teacher: Students may not come up with all of the characteristics and processes listed below, or they may come up with different ones. This is okay. The important thing is to get them to talk about what the inside of the Earth is like and why this is important. It's also important to guide them to start to identify the connections between these characteristics and the important processes involved in cycling carbon in and out of the atmosphere and generating a magnetic field. The indented characteristics don't have a direct importance to humans, but play a role in determining the major Earth processes that affect human habitability. They are really subsystems to the carbon cycle, so students may not list them here nor include them in their concept map. Again, this is fine. We include them in the discussion, so students will see how they are part of the larger systems.

Characteristic/ Process	Importance to humans
Volcanoes	Release carbon dioxide into the atmosphere, affecting the surface temperature.
Trapping of carbon in rocks and shells	Take carbon out of the atmosphere, affecting the surface temperature.
Slow mantle/crust movement	Volcanoes (that release carbon dioxide, affecting temperature) occur along plate boundaries that are moving toward each other or away from each other. The subduction of the plates is important in the process that cycles carbon in and out of our atmosphere.
Convection	The mantle moves in convection cells. Plate movement is related to the rate of mantle convection.
Density	Convection is driven by density of materials. As a substance becomes denser, it sinks. As it becomes less dense, it rises.
Internal heat/pressure	Internal heat and pressure affect the density of materials.
Liquid outer core	Generates a magnetic field that, with our atmosphere, helps protect us from solar wind and space radiation.

- Say: In the next activity, we'll explore how these characteristics and processes interact with the planetary temperature system and human body systems to support human survival.

Explore

(approximately 20 minutes)

Fumaroles (steam vents) on slope of Roaring Mountain give testimony to Yellowstone's volcanic past and serve as a reminder of existing subsurface heat; National Park Service, USDI

1. Have students draw concept maps and write explanations that show how the Earth's interior processes and characteristics interact with the atmospheric gases, planetary temperature system, and support human survival.

Note to Teacher: You might have students use a software tool to create their concept maps. A very easy to use, free concept map software that runs on both Windows and Mac OS X is called Cmap Tools and can be downloaded from: http://cmap.ihmc.us/.

- Go over the System Concept Map directions and rubric with students. Encourage students to look for ways to connect all parts to form one large concept map.

- Students could start their concept maps in several different ways:
  a. Students might branch off from "amount of carbon dioxide" and think about what factors determine the amount of carbon dioxide and the characteristics that drive these processes.
  b. Students might begin from "pressure" and add characteristics of Earth's interior affected by pressure, eventually connecting to processes that affect the planetary temperature system.
  c. Students may draw connections to "star type" and how characteristics of Earth's structure protect humans.
  d. Some students may deviate from traditional concept maps by showing cycles or flows that have sequences. As long as students are showing connections, this is fine.

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2. The following are some suggestions and questions that may help to guide the thinking of those students who are having trouble making connections.

- Draw and explain the parts of the system that play a role in the Earth's planetary temperature system.

- How is pressure important to Earth's interior processes?

- What are the parts of the system that protect us from solar wind? How do the parts connect to the overall system?

Explain

(approximately 20 minutes)

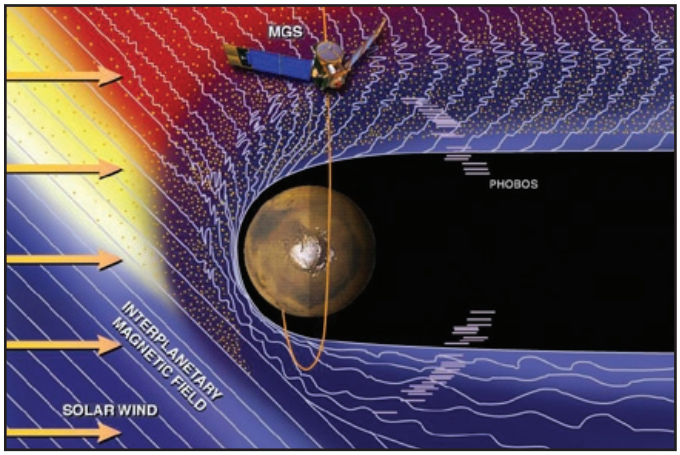


Illustration of supersonic "solar wind" in the vicinity of Mars with Mars Global Surveyor satellite approaching planet prior to over-flight of the pole; NASA

1. Have students explain their concept maps, the connections they've made, and why to a partner.

Note to Teacher: Every student will have a different way of thinking about concepts, and concept maps can be powerful for seeing how students are making connections. They may not all be identical and some may reveal faulty logic. This is an opportunity to probe into how students are thinking about and connecting ideas and help them to correct any misunderstandings. The Sample Concept Map on page 219 is only one possible concept map.

2. The following types of questions may help students to see connections they may not have made or made erroneously.

- Question: How do the Earth's structure and processes affect the amount of carbon dioxide in the atmosphere?
- *Answer: Earth has volcanoes, which release carbon dioxide into the atmosphere. Carbon is removed from the air and reacts with rocks. Streams and rivers move the dissolved carbon into the ocean where it forms shells and limestone. Eventually, the carbon in the limestone is released as gas from volcanoes once again. These processes regulate the amount of carbon dioxide in the atmosphere.*

- Question: How does this carbon cycling influence the surface temperature of a planet? How is this important for life?
- *Answer: The cycling of carbon in and out of the atmosphere ensures that there is neither too much carbon dioxide nor too little. Carbon dioxide is a greenhouse gas that absorbs heat that radiates from the surface of a planet and reradiates some of it back to the planet's surface, raising its surface temperature. A moderate temperature that allows water to be a liquid at all times is essential for human survival. Greenhouse gases play an important role in determining whether a planet's surface temperature will be within an acceptable range for human survival.*

- Question: What characteristics of Earth's interior allow carbon to be cycled in and out of the atmosphere?
- *Answer: The slow movement of the crust and upper mantle results in volcanoes at plate boundaries. As the Earth's plates move, the limestone formed in the oceans is recycled back into the Earth, where volcanoes release it as a gas. Plate motion is affected by the movement of the mantle. Mantle movement occurs as a result of convection, when Earth's internal heat decreases the density of mantle material, which rises, cools, and becomes denser causing the material to sink down again.*

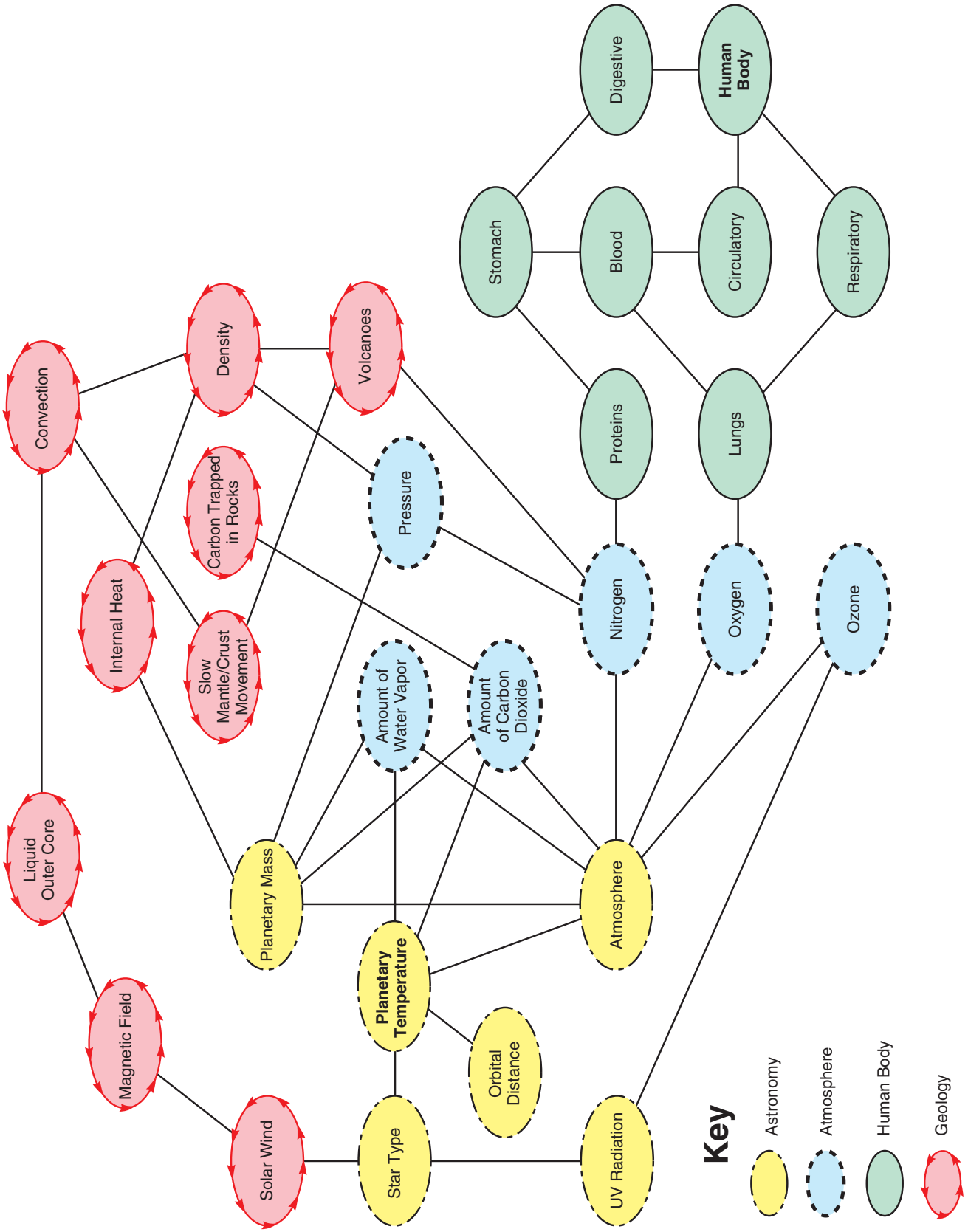
- Question: How are these geologic characteristics like subsystems?
- *Answer: The carbon cycle is a system that includes volcanoes, plate movement, and mantle convection. The characteristics that play a role in causing volcanoes make up another system, which is a subsystem.*

- Question: What affects the states of matter of the Earth's interior?
- *Answer: Earth's mantle is viscous, allowing it to slowly flow and move. This is partly because of the pressure that comes from the Earth's mass, which plays a role in making the inside of the Earth hot.*

- Question: What role does the Earth's core play in supporting human survival, and how did you connect it to your system?
- *Answer: The Earth's liquid outer core generates a magnetic field that, with our atmosphere, helps to protect us from harmful solar wind and cosmic rays. You could connect liquid outer core to solar wind that in turn, could connect to star type, since our star produces the solar wind.*

- Question: Looking at your system, do the Earth's structure and processes have a direct affect on human habitability? Does this make these factors less important?
- *Answer: The geological characteristics don't connect directly to the human body system. However, this does not make them less important than other factors. Without these processes and characteristics, Earth would be uninhabitable to humans. For example, if carbon dioxide was not regulated in Earth's atmosphere by the carbon cycle, we might have an increase or decrease in Earth's surface temperature, which could be harmful to human habitability.*

Sample Concept Map



Extend/Apply

(approximately 25 minutes)

Geologists installing seismic station near the dome of Mount St. Helens; USGS

1. Introduce the final project that will summarize student learning from this unit.

- Go over the Final Geology Project directions and rubric.

