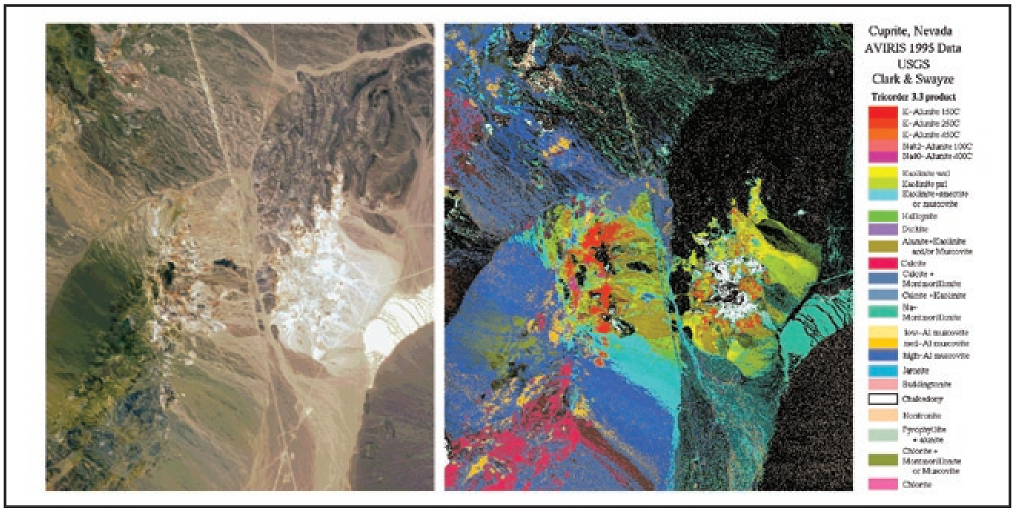
Lesson 13: Astronomy Mission Module



Spectrometer mapping of the Mineralogy and Lithology of Canyonlands, Utah; USGS

Students use an online, multimedia module to simulate the techniques that scientists might use to find a star system and planet that meet the astronomical conditions required for human habitability. Students then summarize their learning from this unit in a final project.

Main Lesson Concept:
Scientists use methods such as spectroscopy, Doppler Shift, photometry and Kepler's Third Law: to collect data from a star. They then interpret this data to determine if the star system has the astronomical conditions required for human habitability.

Scientific Question:
What are the chances that there is a star system other than our own that has the astronomical conditions required for human habitability? Explain.

Objectives	Standards
• Students will use scientific inquiry to describe the process scientists use to find a star system that has the astronomical conditions required for human habitability. • Students will compare and analyze data to find a star system that meets the astronomical conditions required for human habitability.	**Addresses:** 2061: 1B (6-8) #1 NSES: A (5-8) #1 NCTM: 5, 9 ISTE: 3, 5, 6

Assessment	Abstract of Lesson
Write-up in Astro Journal, printout of Astronomy Mission Newspaper Article.	Students predict the chances of finding another star system with the astronomical conditions required for human habitation. They engage in an online Astronomy Mission module in which they simulate the methods scientists might use to find a star system with these characteristics. They then describe this process.

Prerequisite Concepts	Major Concepts
• Humans need food, water and a moderate temperature in order to survive. (Lesson 1) • The following characteristics allow Earth to remain habitable to humans: – A yellow star; – Any Jupiter-size planets must be in a circular orbit beyond three astronomical units (AU); – An Earth-size planet of a mass that is between one-fourth and four times Earth's mass; – The orbit of the Earth-size planet is in the Habitable Zone. (Lesson 2) • Scientists categorize stars by their temperature and brightness or luminosity. (Lesson 9) – Stars in the middle of the main sequence on the HR Diagram (yellow stars) are ideal for human life, as they burn at a moderate temperature that remains relatively stable over time. (Lesson 9) • The Habitable Zone is the distance from a star where liquid water can exist on a planet's surface at all times. (Lesson 9) • The amount of atmosphere on a planet depends on the planet's gravity, which is determined by the planet's mass. (Lesson 11) • If Jupiter were in an elliptical orbit at 1 AU, it could cause a change in Earth's orbit, which would have consequences for the planetary temperature system. (Lesson 12)	• Scientists define a scientific question for study, make a hypothesis based on this question, collect data to answer the question, report their results and draw conclusions. • Scientists can use spectroscopy to locate yellow stars. • Scientists can use Doppler Shift to detect Jupiter-size planets in an elliptical orbit. • Scientists can use photometry to detect Earth-size planets. • Scientists can use Kepler's Third Law to determine if any Earth-size planets are orbiting in the Habitable Zone. • Spectral data, graphs and measurements are the types of data that astrophysicists can collect using their instruments. This data is then interpreted for meaning.

Suggested Timeline (45-minute periods):

Day 1: Engage and Explore – Part 1 sections (35 minutes)
Day 2: Explore – Part 2 section
Day 3: Explain and Extend/Apply sections
Day 4: Evaluate section (25 minutes)

Materials and Equipment:

- A class set of Astro Journals Lesson 13: Astronomy Mission Module and Astrobiology Missions Activity
  (Most of this is optional, as it will be completed online; however, you will need the Description section).
- Astronomy Mission Walkthrough (optional)
- 1 to 30 computers with Internet browser, Internet connection and the Shockwave Player, version 8.5 or later, installed
- A printer connected to the computers
- Chart Paper
- ”Y” cables (optional, used for student pairs)
- headphones

Preparation:

- Duplicate a class sets of Astro Journals.
- Download and install Shockwave Players on computers from http://www.macromedia.com/downloads. Test these at http://astroventure.arc.nasa.gov by clicking "Astronomy Mission."
- Test Astrobiology Mission links to make sure sites are current. If they are not, research other sites using provided NASA resources.
- Prepare and post chart paper with major concept of the lesson and human survival needs.
- Gather headphones and "Y" cables.
- Duplicate class set of Lesson 13: Astronomy Mission Module and Astrobiology Missions Activity.

* A generic Astro Journal and Scientific Inquiry Rubric are included at the end of Lesson 1. If you prefer, you can have students use the generic Astro Journal instead of the ones designed to go with each lesson. This might be especially useful for older students who are already familiar with the inquiry material.

System Requirements to Run Astronomy Mission 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 that may need more guidance.
- Encourage students to talk about what they are learning, as they go through the computer activity.

Advanced Extensions

Research and report on the methods used to find planetary systems outside of our Solar System.

- How were these planets detected?
- What are the characteristics of these systems?
- Do any of the planets detected outside of our star system meet the astronomical conditions required for human habitability? Explain.

Engage

(approximately 15 minutes)

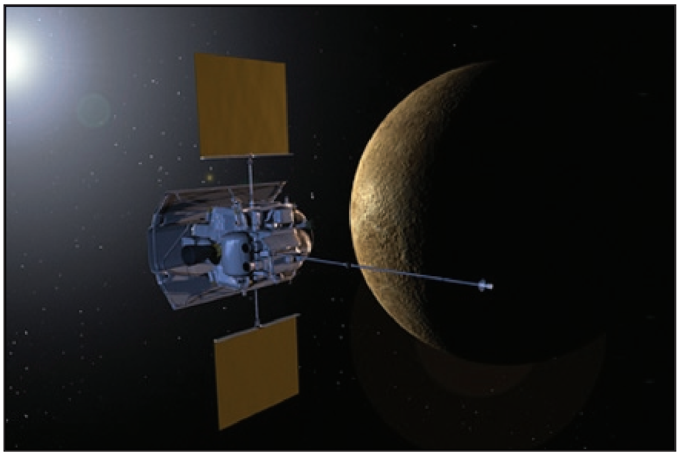


Illustration of Mercury Surface, Space Environment, Geochemistry, and Ranging (MESSENGER) spacecraft in orbit at Mercury; NASA

1. Review Part 3.

- Question: What have we learned are the necessary astronomical conditions for human habitability?
- *Answer: The following astronomical characteristics allow a planet to remain habitable to humans:*
  - *A yellow star.*
  - *No Jupiter-size planets or any Jupiter-size planets in a circular orbit beyond three astronomical units (AU).*
  - *An Earth-size planet of a mass that is between one-fourth and four times Earth's mass.*
  - *The orbit of the Earth-size planet is in the Habitable Zone.*

- Question: Why do we need these astronomical conditions?
- *Answer: The temperature of a star and the orbital distance of a planet work together to maintain a moderate temperature on a planet so that water can be present in liquid form at all times. The mass of a planet determines how much of an atmosphere the planet has, which also contributes to maintaining a moderate temperature on the planet. No Jupiter-size planets or other large objects can interfere with the stability of this system.*

2. Introduce the purpose of the lesson.

- Say: Now that we know what astronomical conditions are needed for human habitability and why, we are now going to look at how scientists might go about finding such a system.

3. Bridge to this lesson.

- Question: What methods do you think scientists might use to look for a star system with the characteristics we have listed?
- *Answer: (Accept all answers. Students may suggest that scientists could use telescopes to look at stars. Use this as an opportunity to assess students' prior knowledge. Encourage students to discuss the kinds of information they think astrophysicists might be able to learn using a telescope. Ask them how they think scientists would determine a star's type or how they would detect any planets around a star. Ask students if scientists have found any planets outside of our star system and what these planets are like.)*

Note to Teacher: Over 70 planets have been found outside of our Solar System. Most of these are the size of Jupiter or larger. The smallest is about the size of Saturn. Thus far, scientists have used Doppler Shift to detect these planets. Doppler Shift is only effective in detecting large planets. The process of photometry described in Astronomy Mission used to detect Earth-size planets is a proposed method for future missions such as the Kepler Project. To learn more about this project, visit: http://www.kepler.arc.nasa.gov

- Say: A telescope is one instrument that astrophysicists and astronomers use to detect the light of stars so that we can learn more about them.

- Question: Are all telescopes the same?
- *Answer: There are many types of telescopes that can collect different kinds of radiation. The telescopes we usually think of collect visible light or the light people can see with their eyes. There are also telescopes that collect ultra-violet light, microwaves or other radiation that we can't see.*

- Question: Are telescopes the only instruments we can use to study stars?
- *Answer: No, there are other devices that scientists can attach to their telescopes to gather additional information. For example, scientists can attach a spectrometer to a telescope to determine the temperature of a star, or a photometer can be used to detect a change in a star's brightness. Often, astrophysicists collect many measurements and use math equations to find out other information about a star. Computers are also a very important tool that astrophysicists use.*

- Say: As Astro-Venture Senior Astronomers, you will be learning about some of the tools and methods scientists use to study stars. As you complete the online Astro-Venture Astronomy Mission module, it is your mission to find a star system that has the astronomical conditions required for human habitation.

