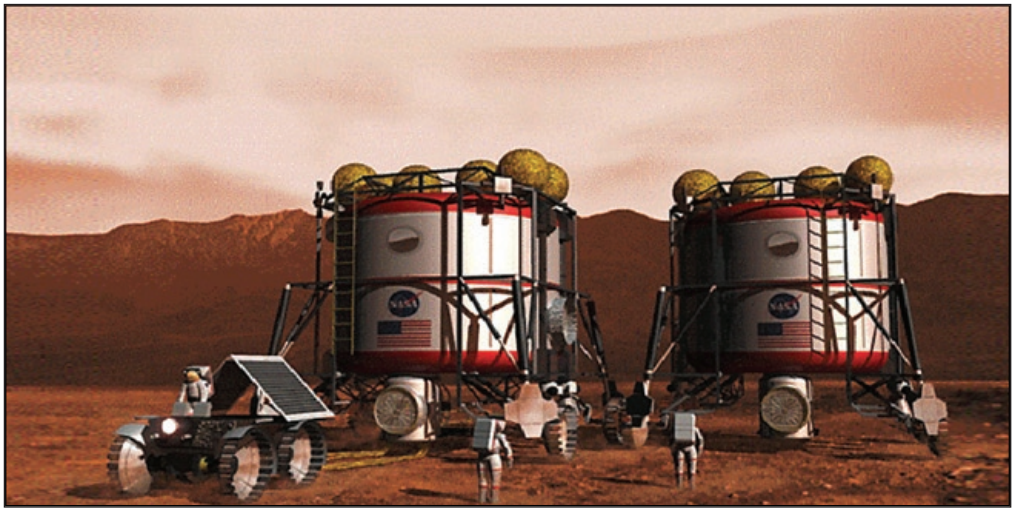

"Habitats Docking at Mars Base" illustration: Mars crew beginning surface exploration and habitation activities; John Frassanito and Associates, NASA

Students review the basic requirements for human survival. Using an online, multimedia module, they change amounts of gases in our atmosphere and draw conclusions about the amount of each gas that is necessary for human survival.

Main Lesson Concept:
Certain atmospheric conditions help to support human survival.

Scientific Question:
What atmospheric conditions are required for human survival?

Objectives	Standards
• Students make changes to our atmosphere and write descriptive, objective observations of the effects of these changes on Earth. • Students will identify the characteristics of our atmosphere that are required for human survival.	**Meets:** NSES: A (5-8) #1 ISTE: 3, 5 **Partially meets:** NSES D (5-8) #1.8 **Addresses:** 2061: 4B (6-8) #2

Assessment	Abstract of Lesson
Write-up in Astro Journal.	Students review the basic requirements for human survival and predict how human survival requirements are met by characteristics of our atmosphere. They engage in an online Atmospheric Science Training module in which they make changes to the Earth's atmospheric conditions and observe the effects of these changes on Earth. They then draw conclusions about which atmospheric conditions are necessary to support human survival.

Prerequisite Concepts	Major Concepts
• Humans need water, oxygen, food, gravity, a moderate temperature, and protection from poisonous gases and high levels of radiation to survive. (Astronomy Lesson 1) • Gases have no definite shape or volume due to their extremely weak molecular bonds, which allow them to move freely. (Astronomy lessons 3 and 4) • Systems consist of many parts that usually influence each other. Something may not work as well (or at all) if a part of the system is missing, broken, worn out, mismatched or misconnected. (Astronomy Lesson 7) • Scientific observations are detailed descriptions of what can be learned using the senses and scientific instruments. These scientific observations do not include ideas, opinions, or speculations about what is being observed. • A cause is something that produces an effect or result.	The following atmospheric characteristics allow Earth to remain habitable to humans: • 0.0001 to 20% water vapor • 0.001 to 0.03% carbon dioxide • more than 80 Dobson Units of ozone in the stratosphere • 15 to 30% oxygen • More than 5% nitrogen

Note to Teacher: Atoms, elements, molecules, chemical reactions, oxidation, and air pressure are all explored and defined in later lessons. In this lesson, students simply need to make good observations about "what" is needed for human survival. Lessons 2 to 7 will give them the "whys" behind these needs.

Suggested Timeline (45-minute periods):

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

Materials and Equipment:

- Human Survival Transparency
- 1 Atmospheric Chemist Career Fact Sheets for each group
- 1 Atmospheric Conditions Transparency
- A class set of Astro Journal Lesson 1: Atmospheric Science Training Module
- 1 Planetary Atmosphere Comparison Chart for each group
- 1 copy Atmospheric Science Training Walkthrough (optional)
- 1 to 30 computers with Internet browser, Internet connection and the Flash Player version 6 or later installed (See System Requirements)
- A printer connected to the computers
- Chart paper
- Overhead projector
- LCD projector or TV connected to a computer with video card (optional)
- Atmospheric Science Training screen shot transparencies (Optional. These are found as a separate PDF on the Astro-Venture Web site.)

Preparation:

- Prepare class sets of Astro Journal.
- Prepare overhead transparencies.
- Make copies of Astro Journal, Planetary Atmosphere Comparison Chart and Atmospheric Chemist Career Fact sheets.
- Download and install Flash Players on computers from http://www.macromedia.com/downloads. Test these at http://astroventure.arc.nasa.gov by clicking "Atmospheric Science Training."
- Prepare chart paper with major concept of the lesson and human survival needs to post at the end of the lesson.