Note to Teacher: Some students may be interested in creating this guided tour on the computer using a slide show program such as "PowerPoint," "Hyperstudio," or "Kid Pix." This would be an excellent way for them to create images of the interior of the Earth and engage the class in a virtual tour of the Earth as a slide show or video.

- Draw students' attention to the Earth's geologic structure and processes that were the focus of this unit and their importance to human survival.

- You may want to brainstorm some of the advertising language and techniques that might be used to make the guided tour persuasive and inviting to tourists. These might stress the unique nature of a trip through the inside of the Earth or cost-saving hooks such as "two for the price of one."

- Allow students time to work on their final projects.

Note to Teacher: You may want to allow students to finish their guided tours as homework. Otherwise, you may need to allow more class time for completion.

Evaluate

(approximately 45 minutes)

Earth as seen from orbit; NASA

1. Allow students to complete their guided tours.

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2. Have students share their guided tours with a partner or group.

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3. You may want to choose one or two guides from the class and take the class on an imaginary tour of the Earth's interior.

Note to Teacher: As you go through this tour and discussion, you may want to refer to the Earth's Structure Transparency included at the end of the lesson.

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4. Discuss students' guides to ensure they have mastered the major concepts.

- Question: As tourists are travelling toward the center of the Earth, what kinds of changes would they notice?
- *Answer: They would notice that pressure would increase, that the composition of the Earth would become denser, and that the core is hotter than the upper layers.*

- Question: If the tourists asked what causes these changes, what would you tell them?
- *Answer: The pressure grows due to the weight of the overlying layers, which also causes internal heat to be generated. Denser materials sink below less dense material, causing layering.*

- Question: What would tourists notice about the states of matter inside the Earth?
- *Answer: They'd notice that the crust and upper mantle (lithosphere) is solid and brittle, that the lower part of the upper mantle (asthenosphere) was partially molten and the lower mantle is solid, but viscous, which allows it to flow rather than break. They'd also notice that the outer core is liquid and the inner core is solid.*

- Question: What would they notice about the relative size of the layers?
- *Answer: They'd notice that the lithosphere is very thin compared to the mantle and core.*

- Question: What processes would tourists observe and how are they important to human survival?
- *Answer: Tourists would see the process of how the movement of the liquid outer core around the inner core creates a magnetic field that helps protect humans from solar wind and space radiation. They would further see how plates move on the mantle, colliding and moving away from each other and that volcanoes occur at these plate boundaries. Finally, they would see how carbon is cycled in and out of the atmosphere by being trapped in limestone, subducted under a lithospheric plate, and then released through volcanoes. The carbon cycle regulates the amount of carbon dioxide in the atmosphere, which maintains a moderate surface temperature necessary for human survival.*

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5. Collect students' Final Geology Projects and System Concept Maps, and evaluate them to ensure that they have each mastered the major concepts:

- The structure, composition, and mass of the Earth determines its structure and processes, all of which affect Earth's atmosphere and ability to support human survival.
- Like all systems, the Earth's structure is made up of parts that influence each other and can be part of other systems.
- The structure and composition of Earth's layers can affect the survival of humans.
- The amount of carbon dioxide in the atmosphere is an important factor in maintaining a moderate surface temperature.
- The amount of carbon dioxide in the atmosphere is determined by the carbon cycle, in which carbon is trapped in rocks and shells and then broken down and released through volcanoes.
- The slow movement of the crust and upper mantle results in volcanoes at plate boundaries. Movement in the mantle occurs as a result of convection. As mantle material increases in temperature, it becomes less dense and rises. When the temperature of the mantle material decreases, the density of the material increases and it sinks down.
- The lower part of Earth's upper mantle is partially molten. Earth's lithospheric plates float upon this layer.
- Earth's lower mantle is solid, but capable of flow due to the extreme pressures inside the Earth. The extreme pressure comes from the Earth's mass, which plays a role in making the inside of the Earth hot.
- The Earth's liquid outer core generates a magnetic field that, with the atmosphere, helps protect us from cosmic rays produced by exploding stars and harmful solar wind produced by our star, the Sun.

6. Bridge to next unit.

- Question: We've learned about the importance of the Earth's structure and processes for human habitability and we've learned about the importance of atmospheric gases and astronomical characteristics of our solar system for human habitability. If a planet has these astronomical, atmospheric, and geological characteristics, is it habitable to humans?
- *Answer: Not necessarily. There are still biological characteristics that the planet must also have.*

- Say: In the next unit we will learn about the biological characteristics that are necessary for human survival.

Note to Teacher: After each lesson, consider posting the main concept of the lesson some place in your classroom. As you move through the unit, you and the students can refer to the "conceptual flow" and reflect on the progression of the learning. This may be logistically difficult, but it is a powerful tool for building understanding.

System Concept Map Activity

Draw a concept map that shows how the geologic structure and processes connect to the planetary temperature system and human body system to support human survival. Use different colors for the planetary temperature system, the human body system, the atmospheric gases, and geological characteristics/processes.

Include the following:

- All geologic processes and characteristics explored in this unit
- The planetary temperature system and its three primary components
- The human body system and important subsystems
- The five atmospheric gases previously explored in the Atmosphere module: carbon dioxide, water vapor, oxygen, ozone, nitrogen
- An explanation of the connections you draw between the systems and the gases and why these connections are important to human survival

Your concept map will be evaluated using the following rubric:

4 Expectations Exceeded	• The concept map clearly and accurately shows connections between all geological characteristics/processes, the planetary temperature system, and the atmospheric gases, forming one large concept map. The description clearly and accurately describes all connections and their relevance to human survival. • The concept map has all required parts, and the design elements (circles, color, and lines) are exceptionally clear and easy to understand.
3 Expectations Met	• The concept map clearly and accurately shows connections between all geological characteristics/processes, the planetary temperature system and the atmospheric gases, but may be in two separate concept maps. The description clearly and accurately describes the connections and their relevance to human survival. • The concept map has all required parts, and the design elements (circles, color, and lines) are clear and easy to understand.
2 Expectations Not Quite Met	• The concept map is not completely clear or accurate in showing connections between some of the geological characteristics/processes, the planetary temperature system, and the atmospheric gases. The description is not completely clear or accurate in describing the connections and their relevance to human survival. • The concept map has most required parts, and the design elements (circles, color, and lines) are a little difficult to read.
1 Expectations Not Met	• The concept map is not clear or accurate in showing connections between geological characteristics/processes, the planetary temperature system, and the atmospheric gases. The description is not clear or accurate in describing the connections and their relevance to human survival. • The concept map is missing several parts, and the design elements (circles, color, and lines) are difficult to read.

Final Geology Project

Create a guided tour of the interior of the Earth that includes stops at:

- Crust
- Where two plates are colliding
- Where two plates are moving away from each other
- At a volcano
- At a formation of limestone
- Mantle
- Outer Core
- Inner Core

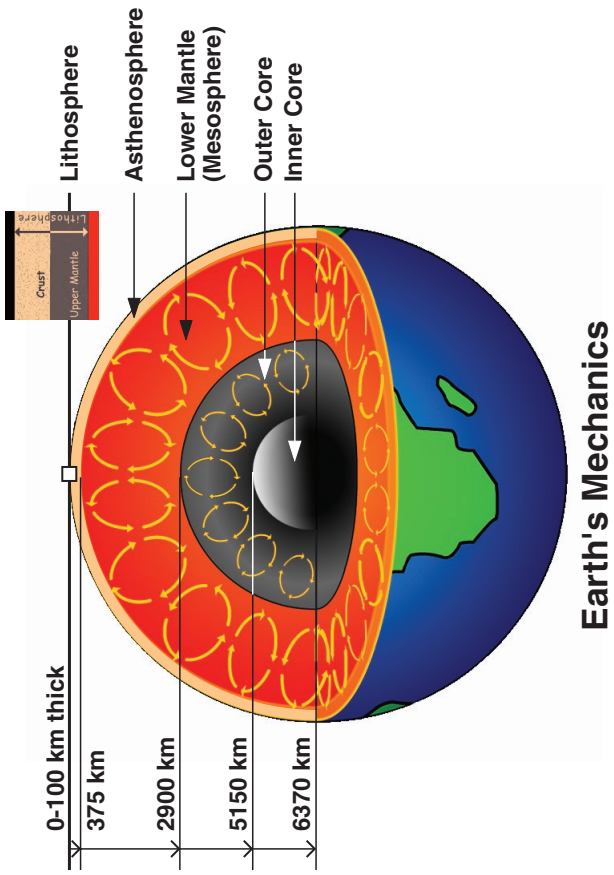
Include the following:

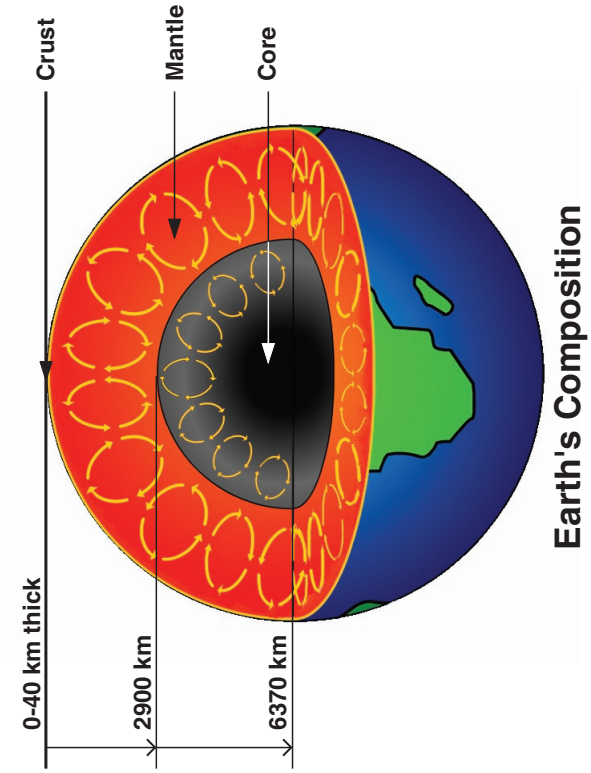
- Drawings and a description of the characteristics of each part of the Earth. Include composition, thickness, density, viscosity, pressure, and temperature in your descriptions. Include an explanation of the asthenosphere and lithosphere.
- Drawings and descriptions of the geological processes occurring inside and on the surface of the Earth. Include a description of movement in the mantle, plate tectonics, the generation of a magnetic field, and the carbon cycle.
- Explanations of how these characteristics and processes play a role in making Earth habitable to humans
- Use persuasive writing in your guide, as you are trying to sell people on the excitement of taking this tour through the Earth.

Your guided tour will be evaluated using the following rubric:

4 Expectations Exceeded	• The guided tour clearly and accurately describes the structure and processes of the Earth and accurately describes the importance of these processes to human habitation. • The guided tour has all required parts, is creative, persuasive, and has accurate and clear illustrations that make the story exceptionally easy to understand.
3 Expectations Met	• The guided tour clearly and accurately describes the structure and processes of the Earth and accurately describes the importance of these processes to human habitation. • The guided tour has all required parts, and has accurate and clear illustrations that make the story easy to understand.
2 Expectations Not Quite Met	• The guided tour is not completely clear or accurate in describing the structure and processes of the Earth or in accurately describing the importance of these processes to human habitation. • The guided tour has most required parts. Illustrations are a little difficult to read.
1 Expectations Not Met	• The guided tour is not clear or accurate in describing the structure and processes of the Earth and in accurately describing the importance of these processes to human habitation. • The guided tour is missing several parts. Illustrations are difficult to read.

Earth Structure Transparency





Astro-Venture Glossary

aerodynamics The way that air moves around objects.

aerospace Having to do with the Earth's atmosphere and space beyond Earth.

algebra A type of math that uses letters as symbols to represent numbers.

analysis The examination of something in detail by studying its parts.

aquatic Living or growing in water.

associate's degree A degree usually earned from a community college, junior college or vocational school after completion of two years of full-time study. This degree generally is equal to the first two years of study toward a bachelor's degree.

asteroid A rocky, metallic object that orbits a star.

asthenosphere Part of the upper mantle below the lithosphere that is partially molten

Astro Journal In Astro-Venture, your Astro Journal is where you record your observations and the scientific process.

astro A prefix, which means star or space.

astrobiologist A person who studies life on Earth and the possibilities for life in the universe.

astrobiology The study of life in the universe.

astronomer A person who studies the universe beyond Earth.

astronomical unit (AU) The average distance from Earth to the Sun, which is equal to 149,598,770 km or 93,000,000 miles.

astronomy The study of space beyond Earth.

astrophysics The science of the stars, objects related to stars and the forces that determine how they interact.

astrophysicist A person who studies the science of the stars, objects related to stars and the forces that determine how they interact.

atmosphere The air. The blanket of gases that surrounds some planets and moons.

atmospheric chemist A person who studies what the atmosphere is made of and studies chemical reactions that change what it is made of.

Astro-Venture Glossary (Cont.)

atom The tiniest particle of an element that has the same chemical properties of the element. The building blocks of all matter.

average Medium-sized. In the middle.

aurora Light radiated by particles in Earth's upper atmosphere.

B.A. (bachelor of arts) A university or college degree earned after completion of at least four years of study.

B.S. (bachelor of science) A university or college degree earned after completion of at least four years of study.

bachelor's degree A university or college degree earned after completion of at least four years of full-time study following high school. B.S. stands for a Bachelor of Science. B.A. stands for a Bachelor of Arts.

bacterium (pl. bacteria) A form of life that is usually one cell and can be seen only with a microscope. There are many different kinds of bacteria and they are the oldest type of life on Earth.

bio A prefix that means life. In Astro-Venture, bio is short for biography, which tells you more about a person's life or background.

biochemistry The study of matter that makes up living things, what the matter is made of, how it's structured and its features.

biological Related to life or living processes.

biology The study of life.

biotechnology The use of living things to create new products such as medicines or new techniques such as waste recycling.

black hole An area of space around an object where gravity is so strong that even light cannot escape from the area.

blue star A hot, bright, massive star that has a surface temperature between 20,000º-60,000º Kelvin.

boiling point The temperature at which a liquid becomes a gas.

bond (chemical) The force between atoms in a molecule.

botany The study of plants.

calculus A type of math that uses special kinds of symbols.

capacity The largest amount that something can hold.

carbon dioxide A colorless gas that can absorb heat in the atmosphere. Plants use carbon dioxide to make their food and animals exhale it when they breathe.

career The order of events that occur in a person's work, over time.

carnivore An animal that only eats meat.

cause Something that produces an effect or result. To produce an effect or result.

cell A microscopic unit that makes up all living things. All living things are made of cells or exist as a single cell.

Celsius A scale that measures temperature where water boils at 100°C and freezes at 0°C. Between the boiling and freezing points, the scale is divided into 100 parts. People in most countries use Celsius. It is named after Anders Celsius.

center of mass The balancing point between two masses.

ceramic Hard, breakable, heat-resistant material made by heating clay at a very high temperature.

chemical Having to do with the study of matter, what it's made of, how it's structured and its features.

chemical change (chemical reaction) When molecules interact to form new molecules.

chemist A person who studies chemistry.

chemistry The study of matter, what it's made of, how it's structured and its features.

chlorofluorocarbons (CFCs) Human-made substances made up of chlorine, fluorine and carbon atoms bound together, which break up and react with oxygen atoms in the upper atmosphere, causing ozone depletion.

college A school where bachelor's degrees can be earned following high school.

combustion A rapid chemical change that occurs when heat is produced faster than it can dissipate. The process of burning.

comet A ball of ice and rock that orbits a star.

community college A school that offers a two-year degree or certificate that is generally equal to the first two years of a four-year college.

compass A device used for finding direction. Using the Earth's magnetic field, the magnetic needle on a compass points north.

composition The parts that form or make up a whole.

Astro-Venture Glossary (Cont.)

computer electronics The study of computer devices and systems and how they work.

Conservation of Matter During chemical change, the number of atoms does not change. Matter is neither created, nor destroyed.

consume To eat.

consumer Any living that eats producers (such as plants) or eats other consumers. Some bacteria are consumers.

convection The rise and fall of material due to differences in temperature.

convection cell A circular current formed when heated material rises and cooler material sinks.

convert To change from one form to another.

core The center of a planet.

cosmic rays High-energy particles released when certain stars explode. Cosmic rays can be harmful to some life forms if they reach the Earth's surface.

crust The outermost layer of a planet with a solid surface.

current A flow of electric charge.

database A collection of data that is organized in a way so that it is quick and easy to find.

decomposer A fungus or bacteria that breaks down the waste and dead bodies of animals and plants, while returning important nutrients into the environment.

deflect To repel or divert something into a different direction.

demo A demonstration. In Astro-Venture, a demo demonstrates how to use the module.

dense Tightly packed matter within a certain space..

density The amount of matter in a certain unit of volume or space.

DNA (deoxyribonucleic acid) A long, complex molecule that contains the codes that control your cells' activities, the chemicals that make up your body and heredity.

doctorate The highest degree awarded by a university earned after completion of at least five years of study beyond a bachelor's degree. A Ph.D. is a doctorate of philosophy.

Doppler shift The change in wavelength as a source of light or sound moves toward or away from you or as you move toward or away from a source of light or sound.

Astro-Venture Glossary (Cont.)

ecosystem A complex system of all the living things in an area and how they interact with each other and their environment.

electrical engineering The scientific technology of electricity for use in designing and developing equipment that produces power and controls machines.

electronics The study of devices and systems that are powered by using electricity.

element A substance that cannot be broken down into other substances. Oxygen, gold and hydrogen are 3 of the 115 elements.

elliptical orbit An orbit that is more oval than circular.

energy What living things use to live, grow, and do work.

engineer A person who designs, constructs or builds. To design, construct or build.

engineering The use of math and science to design and build structures, equipment and systems.

Escherichera coli (E. coli) Bacteria that reside in the large intestines of humans and break down the food we eat.

evaporate To change from a liquid to a gas.

Europa One of Jupiter's 16 moons. Studies of Europa show that it is composed of liquid-water ocean covered by an ice crust. Because it has this liquid ocean, scientists hope to find life there.

extreme environments Places that have very hot or very cold temperatures, are very salty, or have a high acid concentration. Extreme environments are places such as a volcanoes, deep-sea mid-ocean volcanic vents, or cold arctic areas.

Fahrenheit A scale that measures temperature where water boils at 212°F and freezes at 32°F. In the United States, we use both Fahrenheit and Celsius, but most Americans are most familiar with Fahrenheit. It was developed by Gabriel Daniel Fahrenheit.

fieldwork Observations and work done in an actual work environment to gain real-life experience and knowledge.

flammable Easily set on fire.

fluid dynamics The study of liquids and how they move.

fluid mechanics The study of the effect of forces on liquids.

freezing point The temperature at which a liquid becomes a solid.