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4. Present the Scientific Question for this lesson.

- What are the chances that there is another star system that meets the astronomical conditions required for human habitation? Why?

- Tell students that they will be completing the online Astronomy Mission module to search for a star system that meets the requirements necessary for human habitation.

Explore – Part 1

(approximately 15 minutes)

Scientists making Buoy repairs before sunrise in the Tropical Pacific Ocean; NOAA

1. Discuss students' predictions of what they believe are the chances that there is another star system that meets the astronomical conditions required for human habitation and why.

Note to Teacher: Students will be asked to enter their predictions and conclusions in the online module. If you complete the module as a whole class, you may want students to complete all sections of the Astro Journal: Lesson 13. This may also be useful if you want to reinforce the importance of data collection by having students write down the data, rather than simply letting the computer do it.

- Question: What do you think are the chances of finding another star system with the astronomical conditions required for human habitation?
- *Answer: (Accept all answers. Encourage students to give answers in a percentage format. You might have students vote on whether they think there is less than a 50% chance, a 50% chance, or more than a 50% chance of finding a star system with these conditions.)*

- What is your reasoning for giving this answer?
- *Answer: (Answers may vary. Students who feel that it is less likely that a star system with these conditions could be found may explain that in our own Solar System, only 1 out of 9 planets formed with the necessary conditions. Another argument might be that with so many requirements, it seems unlikely that we might find a planet that can meet them all. Students who feel that it is more likely that a star system with these conditions could be found may explain that since there are billions of stars, there is a high probability that at least one of them meets the requirements.)*

Note to Teacher: Scientists do not yet know the answer to this question. Drake's Equation is one method that scientists have identified for trying to calculate this probability. However, at this time we still do not have an accurate estimate of many of the variables in this equation. Therefore, scientists do not agree on the level of this probability. Some scientists, like those who work for Searching for Extra-Terrestrial Intelligence (SETI), believe there is a high probability of finding signs of other intelligent life like humans on other planets. Other scientists, like Peter Ward author of the book Rare Earth, believe that there is a low probability of finding complex life. Astrobiologists, in general, do agree that there is a good chance of finding microbial life, which they believe might be found in our own Solar System.

2. Introduce students to the Astro-Venture Astronomy Mission module.

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

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 or may not 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.**

- Tell students that now that they have completed their Astronomy Training, and understand what astronomical conditions are necessary for human survival and why, they will use Astro-Venture Academy instruments to search for a star system that has these astronomical conditions. They will need to eliminate star systems that don't meet the requirements until they find a system that has all of the necessary conditions.

- Tell students that as they go through this module, they will be Astro-Venture Senior Astronomers and will be using the scientific inquiry process. They will also have help from several NASA scientists.

- Before students begin the Astronomy Mission module, be sure to emphasize with them the importance of making up a password that includes the date and to write this down exactly as they enter it. This password will be required at the end to complete the module. A sample password for the date March 5 might be: nasamarch5.

Note to Teacher: Passwords will be periodically deleted from the database, so it will be important for students to complete the module within two weeks of having begun the module. The purpose of the password is to call up the teams' names and prediction at the end of the module for comparison with their conclusions. When students print out the final page with their predictions and conclusions, the names entered will let you know whose work it is. If students forgot their password or come back after their passwords were deleted, you may want to use a permanent password that we will keep in the database. This password is: av01astro This will allow students to complete the ending; however there will be no prediction entry or names on their final printable page.

- Tell students that they will be asked to switch players for each step. If they are in pairs or small groups, they should switch control of the mouse for each step.

Note to Teacher: The module relies heavily 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," which allow you to plug two pairs of headphones into one computer.

Explore — Part 2

(approximately 45 minutes)

Scientist collecting information from a Global Positioning System (GPS) station on Mount St. Helens; USGS

1. Have students engage in the Astronomy Mission module individually, in pairs, small groups or as a class.

Notes to Teacher:

- **You will need the Shockwave/Flash Player plug-in, which can be downloaded and installed from: http://sdc.shockwave.com/shockwave/download**

- **Also, you will want to have accessibility to a printer, so that students can print their Newspaper articles 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 Astronomy Mission Walkthrough as a guide.**

- **When this module was tested with students in grades 5 to 8, the average completion time was approximately 45 minutes. 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 Astronomy Training module, but is an enhancement added to the Astronomy Mission module.**

- **The Astronomy Mission module scenario is fictional, and all stars are fabricated. At the time this was written, we had yet to find any star systems outside of our own with Earth-size planets. However, the methods used are all authentic astronomy methods, and the procedure is a viable procedure, that with advances in astronomical instruments, could be used to find a habitable star system.**

Explain

(approximately 15 minutes)

Illustration of future astronaut gathering samples on the surface of Mars; NASA

1. Have students share their results and conclusions.

- Question: Did you find a star system with the necessary astronomical conditions for human habitability?
- *Answer: One star system was found with the necessary astronomical conditions for human habitability.*

- Question: What conclusions can you draw from this experience?
- *Answer: (Answers may vary) There are probably many star systems that do not meet the requirements to sustain human life. However, because there are so many stars, there probably is at least one that does. However, because there are so many stars, it can take a long time to study each one to find stars that do meet the requirements.*

- Say: The Astronomy Mission activity is a hypothetical situation. Scientists in fact do not know the probability of finding a star system with the conditions necessary for human habitation. However, many scientists do believe that there is a good chance that there is microbial life on other planets, and there are many missions planned to look for Earth-size planets and signs of life on other planets.

2. Have students complete the Description section of their Astro Journals.

Extend/Apply

(approximately 15 minutes)

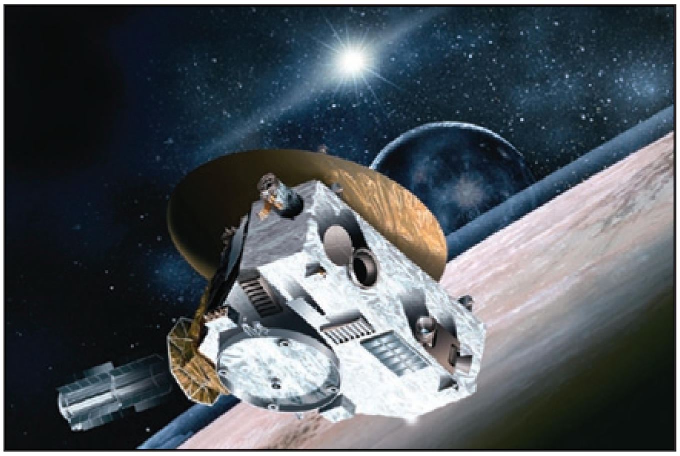

Illustration of New Horizons, a spacecraft with a mission to study Pluto and Charon; NASA

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

- Students visit NASA Web sites to research current astrobiology missions in which Earth-size planets, conditions for life, or life on other planets are being researched.

- Have students use the scientific inquiry process as outlined in the Astrobiology Missions section of their Astro Journals to explain how these missions will be carried out.

- New missions are being added all of the time, but a few missions that were planned at the time this lesson was written include:
  - The Kepler Mission: http://www.kepler.arc.nasa.gov
  - Space Interferometry Mission: http://sim.jpl.nasa.gov/
  - Next Generation Space Telescope: http://ngst.gsfc.nasa.gov
  - Terrestrial Planet Finder: http://tpf.jpl.nasa.gov

- Other useful Web sites include:
  - NASA Astrobiology Institute: http://nai.arc.nasa.gov
  - NASA Ames Astrobiology (Visit the Missions page): http://astrobiology.arc.nasa.gov
  - NASA Origins Program: http://origins.jpl.nasa.gov (Visit the Missions page)
  - NASA SpaceLink: http://spacelink.nasa.gov (search Astrobiology)
  - NASA Quest: http://quest.nasa.gov
    (See Astrobiology Press Releases under "In the News," or search the archives.)

- Students might also visit Internet search engines, and enter key words such as, "extra-solar planets," "astrobiology," or "exobiology."

Evaluate

(approximately 25 minutes)

Spacewalking astronaut at Shuttle payload bay; NASA

1. Have students share their descriptions of their own missions and other NASA missions using the scientific inquiry process to explain these missions.

- Question: What was the process that you used to find a star system with the astronomical conditions necessary for human habitation?
- *Answer: We predicted what the chances were of finding such a star. We then used:*
  - *spectroscopy to find yellow stars;*
  - *Doppler Shift to eliminate any stars that had Jupiter-size planets in an elliptical orbit;*
  - *photometry to find Earth-size planets;*
  - *Kepler's Third law to determine if the Earth-size planets were orbiting in the Habitable Zone.*
  - *Finally, we recorded our results and drew conclusions about what our results mean.*

- Question: From this activity, what have you learned are the important parts of the scientific inquiry process?
- *Answer: It is important to have a good scientific question to explore. It is also important to make an educated guess about what you believe the answer to this question will be. Then it is important to collect data that will help to answer this question. Whether or not your prediction was correct is not important. Either way you learn something and can draw important conclusions.*

- Question: Does the process end with these conclusions?
- *Answer: No, often what we learn from one mission brings up new questions, which inspire new investigations.*

- Question: What new questions does this discovery raise?
- *Answer: (Answers may vary, but hopefully students will raise the question: Does this planet meet other requirements for human habitation?)*

2. Bridge to the next lesson.

- Discuss whether the planet located is definitely habitable.

- Question: Is the planet we located definitely habitable to humans?
- *Answer: The planet meets the astronomical conditions; however, it may not meet other requirements. For example, we do not know if the planet has water, oxygen, food, and protection from radiation and poisonous gases.*

- Question: How might we find out if this planet meets other requirements for human habitability?
- *Answer: In order to find out if this planet meets other requirements for human habitability we would need to study the planet further.*

3. Tell students that in the next lesson they will need to convince others at the Astro-Venture Academy that further exploration of their planet is worthwhile.

4. Collect Newspaper Articles and Astro Journals and evaluate them using the Scientific Inquiry Evaluation Rubric to make sure students are ready for the next lesson.