*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 that may need more guidance. Have them type the observations that the student verbalizes.
- Have students draw their predictions and other Astro Journal responses.

Advanced Extensions

Research and report on whether other gases such as helium, methane, argon, neon, krypton, and hydrogen are necessary for life and why or why not.

Engage

(approximately 10 minutes)

Idaho farm ponds providing livestock water, gully control, and fish and wildlife habitat; National Resource Conservation Service, USDA

1. Review human survival needs (Astronomy Lesson 1), astronomical conditions that support human survival (Astronomy Lesson 2), systems (Astronomy Lesson 7), and introduce the purpose of this lesson/unit.

- Question: As members of the Astro-Venture Academy, what is our goal?
- *Answer: Our goal is to find, study, and design planets that would be habitable to humans.*

- Question: In the first lesson of Astronomy, what elements did you learn are necessary for human survival?
- *Answer: The elements that humans need for survival are: food, gravity, oxygen, water, a moderate temperature, and protection from poisonous gases and high levels of radiation.*

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2. Put up the Human Survival Transparency outlining these needs, reasons, and factors that provide for these needs.

- Question: In Astronomy, which of these necessary elements did we learn are influenced by astronomical conditions in our star system and planet?
- *Answer: We learned that star type, orbital distance, and planetary mass all work together to determine the surface temperature of our planet, which determines whether the planet can have liquid water. We also learned that planetary mass determines the amount of gravity on a planet and that the orbit of any large objects, such as Jupiter, could disrupt this system.*

- Write these factors on the transparency for Moderate Temperature under "What Factors Provide This" as follows:

Humans Need:	Reason:	What Factors Provide This:
Food	Gives us energy so that we can move, grow and function. It also gives us nutrients to build and mend bones, teeth, nails, skin, hair, flesh and organs.	
Oxygen	Helps us to obtain energy from sugars.	
Water	Allows nutrients to circulate through the body. Helps to regulate body temperature. The cells that make up our bodies are made mainly of water.	(related to temperature)
Moderate temperature (Average global temperature above 0°C and below 50°C)	Allows us to maintain an average body temperature of 98.6° F/37°C and to maintain water in a liquid state at all times.	Star type Orbital distance Planetary mass (Orbits of large planets/ objects could disrupt)
Protection from poisonous gases and high levels of radiation	To prevent cancer, disease and damage to the body.	
Gravity	Allows our biological systems to develop and function normally. Holds the atmosphere to the Earth so it doesn't exscape into space.	Planetary mass

- Question: So far, we've mostly only looked at the needs for a moderate temperature, gravity, and water, which are pretty important. If a planet has all of these astronomical conditions, is it habitable to humans? Explain.
- *Answer: It is not necessarily habitable to humans, because it may not have other conditions necessary for human habitation. The Earth is a system and requires many different factors to work together for the system to work.*

- Question: What could happen if a part of the system were missing or broken?
- *Answer: The system may not work as well (or at all).*

- Question: What other needed elements still need to be understood in order to make sure a planet is habitable to humans?
- *Answer: We need to understand what factors will allow our planet to have food, oxygen, and protection from poisonous gases and high levels of radiation.*

- Say: We will now begin to explore Earth's atmosphere and how it supports our survival needs, so that we can determine what conditions to look for on other planets and what to include in the design of a habitable planet.

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3. Draw on students' prior knowledge of the atmosphere and gases (Astronomy Lessons 3 and 4).

- Question: What is the atmosphere?
- *Answers may include: The atmosphere is air that surrounds the planet.*

- Question: Can you see the atmosphere? How do you know it is there?
- *Answer: Air is mostly transparent, but sometimes you can see clouds or fog in the atmosphere. We know it is there, because we can feel it and can see the wind blowing trees and other things around.*

- Question: How high up does the atmosphere go? How do you know?
- *Answers may include: It goes up very high (hundreds of kilometers), because we can see clouds up there, and because airplanes (which need air to fly) can fly very high.*

- Question: What is the atmosphere made of?
- *Answer: (Some students may know the specific gases. At this point we are mostly making sure that students understand that the atmosphere is composed of gases.)*

- Question: In Astronomy, what did we learn about the characteristics of gases, and what determines these characteristics?
- *Answer: We learned that gases have no definite shape or volume due to their extremely weak molecular bonds, which allow them to move freely.*

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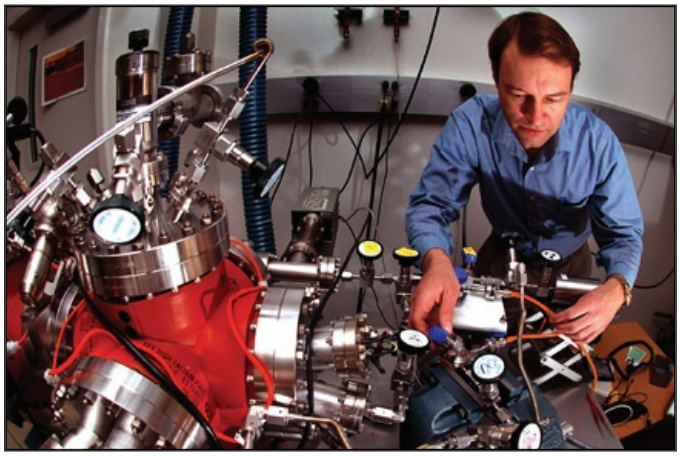
4. Present the Scientific Question for this lesson.

- Scientific Question: What atmospheric conditions are required for human survival?