Astro-Venture Glossary (Cont.)

fungus (pl. fungi) A group of living things that absorb food from their environment and aid in the decomposition of dead things. Examples of fungi are mushrooms, yeast, and molds.

galaxy A large group of stars that are held together by gravity.

gas A state of matter that has no definite shape or volume. In a gas, the molecules are so loose, they can spread apart or can squeeze together, depending on the container they are in.

genetics The study of genes and how they transmit features from parents to their children.

geologist A person who studies Earth's origin, history and structure.

geology The study of Earth's origin, history and structure.

geometry A type of math that involves the measurement and features of shapes, points, lines, angles, surfaces and solids.

global effect The effect on the whole Earth that occurs as a result of some change.

graphics Information that is represented with images or pictures.

gravity A force of attraction that exists between objects. The greater the mass and diameter of an object, the greater its gravitational pull.

greenhouse effect Some gases, such as carbon dioxide and water vapor, absorb heat energy and hold it in the atmosphere raising the surface temperature of a planet.

habitable Fit to live in.

Habitable Zone (HZ) The range of distances from a star where liquid water can exist on a planet's surface.

hardware Computers and the equipment used with computers such as monitors, printers and disk drives.

herbivore An animal that only eats plants.

HR Diagram A diagram created by two scientists, Ejnar Hertzsprung and Henry Norris Russell, to show how the brightness and temperature of stars are related.

human factors engineering The use of psychology and other areas of science to develop systems that people use in a way that makes the system easy, safe and useful.

hypothermia An abnormally low body temperature.

Ice Age A long, cold period when a large part of a planet is covered with glaciers.

inert An element or substance that does not easily react or interact with other elements or substances.

junior college A school that offers a two-year degree or certificate that is generally equal to the first two years of a four-year college.

Kelvin A scale that many scientists use to measure temperature. Units of Kelvin are the same as Celsius degrees, but the scale is adjusted so that zero represents absolute zero, which is the temperature at which all particles (electrons, atoms, molecules, etc.) have minimal motion. Water boils at 373 Kelvins and freezes at 273 Kelvins. The Sun is about 5,000 to 6,000 Kelvins. This scale is named after the nineteenth-century British scientist Lord Kelvin.

laboratory A building used for scientific research.

Lactobacillus acidphilus (L. acidophilus) A type of bacterium that turns milk into yogurt.

limestone A type of rock usually formed in the oceans, made of carbon and calcium. Limestone is important in the carbon-rock cycle.

liquid A state of matter that has a definite volume but no definite shape. In a liquid, the bonds of molecules are looser than in solids so that the molecules can slide past each other.

lithosphere. The rigid layer formed by the crust and uppermost part of the mantle that moves together as plates on top of the Earth's surface. The lithosphere rides on top of the asthenosphere.

luminosity The amount of power or "wattage" put out by a star. How bright a star appears to us depends on its luminosity and its distance.

M.A. (master of arts) A university degree earned after completion of at least one year of study beyond a bachelor's degree.

magma Molten rock found in the upper part of the mantle and crust.

magnetic field Area surrounding magnets that deflects charged particles or other magnets.

main-sequence stars Stars ranging from hot blue to cool red dwarfs. The most common type of star. They are not giants, supergiants, white dwarfs or red dwarfs.

mantle The part of a planet between the crust and the core.

mass The amount of matter in an object.

master's degree A university degree earned after completion of one to two years of study beyond a bachelor's degree. M.S. stands for a Master of Science degree. M.A. is a Master of Arts degree.

matter Anything that has mass and volume. Anything that takes up space.

Astro-Venture Glossary (Cont.)

mechanical engineering The use of math and science to design and build structures, equipment and systems that produce heat or power.

melting point The temperature at which a substance changes from a solid to a liquid.

mesosphere The part of the Earth's mantle that is below the asthenosphere and above the outer core.

metal A group of elements that is shiny, bendable and conducts heat and electricity.

meteoroid Small rocky object that orbits a star.

meteorology The study of the conditions in the atmosphere, especially weather.

microbe A living thing that is so small, it can be seen only with a microscope. Bacteria, viruses, and algae are examples of microbes.

microbiology The study of microbes.

microscope An instrument that uses lenses to make small objects appear large.

migrate To move from one place to another, usually for breeding or feeding.

molecule A group of atoms bonded together. Molecules act like a single particle.

molten Made liquid by heat. Melted.

moon A natural object that orbits a larger object, usually a planet.

M.S. (master of science) A university degree earned after completion of at least one year of study beyond a bachelor's degree.

mutation A change in the DNA of a living thing.

navigate To control the path or route of a ship, aircraft or spacecraft.

nebula A huge cloud of gas and dust in space from which stars are born.

nervous system A system in animals that controls the body functions and senses. In humans it includes the brain, spinal cord and nerves.

network A number of computers connected together so that information can be sent between them.

neutron star The remains of a supernova that become an extremely dense, tightly packed star.

nitrogen A colorless, tasteless, odorless gas that makes up 78 percent of the atmosphere and is a necessary part of all living tissues.

Nitrogen Cycle The continuous movement of nitrogen from the atmosphere through bacteria, into the soil, to plants, to animals and its return to the air.

nutrient Any of a number of substances (such as nitrogen, carbon, and phosphorus) that all living things need to survive.

observation The act of watching carefully.

observatory A building designed for making observations of stars or other objects in space.

occupation The activity that a person does as their regular work. A job.

omnivore Any animal that eats both plants and animals.

orbit The path of an object around another object, caused by gravity. To move around another object.

organism A living thing.

oxidation A chemical change in which a substance combines with oxygen.

oxygen A colorless, odorless gas that is released by plants into the air, is essential to animals for breathing, and is highly flammable when it reacts with other substances.

ozone A gas made of three oxygen atoms bonded together. When ozone is located high in the atmosphere, it protects life from harmful ultraviolet radiation but can be harmful to life at Earth's surface.

ozone depletion When ozone loss is greater than ozone creation.

ozone layer The layer of gas in the stratosphere that protects the Earth from harmful ultraviolet rays.

paleontology The study of fossils.

particle A basic unit of matter or energy.

period of revolution (period) The amount of time it takes the planet to orbit its star. Earth's period is 365 $^{1}/_{4}$ days or one year.

Ph.D. (doctorate of philosophy) The highest degree awarded by a university, earned after completion of at least nine years of college study following high school. This includes four years to earn a bachelor's degree and five to seven years to earn a Ph.D.

Astro-Venture Glossary (Cont.)

photometer An instrument that measures the intensity of light.

photometry The measurement of the intensity of light.

photosynthesis The process by which plants, algae and some bacteria convert sunlight, water, and carbon dioxide to oxygen and sugar.

physical science Any of the sciences, such as chemistry, physics, astronomy and geology that investigate the features of energy and nonliving matter.

physics The study of matter and energy and how they work together.

physiology An area of biology that studies the major functions of plants and animals such as growth, reproduction, photosynthesis, respiration and movement.

phytoplankton Producers that live in oceans and convert sunlight, carbon dioxide, and water into sugars and oxygen. Phytoplankton include things like algae and some bacteria.

planet A body that orbits a star and does not give off its own light. A planet is generally much smaller than a star and can be made of solid, liquid, and/or gas.

planetarium A device that projects images of stars, planets and other objects in space and their movement onto the surface of a round dome.

planetary sciences The study of a planet or planets, what they are made of, how they are structured and their orbits.

plate A large, rigid segment of Earth's lithosphere that moves in relation to other plates over the mantle.

pole Areas of a magnetic field where magnetism is concentrated. Earth's magnetic field has a north pole and a south pole.

pollinate To place pollen on a flower so it can make a seed.

pre-calculus A math class taken to introduce calculus.

precipitate To cause water vapor to become liquid and fall as rain or snow.

predict To tell what you think will happen in the future.

pressure The amount of force pushing on an object caused by the molecules surrounding it.

prism A three-dimensional glass or crystal object with flat sides and edges that can break up light into separate colors, creating a spectrum.

Astro-Venture Glossary (Cont.)

probe A device sent into space to explore and research objects.

producer Living things that can make their own food from sunlight, carbon dioxide, and water.

property A quality that defines a substance.

propulsion dynamics The study of the forces that move, drive or propel an object forward.

protein Building blocks of life that make up skin, fingernails and other plant and animal tissues. Proteins also help animals to digest food and perform many other important functions for life.

protostar A young star that glows as gravity makes it collapse.

psychology The study of how the brain processes information and how humans behave.

radiation The transfer of energy by waves. Humans and other life forms can become very ill or even die from exposure to too much of certain types of radiation.

reactive An element or substance that tends to easily interact with other elements or substances.

reactivity The tendency to easily interact with other elements or substances.

red giant A very large, bright, but cool star that normally has a temperature between 3,000 to 6,000 Kelvins. After millions or even billions of years, when a main-sequence star has burned up the fuel in its core, it expands into a red giant.

red star (red dwarf) A very cool, dim, small star that burns very slowly and has a surface temperature less than 3,500 Kelvins.

regulate To keep under control or maintain a natural balance.

reproduction The act of producing children or offspring.

resistance The ability to withstand or oppose a force.

respiration The act or process of breathing.

restart To start over.

role-play To take on the role of another person. To pretend to be that person.

rotate To spin on an axis.

scavenger Any animal that eats dead animals.

Astro-Venture Glossary (Cont.)

sensor A device that detects and responds to a signal.

seismic waves Vibrations caused by earthquakes.

seismometer A scientific instrument designed to measure the vibrations caused by earthquakes as they travel through a planet.

software Computer programs that control how a computer functions.

solar flare A burst of gases from a small area of the sun's surface that puts out intense radiation.

solar wind Particles that move away from the sun at high speeds. The solar wind is deflected by Earth's magnetic field.

solar system Our Sun and the objects that travel around it.

solid A state of matter that has a definite shape and volume. In a solid, molecules are bonded together very tightly so that the solid keeps it shape or it is broken.

space science Any of several sciences, such as astrobiology, that study occurrences and objects in space other than Earth.

specialist A person who is an expert on a particular topic.

spectrometer An instrument that measures spectra.

spectroscopy The measurement and analysis of spectra.

spectrum (pl. spectra) A rainbow or band of different colors made when light is broken up into wavelengths.

sputtering The process by which particles are changed or sent into space if hit by solar wind and cosmic rays.

star A large, hot ball of gases, which gives off its own light.

star system A star and the objects that orbit around it.

star type The category that a star fits into based on the features it shares with other stars in that category.

statistics A type of math that involves collecting, organizing and interpreting numbers.

stratosphere A layer of the Earth's atmosphere that is above the troposphere, between about 11 and 50 km above the Earth's surface.

structure The way something is built or made.