In particular, assess students understanding of the scientific inquiry process.

Note to Teacher: After each lesson, consider posting the main concept of the lesson some place in your classroom. As you move through the unit, you and the students can refer to the 'conceptual flow' and reflect on the progression of the learning. This may be logistically difficult, but it is a powerful tool for building understanding. For this lesson, the chart of what is needed and why those conditions are needed should also be posted

Astro Journal Lesson 13: Astronomy Mission Module

Name _______________________________ Date ______________ Class/Period ___________________

Scientific Question:
What are the chances that there is a star system other than our own that has the astronomical conditions required for human habitability? Explain.

1. Hypothesis/Prediction: What do you think are the chances that there is a star system other than our own that has the astronomical conditions required for human habitability? Explain.

2. Materials: What source will you use to gather data that will help answer this question?

3. Data Collection: The following may be recorded online. However, you may use the following chart to record your observations. As you analyze each star, place an X next to "Habitable" or "Uninhabitable." On each step, cross out the stars that were "Uninhabitable" in the previous step.

Step 1: Spectroscopy

Astro Table	Alisan	AlphaL	Amberix	Conrad8	DJRex	Dozeria	GRTIO	4X-Tina	R-Sim2	8Terion	Marchel	Wilmo4
Habitable												
Uninhabitable												

Step 2: Doppler Shift

Astro Table	Alisan	AlphaL	Amberix	Conrad8	DJRex	Dozeria	GRTIO	4X-Tina	R-Sim2	8Terion	Marchel	Wilmo4
Habitable												
Uninhabitable												

Astro Journal Lesson 13: Astronomy Mission Module

Name ________________________________ Date _______________ Class/Period ____________________

Step 3: Photometry

Astro Table	Alisan	AlphaL	Amberix	Conrad8	DJRex	Dozeria	GRTIO	4X-Tina	R-Sim2	8Terion	Marchel	Wilmo4
Habitable												
Uninhabitable												

Step 4: Kepler's Third Law

Astro Table	Alisan	AlphaL	Amberix	Conrad8	DJRex	Dozeria	GRTIO	4X-Tina	R-Sim2	8Terion	Marchel	Wilmo4
Habitable												
Uninhabitable												

5. **Results:** Out of the 14 stars you analyzed, how many had the astronomical conditions required for human habitability? Name the star(s).

6, **Conclusions:** What can you conclude from these results? Compare and contrast your prediction and results. How did conducting the research change your original ideas?

7. **Description:** Write a paragraph (on the back of this page) describing the process that you used to find a star system that has the astronomical conditions required for human habitability. Be sure to include all parts of the scientific inquiry process.

Astrobiology Missions Activity

Name: ______________________________

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.

- New missions are being added all of the time, but a few missions that were planned at the time this lesson was written include:
  - The Kepler Mission: http://www.kepler.arc.nasa.gov
  - Space Interferometry Mission: http://sim.jpl.nasa.gov/
  - Next Generation Space Telescope: http://ngst.gsfc.nasa.gov
  - Terrestrial Planet Finder: http://tpf.jpl.nasa.gov

- Other useful Web sites include:
  - NASA Astrobiology Institute: http://nai.arc.nasa.gov
  - NASA Ames Astrobiology (Visit the Missions page): http://astrobiology.arc.nasa.gov
  - NASA Origins Program: http://origins.jpl.nasa.gov (Visit the Missions page)
  - Planet Quest: http://planetquest.jpl.nasa.gov
  - NASA SpaceLink: http://spacelink.nasa.gov (search Astrobiology)
  - NASA Quest: http://quest.nasa.gov
    (See Astrobiology Press Releases under "In the News," or search the archives.)

Title of the mission:
Web site address where information on this mission was found:
Scientific question being studied by this mission (What are scientists trying to learn?):
Scientific hypothesis (What do scientists think they will find on this mission?):

Materials and instruments scientists will use to gather data:
Methods and procedure scientists will use to gather data:
If the mission is completed, report the results that were found.
If the mission is completed, what conclusions did scientists draw?

Astronomy Mission Walkthrough

The following is an explanation of each section of Astronomy Mission. It offers suggestions for how you might take a whole class through the module, if you only have one computer with the ability to project. Audio is crucial to this module, so you will want to have a computer with speakers.

Introduction

- Students will be asked to enter a password from Astronomy training (av2002astro) or to answer the four questions from Training to ensure that they know the astronomical conditions required for humans.
- Astro Ferret will give an introduction to Astronomy Mission. Have students listen to this introduction. The arrow in the bottom left corner will allow you to replay each screen. The bottom right arrow allows you to advance to the next screen.

Note to Teacher: When this module was tested with students in grades 5 to 8, the average completion time was approximately 35 minutes. You should be able to complete the activity in a class period. However, if you do not complete the module, it is possible to come to where you left off by either writing down the URL of the page you are on, or by bookmarking the page and writing down the name of the bookmark. This is NOT possible in the Astronomy Training module, but is an enhancement added to the Astronomy Mission module.

- On the prediction page, make up a password for the class that includes the date. Write down this password, as you will need it again at the end of the module.

- If students complete this module in pairs or small groups, we encourage each student to enter their first name. However, when completing this as a whole class, we suggest entering a name such as “Mrs. Jones’ class.”

Note to Teacher: Passwords will be periodically deleted from the database, so it will be important for students to complete the module within two weeks of having begun the module. The purpose of the password is to call up the teams’ names and predictions at the end of the module for comparison with their conclusions. When students print out the final page with their predictions and conclusions, the names entered will let you know whose work it is.

- Ask students what they predict are the chances that there is another star system that meets the astronomical conditions for human survival and why. Enter a prediction that is agreeable to the class.

- Once the class has completed all fields, click “Enter.”

- Astro Ferret will explain the materials and procedure that students will use on their mission.

Step Animations

- There are four steps in the Astronomy Mission:
  1. Using Spectroscopy to Determine a Star's Type
  2. Using Doppler Shift to Detect Jupiter-Size Planet's in an Elliptical Orbit
  3. Using Photometry to Detect Earth-Size Planets
  4. Using Kepler's Third Law to Determine if Earth-Size Planets are in the Habitable Zone

Note to Teacher: The concepts presented in Astronomy Mission are simplified for this grade level and are largely supplied as background information. Although students are shown how the data is derived and what it means, students in this grade range are not expected to understand the complexities of how these data collection methods work. The activity requires them to compare data and to draw conclusions about what the data mean, which students have been able to do very successfully in the user testing we conducted.

- Each step begins with an animation in which a NASA expert and Astro explain the scientific technique featured in each step. They show how scientists use this technique to gather data, what this data looks like, what it means and how scientists interpret this data.

- To begin each step, Astro will introduce the NASA expert.

- The expert and Astro will go through a sequence of animations that will show how the data is derived and what it means. When an expert asks Astro a question, you may want to pose the same question to the class to assess their understanding of the concepts.

- "Link to Script" will bring up a window with the full script of all dialogue spoken in each step.

- "Tech Notes" will bring up a window with a summary of the main concepts in each step.

- "Career Fact Sheet" will bring up a printable PDF file with the career fact sheet of the specialist for that step.

Step Activities

- Following the animation, students engage in an interactive activity in which they apply the concepts they have just learned. You may wish to have students take turns coming up to the computer to analyze each star system.

- Click a star that has a teal circle around it.

- The Star Data shows the data collected from that star.

- The Reference Chart shows the different data types possible and what is meant by each of the data. Click the arrows to see each possible data type.

- The questions ask students to interpret the data and decide whether the star system is habitable or not. Click the circle next to the answer you wish to select.

- Click "Notes" to see the Tech Notes summary of the concepts for each step.

- Click "Hint #1" for help on how to decide what the data mean.

- Click "Hint #2" for help on deciding whether the star system would be habitable or not.

- Once students answer the questions correctly, the star will be checked off as completed and will be recorded as "habitable" or "uninhabitable" in the Astro Table.

- When students correctly analyze all stars, they will be congratulated and advanced to the next step.

- For steps, 2, 3 and 4, students will be alerted that the stars eliminated from the previous step will be removed from the screen. Subsequently, there will be fewer stars to analyze for each additional step.

- The stars that are eliminated at each step are as follows:

Step 1: Spectroscopy

Astro Table	Alisan	AlphaL	Amberix	Conrad8	DJRex	Dozeria	GRTIO	4X-Tina	R-Sim2	8Terion	Marchel	Wiomo4
Habitable		X	X		X	X	X	X	X	X	X	
Uninhabitable	X			X								X

Step 2: Doppler Shift

Astro Table	Alisan	AlphaL	Amberix	Conrad8	DJRex	Dozeria	GRTIO	4X-Tina	R-Sim2	8Terion	Marchel	Wiomo4
Habitable			X		X	X	X			X	X	
Uninhabitable		X						X	X			

Step 3: Photometry

Astro Table	Alisan	AlphaL	Amberix	Conrad8	DJRex	Dozeria	GRTIO	4X-Tina	R-Sim2	8Terion	Marchel	Wiomo4
Habitable			X			X					X	
Uninhabitable					X		X					

Step 4: Kepler's Third Law

Astro Table	Alisan	AlphaL	Amberix	Conrad8	DJRex	Dozeria	GRTIO	4X-Tina	R-Sim2	8Terion	Marchel	Wiomo4
Habitable											X	
Uninhabitable			X			X						

Conclusion

- After successfully completing the last step, Astro will ask students to enter their password that they chose at the beginning. This must be typed exactly as it was originally entered. Click "Enter."

Note to Teacher: If students forgot their password or come back after their password was deleted, you may want to use a permanent password that we will keep in the database. This password is: av01astro This will allow students to complete the ending; however there will be no prediction entry or names on their final printable page.

- Students will see their prediction that they entered at the beginning. They will be asked to enter their conclusion and to name their planet. Click "Enter."

- Students will see a newspaper article written about them that will include their names, the name of their planet, their original prediction and final conclusions. The article summarizes the process the students went through to locate a star system with the astronomical conditions required for human habitability. Read this article with the class.

- Print out a copy of this article by going to the "File" menu of your browser and selecting "Print."

- Discuss whether the planet located is definitely habitable.