- Tell students that they will be role-playing scientists and using a computer activity to find out which atmospheric conditions humans need to survive and why.

Explore — Part 1

(approximately 35 minutes)



Scientist sampling miniature atmospheres; Sandia National Laboratories, USDOE

1. Introduce Atmospheric Science careers.

- Tell students that, as they go through the Atmosphere module, they will be role-playing atmospheric chemists.
- Ask students what kinds of things they think an atmospheric chemist might do and what kind of knowledge they might need to have.
- Pass out the Atmospheric Chemist Career Fact Sheets for students to read and discuss this career.

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2. Put up the Atmospheric Conditions Transparency, and help students identify possible atmospheric conditions for human survival.

- Say: In the Atmosphere section of Astro-Venture, we will be focusing on the gases that can make up a planet's atmosphere, and we will examine how these gases help to support the conditions we need to survive. We will call these conditions the "atmospheric conditions."
- Question: What do you think are some of the characteristics of our atmosphere that allow Earth to be habitable to humans?
- *Answer: (Accept all answers. Record these ideas on the Atmospheric Conditions Transparency under Predicted Atmospheric Condition.)*

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3. Have students record their predictions in the Prediction section of their Astro Journal of the astronomical conditions that they predict are necessary for human habitation on a planet.

4. Introduce students to the Astro-Venture Atmospheric Science Training Module

- The Astro-Venture Atmospheric Science Training Module can be found on the Astro-Venture Web site at http://astroventure.arc.nasa.gov. Click "Atmospheric Science Training" to load the module. If you cannot project the computer, you may want to create transparencies of the Atmospheric Science Training screen shots located as a separate PDF on the "Teachers/Parents" section of the Astro-Venture Web site.

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 they will be engaging in an online activity where they will change aspects of the atmospheric conditions of our planet and will observe the effects on Earth. They will then draw conclusions about the atmospheric conditions needed for human survival.

- Tell students that as they go through this module, they will be Astro-Venture Junior Atmospheric Chemists, and will be evaluated on how detailed their observations are, and whether they give reasons for the effects they observe. They will be able to use their notes on the Astro Challenge, so they should take thorough notes.

- You may want to model for students an example of a "good observation." Either project from a computer for the class to see or create transparencies of screen shots included in this lesson to walk the students through the following. (On the computer, you will need to click through the introduction to get to this part.)
  – Click "Water Vapor."
  – Click "none."
  – Click "Play" to see the effect on Earth.

– Ask students to describe what happened to Earth and why. You can click the "Replay" button to see the animation as many times as is you want. Also, you may want to click Astro Facts to read background information that may help to understand what is happening in the animations and to model for students the use of the Astro Facts.

– Record a good example of the kinds of observations you expect from students such as: "First the animals died. Then the plants died. It became cold."

Note to Teacher: The sequence of events in this module is important. You may want to model this for students.

– Click "Enter" to see another scientist's observation. Stress to students that they do not need to type the exact same thing, but should have the same general idea.

Note to Teacher: Students can change their answer after they click "Enter." Both their original answers and their new answers will be printed in their Astro Journal so that you can see if they are making good, initial observations.

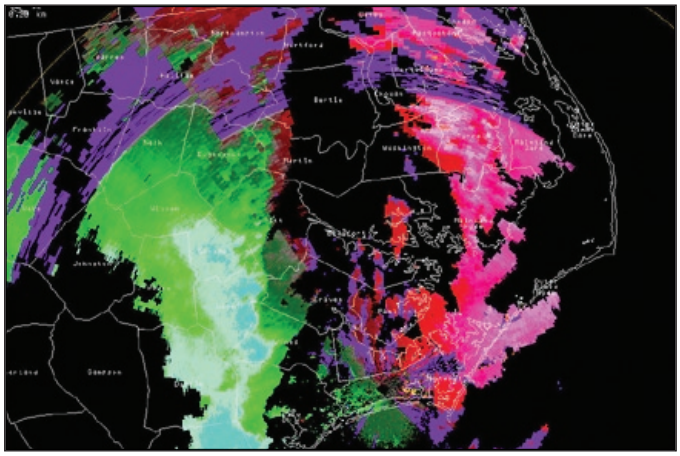
– Point out to students that when they have completed an observation, the factor that they chose turns purple. They must complete all observations in all five major sections before they can advance to the Astro Challenge section.

Note to Teacher: Some students may wonder why they can't just find the characteristics that allowed Earth to remain habitable and go on. Making good observations about the effects of life-threatening levels will help students understand why each gas amount is important to life.

– Click "Astro Facts" to read helpful background information about each main topic. This information can help students understand some of the effects they are observing and the overall importance of each gas to human life.
– Within the "Astro Facts," glossary words are in white. Click a white word and the definition will come up in a box. Click the "X" to close this box.
– Click the back arrows to return to the animations.
– Click "medium."
– Click "Play."
– Ask students to give a detailed observation such as, "The Earth would remain habitable."

