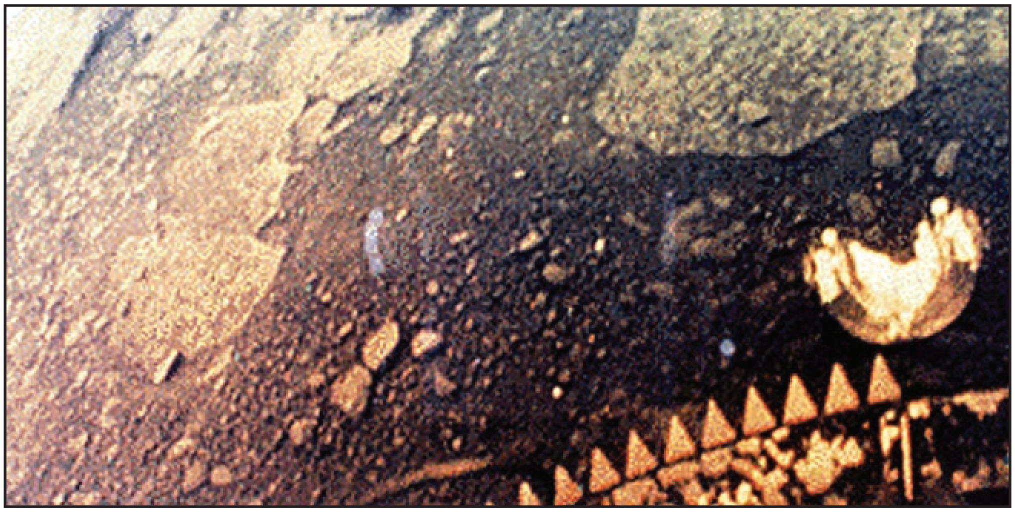
Atmospheric Science Educator Guide

Lesson 9: Atmospheric Science Mission



Surface of Venus at foot of Russian Venera lander; NASA

Students use an online, multimedia module to simulate the techniques that scientists might use to find a planet that has the atmospheric conditions required for human habitability. They learn about NASA research and careers in atmospheric sciences.

Main Lesson Concept:

Scientists use methods (such as spectroscopy) and instruments (such as a spectrograph, thermometer, and barometer) to collect data from a planet. Scientists then interpret this data to help answer a scientific question, such as whether the planet has the necessary atmospheric conditions to support human habitability.

Scientific Question:

How do scientists go about investigating whether a planet has the necessary atmospheric conditions for human habitability?

Objectives	Standards
• Students make predictions as to whether the atmospheres on Mars and Venus can support human habitability. • Students make observations, compare data, and reach conclusions regarding the atmospheric pressure, temperature, and composition on Mars and Venus. • Students identify the types of instruments that scientists use to gather data on the atmosphere of other planets. • Students identify the type of data scientists gather with these instruments.	**Addresses:** 2061: 1B (6-8) #1, 2 NSES: A (5-8) #1, 2 ISTE: (5-8) #3, 5, 6

Assessment	Abstract of Lesson
Write-up in Astro Journal and responses to Astro Journal final questions.	Students predict whether the atmospheric conditions on Mars and Venus support human habitability. They engage in an online Atmospheric Science Mission module in which they simulate the methods scientists might use to determine whether Mars and Venus have the necessary atmospheric compositions, temperatures, and pressures to support human habitability. They share their results with the class and describe the process they used.

Prerequisite Concepts	Major Concepts
• Scientists do not pay much attention to claims about how something they know about works unless the claims are backed up with evidence that can be confirmed and with a logical argument. (2061: 1B (3-5) #4) • Humans need water, oxygen, food, gravity, a moderate temperature and protection from poisonous gases and high levels of radiation to survive. (Astronomy Lesson 1) • The atmosphere of a planet affects the planetary temperature system, which determines the temperature of that planet. (Astronomy Lesson 10) • Humans need oxygen, carbon dioxide, nitrogen, ozone, and water vapor in certain quantities. (Atmosphere Lesson 1) • Carbon dioxide and water vapor are greenhouse gases that absorb energy radiated from Earth's surface and release some of it back towards the Earth, increasing the surface temperature. (Atmosphere Lesson 3) • Oxygen is a highly reactive element involved in chemical reactions that release heat energy. Oxygen is important to humans because it helps to convert sugars into energy in the cells. (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)	• Scientific investigations may take many different forms, and scientists use many different instruments to collect data for analysis. • Although there is no fixed set of steps that all scientists follow, scientific investigations usually involve the collection of relevant evidence, the use of logical reasoning, and the application of imagination in devising hypotheses and explanations to make sense of the collected evidence. • Hypotheses are valuable, even if they turn out not to be true, if they lead to fruitful investigations. • Tools often give more information about things than can be obtained by just observing things without their help.

Suggested Timeline (45-minute periods):

Day 1: Engage and Explore – Part 1 sections
Day 2: Explore – Part 2 section
Day 3: Explain and begin Extend/Apply sections
Day 4: Extend/Apply and Evaluate sections

Materials and Equipment:

- Human Survival Chart (optional)
- A class set of Astro Journal Lesson 9: Atmospheric Science Mission Module (Most of this is optional, as it will be completed online, but unbolded sections are not online.)
- Signs or name tags for each student to indicate the element they represent
- 1 to 30 computers with Internet browser, Internet connection, JavaScript enabled and the Flash Player installed*
- 1 printer connected to the computers
- 1 "Y" cable for each computer
- Headphones for each student
- Atmospheric Chemist, Climatologist, and Meteorologist Career Fact Sheets
- Career Summaries
- Atmospheric Science Mission Module Walkthrough (optional)

Preparation:

- Duplicate a class set of Astro Journal Lesson 9: Atmospheric Science Mission Module, Atmospheric Chemist, Climatologist, and Meteorologist Career Fact Sheets and Career Summaries.
- Download and install the Flash Player 6 (or higher) plug-in on the computers. You can download the plug-in from http://www.macromedia.com/downloads/.
  Test these at: http://astroventure.arc.nasa.gov by clicking "Atmospheric Science Mission."
- Gather and set up headphones and "Y" cables.
- Make an overhead transparency of Human Survival Chart (optional).

*System Requirements to Run Atmospheric Science Training Module

Operating System	Browser
Windows 95 Windows 98 Windows Me Windows NT Windows 2000 Windows XP or later	Internet Explorer 4.0 or later, Netscape Navigator 4 or later, Netscape 6.2 or later with standard install defaults, Firefox
Macintosh: System 8.6 System 9.0 System 9.1 System 9.2	Netscape 4.5 or later, Netscape 6.2 or later, Microsoft Internet Explorer 5.0 or later
Macintosh OS X	Microsoft Internet Explorer 5.1 or later Netscape 6.2 or later, Firefox

RAM
Memory requirements vary depending on your operating system, browser and plug-in version combination. We recommend a minimum of 128 MB.

Sound
Astro-Venture uses narration and some sound effects. Computers will require a sound card and either headphones or speakers. Pairs of students using the same computer can use a y-cable to connect two pairs of headphones to one computer.

Differentiation

Accommodations
For students who may have special needs:

- Pair advanced students with students who may need more guidance.
- Have students work with a partner on the Astro Journal writing or report orally to the teacher.
- Encourage students to talk about what they are learning as they go through the activity.

Advanced Extensions
Design your own mission to study the atmosphere of another planet or moon:

- What planetary body will you study? Why?
- What question will you try to answer?
- What is your hypothesis of what the answer to your question will be?
- What is the purpose of the mission?
- What scientific instruments will be used to gather data?
- What will the results of your research help us to learn?

Engage

(approximately 25 minutes)

Skylab 3 astronaut near the Apollo Telescope Mount on the International Space Station; NASA

1. Review the Atmospheric Science Training Module

- Question: What have we learned are the atmospheric conditions necessary to support human habitability?
- *Answers may include: It seems like in the winter, whenever it is clear it is colder, and when its cloudy it gets warmer.*

- Question: What three factors did we learn in Astronomy determine the surface temperature of a planet?
- *Answer: The following atmospheric conditions are necessary for human habitability:*
  - *0.000001 to 20% water vapor*
  - *0.001 to 0.03% carbon dioxide*
  - *15 to 30% oxygen*
  - *More than 80 Dobson Units ozone in the stratosphere*
  - *More than 5% nitrogen*

- Question: Why are carbon dioxide and water vapor important to life?
- *Answer: They are greenhouse gases that benefit humans by maintaining a stable, moderate temperature. These gases absorb heat that radiates from the Earth's surface, and release some of it back towards the Earth.*

- Question: What temperature range do humans need?
- *Answer: We need an average temperature above 0°C and below 100°C, where water can be a liquid. But we also need a temperature that is comfortable for our bodies to function — between 0° and 50°C.*

- Question: What important survival need does nitrogen help with?
- *Answer: Because nitrogen is inert, it can compose a large percentage of our atmosphere without causing negative effects to life, and is, thus, ideal as a large contributor to the air pressure on Earth necessary to support our bodies.*

- Question: What other important role does nitrogen play in survival?
- *Answer: Nitrogen is a fundamental building block of proteins, which are essential for life.*

- Question: Why is oxygen important for human survival?
- *Answer: Oxygen's tendency to react allows human cells to obtain energy from sugars and it makes up ozone.*

- Question: Why is ozone important to human survival?
- *Answer: Ozone molecules absorb ultraviolet radiation, preventing the ultraviolet radiation from reaching the Earth and harming animals and some plants.*

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2. Introduce the purpose of the lesson.

- Say: Now that we know the atmospheric conditions necessary to support human habitability, we are going to investigate how scientists would go about determining if a planet met these requirements. We are going to simulate this process by examining the atmospheric conditions on Mars and Venus to see whether these planets can support human habitability.

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3. Discuss the characteristics of scientific investigations.

- Question: What is the process that you've been using to carry out investigations in Astro-Venture? (You may want to identify a specific investigation that students carried out, such as the testing of the UV beads in Atmosphere Lesson 6.)
- *Answer: (Allow students to discuss their ideas about this. Students may say that they made a prediction or hypothesis, gathered data, and drew conclusions.)*

- Question: What did you use to gather information in different investigations? What do scientists use to collect data or to gather evidence?
- *Answer: (Allow students to discuss their ideas about this. They may say that they used rulers, thermometers, scales, magnifying glasses, and their eyes or other senses.)*

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4. Introduce the scientific questions for this lesson.

- Say: As we simulate a scientific mission to examine the atmospheres of Mars and Venus, we will be paying attention to how scientists conduct scientific investigations and will be trying to answer the question:
  - How do scientists go about investigating whether a planet has the necessary atmospheric conditions for human habitability?

- Question: How do you think NASA scientists go about conducting an investigation? Do you think they conduct an investigation the same way you have been?
- *Answer: (Allow students to discuss their ideas about this.)*

- Say: Think about these questions while you simulate this mission as NASA scientists.

- Question: So if we are going to investigate the atmospheres of Mars and Venus to see if they will support human habitability, what scientific questions are we trying to answer? What is your hypothesis about whether Mars' atmosphere's can support human habitability? What is your hypothesis about whether Venus' atmosphere's can support human habitability?

- Have students write their scientific questions and hypotheses in their Astro Journals.

Note to Teacher: Students will be given the scientific questions in the online simulation and will be asked to type in their hypotheses.

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5. Draw on prior knowledge and discuss possible methods for studying planetary atmospheres.

- Question: How might we tell whether a planet has an atmosphere?
- *Answer: (Allow students to discuss their ideas about this. Students will probably focus on visible evidence and may observe that a planet with an atmosphere may have visible clouds or a visible "halo" of light filtering through the atmosphere.)*

- Question: Can our atmosphere be felt?
- *Answer: (Students may observe that we can feel wind.)*

- Question: What happens when you go from a low place in the atmosphere to a higher place in the mountains or on a plane?
- *Answer: (Students may observe that they have felt their ears pop, that athletes may get out of breath, and that plastic bottles expand.)*

- Question: What causes this?
- *Answer: There is a change in pressure, because there is less atmosphere pushing on you as you go higher, and more as you go closer to the Earth's surface.*

- Question: So how might we be able to tell if a planet has an atmosphere if we cannot see an atmosphere?
- *Answer: We could measure the atmospheric pressure.*

- Question: What else will we want to find out about the atmospheres of Mars and Venus to determine if they are habitable?
- *Answer: We will want to know the composition of the atmospheres to see if the gas levels are within the range needed for human habitability.*

- Question: Besides pressure and amounts of gases, what other important role does atmosphere play for human habitability? (You could refer to the Human Survival Chart in Atmosphere Lesson 7 to help to answer this question.)
- *Answer: Atmosphere plays a role in the surface temperature of a planet, because greenhouse gases absorb heat and reradiate it back to a planet's surface.*

- Question: What methods do you think scientists might use to investigate the atmospheric pressure on Mars and Venus? The temperature? The air composition?
- *Answer: (Accept all answers. Use this as an opportunity to assess students' prior knowledge. Encourage students to discuss the kinds of information that scientists might need and the kinds of instruments that they might use to get this information.)*

- Question: What type of information about other planets can we get from the Earth? What are the advantages and disadvantages of that?
- *Answer: We can analyze the light we see through a telescope. The advantage is that it does not cost that much—just the cost of the telescope and equipment. The disadvantage is that the light goes through the layers of our atmosphere.*

- Question: How can we get a telescope or other instrument above the Earth's atmosphere?
- *Answer: We could put the instrument on something we can control that is outside the Earth's atmosphere, such as an orbiting satellite—or on an airplane that flies above most of the Earth's atmosphere.*

Note to Teacher: NASA has used this method many times with telescopes such as Hubble, which orbits high above the Earth's atmosphere (600 kilometers) and has allowed us to gather images of astronomical objects never seen before. Another orbiting telescope is the Spitzer Space Telescope. Similar planned missions are those of the Terrestrial Planet Finder and Kepler, which will also orbit high above the Earth's atmosphere and will allow us to search for Earth-size planets for the first time. Another technique that NASA has used is to fly an airplane with an onboard telescope in the Earth's upper atmosphere (12 to 15 kilometers high). Kuiper was one such airplane. Currently NASA is developing a similar airplane called SOFIA (Stratospheric Observatory for Infrared Astronomy). To learn more about these missions, visit the following Web sites.