  – Question: Is the planet we found definitely habitable to humans?
  – *Answer: The planet meets the astronomical conditions; however, it may not meet other requirements. For example, we do not know if the planet has water, oxygen, food, and protection from radiation and poisonous gases.*

  – Question: How might we find out if this planet meets other requirements for human habitability?
  – *Answer: We would need to study the planet further.*

- Click the trading card link to bring up the printable trading cards of the experts in this module.

- Click the arrow to go to the final page, which explains that further study of this planet will need to be conducted in additional Astro-Venture modules.

Lesson 14: Final Project

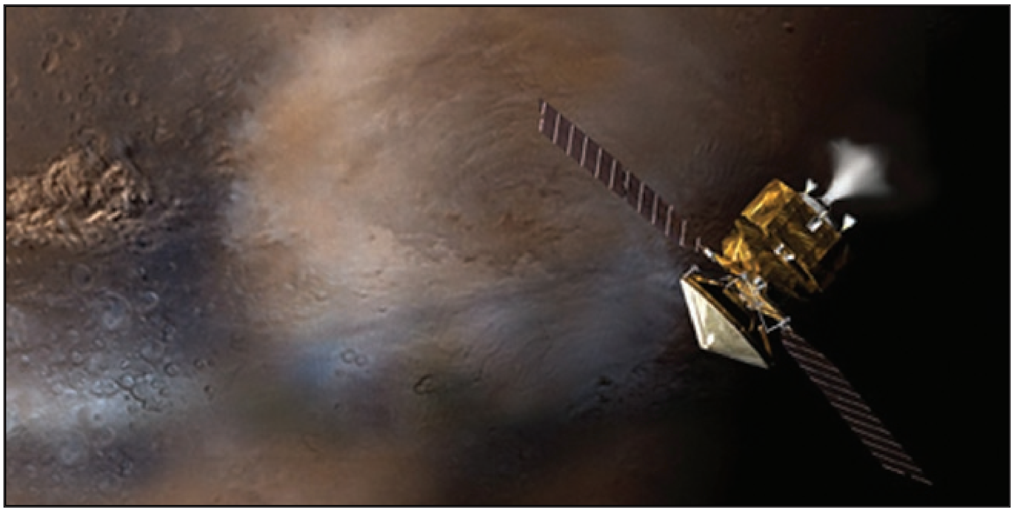

Illustration depicting Mars Reconnaissance Orbiter going into orbit around the Red Planet; NASA

Students use an online, multimedia module to simulate the techniques that scientists might use to find a star system and planet that meet the astronomical conditions required for human habitability. Students then summarize their learning from this unit in a final project.

Main Lesson Concept:

The astronomical requirements for habitability are not sufficient for sustaining human life on a planet. Additional requirements must be met to sustain human life on a planet.

Scientific Question:

What other requirements must a planet meet to be habitable to humans and how might a scientist determine if a planet meets these requirements?

Objectives	Standards
Students will write a proposal to convince the “World Science Foundation” that the star and planet they found is worthy of further study and exploration. They will include a description of how the planet meets astronomical requirements for human habitability, additional requirements that must be met, the benefits of conducting this study and the type of further study they would recommend for determining if the planet meets these additional requirements.	**Meets:** NSES: A (5-8) #1

Assessment	Abstract of Lesson
Write-up of Proposal	Students discuss what they know about the astronomical conditions of the planets they have found and what they still need to know in order to determine if it is habitable to humans. They research possible methods for answering these questions and write a proposal on how and why their planet should be further researched.

Prerequisite Concepts	Major Concepts
• Humans need water, oxygen, food, gravity, a moderate temperature and low levels of poisonous gases and high levels of radiation to survive. (Lesson 1) • The following astronomical characteristics address some of these requirements that help to make Earth habitable to humans: – A yellow star – Jupiter in a circular orbit beyond three astronomical units (AU). – An Earth-size planet of a mass that is between one-fourth and four times Earth's mass – The orbit of the Earth-size planet is in the Habitable Zone. (Lesson 2)	From the astronomical requirements met by the planet located in Lesson 13, we can draw the following conclusions: • The planet is likely to have enough gravity for our biological systems to operate normally • The planet is likely to have a moderate temperature necessary for human survival and to maintain water in a liquid state. However, we do not know if the planet has food, oxygen, water, low levels of poisonous gases and protection from high levels of radiation. We do not even know if the planet has an atmosphere and the right amount of gases in the atmosphere to maintain a moderate temperature. • Further study of the planet, using powerful, space-based telescopes, interferometry and spectroscopy are necessary. Sending probes to the planet would give us more precise data. • Study of habitable planets can help us better understand Earth and can help us to conclude whether life on Earth is unique.

Suggested Timeline (45-minute periods):

Day 1: Engage and Explore sections
Day 2: Explain and Extend/Apply sections
Day 3: Evaluate section (one half of class presentations)
Day 4: Evaluate section (one half of class presentations)

Materials and Equipment:

- A class set of Astro-Venture Proposal Guidelines
- Human Needs Chart from Lesson 1
- 1 to 30 computers with Internet browser and Internet connection
- Chart Paper

Preparation:

- Duplicate class sets of Astro-Venture Proposal Guidelines.
- Test Astrobiology Mission links to make sure sites are current. If they are not, research other sites using provided NASA resources.
- Prepare chart paper with major concept of the lesson to post at the end of the lesson.
- Duplicate and post the Human Needs Chart: Lesson 1

Differentiation

Accommodations
For students who may have special needs:
- Pair more advanced students with students that may need more guidance.
- Evaluate students on oral presentations of proposals.

Advanced Extensions
Research and report on current methods used to power a probe to another planet or location in our Solar System.
- How fast do these probes travel?
- How is their direction controlled?
- How is their data collection controlled?
- What would be the advantages and disadvantages of using these techniques to send a probe outside of our Solar System?

Engage

(approximately. 15 minutes)

Eating dinner in microgravity aboard the Space Shuttle; NASA

1. Review requirements for human survival from Lesson 1 and overall Astro-Venture goal.

- Question: What is the overall goal we've been working on at the Astro-Venture Academy?
- *Answer: At the Astro-Venture Academy, we are studying and trying to find another planet that would be habitable to humans.*

- Question: What are the basic human survival needs that this planet must meet?
- *Answer: (Refer students to the posted chart of human needs from Lesson 1.) We need water, oxygen, food, gravity, a moderate temperature and low levels of poisonous gases and protection from high levels of radiation to survive.*

2. Review Lesson 13 and bridge to Lesson 14.

- Question: In your Astronomy Mission you located a star system and planet. What characteristics does this star system have?
- *Answer: The star system has a yellow star, a Jupiter-size planet in a circular orbit beyond three AU, and an Earth-size planet orbiting in the Habitable Zone.*

- Question: What do these characteristics tell us about the Earth-size planet in terms of its ability to support human life?
- *Answer: The star type, planet size and orbital distance tell us that the planet is likely to have a moderate temperature which would allow the planet to maintain water in a liquid state and would allow humans to maintain a moderate body temperature. The planet size also means that the planet is likely to have sufficient gravity for human biological systems to function normally. The orbit of the Jupiter-size planet means that the Earth-size planet is not likely to be disturbed by the larger planet.*

- Question: Is this planet habitable to humans?
- *Answer: We do not have enough information to know if the planet is habitable to humans.*

- Question: What additional questions do you have about this planet that you would need answered in order to decide if it is habitable or not?
- *Answer: (Accept all answers and record them on the board. Have students connect questions to the list of human needs, and ensure that all needs are addressed.) Questions may include:*
  - *Does the planet have liquid water?*
  - *Does the planet have an atmosphere?*
  - *Does the planet's atmosphere include enough oxygen?*
  - *Does the planet's atmosphere include the right amount of Greenhouse gases (or gases that will trap the right amount of heat)?*
  - *Does the planet have an average global temperature below 50º Celsius?*
  - *Does the planet have food or the conditions necessary for growing food?*
  - *Does the planet have a low level of poisonous gases that won't kill humans?*
  - *Does the planet have protection from high levels of radiation coming from the star or from cosmic rays?*

MISCONCEPTION: Students may believe that because the planet has the astronomical requirements, that it has the right atmosphere, moderate temperature and liquid water. It is important to help them realize that these conclusions cannot be made at this time. We have no evidence that the planet has water, atmosphere of any kind nor the right temperature. To bring out these misconceptions, ask students the following questions:
- Question: Does the planet have liquid water? How do you know?
- Question: Does the planet have an atmosphere? How do you know?
- Question: Does the planet have a moderate temperature? How do you know?

To further challenge these misconceptions, ask students to describe various possible scenarios for the planet they found. These might include:

- A planet with a large quantity of Greenhouse gases that trap heat and cause the surface to be hot enough to melt led.
- A planet with no atmosphere such that its temperature would vary between very hot when facing the star and very cold when facing away from the star.
- A planet with the right temperature but no liquid water present.
- A planet that has liquid water, the right amount and type of atmosphere and the right temperature.

- Question: How many of you think that it would be worthwhile to do some further study of this planet? Why?
- *Answer: (Accept all reasonable answers.)*

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3. Introduce the purpose of the lesson and the Scientific Question.

- Say: Scientists often make discoveries that help to answer one question, but those discoveries bring up more questions. Science is a never-ending exploration and search for answers. However, there is a limit in time and money that determines what research actually happens. Scientists have to convince organizations that have money that their research is worth being funded. Now that you have found a planet that meets some of the conditions required for human habitation, you must convince the World Science Foundation that your planet is worthy of further study. The Scientific Questions that you will be addressing in your proposal to this organization are:
  – What other requirements must a planet meet to be habitable to humans?
  – How might a scientist determine if a planet meets these habitability requirements?

Your ability to continue your research at the Astro-Venture Academy will depend on the acceptance of your proposal by the World Science Foundation.

Explore

(approximately 30 minutes)

Scientist performing research related to sorting and counting different species of fish; Miller Freeman vessel, NOAA

1. Have students explore methods that NASA and other scientists are using to study extra-solar planets.

Have students visit the following Web sites to understand the methods used in the study of extra- solar planets and to determine what kind of information could be learned about extra-solar planets using the described methods. Students should note methods that they think would help to answer the questions they have listed.