Explore – Part 2

(approximately 45 minutes)



Radar imagery showing squall line crossing eastern North Carolina; National Weather Service, NOAA

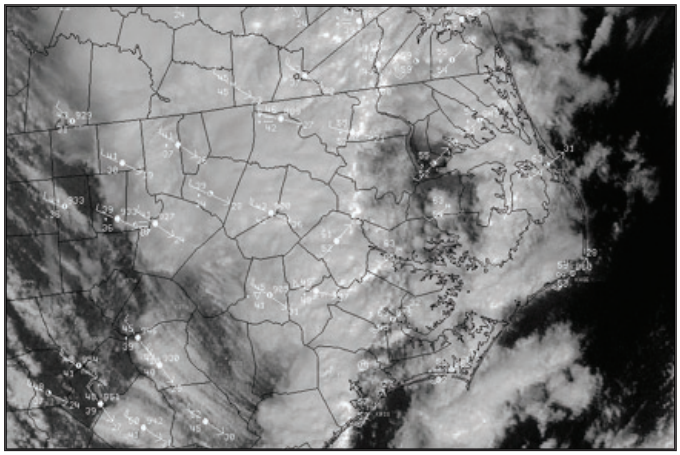
1. Have students engage in the Atmospheric Science Training module individually, in pairs, small groups, or as a class.

- Students should visit: http://astroventure.arc.nasa.gov and click "Atmospheric Science Training."

Note to Teacher: You will need the Flash 6 Player plug-in, which can be downloaded and installed from http://www.macromedia.com/downloads. When tested with grades 5 to 8, the average completion time was 30 minutes with a range of completion times between 22 to 32 minutes. Please note that this was the completion time when students used the Astro Facts very little or not at all. It's possible that with your encouragement to use the Astro Facts that students will make better use of this resource and will take longer to complete the module. Also, you will want to have accessibility to a printer, so students can print their Astro Journals at the end of the module. These can be used for evaluation purposes. Students will also receive a certificate of achievement for completing the module. Make sure students are clear about the printing rules for both the Astro Journal and the certificate. After the Astro Challenge, they will have the option to print these items. This will be the only opportunity to print; students cannot go back later to print. If you want to take the whole class through the module using one computer, use the Walkthrough at the end of this lesson as a guide.

Explain

(approximately 15 minutes)



Satellite imagery depicting strong surface front crossing eastern North Carolina; National Weather Service, NOAA

1. Have students fill out the Results and Conclusion section of their Astro Journals.

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2. Discuss students' Conclusions and record them on the Atmospheric Conditions Transparency.

- Question: What atmospheric conditions did you observe are necessary for human habitation of a planet?
- *Answer: (Record on the board) We need:*
  - 0.0001 to 20% water vapor
  - 0.001 to 0.03% carbon dioxide
  - more than 80 Dobson Units of ozone in the stratosphere
  - 15 to 30% oxygen
  - More than 5% nitrogen

- Question: Why do we need each of these? What happens to the planet otherwise?
- *Answer: (Record the reasons next to each factor.)*

Observed Atmospheric Condition	Reason
0. 0001 to 20% water vapor (medium levels)	To maintain a moderate temperature on Earth. To provide water for life.
0.001 to 0.03% carbon dioxide (low levels)	To maintain a moderate temperature on Earth.
More than 80 Dobson Units of ozone in the stratosphere (high levels)	To protect animals and some plants from harmful radiation.
15 to 30% oxygen (medium levels)	For animals to breathe.
More than 5% nitrogen (high levels)	To provide proteins and other building blocks for life. On Earth, high levels of nitrogen also provide air pressure.

Note to Teacher: Students may have questions about Dobson Units. You may want to discuss with students that this is a different measurement used for ozone, because ozone is not distributed evenly throughout the atmosphere. It is concentrated into a layer high in the stratosphere. A Dobson Unit (DU) is a measurement of how thick the ozone layer would be if it were concentrated and brought down to the surface of the Earth and covered the entire planet. Earth's current level of 300 DU would measure 3 millimeters thick if it covered the planet's surface.

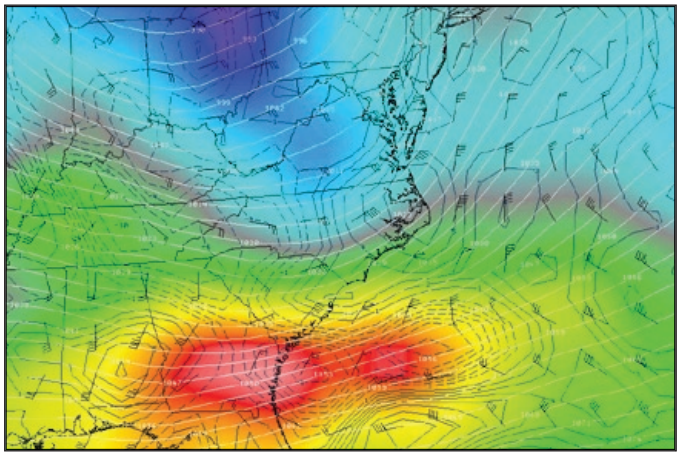
- Question: Of all of our human survival needs, for which ones does atmosphere have an important role?
- *Answer: Atmosphere plays a role in maintaining a moderate temperature, protecting us from harmful radiation, providing oxygen, water vapor and proteins in our food.*

- Put up the Human Survival Needs Transparency again and add this new information to it as follows: (Atmospheric factors are italicized to differentiate from Astronomy factors.)