Astro-Venture Glossary (Cont.)

subduction The process where a lithospheric plate dives beneath another lithospheric plate.

submit T o send, give or turn in. In Astro-Venture, you click "Submit" to send your Astro Journal answers to scientists for review.

supergiant Stars that are greater than ten times the mass of the Sun, expand into extremely large, bright stars called supergiants.

supernova A star that explodes. Often a supernova is a supergiant that has become unstable.

surface effect The effect on a small section of Earth as seen from the surface that occurs as a result of some change.

systems engineering The use of math and science to design and build groups of connected parts that work together as a whole.

technical institute A school that trains people in specific skills for certain occupations that use technology.

Tech Notes In Astro-Venture, the Tech Notes give you background information and a glossary about the topics you select.

telescope An instrument that collects light and makes distant objects appear larger and closer.

temperature The measurement of how hot or cold something is.

theory A general statement that explains the results obtained from scientific investigations.

thermal Having to do with heat.

thermodynamics T he study of how heat moves.

trigonometry A type of math that studies and compares angles in a right triangle.

trivia Factual information that is not important but may be interesting to know.

troposphere A layer of the Earth's atmosphere that begins at Earth's surface and extends to 11 km above the Earth's surface.

ultraviolet radiation (UV) Invisible radiation between visible violet light and X rays. Ultraviolet radiation causes sunburn and can harm life.

uninhabitable Not fit to live in.

universe All existing things, including Earth, the solar system and the galaxies.

Astro-Venture Glossary (Cont.)

university A school where bachelor's degrees, master's degrees and doctoral degrees can be earned following high school.

virus A particle so small it can be seen only with a microscope and can reproduce inside a living cell.

viscosity Measurement of how much a substance resists flow.

vocational school A school that trains people in specific skills for certain occupations.

volume The amount of space an object takes up.

water vapor The form water takes when it is a gas in the atmosphere.

wavelength The distance from one peak to the next on a wave.

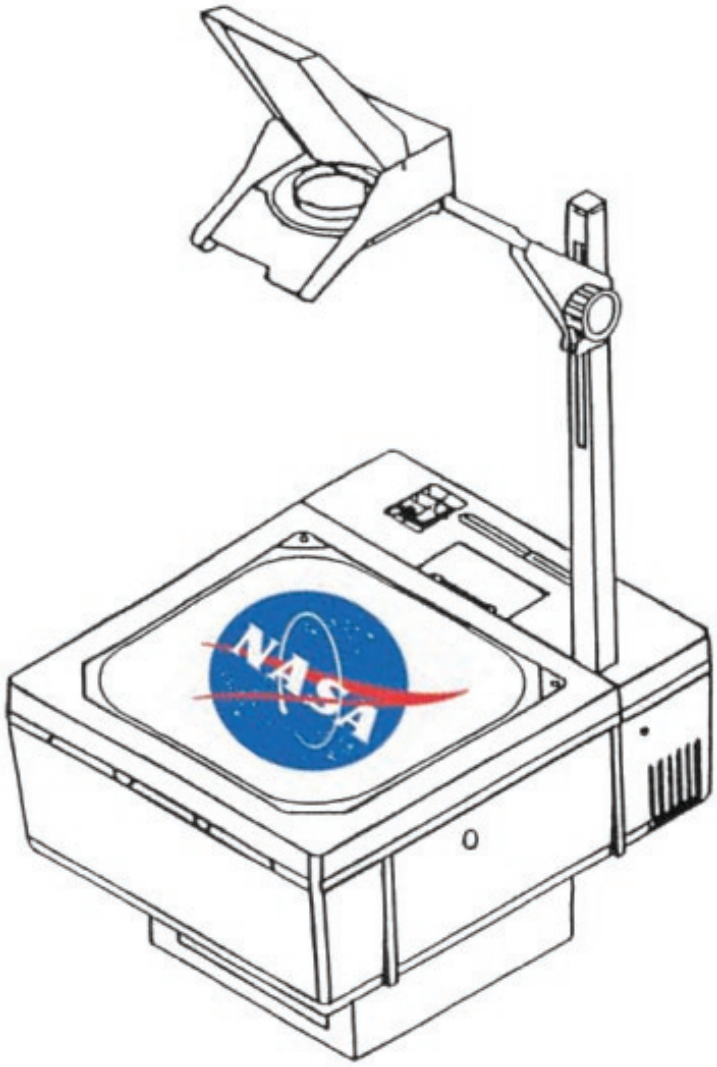
weathering The process of breaking down rocks on Earth's surface.

white dwarf The end of a low mass star's life, when the star's core shrinks and its surface becomes white hot. These stars are very hot but dim.

yellow star A medium-sized star that has a surface temperature between 5,000 to 6,000 Kelvins.

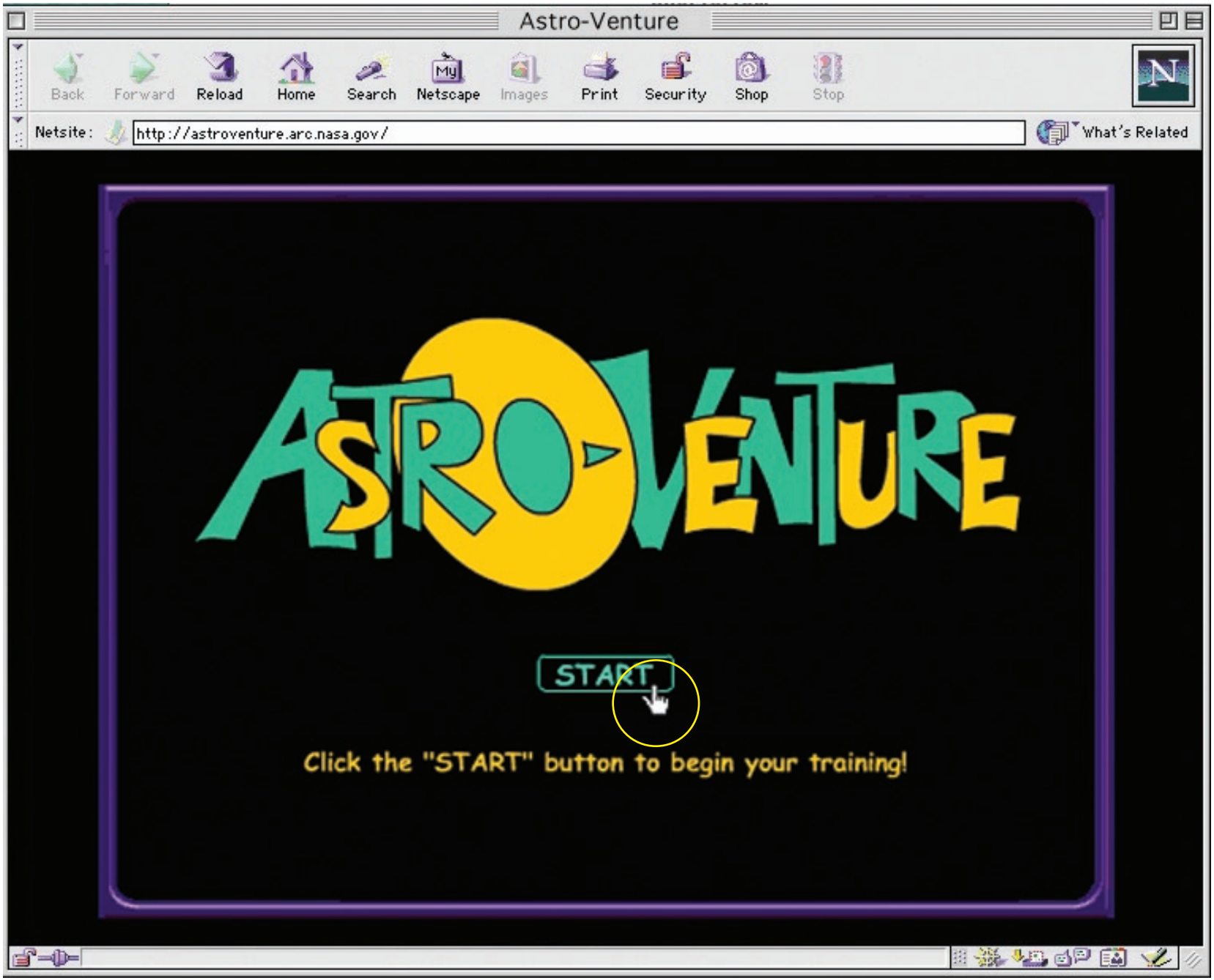
zoology The study of animals.