- Terrestrial Planet Finder: http://tpf.jpl.nasa.gov
- NASA Astrobiology Institute: http://nai.arc.nasa.gov
- NASA Ames Astrobiology: http://astrobiology.arc.nasa.gov (Visit the Missions page.)
- NASA Origins Program: http://origins.jpl.nasa.gov (Visit the Missions page.)
- The Kepler Mission: http://www.kepler.arc.nasa.gov
- Next Generation Space Telescope: http://ngst.gsfc.nasa.gov
- NASA SpaceLink: http://spacelink.nasa.gov (search Astrobiology)
- NASA Quest: http://quest.nasa.gov (See Astrobiology Press Releases under “In the News,” or search the archives.)
- Students might also visit Internet search engines, and enter key words such as, “interferometry “spectroscopy,” or “astrobiology.”

Explain

(approximately 15 minutes)

Restored wetland near Jackson, Wyoming; Natural Resources Conservation Service, USDA

1. Have students share their results and conclusions in small groups.

Have them share methods that could help to answer each listed question. Possible answers might include the following:

Questions	Possible Methods to Answer
• Does the planet have liquid water? • Does the planet have an atmosphere? • Does the planet's atmosphere include enough oxygen? • Does the planet's atmosphere include the right amount of Greenhouse gases (or gases that will trap the right amount of heat)? • Does the planet have a low level of poisonous gases that won't kill humans? • Does the planet have protection from high levels of radiation coming from the star or from cosmic rays?	A combination of the following methods would help to answer these questions: • Spectroscopy to obtain the absorption spectrum of a planet and determine the atmospheric composition. (Signs of water vapor in this spectrum would be evidence that the planet may have liquid water.) • These instruments would need to be on a telescope above the Earth's atmosphere. Alternatively, a probe with these instruments could be sent closer to the planet.
• Does the planet have an average global temperature above 0° and below 50° Celsius?	• Once we know the atmospheric composition, star type and planetary distance we will be able to do calculations and draw conclusions about the temperature range of the planet. A precise measurement may require that a probe be sent to the planet.
• Does the planet have food or the conditions for growing food?	• A very high resolution spectroscope to obtain an even more detailed absorption spectrum of a planet can be used to look for presence of chemicals that we do not expect to find unless biological activity is pumping it into the atmosphere. Chemicals like ozone and free oxygen cannot exist without being replenished by some biological process. Thus, if we detect these chemicals, it is a good indicator of life. Methane is also another indicator of life. • Again to be absolutely sure that plants or animals are present or could survive, a probe would probably need to be sent to the planet.

- Question: In general, what can you conclude will be necessary for further research?
- *Answer: We can conclude that, in order to do further research, we will need very powerful telescopes that are above our atmosphere. To really be sure, we may need to send a probe closer to the planet.*

Note to Teacher: Currently, we have not sent a probe outside of our Solar System. The technology and time that is required for such a mission would be considerable. Although no missions are currently planned or considered feasible for such a mission in the near future, it may be possible in the distant future. Similarly, students may suggest that scientists need to visit the planet. Discuss the advantages and disadvantages of sending people to another planet outside of our Solar System. The advantages might include that humans can gather more precise data, more quickly and with fewer mistakes. The disadvantages might include the risk of human life and added cost and constraints of sending a spacecraft that must sustain human life and return it to Earth. It should be noted that with current technology, the time it would take a probe to reach the nearest star would exceed a human's life span.

Extend/Apply

(approximately 30 minutes)

"Lunar Base Samples" illustration; Robert McCall, NASA

1. **Have students write their proposals to the World Science Foundation using the Astro-Venture Proposal Guidelines.**

Evaluate

(approximately 90 minutes)

Scientists discussing stream structures and sediment buildup to improve salmon habitat; Natural Resources Conservation Service, USDA

1. Have students present their proposals to the "World Science Foundation proposal committee."

- Give students five minutes to verbally present their argument to the class. Have the class ask questions about each students' proposal to help determine which proposals they think are most worthy of funding. Some of the important conclusions that students should arrive at and discuss include:
  - We can conclude that the planets we have found are likely to have enough gravity for our biological systems to operate normally and to have a moderate temperature necessary for human survival and to maintain water in a liquid state. However, we do not know if the planet has food, oxygen, water, low levels of poisonous gases and protection from high levels of radiation. We do not even know if the planet has an atmosphere and the right amount of gases in the atmosphere to maintain a moderate temperature.
  - Further study of the planet, using powerful, space-based telescopes, interferometry and spectroscopy or probes to the planet are necessary.
  - Study of habitable planets can help us better understand Earth and can help us to conclude whether life on Earth is unique.
- After students have presented their proposals, have the class vote on the proposal they would fund and why. Their reasons should include evidence that the proposal will result in worthwhile research and that the methods proposed are appropriate to the mission.

2. Discuss students' conclusions and have students summarize their learning of this unit.

- Question: In completing your Astronomy Training and Mission, what important concepts did you learn about habitable planets?
- *Answer: (Answers may vary. Record answers on the board. Help students to identify the following key concepts.)*
  - *Humans need water, oxygen, food, gravity, a moderate temperature, low levels of poisonous gases and protection from high levels of radiation to survive.*
  - *Liquid water is necessary for human survival, and the right temperature is a very important condition for maintaining liquid water on the surface of a planet.*
  - *Star type, planet mass and a planet's distance from a planet all work together to determine the surface temperature of a planet.*
  - *If the astronomical requirements of a planet and star system are met, this does not necessarily mean the planet is habitable to humans.*

3. Bridge to the next unit.

- Say: Congratulations on your successful Astronomy research at the Astro-Venture Academy. You have really helped to contribute to our understanding of habitable planets. If your proposals are accepted, you will be trained in other requirements for human habitation in the areas of: Geology, Atmospheric Sciences and Biology and you will engage in a mission to conduct further study of your planet to see if it meets these requirements. Good luck!

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

Astro-Venture Proposal Guidelines

You have located another planet and star system that has some of the conditions required for human habitability. In order to determine if it meets all of the requirements for human habitability, you will need to conduct further research. On a separate sheet of paper, write a proposal to the World Science Foundation, and convince the foundation that the star and planet you found is worthy of further study and exploration. Include the following:

- A description of the planet and star system you have found and what evidence you have that it meets the astronomical conditions required for human habitability

- Why these astronomical conditions are important for human habitability

- A description of additional requirements that must be met for the planet to be habitable to humans

- Possible methods that could be used to determine if the planet meets these additional requirements

- An explanation of what the benefits would be to conducting further research of this planet

Your concept map will be evaluated using the following rubric.

4 Expectations Exceeded	• Proposal clearly and accurately explains requirements for human habitability and provides accurate conclusions about the planet found. • Proposal has all required parts and uses examples and reasoning to create an exceptionally powerful and detailed persuasive argument.
3 Expectations Met	• Proposal clearly and accurately explains requirements for human habitability and provides accurate conclusions about the planet found. • Proposal has all required parts, makes specific references to examples, and uses good reasoning in explanations.
2 Expectations Not Quite Met	• Proposal is not completely clear or accurate in explaining requirements for human habitability and accurate conclusions were not drawn about the planet found. • Proposal has most required parts, makes some specific references to examples, and uses some good reasoning in explanations.
1 Expectations Not Met	• Proposal is not clear or accurate in explaining requirements for human habitability and accurate conclusions were not drawn about the planet found. • Proposal is missing several parts, makes few specific references to examples, and uses little or no good reasoning.

Astronomy Educator Guide

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.

Astronomy Educator Guide

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.

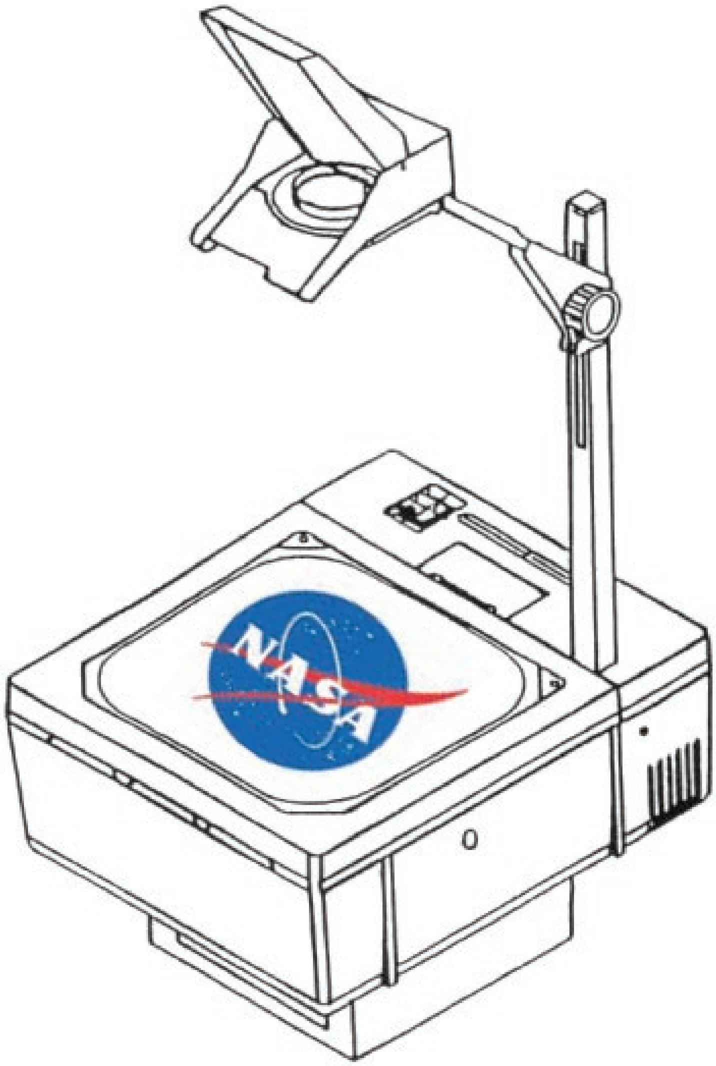
weathering The process of breaking down rocks on Earth's surface.