Humans Need:	Reason:	What Factors Provide This:
Food	Gives us energy so that we can move, grow and function. It also gives us nutrients to build and mend bones, teeth, nails, skin, hair, flesh and organs.	*Nitrogen is a nutrient*
Oxygen	Helps us to obtain energy from sugars.	*Oxygen helps us get energy from sugars*
Water	Allows nutrients to circulate through the body. Helps to regulate body temperature. The cells that make up our bodies are made mainly of water.	(related to temperature) *Water vapor is a greenhouse gas in our atmosphere*
Moderate temperature (Average global temperature bove 0°C and below 50°C)	Allows us to maintain an average body temperature of 98.6°F/37°C and to maintain water in a liquid state at all times.	Star type Orbital distance Planetary mass (Orbits of large planets/objects could disrupt) *Greenhouse gases reradiate heat*
Protection from poisonous gases and high levels of radiation	To prevent cancer, disease, and damage to the body.	*Ozone protects from UV* *Our atmosphere doesn't have high levels of poisonous gases*
Gravity	Allows our biological systems to develop and function normally. Holds the atmosphere to the Earth so it doesn't escape into space.	Planetary mass *Nitrogen provides pressure*

Extend/Apply

(approximately 15 minutes)



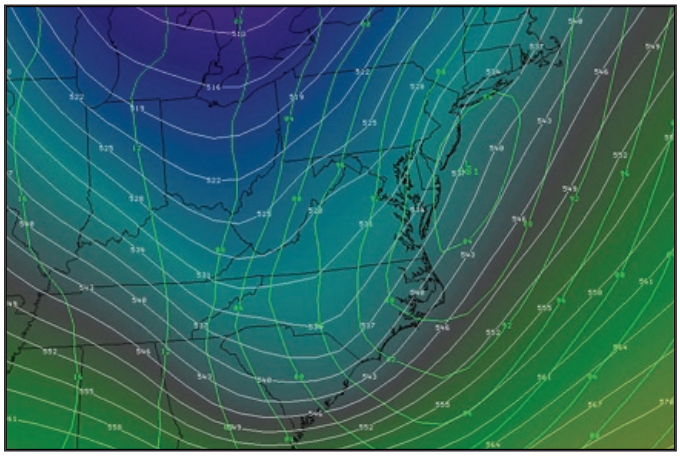
Model Jet Analysis showing windspeed and divergence; National Weather Service, NOAA

1. Have students apply these atmospheric conditions to another planet in our Solar System.

- Have students choose another planet in our Solar System, and use the Planetary Atmosphere Comparison Chart to describe what atmospheric conditions would need to change in order for the selected planet to be habitable. They should record this information in the Creating Habitable Conditions for Other Planets section of their Astro Journals.

Evaluate

(approximately 15 minutes)



Model Synoptic Analysis illustrating configuration and magnitude of weather troughs; National Weather Service, NOAA

1. As a class, have students share their planet and discuss what atmospheric changes would be necessary to make it habitable to humans.

- Based on what students know so far, their assessments should include observations that all planets lack oxygen and ozone and some have too much carbon dioxide.

2. Have students complete their Astro Journals.

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

- We need the following levels of gases in our atmosphere:
  - 0.0001 to 20% water vapor
  - 0.001 to 0.03% carbon dioxide
  - more than 80 Dobson Units of ozone in the stratosphere
  - 15 to 30% oxygen
  - More than 5% nitrogen

4. Bridge to next lesson.

- Question: What do you think makes each gas different, giving it unique properties that contribute to human survival?
- *Answer: (Allow students to discuss their ideas about this.)*

- Say: In the next lesson, we will begin to look at the components of gases and determine each gas's unique properties, which determine its role in helping humans.

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.

Astro Journal Lesson 1: Atmospheric Science Training Module

Name _____ Date _____ Class/Period _____

Scientific Question:
What atmospheric conditions are required for human survival?

1. Prediction: What atmospheric conditions do you think humans need to survive? Why?
2. Data: The following may be recorded and printed online. However, if you are unable to print from the computer, you may use the following chart to record your observations.

Cause	Effect on Earth
No water vapor	
Medium levels of water vapor	
High levels of water vapor	
No carbon dioxide	
Low levels of carbon dioxide	
Medium levels of carbon dioxide	
High levels of carbon dioxide	
No ozone	
High levels of ozone	
No oxygen	
Medium levels of oxygen	
High levels of oxygen	
No nitrogen	
High levels of nitrogen	

Astro Journal Lesson 1: Atmospheric Science Training Module

Name _____ Date _____ Class/Period _____

3. Results: What atmospheric conditions are required for human survival? Why? (Create a revised list below based on what you learned from the Atmospheric Training Module.)

4. Conclusions: Compare and contrast your prediction and results. How did conducting research change your original ideas?

5. Creating Habitable Conditions for Other Planets: Choose another planet in our Solar System. Write a paragraph explaining what atmospheric conditions would need to change in order for this planet to be habitable and why.

Atmospheric Science Training Walkthrough

The following is an explanation of each section of Atmospheric Science Training. 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 the screen image for classroom viewing.

Introduction

1. Go through the introduction with students. This introduces types of atmospheric careers and explains the activity students will be going through to make changes to different gases in the Earth's atmosphere, to observe the effects, and to record these effects.

2. Enter a name for the class, and click "Enter."

3. When you first enter the main activity, there is a movie that shows the Earth, the layers of the atmosphere, and the gases that compose the atmosphere and where they are located. This movie only plays once and cannot be repeated. All buttons are inactive during this short movie.

Activity

1. Astro Ferret directs you through the steps the first time. After that you are on your own, but can click Astro for a reminder.

2. Click "Water Vapor."

3. Click "none."

4. Ask students what they predict will happen to Earth.

5. Click "Play" to see the effect on Earth.

6. Ask students to describe what happened to Earth and why. You can click the "Replay" button to see the animation as many times as is you want. Also, you may want to click Astro Facts to read background information that may help to understand what is happening in the animations.