National Aeronautics and
Space Administration

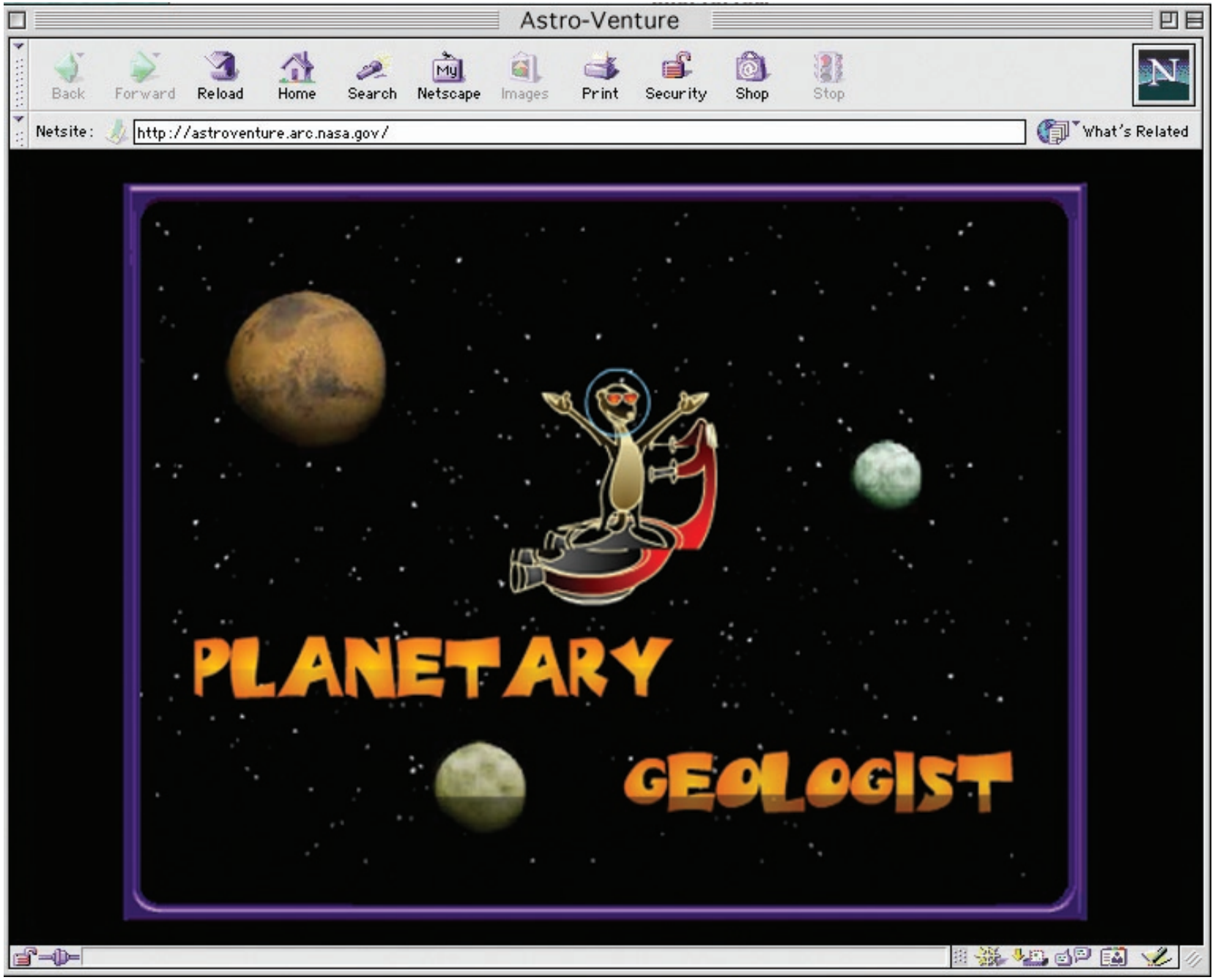


Astro-Venture
Geometry
Educator Guide

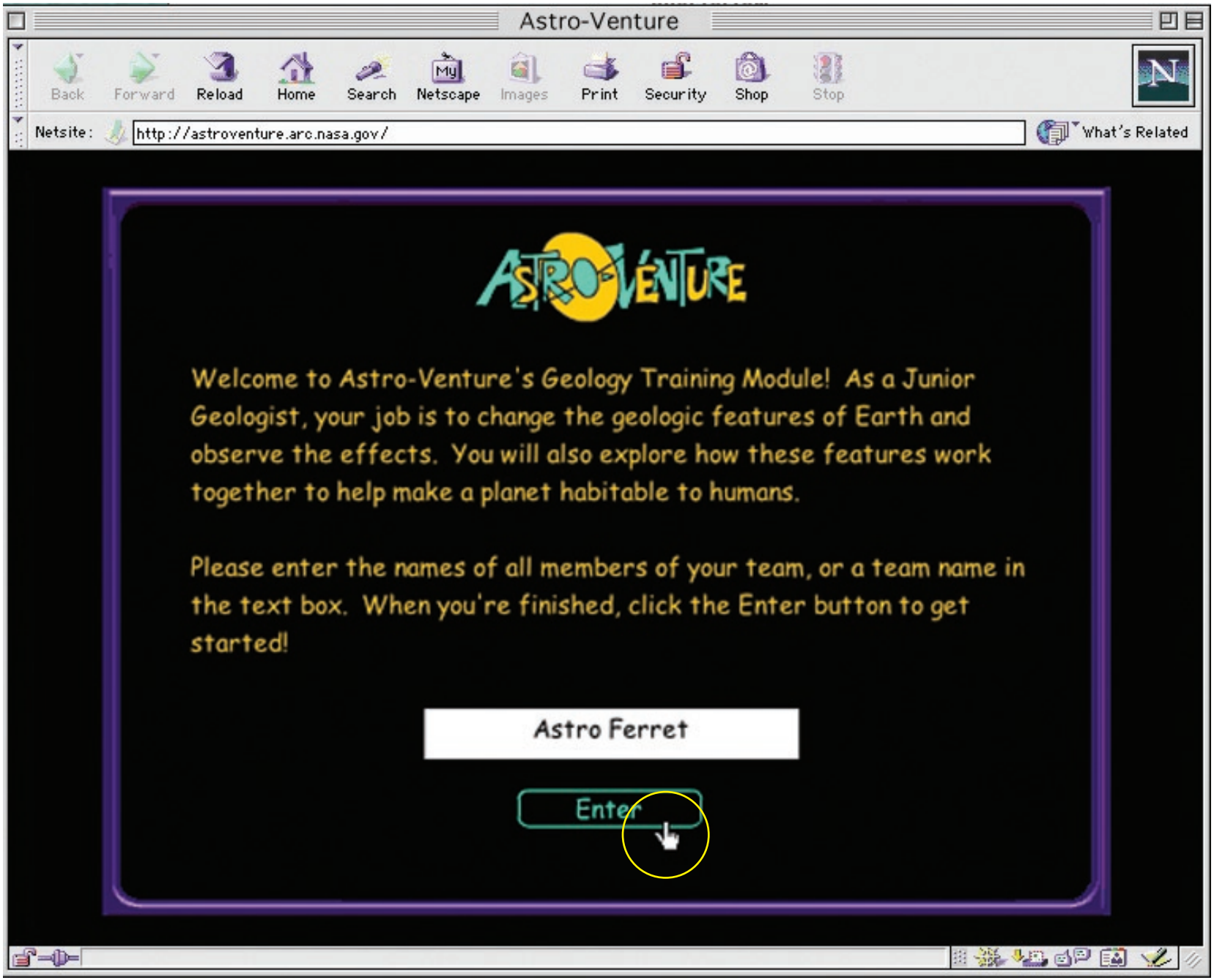
Screen Shots



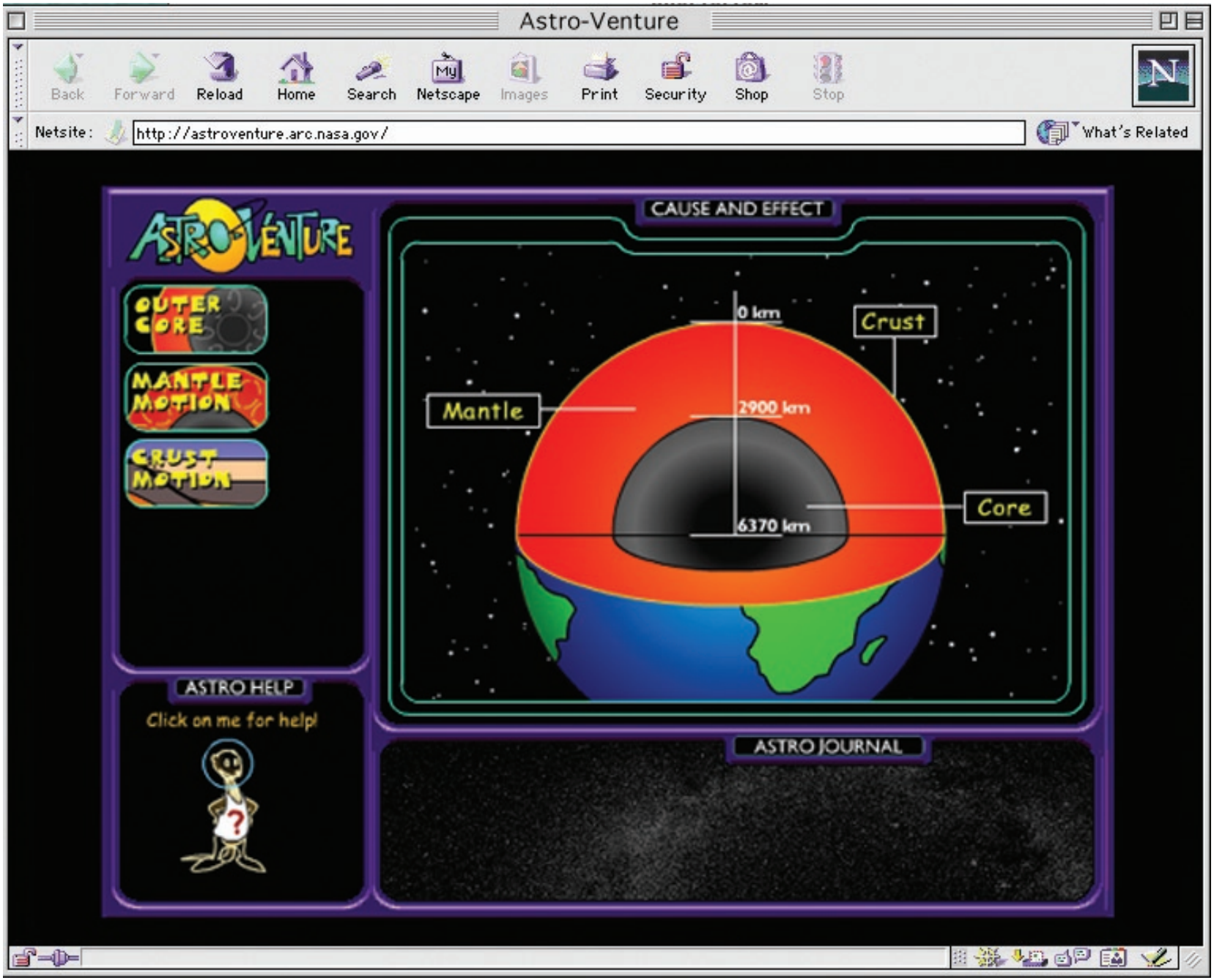
1. Press start to begin Training Module.