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



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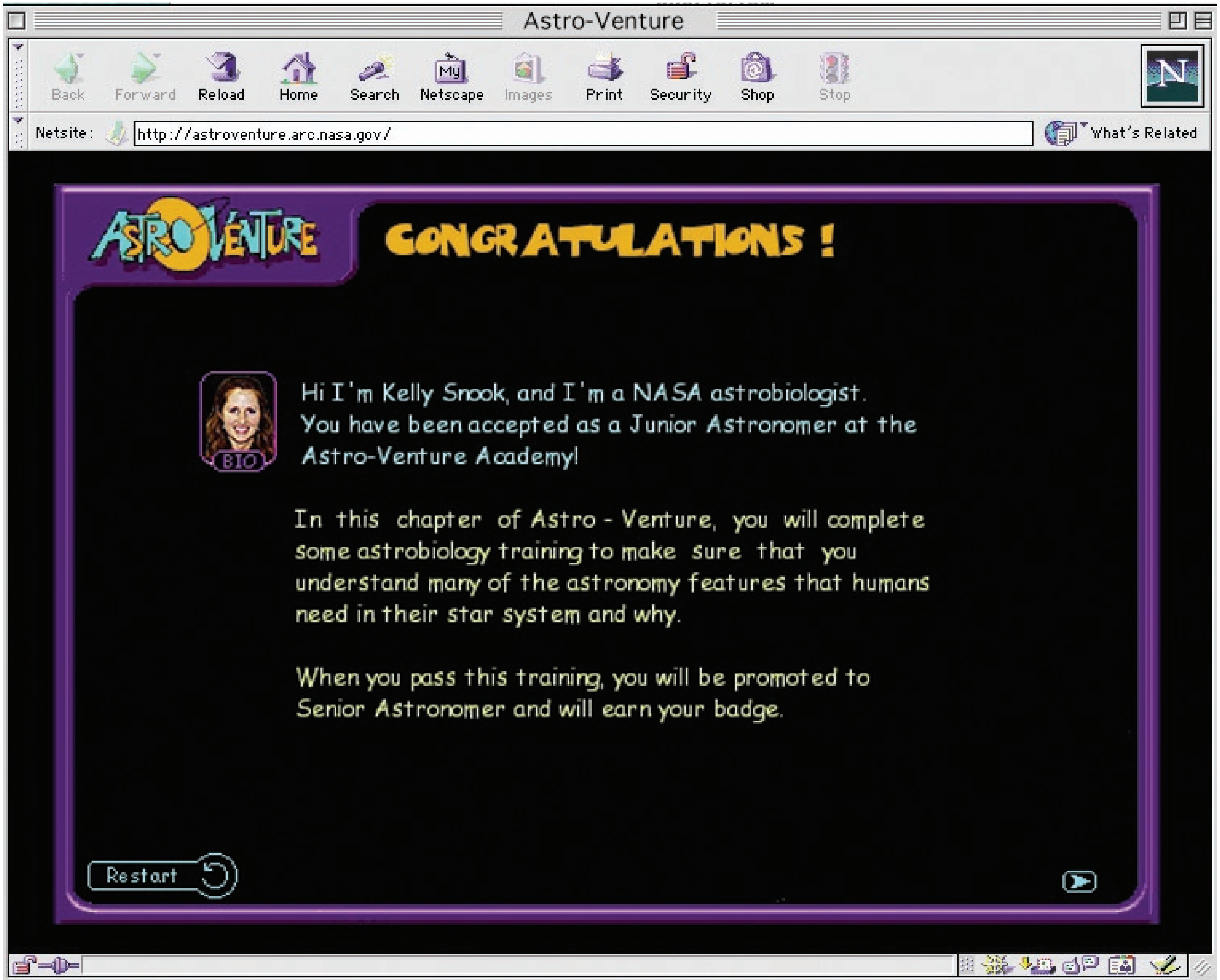
Screen Shots