- **Hubble Space Telescope: http://hubble.nasa.gov**
- **Spitzer Space Telescope: http://www.spitzer.caltech.edu/**
- **The Kepler Mission: http://www.kepler.arc.nasa.gov/**
- **Terrestrial Planet Finder: http://tpf.jpl.nasa.gov**
- **Kuiper Airborne Observatory: http://quest.arc.nasa.gov/lfs/lfshp.html**
- **SOFIA: http://sofia.arc.nasa.gov/**

6. Have students design a plan for answering their scientific question and testing their hypotheses.

- Say: As Astro-Venture Senior Atmospheric Scientists, you will be learning about some of the tools and methods scientists use to study planetary atmospheres, as you complete the online Astro-Venture Atmospheric Science Mission module. It is your mission to determine if Venus and Mars have the atmospheric conditions required for human habitation.

MISCONCEPTION: Upper elementary- and middle-school students may not understand experimentation as a method of testing ideas, but rather as a method of trying things out or producing a desired outcome. To bring out this misconception, ask students what the purpose of an experiment is. Ask them what is being tested and for what purpose. Emphasize that the purpose of the experiment is to test the hypothesis to see if it's true. Ask them if they test the hypothesis and find it's not true, what that means. If they say that that means the experiment failed, guide them to see the benefits of such a result. Stress that experiments need to be objective. Therefore, there is no such thing as a "failed" or "successful" experiment, but rather only scientific results that help us to answer a question. As students design the following plan, guide them to write plans that will give evidence to show whether the hypothesis is true or not.

- In their Astro Journals, have students record their plan on how they think they would go about investigating Mars and Venus' atmosphere to find out if they would support human habitability.

- Tell students that they will be completing the online Atmospheric Science Mission module to simulate the process that scientists would use to determine whether Mars and Venus have atmospheric conditions necessary to support human habitability.

Explore – Part 1

(approximately 20 minutes)

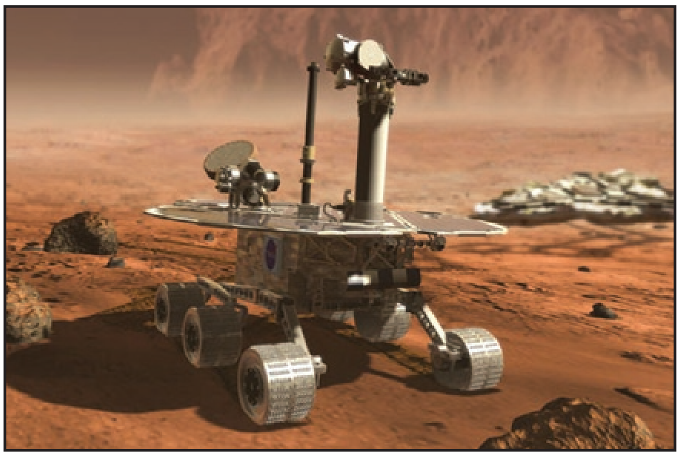

Illustration of either twin rover, Spirit or Opportunity on Mars; NASA

1. Discuss students' plans on how they would determine the habitability of Mars' and Venus' atmospheres.

- The Astro-venture Atmospheric Science Mission unit can be found on the Astro-Venture Web site at http://astroventure.arc.nasa.gov. Click "Atmospheric Science Mission" to load the unit.

Note to Teacher: If the text in the multimedia module is small and thus difficult to read, you can increase the screen resolution of the computers so that the module fills more of the screen and the text is larger. To do this, follow the directions below:

For PC

1. **Locate the lower left-hand "Start" button and select it.**
2. **Choose "Settings."**
3. **Select "Control Panel."**
4. **Locate the "Display" icon and click it.**
5. **From the tab choices select "settings."**
6. **Adjust "Screen Resolution" from the drop down or slider bar. (Select "800X600" for best results.)**
7. **Click "ok" when finished.**
8. **Click "apply changes" if necessary. (A computer restart may be required on some machines.)**

For Mac

1. **Locate the Apple icon in the top left-hand corner and select it.**
2. **Choose "System Preferences."**
3. **Locate the "Display" icon and click it.**
4. **Adjust "Resolution" from the menu of choices. (Select "800X600" for best results.)**
5. **Resolution will change immediately. Close the "Display" window.**

- Discuss student hypotheses as to whether Mars and Venus have atmospheres that can support human life and their reasoning behind their hypotheses.

- Discuss student plans for testing their hypotheses.

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2. Introduce students to the roles in the Astro-Venture Atmospheric Science Mission.

- Tell students that as they go through the Atmospheric Science Mission, they will be role-playing atmospheric scientists.

- Ask students what kind of knowledge or expertise they might need to have on their team to carry out their mission.

- Pass out the Atmospheric Chemist, Climatologist, and Meteorologist Career Fact Sheets and Career Summaries for students to read and discuss.

Note to Teacher: The Career Fact Sheets and Career Summaries are included in the back of this lesson so that you can easily duplicate them for students. The first section of the online mission also provides this information, so students can view them online in PDF format or print them out from the Web site. You might consider having students go through the roles section on the computer during one class period and then embark on the mission section during a subsequent class period. Alternatively, you can do the roles off line with the class, and they can then skip this section on the computer to help cut down on the time students will need to be online.

- Have students identify the role or roles they will take on in the mission. Have them record their role or roles in their Astro Journals. Tell students that they will need to remember their role or roles, as each role will be asked to use their expertise during different parts and will take control of the mouse for that activity.

Note to Teacher: There are three roles for this module; however, we found in testing that students worked better in pairs than in threes. We suggest having students work in pairs and having one student take on two roles, as all three roles must be filled in the mission. Career Summaries of the roles and Career Fact Sheets are found at the end of this lesson.

- Tell students that their special knowledge for their area will be needed during certain parts of the mission, and they will need to be in control of the mouse when prompted.

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3. Introduce students to the Atmospheric Science Mission.

- Tell students that they will be embarking on an important mission in their chosen roles to analyze data from Mars and Venus and determine if they meet the atmospheric requirements for human survival and why or why not.

Explore – Part 2

(approximately 45 minutes)

"Ascent Vehicle Descending to Martian Surface" illustration: Unmanned craft delivering supplies prior to arrival of human crew; John Frassanito and Associates, NASA

1. Introduce students to the Astro-Venture Atmospheric Science Mission module.

- Tell students that they will use their Astro-Venture Academy instruments to determine whether Mars and Venus have atmospheres that support human survival.
- Tell students that as they conduct this mission, they should think about the process and techniques that they are using.
- Tell students that they will go through the module as Astro-Venture Senior Atmospheric Scientists and will use the scientific inquiry process. They will also have help from several NASA scientists.

Note to Teacher: The module relies on audio, so we suggest that you obtain headphones for each computer. If pairs of students will share a computer, we suggest using "Y cables" that allow you to plug a pair of headphones into one computer.

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2. Have students engage in the Atmospheric Science Mission Module individually, in pairs, small groups, or as a class. If they are in groups of three, each student can take on a scientist's role.

MISCONCEPTION: Students of all ages find it difficult to distinguish between a theory and the evidence for it, or between description of evidence and interpretation of evidence. The following and later discussion can help to identify and confront this misconception. When discussing results and conclusions, encourage students to differentiate these as they communicate by saying or writing, "My conclusions are…" and "The evidence I have to support these conclusions are…"

- You may want to discuss with students the difference between a hypothesis and evidence and the difference between results and conclusions before they begin their investigation.
  – Question: You have written down hypotheses of what you think the answers to your scientific questions are. Are the hypotheses correct?
  – *Answer: We do not know yet.*

– Question: How will we know if they are true or not?
– *Answer: We need to gather some evidence that proves them true or proves them not true.*

– Question: What is the difference between the data we gather and the conclusions we make?
– *Answer: The data are just information or evidence. Our conclusions are made once we interpret the data or decide what the data mean.*

– Question: Can different scientists have different conclusions with the same results?
– *Answer: Yes, scientists might interpret the data differently. They may not agree on what the data means.*

- Students can access the module at http://astroventure.arc.nasa.gov and click on "Atmospheric Science Mission."

- Filling out the instruments, data, and conclusions for each section in their paper Astro Journal is optional. These can be recorded and printed online, but if students are unable to print, the paper journal is provided as another option.

Note to Teacher:
- **You will want to have accessibility to a printer, so that students can print their newspaper articles and Astro Journals at the end of the module. These can be used for evaluation purposes.**
- **If you want to take the whole class through the module using one computer, use the Atmospheric Science Mission Walkthrough as a guide.**
- **Most students should be able to complete the activity in a class period. However, if a student does not complete the module, it is possible to come to where they left off by either writing down the URL of the page they are on, or bookmarking the page and writing down the name of the bookmark. This is NOT possible in the training modules, but is an enhancement added to the mission modules. However, any information stored in the Astro Journal will not be permanently stored on the hard drive, and therefore won't be available to students if they quit the browser and come back later.**

- All of the information in the Atmospheric Science Mission Module is accurate based on the most recent NASA data available at the time of development.

Explain

(approximately 30 to 40 minutes)

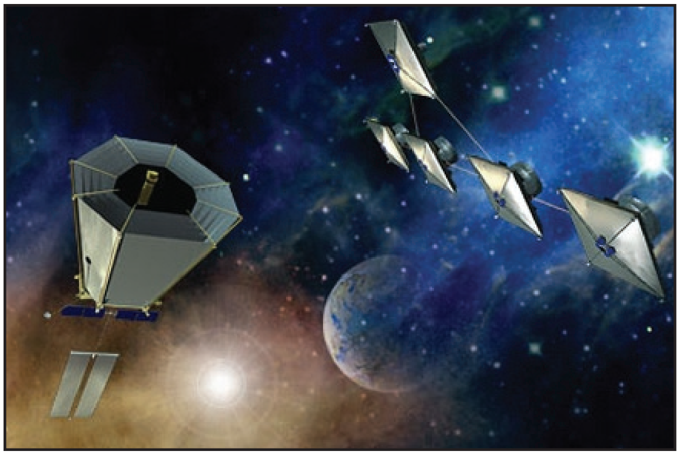


Illustration of Terrestrial Planet Finder observatory to study all aspects of planets outside of the Solar System; NASA

1. Have students discuss/share their results and conclusions.

Note to Teacher: As you discuss the following, you may want students to report on their area of expertise based on the role they held. One way to do this is to have students meet in three groups by area of expertise to discuss and decide how to present their results.

- Question: What is the difference between the statements you wrote down as your results and the statements you wrote down as your conclusions?
- *Answer: Our results are observations or facts. Our conclusions are how we interpret the facts in terms of answering our scientific question.*

- Question: Looking at your results, what conclusions did you make about whether the atmosphere on Mars can support human life? What evidence do you have to support this conclusion?
- *Answer: Our conclusion is that Mars cannot support human life. The evidence we have to support this is that the atmospheric pressure and temperature on Mars are too low. Also, Mars has no ozone or oxygen and does not have enough water vapor.*

- Question: Looking at your results, what conclusions did you make about whether the atmosphere on Venus can support human life? What evidence do you have to support this conclusion?
- *Answer: Our conclusion is that Venus cannot support human life. The evidence we have to support this is that the atmospheric pressure and temperature on Venus are too high. Venus has no water vapor, ozone or oxygen.*

2. Have students complete the Final Conclusions on Scientific Investigations section of their Astro Journals.

3. Discuss what students learned about how scientists conduct an investigation.

- Question: What did you, as scientists, do in carrying out your investigation?
- *Answer: (Answers will vary, but should include gathering data or making observations to help to answer a question and test a hypothesis. They should also include using logical reasoning to draw conclusions from these results.)*

- Question: What instruments did you use to collect data or to gather evidence?
- *Answer: We used a spectroscope, a barometer, and a thermometer.*

- Question: What would happen if scientists didn't have these kinds of tools?
- *Answer: If we didn't have these tools, we could not get as much information about other planets or we would have to think of other ways to get the information.*

- Question: What did the data look like and how did you interpret it?
- *Answer: (Students should describe the graphs they saw and what they meant.)*

- Question: What's the same and what's different between how you do an investigation and how NASA scientists do?
- *Answer: (Answers will vary. Students may observe that scientists use more sophisticated and expensive equipment and conduct much larger investigations than students have. Students may also observe that they form questions, test hypotheses, gather data, use good reasoning and evidence to interpret their data, and draw conclusions just like scientists do.)*

MISCONCEPTION: A commonly held misconception is that there is a fixed set of steps that scientists always follow in carrying out an investigation. While it is always important for scientists to collect relevant evidence and to base their conclusions on logical reasoning, there is no fixed order or process that must be used in science. The following discussion will help with this misconception.

- Question: Thinking back on the different investigations you have carried out, are all investigations identical?

Note to Teacher: You might list different investigations and discuss how each was conducted. For example, in the Atmospheric Science Training module, students changed one factor (or variable) at a time and observed the effect on Earth. In Atmospheric Science Lesson 4, they mixed substances together and observed the chemical properties of the new substance. In the Atmospheric Science Mission, they took temperature, composition, and pressure readings to gather and graph data over time on different planets.