Note to Teacher: "Replay" can be clicked to see the effect multiple times.

7. Have students record their observations in the Data section of their Astro Journal.

8. Call on individuals to share what they wrote and have them type their observations in the Astro Journal on the computer. Ask students if they think "no water vapor" allows Earth to be habitable and why or why not.

9. Record a good example of the kinds of observations you expect from students such as: "First the animals died. Then the plants died. It became cold."

Note to Teacher: The sequence of events in this module is important. You may want to model this for students.

10. Explain that a good scientific observation is detailed and describes what is observed.

11. Tell students that since they will be able to use their notes when they take the Astro Challenge, they should take thorough notes.

12. Click "Enter" to see other scientists' observations. Stress to students that they don't need to type the exact same thing, but should have the same general idea.

Note to Teacher: Students can change their answer after they click "Enter." Both answers will be printed in their Astro Journal so that you can see if they are making good, initial observations.

13. Point out to students that when they have completed an observation, that button turns purple. They must complete all observations in all five major sections before they can advance to the Astro Challenge section.

14. Click "medium."

15. Click "Play."

16. Ask students to give a detailed observation such as: "The Earth remains habitable."

Completion of Activity

1. Continue through each level of "Water Vapor," "Carbon Dioxide," "Ozone," "Oxygen," and "Nitrogen."

2. Have the class record their observations in their Astro Journals and then have individuals take turns typing in their observations in the computer.

3. Have students record in their Astro Journals the levels of each gas that resulted in a habitable Earth.

4. After all observations have been completed, click "Astro Challenge" on Astro Ferret and take the Astro Challenge as a class.

5. Encourage students to go back to the relevant sections and look at their notes in their Astro Journal to help answer the questions.

6. Have students vote on the answers.

Conclusion

1. Have students vote on the results that they found. Discuss how their results compare to their predictions.

2. Print the class certificate and the class Astro Journal, if you wish.

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.

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.

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 analyze data from satellites, radar, and Synoptic surface-observing instruments
- *Weather forecasters*: prepare forecasts for public prepare forecasts for public forecasters and specialized reports for aviation, marine and agriculture
- *Research*: study atmospheric physics, refi ne theories study atmospheric physics, refi ne theories Research 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 data base 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 highschoolers
  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/

Weather Station Manager — Career Fact Sheet

Related Job Titles:

Meteorologist, Weather Officer, Weather Forecaster, Meteorology Researcher, Meteorological Modeling Specialist

Job Description:

As a manager, the primary work deals with supervising the employees (other meteorologists) working in your area. This means dealing with people-related issues and performance evaluation. The meteorologists collect weather data, survey weather indicators and make predictions regarding developing weather patterns. They advise air traffic controllers on weather hazards such as thunderstorms, developing storm cells and fronts, turbulence, icing and other such weather-related phenomena. They issue to controllers weather advisories for aircraft. 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 improve air traffic management in adverse weather conditions.

Interests/Abilities:

- Do watching weather reports on television interest you?
- Do you notice the slightest change in the sky, the air temperature and the wind?
- Do you enjoy motivating people to work as a team?
- Do you like to motivate people toward self-improvement?
- When you take measurements, are you precise and double check your readings for accuracy?

Education/Training Needed:

A Bachelors of Science and a Masters of Science degree in Meteorology from an accredited college or university is required. Experience in computer modeling techniques is helpful for this position. Management training courses are essential for competent and efficient job performance.

Additional Resources:

- National Oceanic and Atmospheric Administration http://www.noaa.gov/
- Weatherwise http://www.weatherwise.org/
- National Severe Storms Laboratory http://www.nssl.noaa.gov/
- National Weather Service http://www.nws.noaa.gov/
- Federal Aviation Administration http://www.faa.gov/
- Schools with programs in meteorology http://www.nssl.noaa.gov/edu/schools.html
- Student Educational Employment Programs http://nasajobs.nasa.gov/stud_opps/employment/index.htm
- NASA Jobs http://nasajobs.nasa.gov/
- NASA Summer High School Apprenticeship Research Program (SHARP) http://www.mtsibase.com/sharp/

Suggested School Subjects/Courses:

- Algebra
- Trigonometry
- Physics
- Meteorology
- Statistics
- Computer modeling
- Psychology (to help deal with people)
- Interpersonal communication (to help deal with people)

Areas of Expertise:

- Meteorology
- Severe storms
- Icing
- Turbulence
- Fronts
- Computer modeling software
- Human resources management

What Can I Do Right Now?

- Get 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 System (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.
- Attend a seminar about basic management skills.

Planetary Atmospheric Scientist

Anthony Colaprete

Research Scientist

Contractor, National Research Council
NASA Ames Research Center

I build computer models of planetary atmospheres and design instruments that make measurements. Current efforts are toward the NASA Ames Mars general circulation model (GCM), a 3D dynamical model that simulates Martian weather and climate. Specifically I am working on including clouds and dust into the CGM. I also am a Co-Investigator on a proposed Mars mission called Pascal. Pascal consists of 18 individual probes that land all over the Martian surface. As a Co-Investigator I am in change of developing a digital camera that will take pictures of the Martian surface during probe descent.