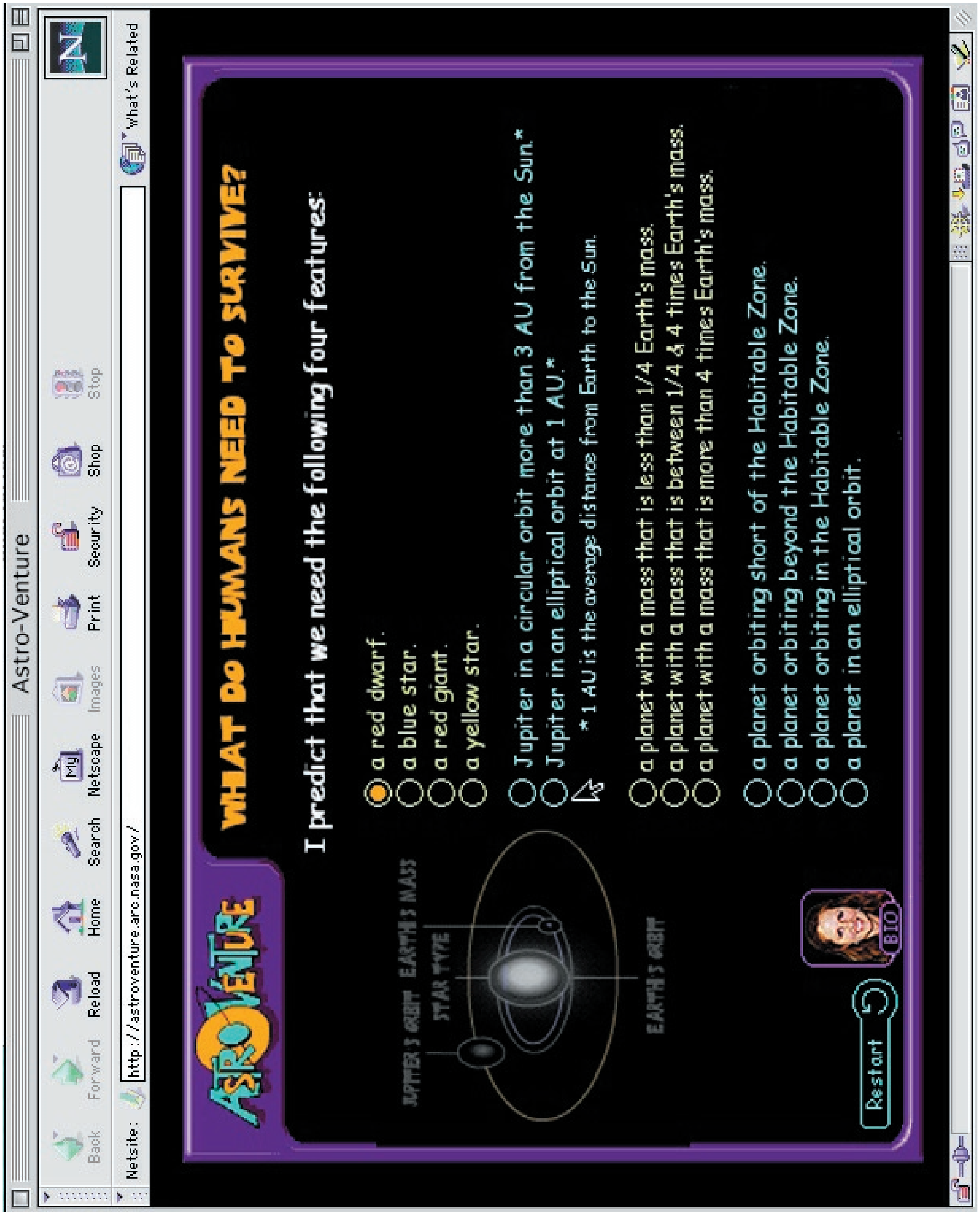
www.nasa.gov

http://astroventure.arc.nasa.gov

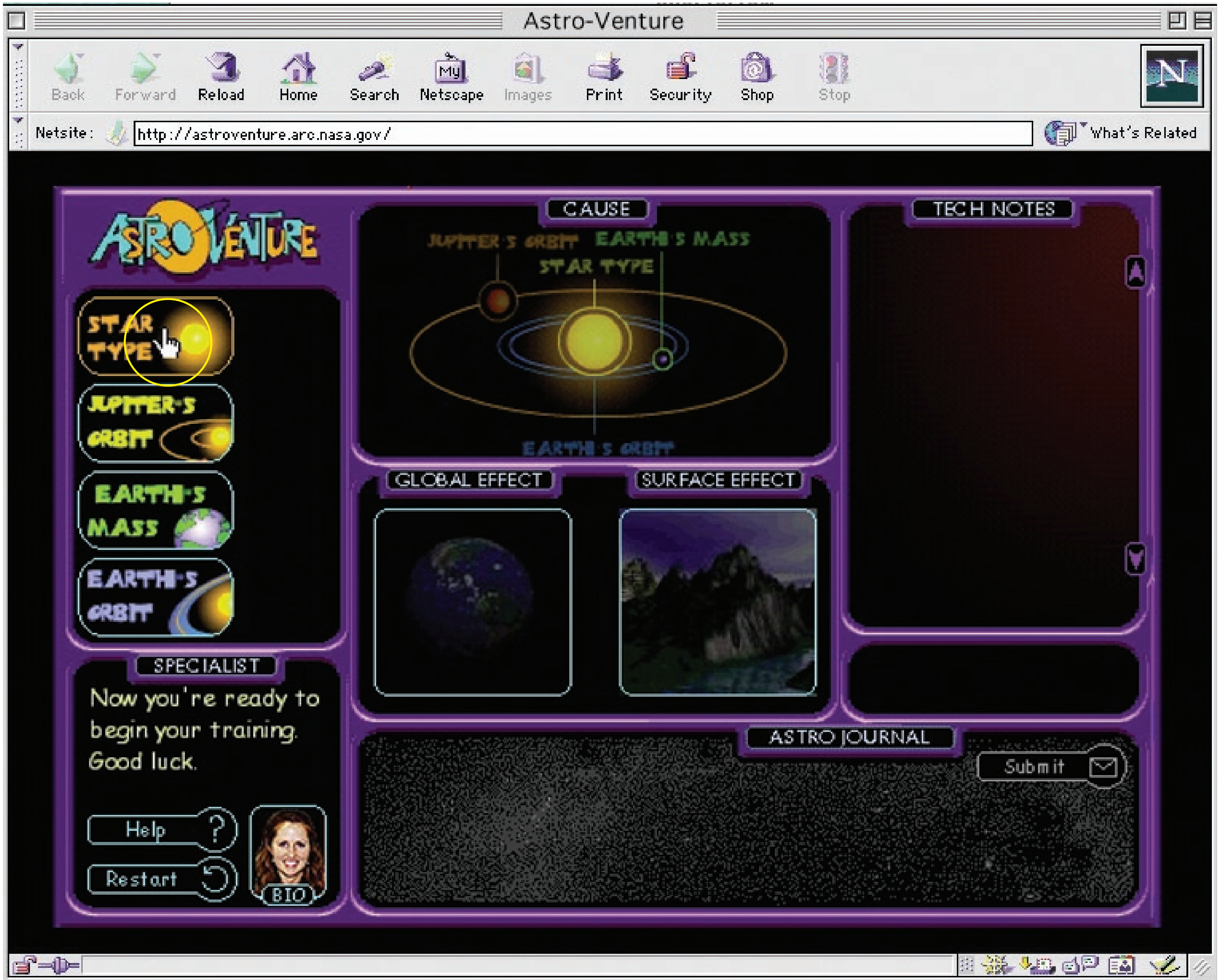


1. Congratulations

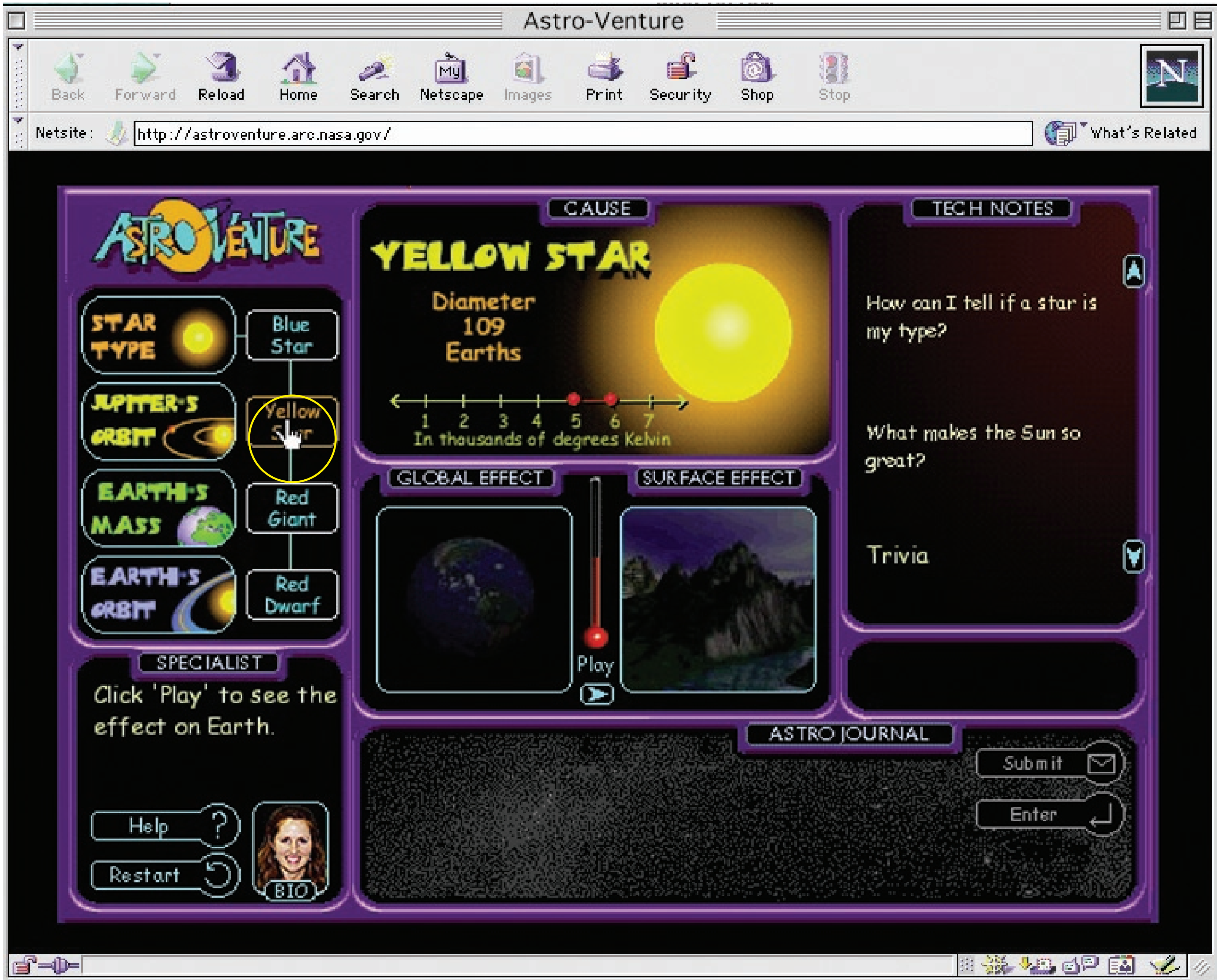
2. Choose Your character.



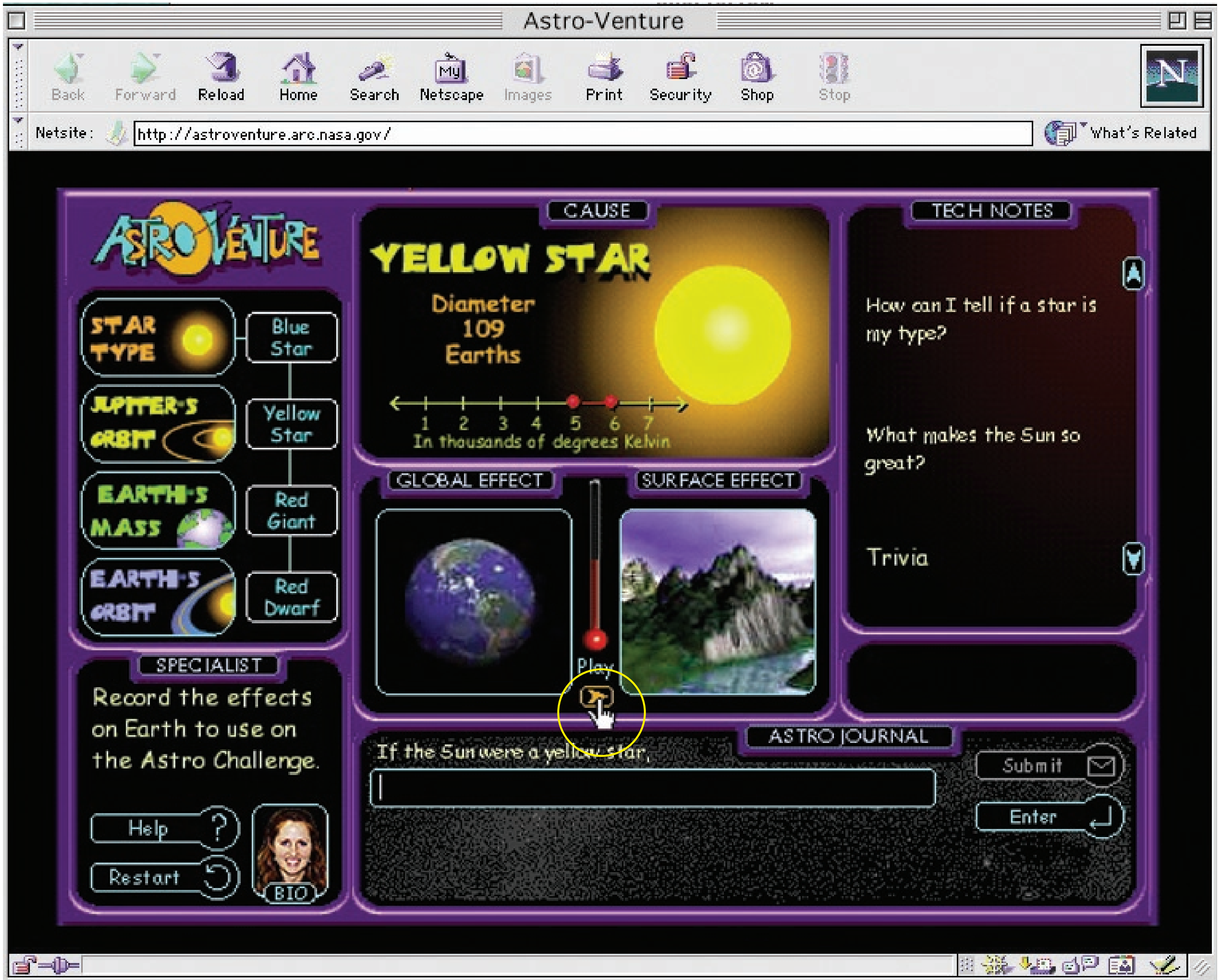
3. What Do Humans Need to Survive? (Prediction)



4A. Select a feature such as "Star Type."