2. Astro Ferret introduction featuring NASA careers



3. Enter your name or your team's name.



4. Astro Ferret introduces the Geology module.

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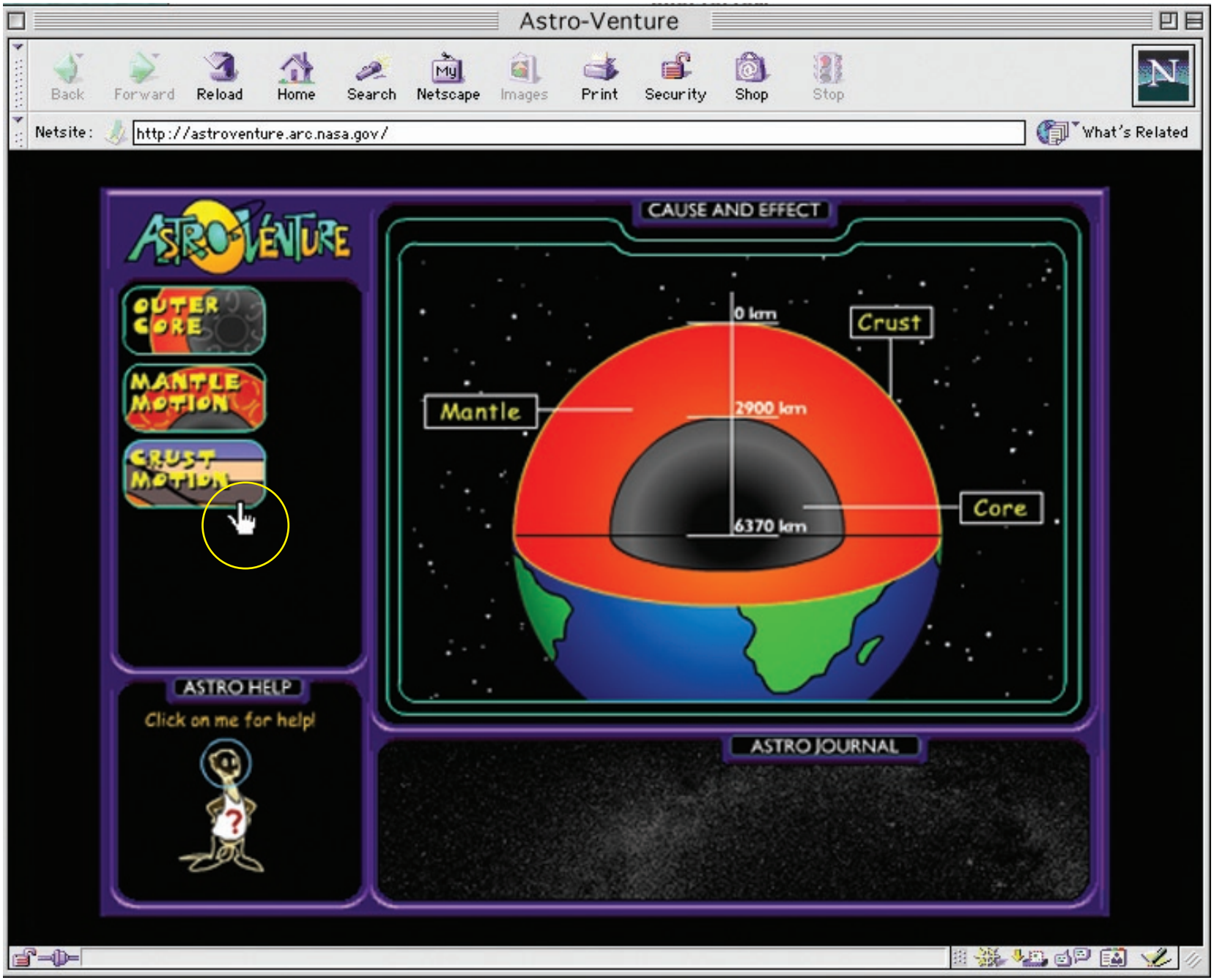
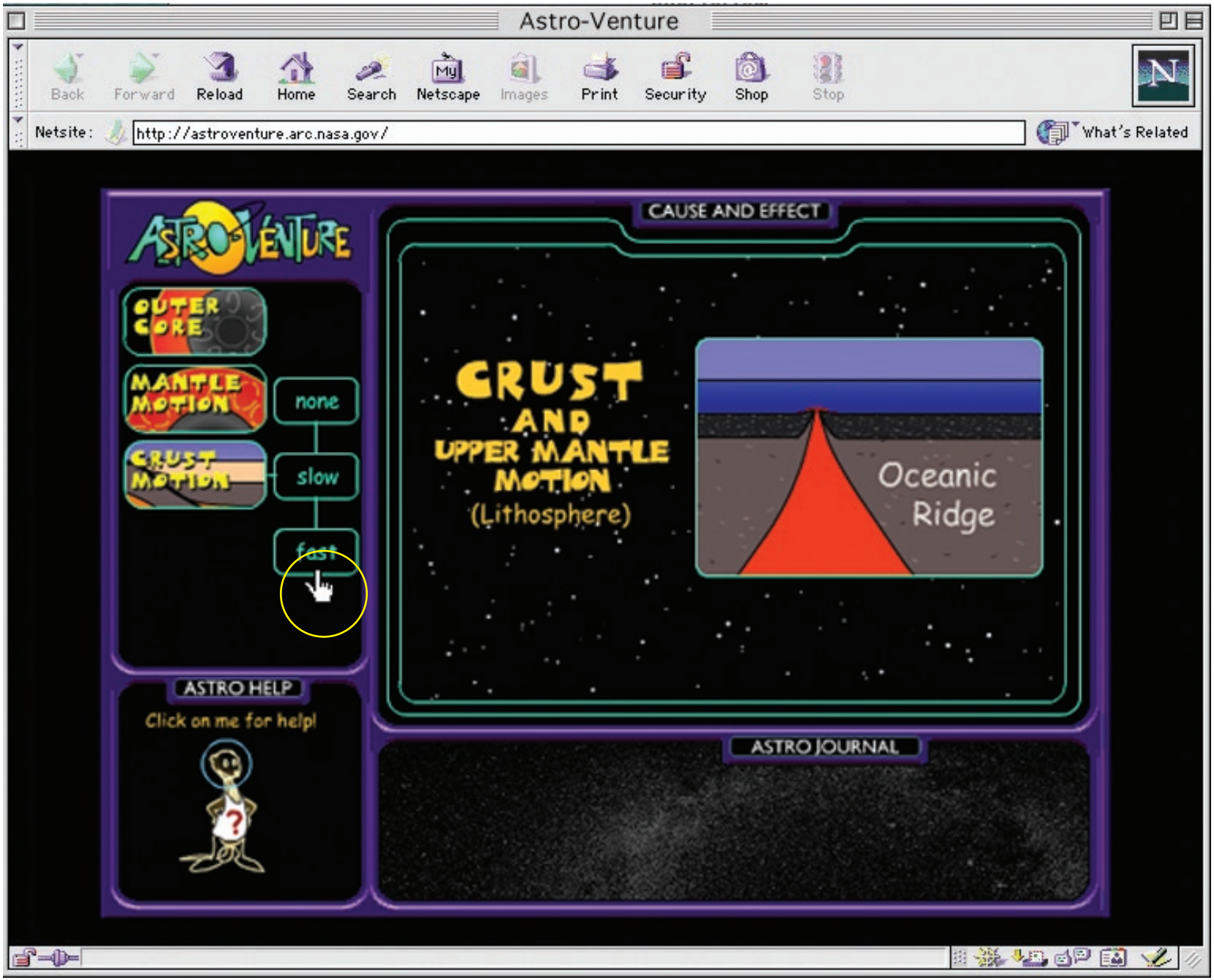
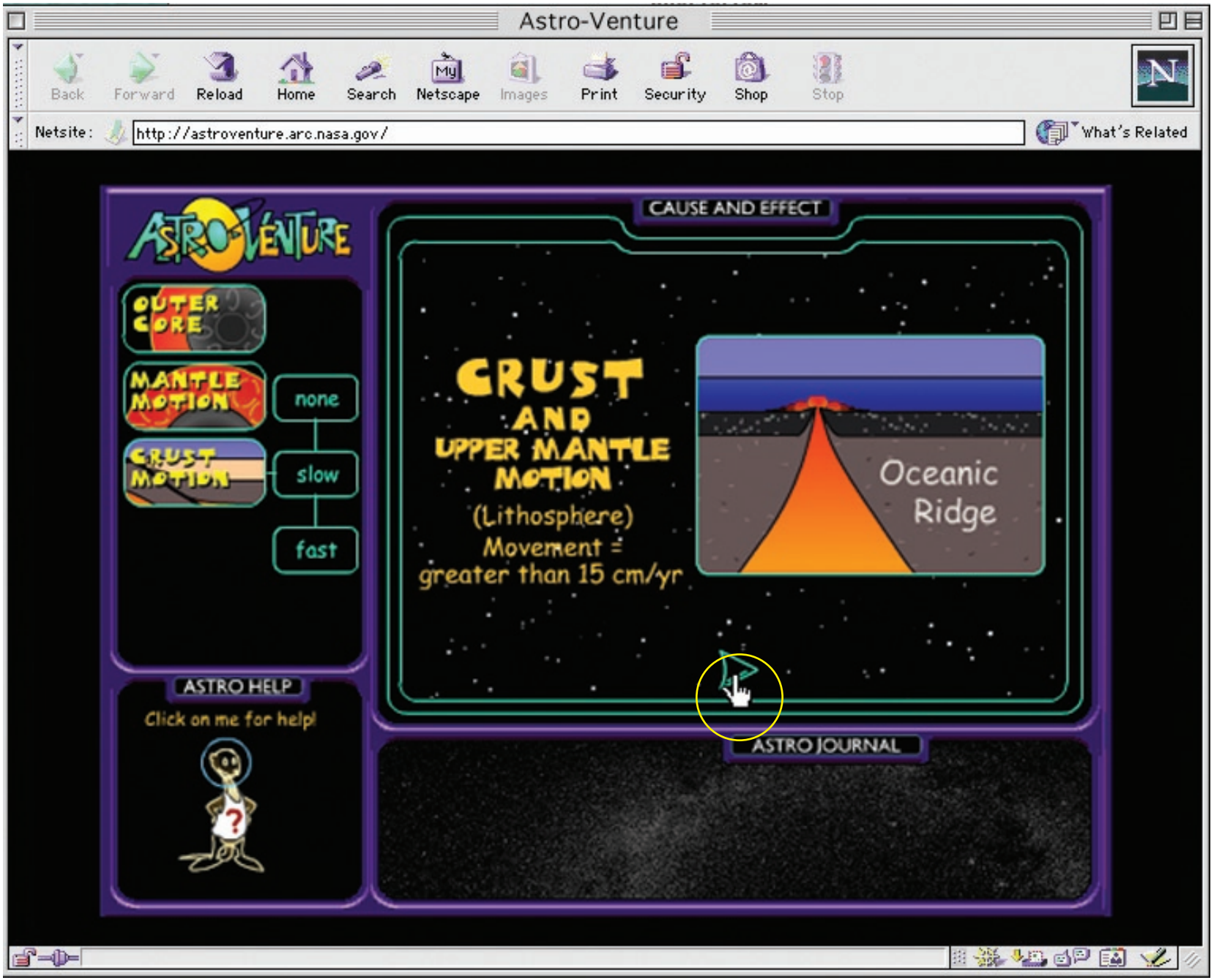