- *Answer: Scientific investigations can take many different forms. Scientists may be able to compare reactions in a laboratory or may make observations on Earth or in space over time.*

- Question: So what can we conclude about how scientists conduct an investigation?
- *Answer: Although there is not a fixed set of steps that all scientists follow, there are some things that are true for all investigations. Scientists use a wide variety of instruments to collect data in investigations, and they use this data and logical reasoning to draw conclusions that help them answer questions and test hypotheses.*

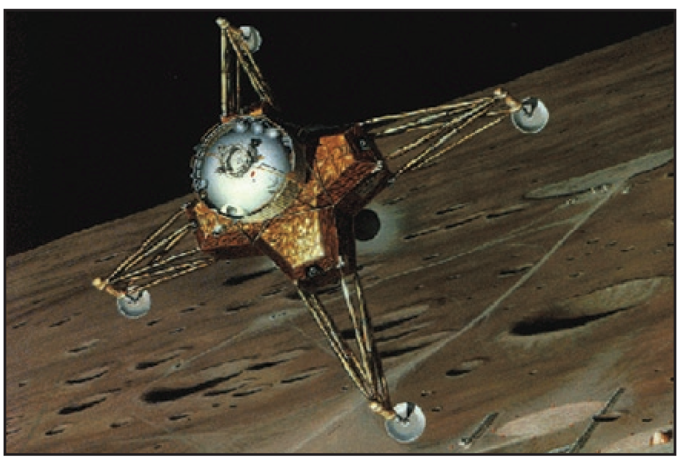
- Question: If a scientist tests a hypothesis and it turns out not to be true, does that mean that she wasted her time?
- *Answer: No. Even if a hypothesis is proven to be wrong, we still learn something that helps to build new scientific knowledge.*

Note to Teacher: You might give students an example of how an incorrect hypothesis can be helpful. Here's one example:
After the warming trends of the planet had been discovered, atmospheric scientists formed the following hypothesis about greenhouse gases emitted into the atmosphere:

> **All of the increases in greenhouse gas concentrations, including carbon dioxide, contribute to the greenhouse effect and global warming of the planet.**
>
> **To test the hypothesis, scientists built a computer model of how the atmosphere should have warmed during this period using the knowledge of how carbon dioxide contributes to atmospheric warming and knowing how much carbon dioxide was released into the atmosphere during the last 20 years. They expected that the predicted temperature increases due to the greenhouse gases during the 20 years would be close to the observed temperature increase. It turned out that the model-predicted temperature was higher than that observed. After careful interpretations of the study, the scientists concluded that the atmosphere-ocean system uptakes more CO_2 than they originally predicted, and not all of the CO_2 released into the atmosphere contributes to global warming.**
>
> **Therefore, the initial hypothesis of the scientists was not exactly correct and it lead to an important discovery that the atmosphere-ocean system is capable of taking up more CO_2 when more CO_2 is released into the atmosphere.**

Extend/Apply

(approximately 30 to 40 minutes)



"Oberth Ascending" illustration: Reusable Lunar Lander called OBERTH leaving a lunar outpost; Pat Rawlings, NASA

1. Have students complete the Astrobiology/Atmospheric Science Missions section of their Astro Journals.

- Students visit NASA Web sites to research current Astrobiology missions.

Missions that are in progress or were planned at the time this lesson was written include:

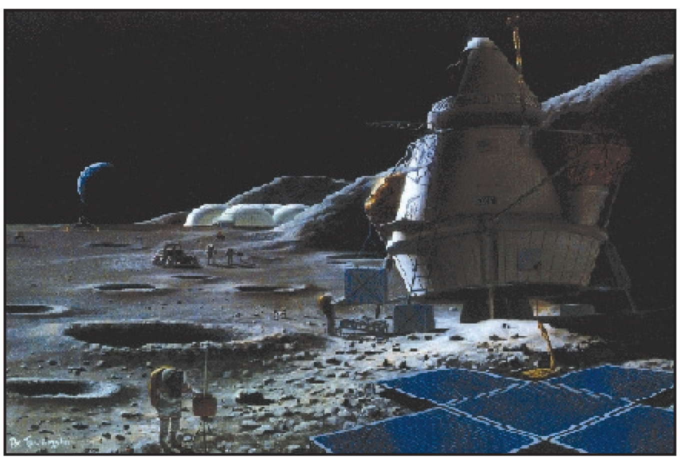
- Mars Exploration Rovers: http://marsrovers.jpl.nasa.gov/home/index.html
- Kepler Mission: http://www.kepler.arc.nasa.gov/
- Mars Odyssey: http://marsprogram.jpl.nasa.gov/odyssey/
- Mars Science Lander: 2009 http://nssdc.gsfc.nasa.gov/planetary/mars_2003_05.html

- Terrestrial Planet Finder, LifeFinder: http://tpf.jpl.nasa.gov
- Cassini/Huygens Probe: http://saturn.jpl.nasa.gov/index.cfm
- Mars Global Surveyor: http://marsprogram.jpl.nasa.gov/mgs/
- Mars Reconnaissance Orbiter: http://marsprogram.jpl.nasa.gov/mro/
- Virtual Planet Laboratory: http://astrobiology.ipac.caltech.edu/
- Spitzer Space Telescope: http://www.spitzer.caltech.edu/
- Stardust: http://stardust.jpl.nasa.gov/
- Jupiter Icy Moons Orbiter: http://www.jpl.nasa.gov/jimo/mission.cfm
- NASA Scout Missions: Sample Collection for Investigation of Mars (SCIM), Aerial Regional-scale Environmental Survey (ARES), Phoenix, Mars Volcanic Emission and Life Scout (MARVEL): http://nssdc.gsfc.nasa.gov/planetary/mars_2003_05.html

Other useful websites:
- NASA Astrobiology Institute: http://nai.arc.nasa.gov/
- JPL Space Missions Page: http://www.jpl.nasa.gov/missions/
- Astrobiology At NASA: http://astrobiology.arc.nasa.gov/
- National Space Science Data Center: http://nssdc.gsfc.nasa.gov/planetary/
- Chronology of Lunar and Planetary Missions: http://nssdc.gsfc.nasa.gov/planetary/chrono.html
- Astrobiology Missions: http://astrobiology.arc.nasa.gov/missions/index.cfm
- PlanetQuest: http://planetquest.jpl.nasa.gov/

Evaluate

(approximately 15 minutes)



"The Laboratory" illustration: Using the moon to test hardware and operations prior to a manned mission to Mars; Pat Rawlings, NASA

1. Have students share the descriptions of the NASA missions using scientific inquiry to explain these missions. To guide this discussion, ask the following questions:

- What form of investigation will/did the NASA scientists use to explore their question?
- What evidence will/did they collect to answer the question and test the hypothesis?
- If the mission is complete, what conclusions did they make?
- If the mission is complete, how did they use the evidence to support their conclusions?

2. Collect students' Astro Journals and evaluate them to ensure that they have each mastered the major concepts:

- Scientific investigations may take many different forms, and scientists use many different instruments to collect data for analysis.

- Although there is no fixed set of steps that all scientists follow, scientific investigations usually involve the collection of relevant evidence, the use of logical reasoning, and the application of imagination in devising hypotheses and explanations to make sense of the collected evidence.

- Hypotheses are valuable, even if they turn out not to be true, if they lead to fruitful investigations.

- Tools often give more information about things than can be obtained by just observing things without their help.

3. Connect back to the overall purpose of Astro-Venture and the unifying concept of systems.

- Question: If we should find a planet or moon outside our solar system that does meet the atmospheric conditions required for human habitability, would that mean that the planet would be habitable to humans?
- *Answer: Not necessarily. The planet would also need to meet the astronomical, geological, and biological requirements for human habitation.*

4. Bridge to next unit.

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

- Say: In the next unit we will learn about the geological 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 learning. This may be logistically difficult, but it is a powerful tool for building understanding.

Astro Journal Lesson 9: Atmospheric Science Mission

Name ______________________ Date ____________ Class/Period ____________

Scientific Question:
How do scientists go about investigating whether a planet has the necessary atmospheric conditions for human habitability?

1. Hypothesis
2. Plan for testing your hypotheses:
3. What role or roles will you take on for this mission?

Astro Journal Lesson 9: Atmospheric Science Mission

Name ______________________ Date ____________ Class/Period ______________

The following questions are asked online with the exception of question "1" for each section. If you are unable to print from the computer, you may use the following charts and questions to record your observations.

Mars Temperature

1. Instruments used:

2. How do the winter temperatures on Mars compare to temperatures on Earth?

- ☐ a. Much colder than Earth.
- ☐ b. About the same as Earth.
- ☐ c. Much hotter than Earth.

3. How do the summer temperatures on Mars compare to temperatures on Earth?

- ☐ a. Winter
- ☐ b. Spring
- ☐ c. Summer
- ☐ d. Fall

Astro Journal Lesson 9: Atmospheric Science Mission

Name ______________________ Date ____________ Class/Period ______________

5. What season has the lowest temperature?

- ☐ a. Winter
- ☐ b. Spring
- ☐ c. Summer
- ☐ d. Fall

Conclusions

6. Are the temperatures on Mars ever habitable to humans? Why or why not?

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Astro Journal Lesson 9: Atmospheric Science Mission

Name ______________________ Date ____________ Class/Period ______________

Venus Temperature
1. Instruments used:
2. How do the winter temperatures on Venus compare to temperatures on Earth?
☐ a. Much colder than Earth. ☐ b. About the same as Earth. ☐ c. Much hotter than Earth.
3. How do the summer temperatures on Venus compare to temperatures on Earth?
☐ a. Much colder than Earth. ☐ b. About the same as Earth. ☐ c. Much hotter than Earth.
Conclusions 4. Based on what you've observed, are the temperatures on Venus habitable to humans? Explain.

Astro Journal Lesson 9: Atmospheric Science Mission

Name ______________________________ Date ______________ Class/Period __________________

Mars Pressure
1. Instruments used:
2. During which season is the air pressure on Mars the highest?
☐ a. Winter ☐ b. Spring ☐ c. Summer ☐ d. Fall
3. During which season is the air pressure on Mars the lowest?
☐ a. Winter ☐ b. Spring ☐ c. Summer ☐ d. Fall
4. How does the air pressure on Mars compare to air pressure on Earth?
☐ a. Much lower than Earth. ☐ b. About the same as Earth. ☐ c. Much higher than Earth.
Conclusions 5. Based on what you observed, is the air pressure on Mars habitable to humans? Why or why not?

Astro Journal Lesson 9: Atmospheric Science Mission

Name ______________________________ Date ______________ Class/Period __________________

Venus Pressure
1. Instruments used:
2. How does the winter air pressure on Venus compare to air pressure on Earth?
☐ a. Much lower than Earth. ☐ b. About the same as Earth. ☐ c. Much higher than Earth.
3. How does the summer air pressure on Venus compare to air pressure on Earth?
☐ a. Much lower than Earth. ☐ b. About the same as Earth. ☐ c. Much higher than Earth.
Conclusions 4. Based on what you've observed, is the air pressure on Venus habitable to humans? Why or why not?

Astro Journal Lesson 9: Atmospheric Science Mission

Name ______________________________ Date ______________ Class/Period __________________

Atmospheric Composition
1. Instruments used:
2. Data Check the boxes to show what gases each planet has in its atmosphere.

	Water Vapor	Ozone	Carbon Dioxide
Mars	☐	☐	☐
Earth	☐	☐	☐
Venus	☐	☐	☐

3. Select two reasons why water vapor is important to human habitability.

☐ a. It's a greenhouse gas.
☐ b. It means the planet's surface might have liquid water.
☐ c. It protects us from ultraviolet radiation.

4. Select two reasons why ozone is important to human habitability.

☐ a. It protects us from ultraviolet radiation.
☐ b. It's a greenhouse gas.
☐ c. It means the planet's atmosphere has a lot of oxygen.

Astro Journal Lesson 9: Atmospheric Science Mission

Name ______________________ Date ____________ Class/Period ______________

5. Select two reasons why carbon is dioxide important to human habitability.

- ☐ a. It means the planet's surface has liquid water.
- ☐ b. It's a greenhouse gas.
- ☐ c. Plants need it for photosynthesis.

Conclusions

6. How does the composition of Mars' atmosphere compare to the atmosphere of Earth? How would these differences affect this planet's habitability?

7. How does the composition of Venus' atmosphere compare to the atmosphere of Earth? How would these differences affect this planet's habitability?

Astro Journal Lesson 9: Atmospheric Science Mission

Name ________________________________ Date _______________ Class/Period ____________________

Final Conclusions on Scientific Investigations
1. Based on what you've learned, do Mars and Venus have atmospheres that could support human life? Why do you think that?
Mars
Venus
The following questions are not asked online; you need the worksheets to answer them.
2. What did you learn about how scientists conduct an investigation?
3. How are the investigations you did the same as the ones NASA scientists do?

Astro Journal Lesson 9: Atmospheric Science Mission

Name ______________________ Date ____________ Class/Period ______________

4. How are the investigations you did different than the ones NASA scientists do?
5. Are all investigations exactly the same? Explain.
6. If a scientist tests a hypothesis, and it turns out not to be true, has she wasted her time? Explain.
7. How did you like the role you played? What do you like about this job? What other information would you like to learn about this job?