My areas of expertise:

- Planetary Atmospheres

How I first became interested in this profession:

I think I've been interested in nature and ecology from the time I was born. As a kid, I was happier running around the woods than sitting at home in front of a TV. My father introduced me to space science and engineering early with "at-home" experiments we would perform together. By the time I was in high school I knew I wanted to be involved in the space sciences. Later in college I realized that I could bring my love for nature and space together by studying the nature of other worlds.

What helped prepare me for this job:

I think all that time I spent running around in the woods helped me the most. While in the woods I would sit and watch how things worked together, how the forest was composed of lots of parts that made a system. Watching the natural system of the forest taught me to observe other systems and recognize trends, relationships and causalities. That is my strongest attribute and helps me every day as I look at data from Mars or Earth. Of course I studied a lot (something I was never very good at) and that helped me build the tools that I use every day at work.

My role models or inspirations:

There were many. First was my father. When I was about 7, he and I cut a battery in half to figure out how it worked (my father is an engineer and knew how to do this without anyone getting hurt!). My wife is a huge source of motivation for me and makes me realize just how wonderful and amazing the entire universe is. Luckily my thesis advisor had enough faith in my abilities to let me make some really good mistakes! He always helped guide me but still let me go off exploring my own crazy ideas.

My education and training:

- 1992 B.A., Physics, University of Colorado
- 1998 M.S., 2000 Ph.D., Astrophysical, Planetary and Atmospheric Science, University of Colorado

My career path:

- 10 years at Colorado Space Grant College—design, fabrication, calibration and flight analysis of instrumentation on shuttle and satellite missions.
- 8 years at the Laboratory for Atmospheric and Space Physics—aerosol modeling for Mars Pathfinder and Mars Global Surveyor.

What I like about my job:

Being a planetary scientist is like being a storyteller. You get to come up with new stories or ideas about how a planet works. My job combines modeling with measurements which lets me work with instruments and missions to other worlds.

What I don't like about my job:

Sometimes there is a lot of paper work that needs to be done that has nothing to do with science. That's a drag.

My advice to anyone interested in this occupation:

Develop the tools needed to be a scientist early on! If you know your math and physics, it frees up your time to think about the real problems. Learn to observe and ask questions. All science starts with an observation, an idea or a question.

Atmospheric Scientist/Researcher

Dr. Jadwiga "Yaga" Beres

Atmospheric Scientist/ Researcher

National Center for Atmospheric Science

I spend most of my days examining atmospheric motions, either by working with lots of equations or by using computer models to understand how the atmosphere works. Once we have a better understanding of how the atmosphere works, we can model it more accurately. From time to time I teach and get involved in educational activities for people of all ages.

My areas of expertise:

- Atmospheric gravity waves generated by convection
- Dynamics of the middle and upper atmosphere

How I first became interested in this profession:

I started researching clear-air turbulence as an undergraduate student. I was in the math department, but my advisor was involved in atmospheric science research. Everything else is history.

What helped prepare me for this job:

The most important thing that helped me prepare for this job was being pushed by my mentors to develop ideas and opinions of my own and to think out of the box. My knowledge of math, physics, and computer programming is very useful every day.

My role models or inspirations:

The professors who are so passionate about their research that they have difficulties NOT thinking about it serve as my inspiration.

My education and training:

- B.S., Mathematics, Purchase College, (State University of New York)
- Ph.D., Atmospheric Sciences, University of Washington

My career path:

- 6 years as a research assistant
- 1 year as a postdoctoral researcher
- 2 years as a teaching assistant
- 1 year as an educational outreach coordinator

What I like about my job:

I very much enjoy the independence and freedom to work on whatever I wish to. Research is a lot like solving puzzles, and I love puzzles and figuring out how things work. I also enjoy being able to share my knowledge with different audiences through teaching and outreach activities.

What I don't like about my job:

Sometimes there is too little interaction with people; research involves a lot of independent work.

My advice to anyone interested in this occupation:

Find a topic that really draws your attention before starting on a project. This job requires a lot of self-motivation, and it is much easier to spend the time on something you really like.

Earth Scientist

Dr. Sadredin "Dean" Moosavi

Earth Scientist

Minnesota State University
NASA BOREAS Project

I help future teachers and general education students to understand the Earth as a system and to understand its place in the solar system. I teach, grade papers, and develop materials and activities to help students of many ages learn about the Earth. A big part of my job is developing and leading field trips. From an afternoon trip to a local river to a week-long excursion to look at lava flows, field trips help us to see the Earth and geologic processes on their own time and spatial scales. Students in this setting get the chance to make scientific observations the same way explorers do; by actually going there and seeing how the small pieces fit into the larger puzzle. When I have time, I also go into the field, specifically the Arctic, to investigate how wetlands produce greenhouse gases such as methane and carbon dioxide. This interface among living organisms, the Earth's waters, and the atmosphere is fascinating because it determines the nature of our very existence and the way our planet has evolved to be so different from its neighbors.

My areas of expertise:

- Boreal and arctic wetland Biogeochemistry
- Global climate change
- Greenhouse gas emissions
- Earth science education

How I first became interested in this profession:

When I was an exchange student I was exposed to the problems caused by acid rain in Europe. The desire to help solve these problems drove me toward the environmental sciences.

What helped prepare me for this job:

I was lucky to have a strong public high school background, which focused on science without neglecting the humanities. My decision to keep my course work program diverse has been crucial to my interdisciplinary work. Most importantly, developing good interpersonal skills combined with a genuine interest in a variety of topics has kept me broadly knowledgeable of science and society.