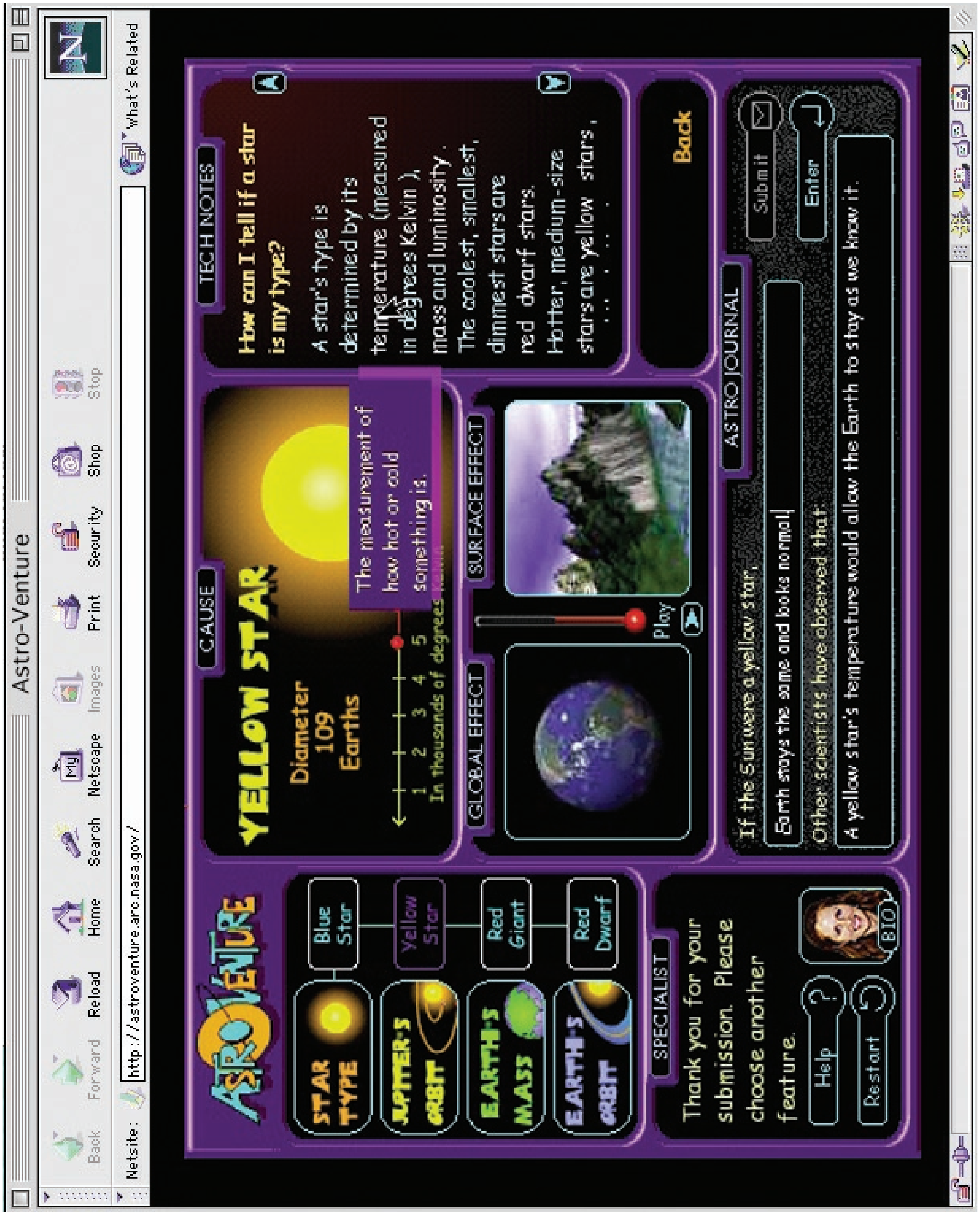
4B. Select a subtopic such as "Yellow Star" to cause a change to our Solar System.



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

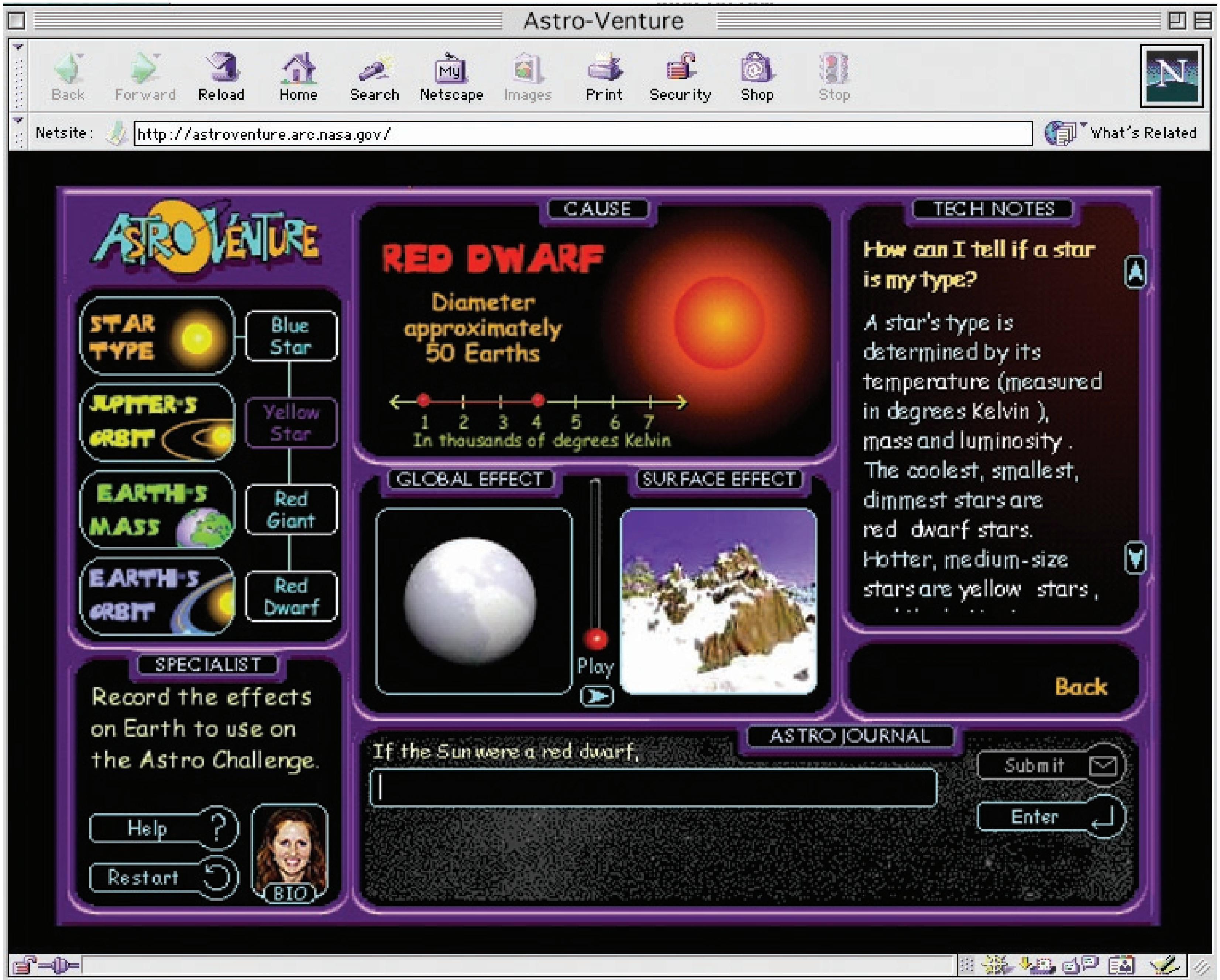
4D. Record what you observe in your Astro Journal.

4E. Look in your Tech Notes for background information and a glossary.



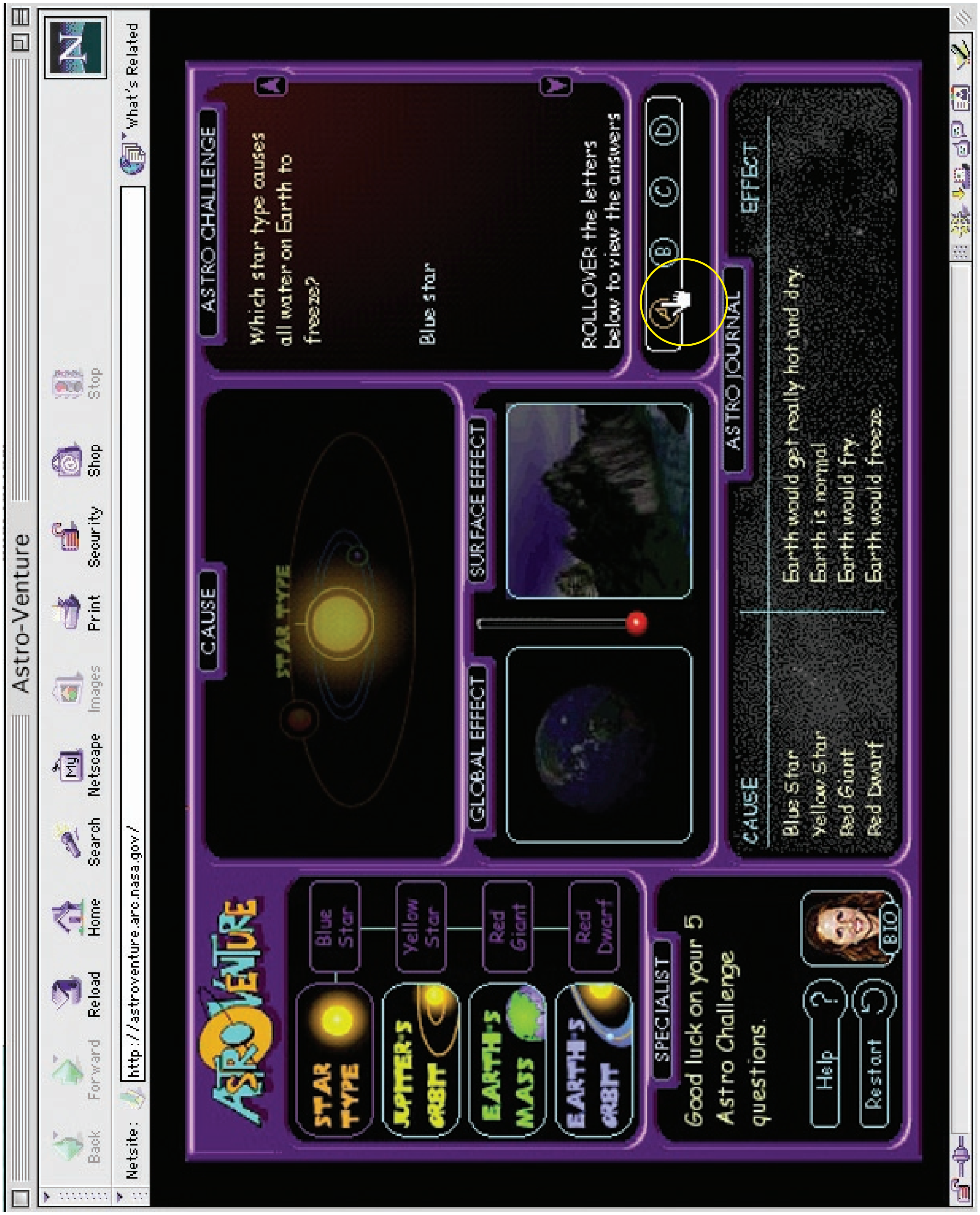
4F. Roll over highlighted words in the Tech Notes for Glossary definitions.

4G. The specialist will give you directions, feedback and help.



4H. Continue using steps 4A thru 4G for all other features and subtopics and record observations.

4l. When you have completed all of your observations, click the Submit button to take your Astro Challenge and earn your badge.



5. Roll over the letters to view the answers in your Astro Challenge.

6. Click above the Specialist's picture for hints to help you with your Astro Challenge.