Astro Journal Lesson 9: Atmospheric Science Mission

Name ______________________ Date ____________ Class/Period ______________

Astrobiology Missions
Visit NASA Web sites to find missions that are looking for Earth-size planets, conditions for life on other planets or signs of life on other planets. Describe these missions using the following guidelines. • Mars Exploration Rovers: http://marsrovers.jpl.nasa.gov/home/index.html • Kepler Mission: http://www.kepler.arc.nasa.gov/ • Mars Odyssey: http://marsprogram.jpl.nasa.gov/odyssey/ • Mars Science Lander 2009: http://nssdc.gsfc.nasa.gov/planetary/mars_2003_05.html • Terrestrial Planet Finder, LifeFinder: http://tpf.jpl.nasa.gov • Cassini/Huygens Probe: http://saturn.jpl.nasa.gov/index.cfm • Mars Global Surveyor: http://marsprogram.jpl.nasa.gov/mgs/ • Mars Reconnaissance Orbiter: http://marsprogram.jpl.nasa.gov/mro/ • Virtual Planet Laboratory: http://astrobiology.ipac.caltech.edu/ • Spitzer Space Telescope: http://www.spitzer.caltech.edu/ • Stardust: http://stardust.jpl.nasa.gov/ • Jupiter Icy Moons Orbiter: http://www.jpl.nasa.gov/jimo/mission.cfm • NASA Scout Missions: Sample Collection for Investigation of Mars (SCIM), Aerial Regional-scale Environmental Survey (ARES), Phoenix, Mars Volcanic Emission and Life Scout (MARVEL): http://nssdc.gsfc.nasa.gov/planetary/mars_2003_05.html Other useful websites: • NASA Astrobiology Institute: http://nai.arc.nasa.gov/ • JPL Space Missions Page: http://www.jpl.nasa.gov/missions/ • Astrobiology At NASA: http://astrobiology.arc.nasa.gov/ • National Space Science Data Center: http://nssdc.gsfc.nasa.gov/planetary/ • Chronology of Lunar and Planetary Missions: http://nssdc.gsfc.nasa.gov/planetary/chrono.html • Astrobiology Missions: http://astrobiology.arc.nasa.gov/missions/index.cfm • PlanetQuest: http://planetquest.jpl.nasa.gov/
1. Title of the mission:
2. Web site address where information on this mission was found:
3. Scientific question being studied by this mission:

Astro Journal Lesson 9: Atmospheric Science Mission

Name ________________________ Date ____________ Class/Period ______________

4. Scientific hypothesis that scientists theorize they will find on this mission:
5. Materials and instruments scientists will use to gather data:
6. Methods and procedure scientists will use to gather data:

Astro Journal Lesson 9: Atmospheric Science Mission

Name ________________________________ Date _______________ Class/Period ____________________

7. If the mission is completed, report the results that were found. Was their hypothesis proven correct or incorrect?

8. If the mission is completed, what conclusions did scientists draw? What can we learn from the results?

Astro-Venture Atmospheric Science Mission Walkthrough

Introduction

1. When students click “Atmospheric Science Mission” they will first be given the opportunity to review the main concepts they should have mastered from Atmospheric Science Training. This is given in the form of four multiple choice questions, which students can either answer and submit to see the correct answers or they can skip by clicking “Skip the quiz” in the bottom left corner. The “Review” arrow shows up if they answer any question incorrectly, and will take them back to the Atmospheric Science Training module. However, they are also given a “Continue” arrow that allows them to proceed to the mission.

2. When students click either “Skip the quiz” from the first screen or “Continue” from the second screen, they will see an animated introduction to the mission. Astro-Ferret will outline the inquiry steps that students will take to complete their mission. Clicking on the circular arrow will allow students to replay this introduction.

Note to Teacher: The Accessibility Notes button brings up a pop-up window with all of the audio narration for deaf students and for those students who may benefit from seeing this text. The Accessibility Notes also provide descriptions of all graphics and animations for blind students.

3. **Mission: Research Roles.** When students click the arrow on the introduction screen, they will enter the page for the roles. Students can click each role to learn more about that career and a NASA scientist in that occupation. They can read a short description of the career and click on the “Let’s Meet______” to open a pop-up and hear an audio clip description from the scientist. From the pop-up window, they can click on “Career Fact Sheet (PDF)” to get more detailed information about the scientist.

Note to Teacher: Students will not likely have time to complete the mission in one class period if they spend a lot of time reviewing the career information, so it is suggested that this be reviewed either off-line or in two separate class periods.

4. **Mission: Choose Your Role.** When students click “Continue” they will be asked to enter a name next to each role to determine who will play each role. Since students will likely be working in pairs or alone, students will have to play more than one role. Each role must be filled before students can continue. The names are not stored but are used to print on the journal at the end, so it is clear whom each journal belongs to.

Note to Teacher: Emphasize with students that they will need to remember their role(s), as they will be asked to take control of the mouse when each role is needed.

5. **Form Your Hypotheses.** When students submit their roles, they will be taken to the hypotheses page where they will need to type in one hypothesis for Mars and one for Venus on whether they think the atmospheres on those planets will support human life and why.

Note to Teacher: Journal responses will not be saved, so students either need to complete the mission in one sitting, so they can print their journal responses at the end or they will need to use the paper version of the journal provided in this lesson.

6. **Mission Control.** After submitting their hypotheses, students will enter mission control where they can choose to look at temperature, pressure, or composition.

Temperature

1. **Choose a Planet: Temperature.** When students choose "Temperature" from mission control, they will be taken to a screen where they can select Mars or Venus. After completing one, the program will automatically send them to the other so that both are completed. The process is similar for both planets.

2. **Cool Facts.** A cool fact about Mars or Venus is given. All of the cool facts from the module are listed at the end of this walk through.

3. **Introduction.** Astro gives an introduction about the spacecraft and instruments used and asks for the meteorologist to take control of the mouse. Students need to click "Access Data" to proceed. The instrument used to measure temperature is a thermometer.

4. **Temperature Data.** Students are asked to analyze seasonal high and low temperature data. They can scroll the reference chart for comparable temperatures of objects and places on Earth. They can click on Tool for an animated explanation of Celsius, graphing, how to read the graphs and how to compare them to the reference chart. Students can also click on Hint for an audio hint from the NASA expert. After considering all of this, students are asked to answer multiple choice or open-ended questions at the bottom of the screen. If they submit an incorrect multiple-choice answer, a pop-up will prompt them to try again. If they do not enter enough text (at least ten characters) they will be prompted to enter more of an explanation. If they submit a correct answer, they will be provided with a summarizing sentence of the correct conclusion and a "Continue" button to take them to the next question.

5. **Scientist Feedback: Temperature.** The last open ended question will ask them to draw conclusions about the habitability of temperatures on Mars or Venus. When they submit this response, they will be taken to a screen where the NASA expert will provide text and audio feedback on habitability of Mars or Venus.

6. **Temperature Completion.** After completing both the Mars and Venus sections, students will be sent to a screen where they have the choice of clicking "Learn More" or returning to "Mission Control" to select a new area to analyze.

7. **Learn More: Temperature.** If students choose to visit this screen, they will go to a series of screens of text, narration, and graphics that describe a relevant upcoming NASA mission. They will be referred to a Web address of this mission, if they want to learn more about it. They will then be given a "Return" arrow that will send them back to the "Temperature Completion" screen from which they can return to "Mission Control."

Pressure

1. **Pressure Introduction.** When students choose "Pressure" from mission control, they will be taken to an animation that explains how pressure changes with altitude and the effect of pressure changes on the human body.

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2. **Choose a Planet: Pressure.** When students click "Continue" from the introductory animation, they will be taken to a screen where they can select Mars or Venus. After completing one, the program will automatically send them to the other so that both are completed. The process is similar for both planets.

3. **Cool Facts.** A cool fact about Mars or Venus is given. All of the cool facts from the module are listed at the end of this walk through.

4. **Introduction.** Astro gives an introduction about the spacecraft and instruments used and asks for the climatologist to take control of the mouse. Students need to click "Access Data" to proceed. The instrument used to measure temperature is a barometer.

5. **Pressure Data.** Students are asked to analyze seasonal high and low pressure data. They can scroll the reference chart for comparable pressures of places on Earth. They can click on "Tool" for an animated explanation of a barometer, millibars, graphing, how to read the graphs and how to compare them to the reference chart. Students can also click on Hint for an audio hint from the NASA expert. After considering all of this, students are asked to answer multiple choice or open-ended questions at the bottom of the screen. If they submit an incorrect multiple-choice answer, a pop-up will prompt them to try again. If they do not enter enough text (at least ten characters) they will be prompted to enter more of an explanation. If they submit a correct answer, they will be provided with a summarizing sentence of the correct conclusion and a "Continue" button to take them to the next question.

6. **Scientist Feedback: Pressure.** The last open ended question will ask them to draw conclusions about the habitability of pressures on Mars or Venus. When they submit this response, they will be taken to a screen where the NASA expert will provide text and audio feedback on habitability of Mars or Venus.

7. **Pressure Completion.** After completing both the Mars and Venus sections, students will be sent to a screen where they have the choice of clicking "Learn More" or returning to "Mission Control" to select a new area to analyze.

8. **Learn More: Pressure.** If students choose to visit this screen, they will go to a series of screens of text, narration, and graphics that describe a relevant upcoming NASA mission. They will be referred to a Web address of this mission, if they want to learn more about it. They will then be given a "Return" arrow that will send them back to the "Pressure Completion" screen from which they can return to "Mission Control."

Composition

1. **Composition Introduction.** When students choose "Composition" from mission control, they will be taken to an animation that explains how data will be collected using a spectrometer above the Earth's atmosphere. Astro-Ferret then asks for the atmospheric chemist to take control of the mouse.

2. **Choose a Planet: Composition.** After the introduction, students will automatically be taken to a screen where they can select Mars or Venus using either the arrows on their keypad or by clicking the arrows on the screen to maneuver the crosshairs over the planet of their choice. Once the target is over the planet and turns yellow, they can click "Take Spectrum" to bring up the spectrum of that planet's atmosphere. They will then need to click "Take another reading" to return to the target screen so that they can maneuver the target over the other planet and take its spectrum. After taking this second spectrum, they will need to click "Analyze Spectrum" to continue.

3. **Composition Data.** Students are asked to analyze composition data. They can scroll the reference chart for the spectra of each individual gas and look for comparable dips in the atmosphere of each planet. Students can click on Tool for an animated explanation of a spectrometer, spectral lines, spectrogram graphs, and how to read and interpret these graphs found in the reference chart. Students can also click on Hint for an audio hint from the NASA expert. After considering all of this, students are asked to check the planets that have each gas and answer multiple choice questions open-ended questions at the bottom of the screen. If they submit an incorrect multiple-choice answer, a pop-up will prompt them to try again. If they do not enter enough text (at least ten characters) they will be prompted to enter more of an explanation. If they submit a correct answer, they will be provided with a summarizing sentence of the correct conclusion and a "Continue" button to take them to the next question.

Note to Teacher: The dips on the graphs may be difficult to interpret. The signature of each planet shows all the gases, and they are comparing to a graph of one gas at a time, so the graphs don't look exactly the same. The Tool button animation shows two examples that may help students with this interpretation. Also, note that the questions in this section are more challenging than the other sections, because more than one planet may have a given gas. Students must check all planets that have a given gas.

4. **Scientist Feedback: Composition.** The last two open ended questions will ask them to draw conclusions about the habitability of compositions on Mars and Venus. When they submit each response, they will be taken to a screen where the NASA expert will provide text and audio feedback on habitability of Mars or Venus.

5. **Composition Completion.** After completing the entire section, students will be sent to a screen where they have the choice of clicking "Learn More" or returning to "Mission Control" to select a new area to analyze.

6. **Learn More: Composition.** If students choose to visit this screen, they will go to a series of screens of text, narration, and graphics that describe a relevant upcoming NASA mission. They will be referred to a Web address of this mission, if they want to learn more about it. They will then be given a "Return" arrow that will send them back to the "Composition Completion" screen from which they can return to "Mission Control."

Congratulations

When students click "Mission Control" after completing all three sections, they will be sent to a Congratulations page. They will be asked to click "Continue" to enter their final results.

Update/Correct Hypotheses

Students are asked to type in their results on what they learned about the habitability of the atmospheres of Mars and Venus. They can click "Access my journal" to open a pop up of all of the answers they entered throughout the mission. Once they have entered their results, they need to click "Submit."

Feedback on Mars Hypothesis

When students click "Submit" they will be brought to a screen with audio and text summarizing feedback on the habitability of Mars' atmosphere.

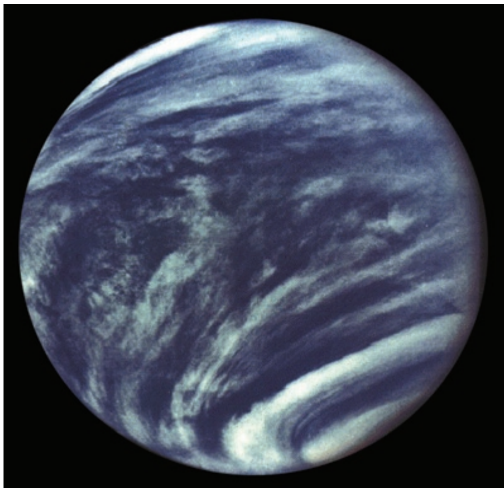
Feedback on Venus Hypothesis

When students click "Continue" they will be brought to a screen with audio and text summarizing feedback on the habitability of Venus' atmosphere.

Print Menu

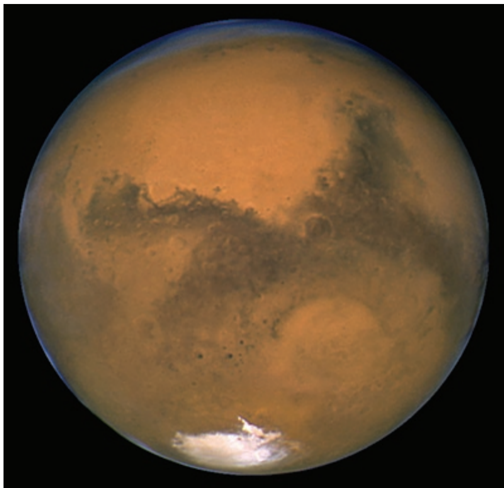
When students click "Continue" they will be brought to a Print Menu screen where they can click "Print Journal" to open a pop-up page of all of their journal responses. At the top of this pop up, students can click "print journal" to print this page. Students can also click "Print Newspaper" to bring up an article in an HTML page about their mission that can be read and printed. Finally, they can click "AV Main Menu" to return to the Astro-Venture home page. NOTE that once students exit to the main menu, their journal data will be lost.

Cool Facts about Venus!



- A day on Venus is longer than its year!
- Venus rotates in the opposite direction of Earth!
- Venus has no moons!
- Because Venus and Earth are almost the same size, Venus is called Earth's "twin."
- Venus was named after the Roman goddess of love and beauty.
- The surface features on Venus are named after famous women.
- Venus is the brightest object in the sky except for the Sun and moon.
- Venus is also known as the "morning star" and the "evening star."
- We have pictures of the Venusian surface from Russian space missions!
- Venus' surface is so hot, it can melt lead!
- Venus has clouds made of sulfuric acid!
- The pressure on Venus is so high, that it is almost the same as being 1 kilometer deep in the ocean!
- Venus has the hottest average surface temperature of any planet in the solar system.
- Venus is the only planet that rotates clockwise. To an observer on Venus, the Sun would rise in the west and set in the east.
- The surface of Venus has lots of volcanoes, mountains, and big cracks.
- Venus receives twice as much of the Sun's light as does Earth.
- It takes light from the Sun 5.9 minutes to reach Venus.
- Wind speeds on Venus average 240 mph.
- At least 85% of the Venusian surface is covered with volcanic rock.