4A. Select a feature, such as "Crust Motion."



4B. Select a sub-menu button, such as "fast."



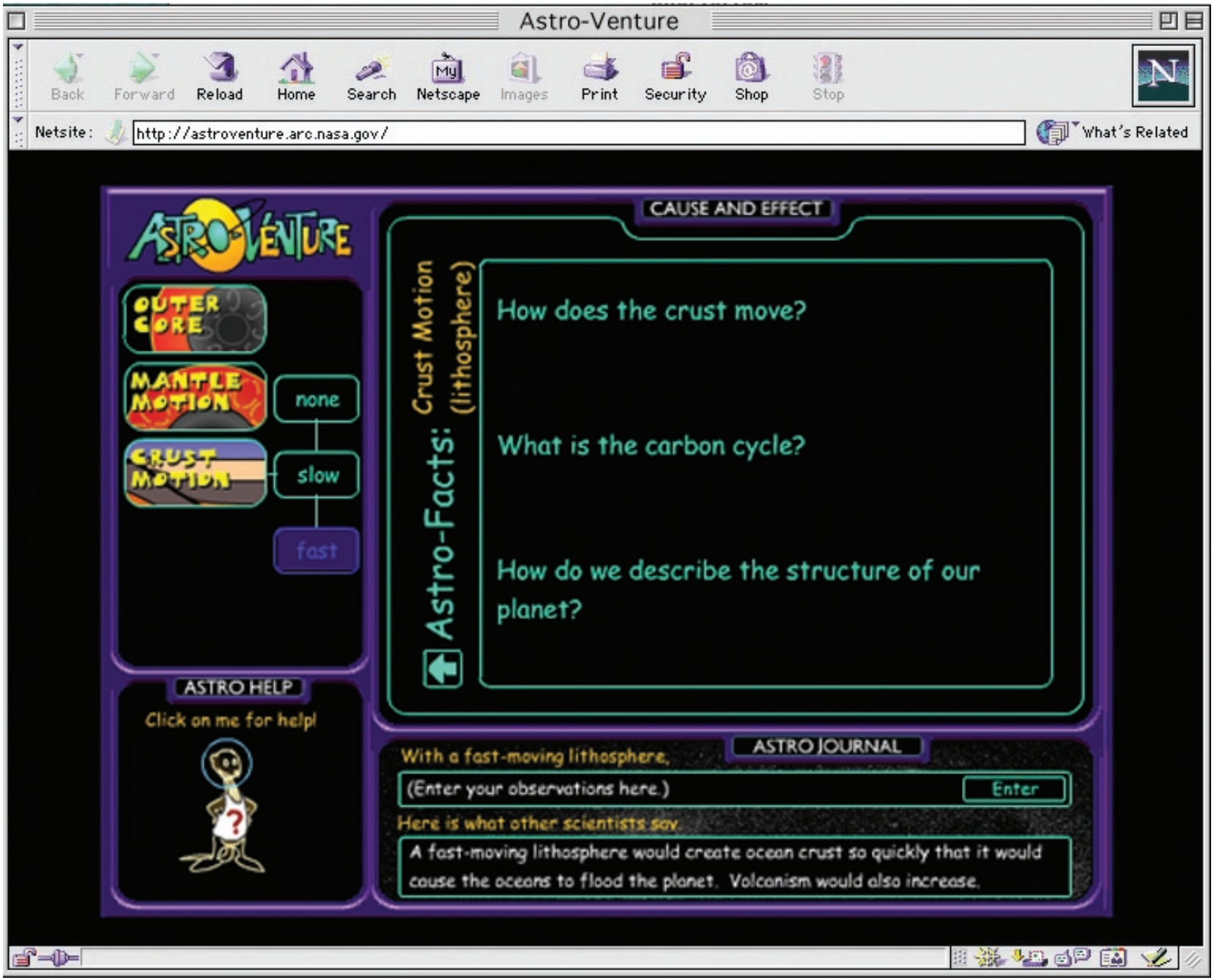
4C. Click on "Play" to see the effect on Earth.

The "Replay" button can be clicked repeatedly to view animation again.

4D. Record what you observe in your Astro Journal.

4E. Be sure to read the Scientist's feedback.

4F. Click on the Astro Facts button for background information and a glossary.

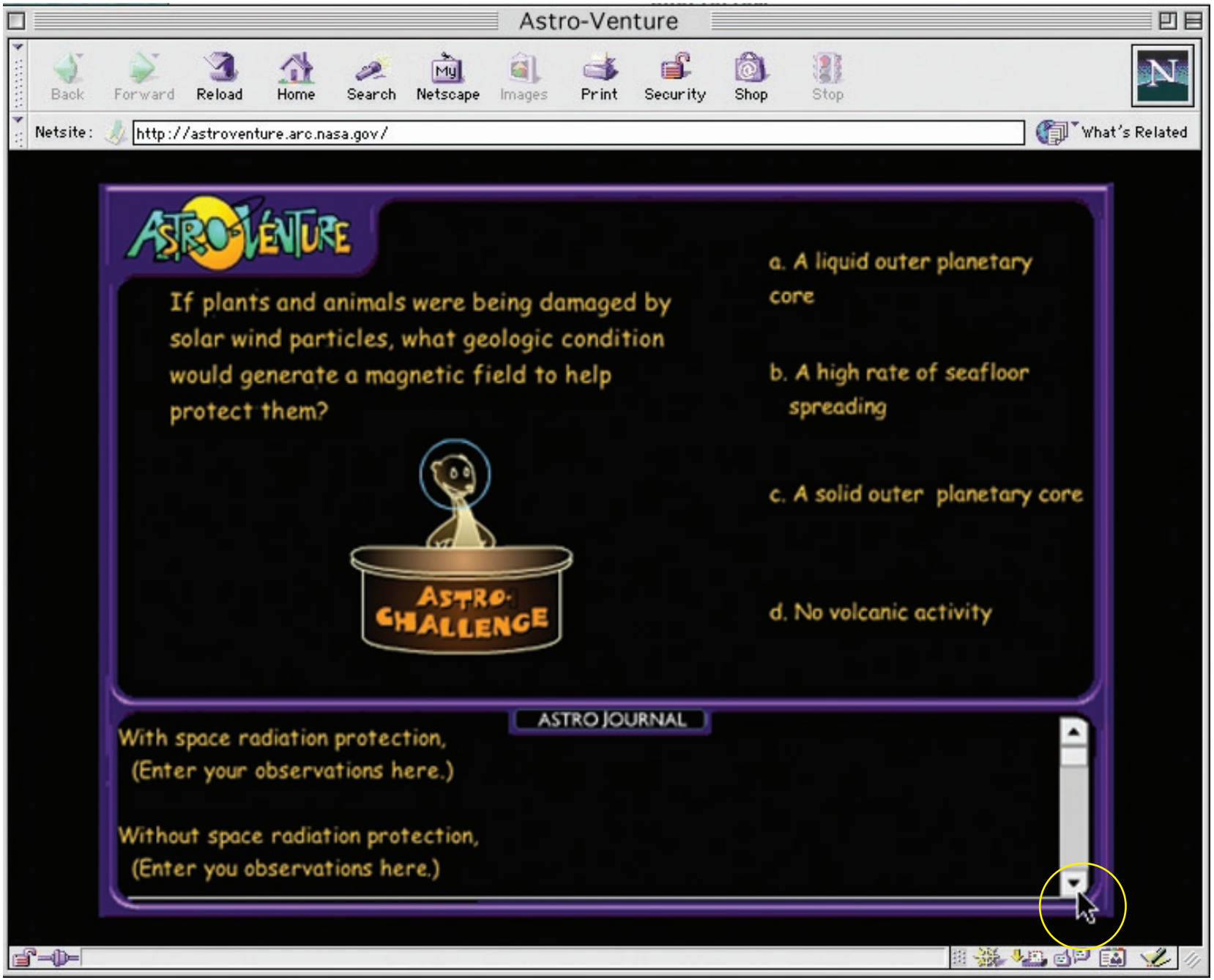


4G. Read about Astro-Facts related to the subject.

4H. Click on Astro Ferret if you need help navigating through the module.

4I. Continue using steps 4A-4H for all other features and sub-menus, and record your observations. (Buttons will turn purple once you have completed the section.)

5. When you have completed all of your observations, Astro Ferret will appear with the Astro Challenge button. Click the button to begin your Astro Challenge.



6. Be sure to use your notes in your Astro Journal to help you with the Astro Challenge.

7. You can print your certificate and Astro Journal.