My role models or inspirations:

I was blessed to have grandparents who believed in the importance of integrating science knowledge and experiences in the natural world as a means for learning. I give credit to my high school English teacher for my interest in reading great works of literature and stories of science and scientists like Alfred Wegener. She also helped me develop my writing skills. I also acknowledge my students over the years; that hard work and dedication to learning continues to inspire my efforts.

My education and training:

- A.S., Science, Finger Lakes Community College
- B.S., Environmental Chemistry, State University of New York, College of Environmental Science & Forestry
- M.S., Earth Science, University of New Hampshire
- Ph.D., Earth Science with specialization in Geochemical Systems, University of New Hampshire

My career path:

- Graduate School, University of New Hampshire, 7 years
- High school chemistry, oceanography, physical science teacher, 2 years
- Assistant Professor of geology, Minnesota State University, 3 years to present

What I like about my job:

I love the opportunity to share science with so many people, especially the people who will be teaching. I love seeking out and generating new knowledge and traveling to interesting places. It is wonderful to make a difference both for people and the environment. Most of all I love trying to understand our place in the universe.

What I don't like about my job:

There is more to do in this job than you can ever hope to achieve in one lifetime! The downside is that some of your time is lost to the paperwork/bureaucratic tasks. Whether attending meetings, seeking funding, grading papers, etc., the time needed for these unavoidable functions is lost from teaching and research.

My advice to anyone interested in this occupation:

Developing skills in math, writing, public speaking, and ALL the basic sciences is important. Do not overspecialize, but get as broad of scientific training as possible without neglecting the arts and humanities. Keep your eye on both short and long term goals when making decisions in your life—even the most direct route to an objective is not always the best choice. Every day is an opportunity to learn something that has use, even if that use is currently hidden. Approach life with openness, collect experiences and skills, and weave them together to make your own unique future.

Planetary Atmosphere Comparison Chart

Planet	Amount of Atmosphere	Atmospheric Composition
Mercury	Trace atmosphere = .000000000000010 bars*	42% oxygen (O_2) 29% sodium (Na), 22% hydrogen (H_2) 6% helium (He) 0.5% potassium (K), possible trace amounts of: argon (Ar), carbon dioxide (CO_2), water (H_2O), nitrogen (N_2), xenon (Xe), krypton (Kr), neon (Ne)
Venus	Atmosphere = 92 bars	96.5% carbon dioxide (CO_2) 3.5% nitrogen (N_2) water (H_2O) – 0. 0020% trace amounts of: sulfur dioxide (SO_2), argon (Ar), carbon monoxide (CO), helium (He) and neon (Ne)
Earth	1 bar (at sea level)	78% nitrogen (N_2) 21% oxygen (O_2) 0.035% carbon dioxide (CO_2) 1 to 4% water vapor (H_2O) 300 Dobson Units ozone (O_3) 0.002% methane (CH_4) 0.9% argon (Ar) trace amounts of: helium (He), krypton (Kr) and hydrogen (H_2)
Moon	0 bars	None
Mars	Atmosphere = 0.0061 bars	95.32% carbon dioxide (CO_2) 2.7% nitrogen (N_2) 1.6% argon (Ar) 0.13% oxygen (O_2) 0.08% carbon monoxide (CO) water (H_2O) – 0.0210%; trace amounts of: nitrogen oxide (NO), neon (Ne), hydrogen-deuterium-oxygen (HDO), krypton (Kr) and xenon (Xe)
Jupiter	Atmosphere > 1000 bars	89.8% hydrogen (H_2) 10.2% helium (He) 0.3% methane (CH_4) ~0.0004% water (H_2O) (varies with pressure) trace amounts of: ammonia (NH_3), hydrogen deuteride (HD) and ethane (C_2H_6)
Saturn	Atmosphere >1000 bars	96.3% hydrogen (H_2) 3.25% helium (He) 0.45% methane (CH_4) trace amounts of: ammonia (NH_3), hydrogen deuteride (HD) and ethane (C_2H_6)
Uranus	Atmosphere > 1000 bars	82.5% hydrogen (H_2) 15.2% helium (He) ~2.3% methane (CH_4) trace amounts of: hydrogen deuteride (HD)
Neptune	Atmosphere > 1000 bars	80.0% hydrogen (H_2) 19.0% helium (He) 1.5% methane (CH_4) trace amounts of: hydrogen deuteride (HD) and ethane (C_2H_6)
Pluto	Atmosphere ~0.000003 bars	Methane (CH_4), nitrogen (N_2)

* 1 bar is the average atmospheric pressure at sea level on Earth.

Human Survival Transparency

Humans Need:	Reason:	What Factors Provide This:
Food	Gives us energy so that we can move, grow, and function. It also gives us nutrients to build and mend bones, teeth, nails, skin, hair, flesh, and organs.	
Oxygen	Helps us to obtain energy from sugars.	
Water	Allows nutrients to circulate through the body. Helps to regulate body temperature. The cells that make up our bodies are made mainly of water.	
Moderate temperature (Average global temperature above 0°C and below 50°C)	Allows us to maintain an average body temperature of 98.6°F/37°C and to maintain water in a liquid state at all times.	
Protection from poisonous gases and high levels of radiation	To prevent cancer, disease and damage to the body.	
Gravity	Allows our biological systems to develop and function normally. Holds the atmosphere to the Earth so it doesn't escape into space.	

Atmospheric Conditions Transparency

Reason					
Observed Atmospheric Condition					
Predicted Atmospheric Condition					