Cool Facts about Mars!



- Mars has huge dust storms that sometimes cover the entire planet!
- The polar caps on Mars grow and shrink with the seasons!
- A year on Mars is almost twice as long as a year on Earth!
- The days on Mars are called "sols."
- Mars might have liquid water on its surface!
- The largest canyon on Mars, called Valles Marineris, is as long as the United States!
- Mars was named after the Roman god of war.
- Mars has two moons, called Phobos and Deimos, which mean "fear" and "panic."
- The month of March was named after the planet Mars.
- Tuesday (Martes in Spanish) was named after the planet Mars.
- Mars gets its red surface from rust.
- The largest volcano on Mars is almost 3 times as tall as Mt. Everest!
- Mars has permanent ice caps at both poles.
- Percival Lowell thought he saw water canals on Mars!
- Some meteorites on Earth are actually pieces of Mars!
- Some scientists think there might be fossils in a Martian meteorite!
- The gravity on Mars is one-third of Earth's.
- It takes light from the Sun 12.5 minutes to reach Mars.
- Martian air contains only about 1/1,000 as much water as the air on Earth.

Career Summaries

Atmospheric Chemist

Atmospheric Chemists are scientists who study the different molecules in a planet's atmosphere. They investigate how these molecules interact with each other and the rest of the planet. They make observations and collect data to understand how the atmosphere reacts to sunlight and many parts of the Earth's surface, including soil, snow, vegetation, and oceans. Atmospheric Chemists use many tools, such as spectrometers, computer models and simulations, satellite data, and spacecraft instruments.

Climatologist

Climatologists collect data and make predictions about climate patterns. They study how Earth's climate changes with time. They use glacial ice cores, tree rings, and other sources of information to learn about the climate in Earth's past. They use computer software programs that help to model Earth's climate. They do research to find out if humans are affecting Earth's present and future climate. Some Climatologists study climates on other planets. Climatologists use tools such as thermometers, barometers, computer models and simulations, satellite data, and spacecraft instruments.

Meteorologist

Meteorologists collect weather data and make predictions about developing weather patterns. They tell air traffic controllers and pilots about weather hazards such as thunderstorms, turbulence, tornadoes, ice, and flooding. They release public weather advisories for vehicles, aircraft, and watercraft. They also participate in weather-related research projects that help to provide more accurate forecasting methods over long time periods. Meteorologists use many tools, such as thermometers, barometers, computer models, and satellite data.

NASA Quest: Highlighting People and Professions related to NASA and its Exploration Mission

Atmospheric Chemist — Career Fact Sheet

Related Job Titles:

Atmospheric Scientist, Environmental Scientist, Air Quality Analyst, Meteorologist, Atmospheric Physicist

Job Description:

Atmospheric chemistry is a multi-disciplinary field that is a sub-set in the broader field of atmospheric science. Atmospheric Chemists are interested in the chemical composition of the atmosphere and how the chemical constituents of the atmosphere interact with each other. Atmospheric Chemists make oberservations and collect data to understand how the atmosphere reacts and changes to sunlight and many parts of the Earth's surface including soils, vegetation, oceans, ice and snow. Some Atmospheric Chemists analyze the composition of our current atmoshere to compare with past data to understand the local, regional, and global impacts of our industrial practices. Atmospheric Chemists can also help gain an understanding of a distant planet's composition because they can analyze the chemistry of a planet's atmosphere remotely.

Interests/Abilities:

- Are you interested in the world around you and the processes that effect our planet?
- Can you perform calculations quickly with great accuracy?
- Are you patient when it comes to completing forms requiring detailed information?
- Do you like to solve logic puzzles?
- Are you a good problem solver?

Education/Training Needed:

The minimum education required for this position is a bachelor's degree in Atmospheric Sciences or Chemistry from an accredited college or university. Experience in hands-on laboratory techniques is extremely helpful for this job. To do research, at minimum a master's degree is required, and a Ph.D. is highly desired for this position.

Suggested School Subjects/Courses:

- Chemistry
- Math (algebra, trigonometry)
- Physics
- Meteorology
- Statistics
- Computer modeling
- Environmental studies
- Electronics

Areas of Expertise

- ***Synoptic***: analyze data from satellites, radar, and surface-observing instruments
- ***Research***: study atmospheric chemistry, refine theories and improve mathematical/computer models of atmospheric composition and its impacts on the planet
- ***Environmental***: monitor pollution from traffic and industry and its effects on the planet

What Can I Do Right Now?

- Buy a chemistry set and learn how different substances interact with each other.
- Set up your own weather station and provide your local radio station with a daily report.
- Read newspapers and magazines to understand how governments and industries make policies related to atmospheric composition.
- Take samples of rain or soil in your neighborhood and analyze them using water and soil test kits from your local hardware store.

Atmospheric Chemist — Career Fact Sheet

Additional Resources:

- American Meteorological Society
  http://www.ametsoc.org/AMS
- Astrobiology Summer Academy
  http://academy.arc.nasa.gov/
- Atmospheric Chemistry and Physics Interactive Science Journal
  http://www.copernicus.org/EGU/acp/
- Education Pays Calculator
  http://www.educationpays.org/calc.asp
- Graduate Student Researchers Program
  http://spacelink.nasa.gov/Instructional.Materials/NASA.Educational.Products/Graduate.Student.Researchers.Program.Brochure/.index.html
- MATHCOUNTS Competition
  http://mathcounts.org/
- Minority University Research and Education Programs
  http://mured.nasaprs.com/
- NASA Cooperative Education Program for college students
  http://spacelink.nasa.gov/Educational.Services/NASA.Education.Programs/Student.Support/NASA.Cooperative.Education.Program/.index.html
- NASA SHARP Internship Program for high-schoolers
  http://www.mtsibase.com/sharp/
- NASA Student Employment
  http://nasajobs.nasa.gov/stud_opps/employment/index.htm
- NASA Student Involvement Program student contests
  http://www.nsip.net/index.cfm
- NASA Jobs
  http://nasajobs.nasa.gov/
- National Center for Atmospheric Research -Atmospheric Chemistry Division
  http://www.acd.ucar.edu
- National Oceanic and Atmospheric Administration
  http://www.noaa.gov
- National Weather Service
  http://www.nws.noaa.gov
- Student's Guide to Astrobiology
  http://www.astrobiology.com/student.html
- Tech-Interns.com
  http://www.tech-interns.com/

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Climatologist — Career Fact Sheet

Related Job Titles:

Climate Officer, Climate Forecaster, Climatology Researcher, Climatological Modeling Specialist, Atmospheric Scientist, Earth Systems Scientist

Job Description:

A Climatologist collects climate data, investigates climate indicators and makes predictions regarding climate patterns. This individual uses computer models to study how Earth's climate changes with time. They use glacial ice cores, lake sediments, tree rings, and other sources of information to determine the climate in Earth's past. They use sophisticated computer software programs that assist them in modeling the Earth's climate and check that data against known information. They conduct research to determine if humans are affecting Earth's present and future climate. Some Climatologists study climates on other planets in our solar system.

Interests/Abilities:

- Do you read and understand charts with special symbols easily?
- Can you perform calculations quickly with great accuracy?
- Do enjoy getting out a road map and figuring out what route to drive when preparing for vacation? Can you see more than one route to a destination?
- Are you curious about your surroundings and what processes shape them?
- Are you patient when it comes to completing forms requiring detailed information?

Education/Training Needed:

The minimum education required for this position is a bachelor's degree in meteorology or atmospheric sciences from an accredited college or university. Experience in computer modeling techniques is extremely helpful for this job. To do research, at minimum a master's degree is required and a Ph.D. is highly desired for this position.

Suggested School Subjects/Courses:

- Math (algebra, trigonometry, calculus)
- Physics
- Meteorology
- Statistics
- Computer modeling
- Geography

Areas of Expertise

- *Synoptic*: analyze data from satellites, radar, and surface-observing instruments
- *Weather forecasters*: prepare forecasts for public and specialized reports for aviation, marine and agriculture
- *Research*: study atmospheric physics, refine theories and improve mathematical/computer models of atmospheric processes and events

What Can I Do Right Now?

- Set up your own weather station and provide your local radio station with a daily report.
- Get some work experience at the local airport, television or radio station as a weather data compiler or weather statistics researcher.
- Call the Automatic Terminal Information Service (ATIS) phone number and listen to the local airport's weather report.
- Learn to read and interpret the various types of weather maps, charts and data available through the Internet.
- Learn how to use database software.

Climatologist — Career Fact Sheet

Additional Resources:

- American Meteorological Society
  http://www.ametsoc.org/AMS
- Astrobiology Summer Academy
  http://academy.arc.nasa.gov/
- Education Pays Calculator
  http://www.educationpays.org/calc.asp
- Gradate Student Researchers Program
  http://spacelink.nasa.gov/Instructional.Materials/NASA.Educational.Products/Graduate.Student.Researchers.Program.Brochure/.index.htmlt
- MATHCOUNTS Competition
  http://mathcounts.org/
- Minority University Research and Education Programs
  http://mured.nasaprs.com/
- NASA Cooperative Education Program for college students
  http://spacelink.nasa.gov/Educational.Services/NASA.Education.Programs/Student.Support/NASA.Cooperative.Education.Program/.index.html
- NASA Jobs
  http://nasajobs.nasa.gov/
- NASA SHARP Internship Program for high-schoolers
  http://www.mtsibase.com/sharp/
- NASA Student Employment
  http://nasajobs.nasa.gov/stud_opps/employment/index.htm
- NASA Student Involvement Program student contests
  http://www.nsip.net/index.cfm
- National Oceanic and Atmospheric Administration
  http://www.noaa.gov
- National Severe Storms Laboratory
  http://www.nssl.noaa.gov
- National Weather Service
  http://www.nws.noaa.gov
- Schools with programs in meteorology
  http://www.nssl.noaa.gov/edu/schools.html
- Student's Guide to Astrobiology
  http://www.astrobiology.com/student.html
- Tech-Interns.com
  http://www.tech-interns.com/

Please take a moment to evaluate this product at:
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NASA Quest: Highlighting People and Professions related to NASA and its Exploration Mission

Meteorologist — Career Fact Sheet

Related Job Titles:

Weather Officer, Weather Forecaster, Meteorology Researcher, Meteorological Modeling Specialist, Atmospheric Scientist, Atmospheric Chemist

Job Description:

A Meteorologist collects weather data, surveys weather indicators and makes predictions regarding developing weather patterns. This individual advises air traffic control and other agencies about weather hazards such as thunderstorms, developing storm cells and fronts, turbulence, tornadoes, icing, flooding, flash flooding and other such weather-related phenomena. They issue to various governmental agencies and the public weather advisories for vehicles, aircraft and watercraft. They use sophisticated computer software programs that assist them in modeling the potential flow and intensity of storm cells and fronts. They are also available to participate in weather-related research projects that seek to provide more accurate forecasting methods over a longer time period.

Interests/Abilities:

- Do you read and understand charts with special symbols easily?
- Can you perform calculations quickly with great accuracy?
- Do enjoy getting out a road map and figuring out what route to drive when preparing for vacation? Can you see more than one route to a destination?
- Are you curious about your surroundings and what processes shape them?
- Are you patient when it comes to completing forms requiring detailed information?

Education/Training Needed:

The minimum education required for this position is a bachelor's degree in Meteorology or Atmospheric Sciences from an accredited college or university. Experience in computer modeling techniques is extremely helpful for this job. To do research, at minimum a master's degree is required and a Ph.D. is highly desired for this position.

Suggested School Subjects/Courses:

- Math (algebra, trigonometry, calculus)
- Physics
- Meteorology
- Statistics
- Computer modeling
- Geography

Areas of Expertise

- ***Aeronautical***: study weather phenomena and its effects on flight (lightning, icing, etc.)
- ***Synoptic***: analyze data from satellites, radar, and surface-observing instruments
- ***Weather forecasters***: prepare forecasts for public and specialized reports for aviation, marine, and agriculture
- ***Research***: study atmospheric physics, refine theories, and improve mathematical/computer models of atmospheric processes, and events
- ***Climatologists***: collect, organize, archive, interpret, and publish climatological data.

What Can I Do Right Now?

- Set up your own weather station and provide your local radio station with a daily report.
- Get some work experience at the local airport, television, or radio station as a weather data compiler or weather statistics researcher.
- Interview pilots about how different weather phenomena affect their aircraft's flight characteristics.
- Call the Automatic Terminal Information Service (ATIS) phone number and listen to the local airport's weather report.
- Learn to read and interpret the various types of weather maps, charts, and data available through the Internet.
- Learn how to use database software.

Meteorologist — Career Fact Sheet

Additional Resources:

- American Meteorological Society
  http://www.ametsoc.org/AMS
- Astrobiology Summer Academy
  http://academy.arc.nasa.gov/
- Education Pays Calculator
  http://www.educationpays.org/calc.asp
- Gradate Student Researchers Program
  http://spacelink.nasa.gov/Instructional.Materials/NASA.Educational.Products/Graduate.Student.Researchers.Program.Brochure/.index.htmlt
- MATHCOUNTS Competition
  http://mathcounts.org/
- Minority University Research and Education Programs
  http://mured.nasaprs.com/
- NASA Cooperative Education Program for college students
  http://spacelink.nasa.gov/Educational.Services/NASA.Education.Programs/Student.Support/NASA.Cooperative.Education.Program/.index.html
- NASA Jobs
  http://nasajobs.nasa.gov/
- NASA SHARP Internship Program for high-schoolers
  http://www.mtsibase.com/sharp/
- NASA Student Employment
  http://nasajobs.nasa.gov/stud_opps/employment/index.htm
- NASA Student Involvement Program student contests
  http://www.nsip.net/index.cfm
- National Oceanic and Atmospheric Administration
  http://www.noaa.gov
- National Severe Storms Laboratory
  http://www.nssl.noaa.gov
- National Weather Service
  http://www.nws.noaa.gov
- Schools with programs in meteorology
  http://www.nssl.noaa.gov/edu/schools.html
- Student's Guide to Astrobiology
  http://www.astrobiology.com/student.html
- Tech-Interns.com
  http://www.tech-interns.com

Please take a moment to evaluate this product at:
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Thank you.

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.

Astro-Venture Glossary (Cont.)

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.

Astro-Venture Glossary (Cont.)

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.

Astro-Venture Glossary (Cont.)

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.

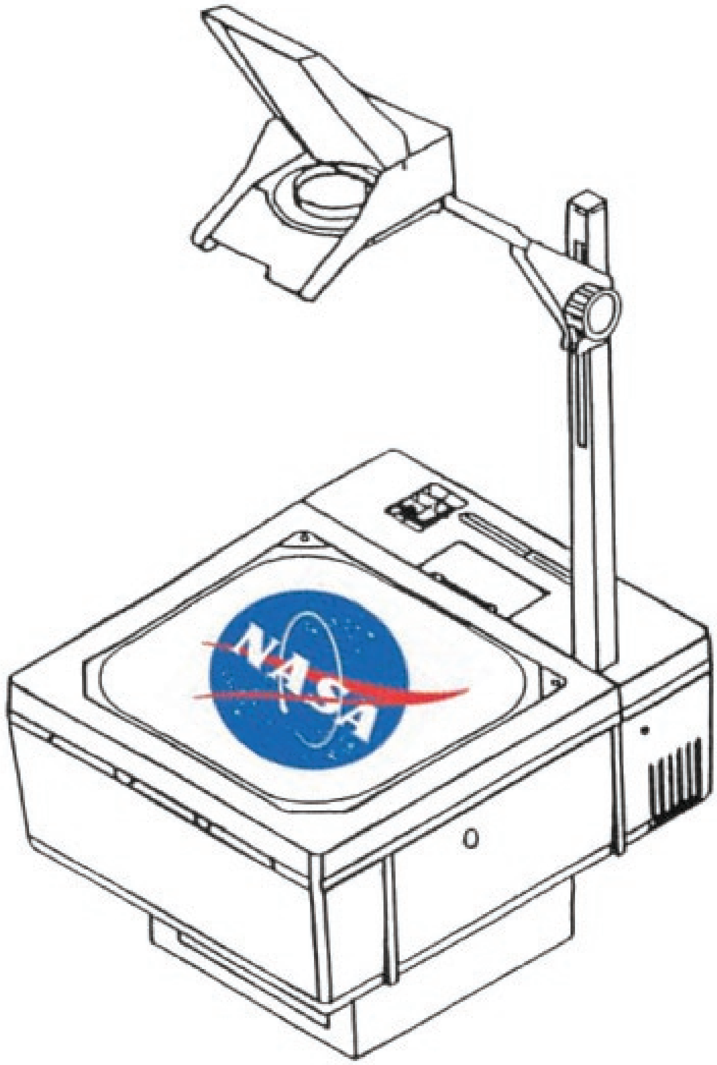
weathering The process of breaking down rocks on Earth's surface.

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



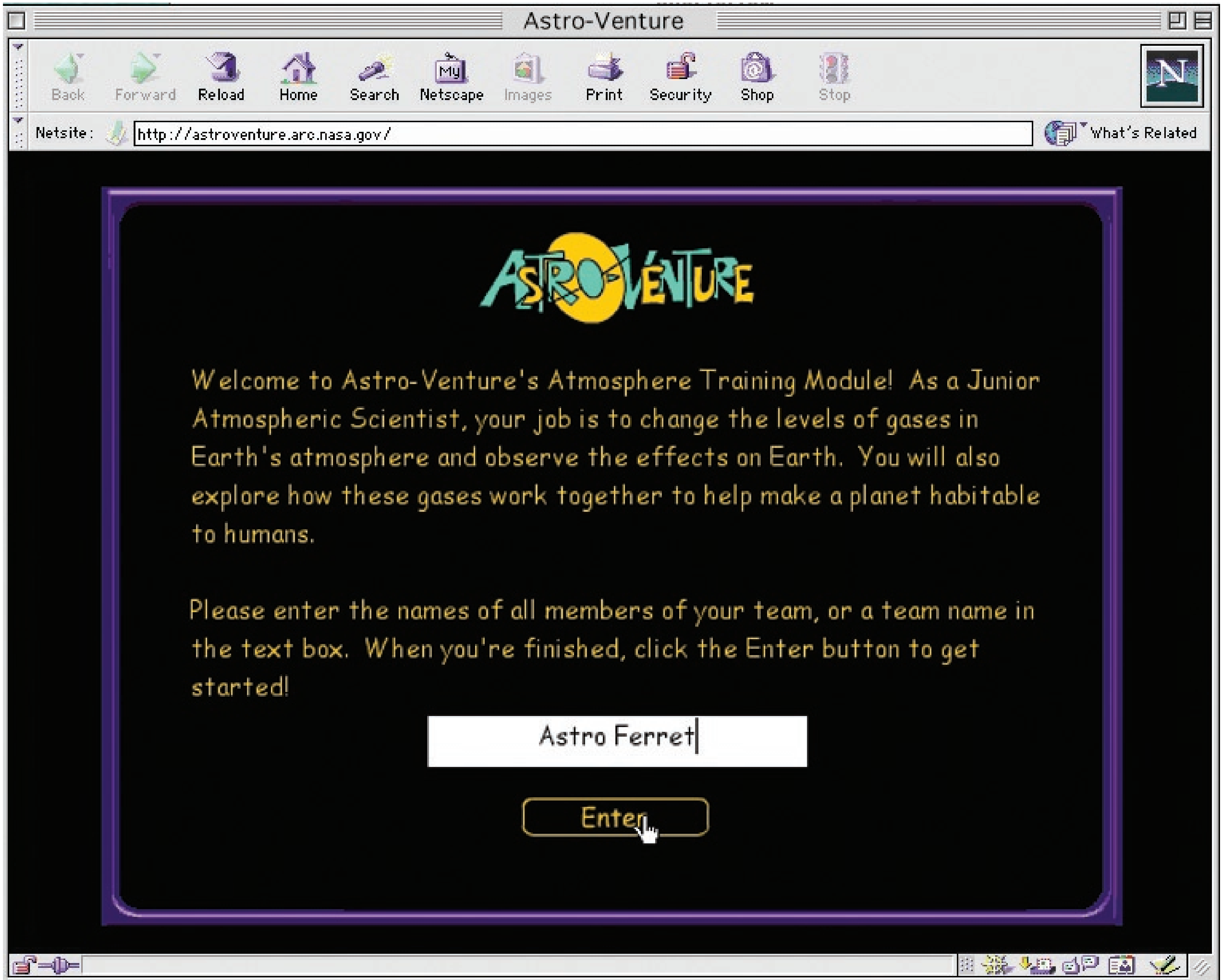
Astro-Venture

Atmospheric Science

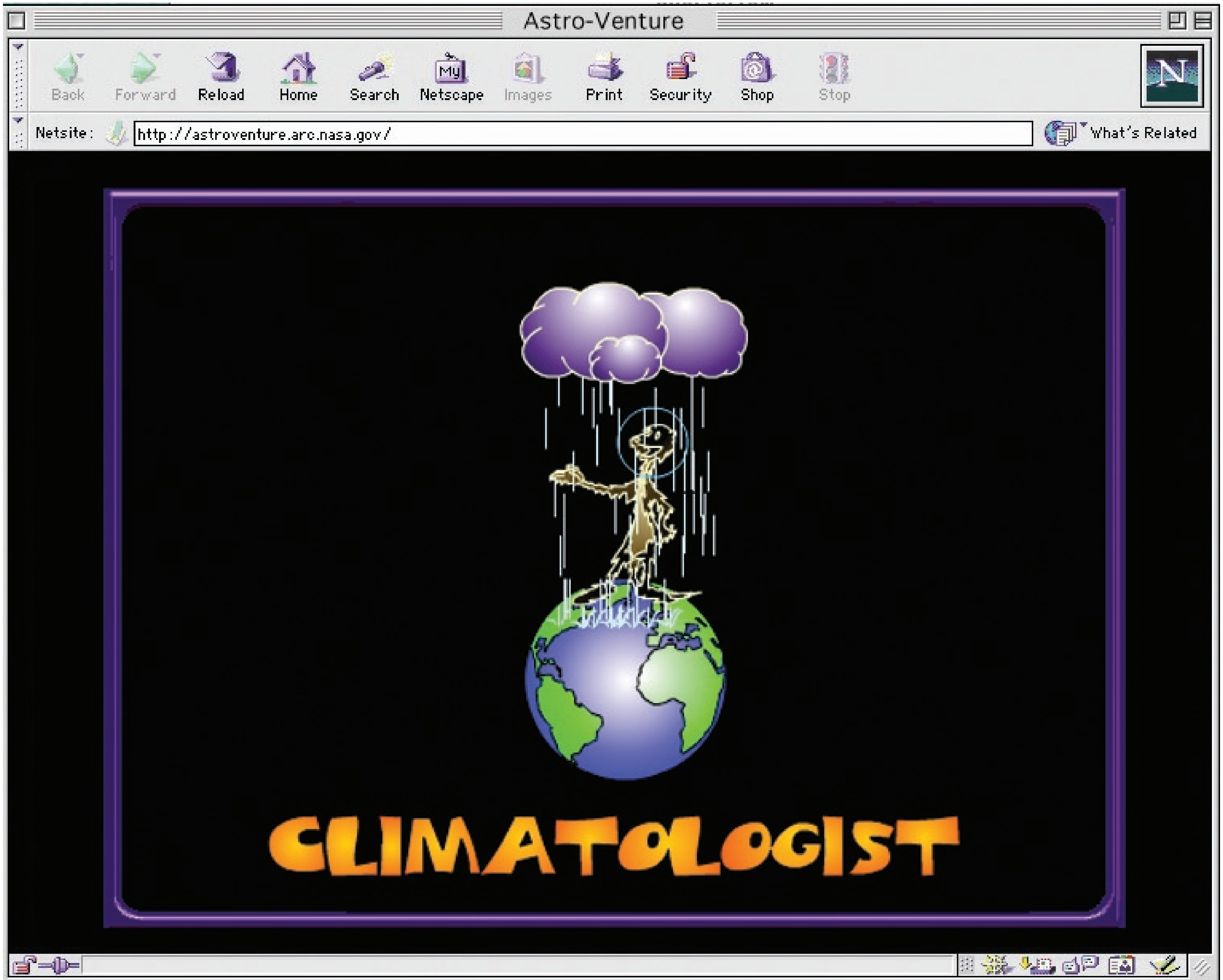
Educator Guide

Screen Shots

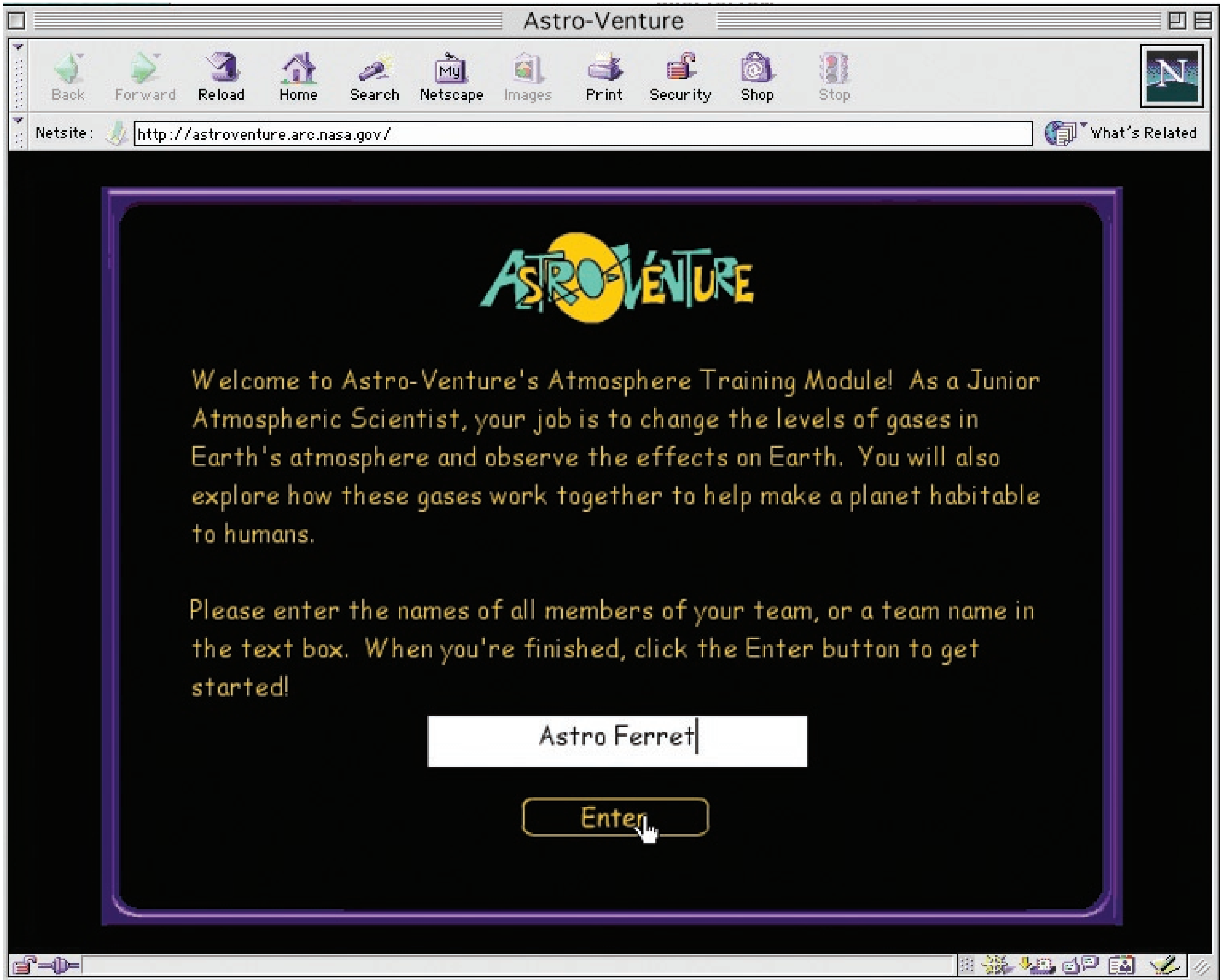
www.nasa.gov http://astroventure.arc.nasa.gov



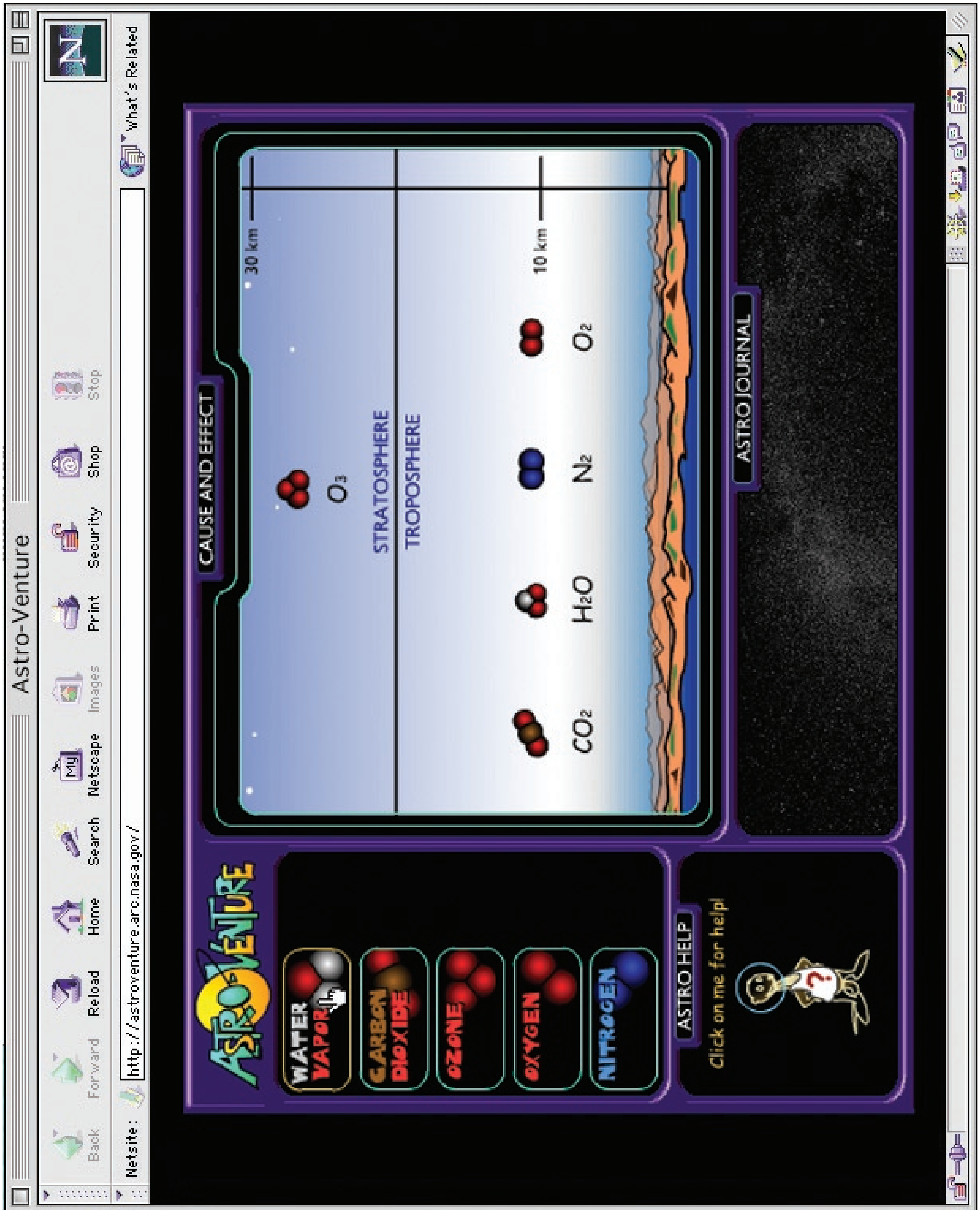
1. Press start to begin Training Module.



2. Astro Ferret Introduction featuring NASA careers.

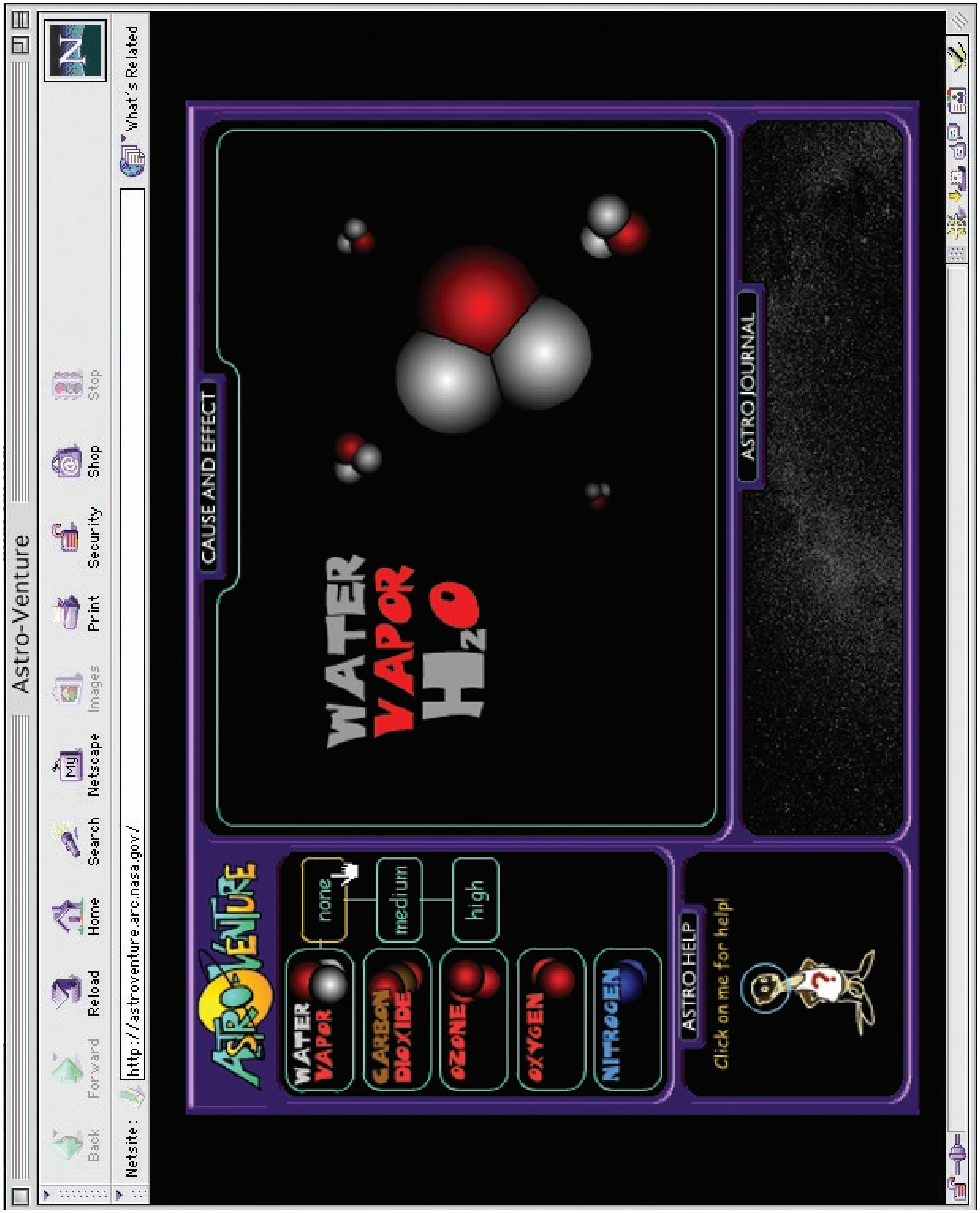


3. Enter your name or your team's name.

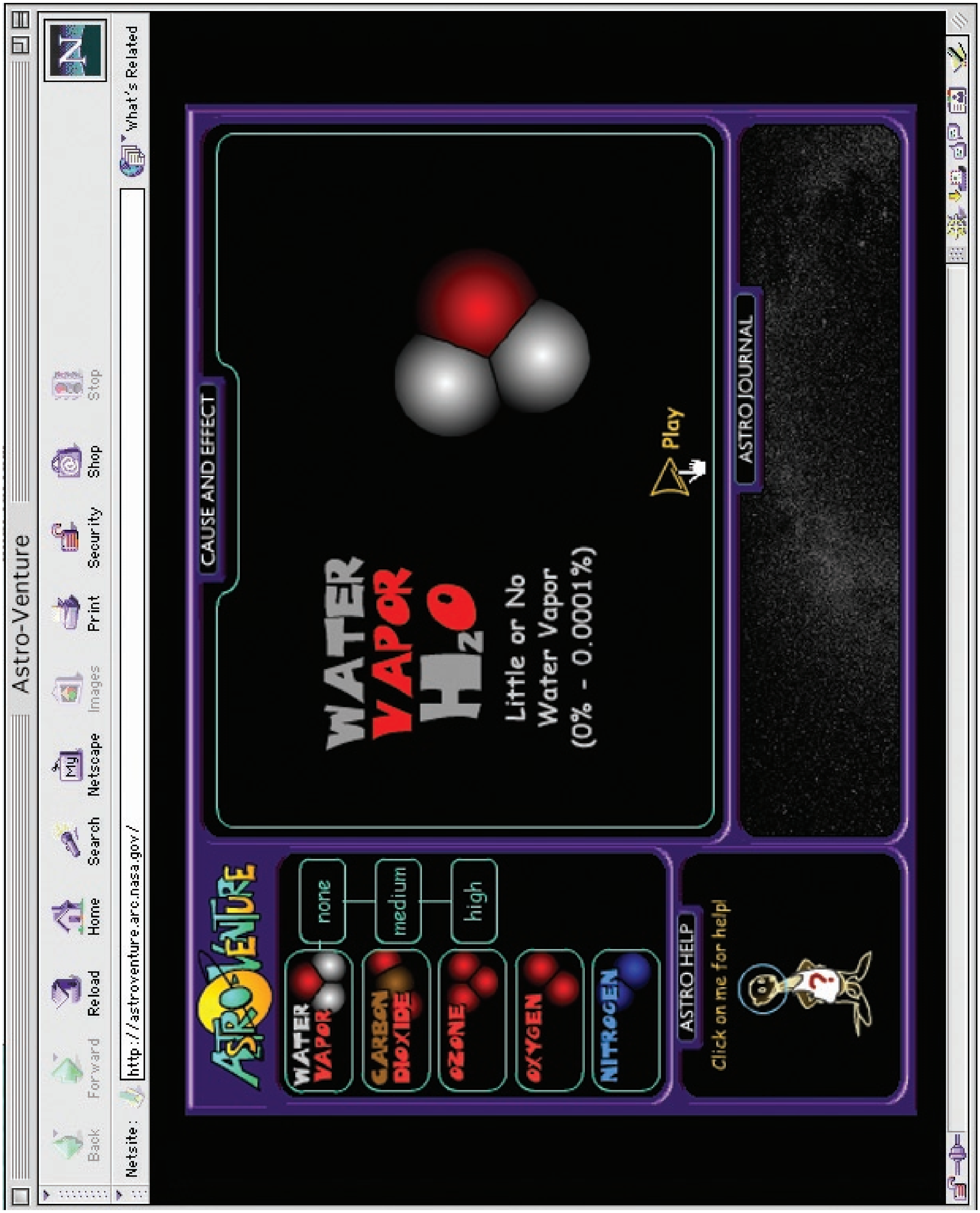


4. Astro Ferret introduces the Atmospheric Science module.

4A. Select a feature such as "Water Vapor."

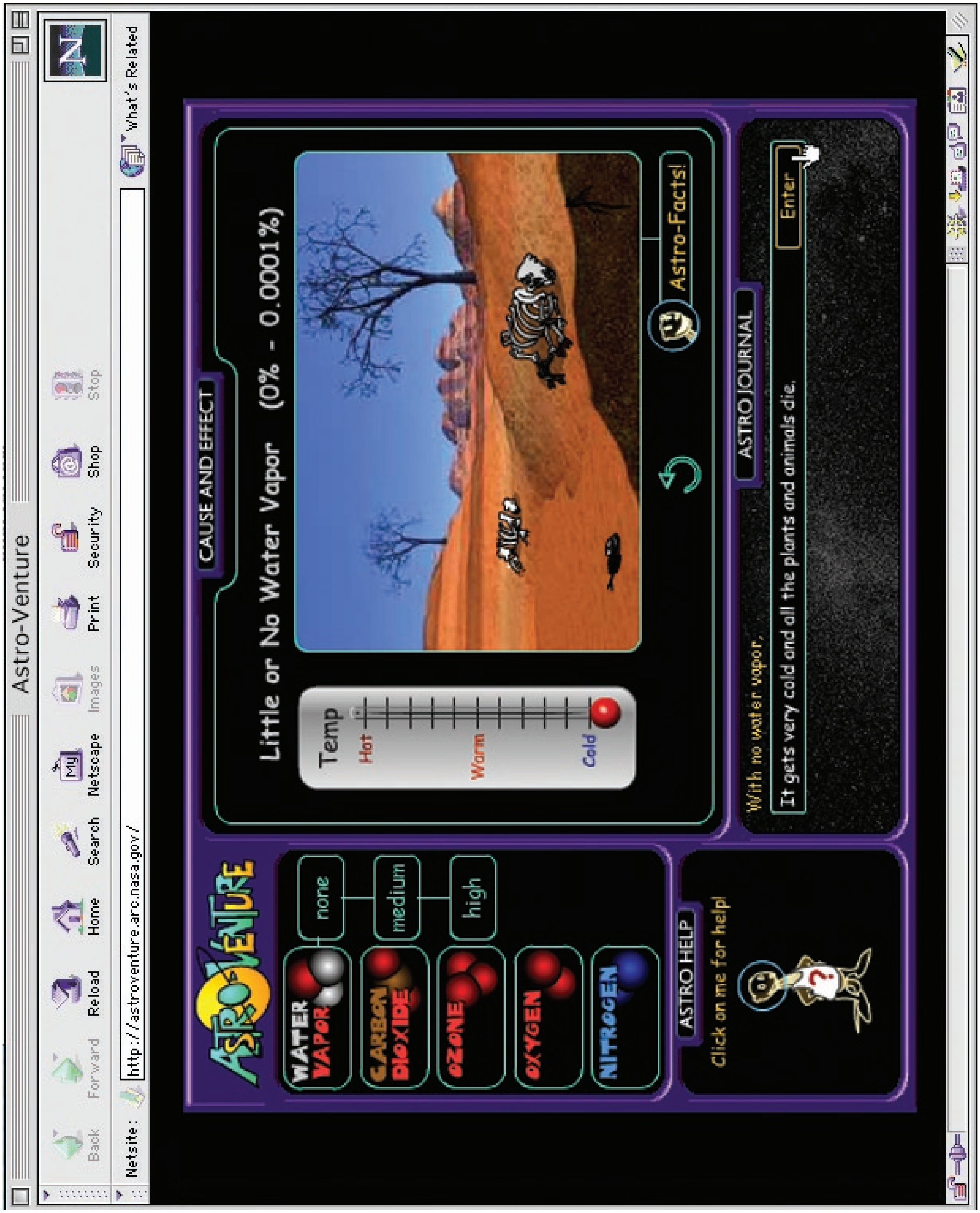


4B. Select a submenu such as "None" to cause a change in our Earth's atmosphere.



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

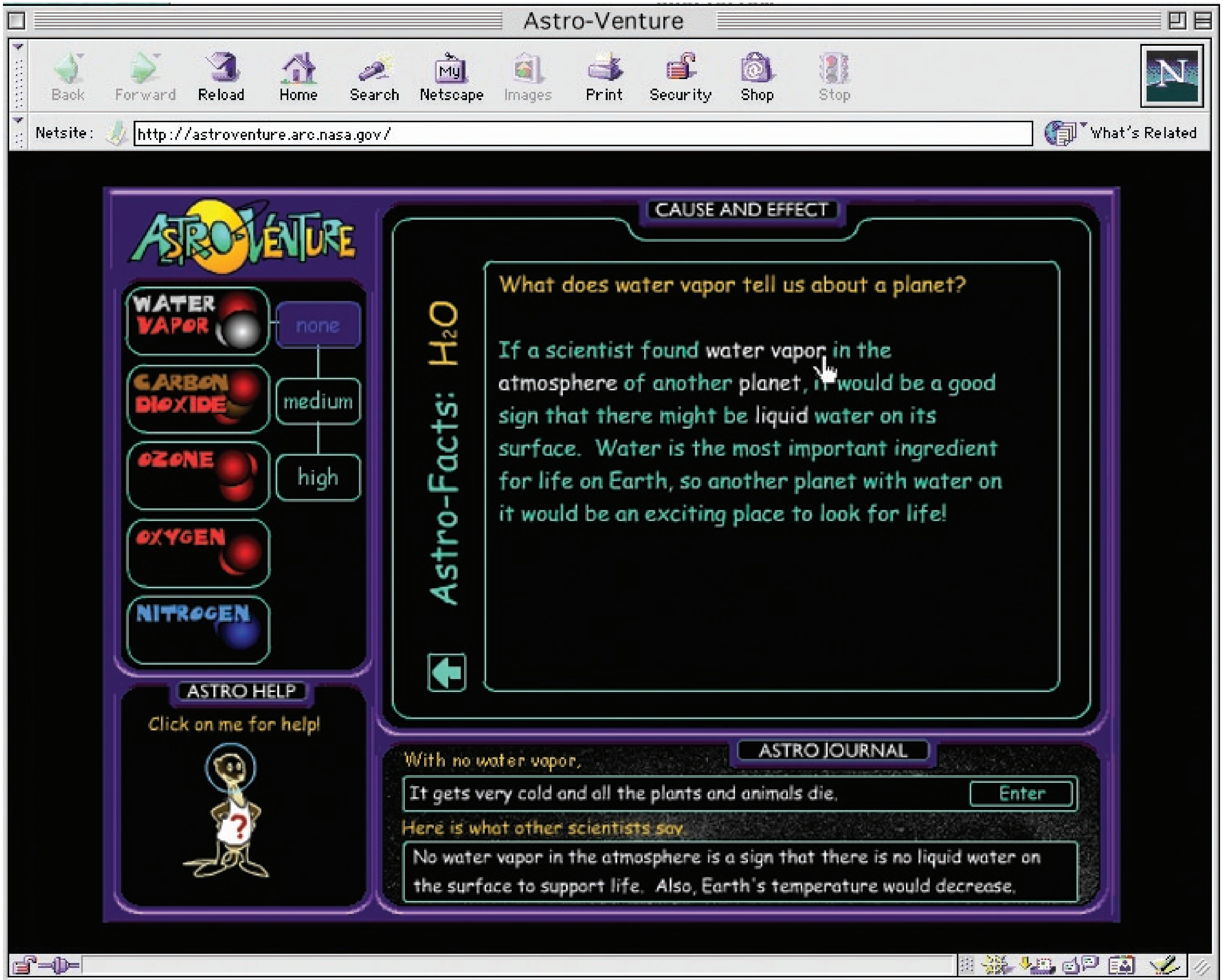
The "Replay" button can be clicked repeatedly to view effect on Earth again.



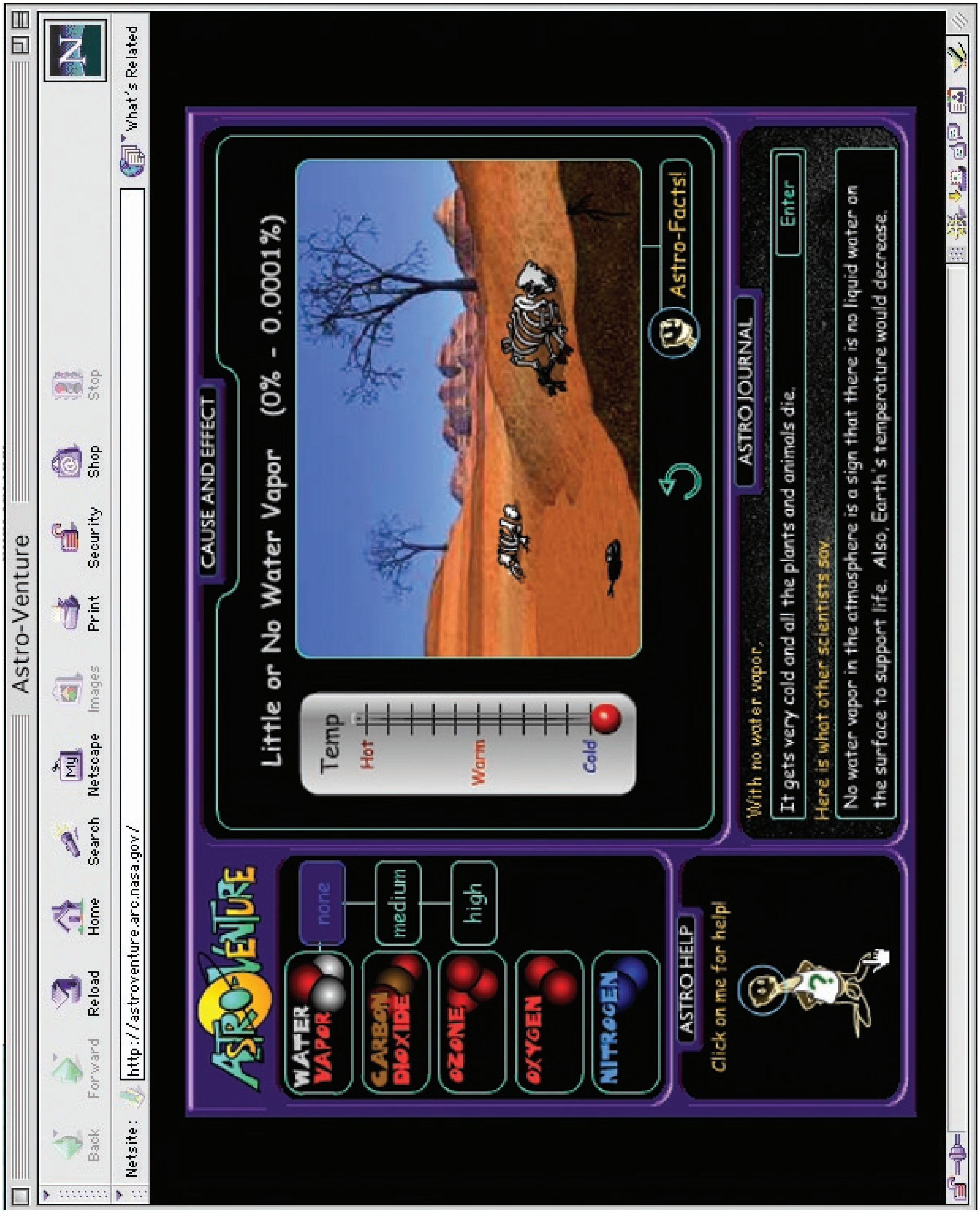
4D. Record what you observe in your Astro Journal.

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

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



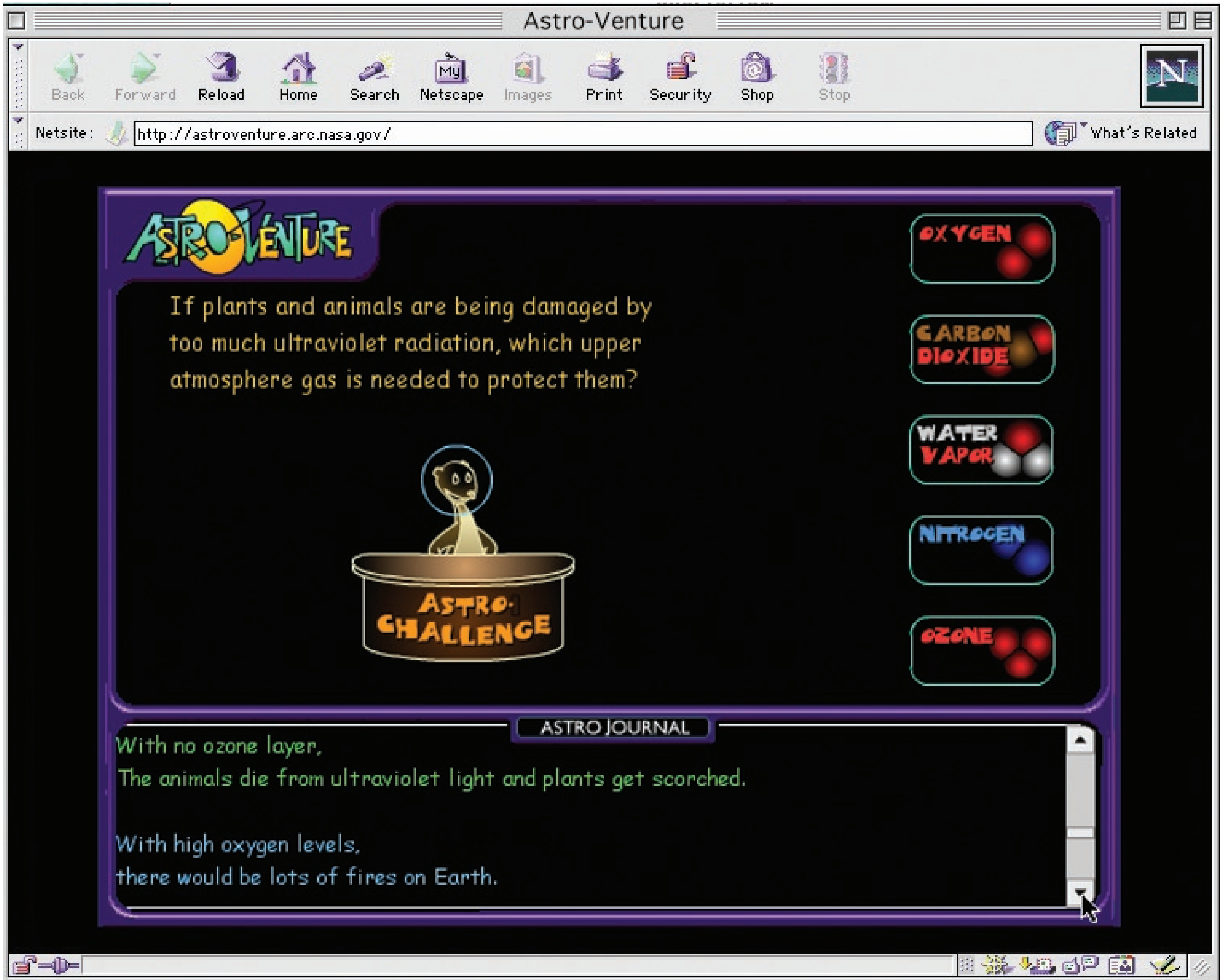
4G. Click on highlighted words in the Astro Facts for glossary definitions.



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

4I. Continue using steps 4A throu 4H for all other features and submenus and record your observations. (Buttons will turn purple once you have completed that 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. **Astro Challenge. Be sure to use your notes in your Astro Journal to help you.**

7. You can print your certificate, and Astro Journal.