10.E: Earthlike Planets - Venus and Mars (Exercises)

For Further Exploration

Articles

Venus

- Dorminey, B. “Cool Science on a Hot World.” *Astronomy* (February 2006): 46. Five-page overview of Venus and the Venus Express mission plans.
- Kargel, J. “Rivers of Venus.” *Sky & Telescope* (August 1997): 32. On lava channels.
- Robertson, D. “Parched Planet.” *Sky & Telescope* (April 2008): 26. Overview of our understanding of the planet.
- Robinson, C. “Magellan Reveals Venus.” *Astronomy* (February 1995): 32.
- Stofan, E. “The New Face of Venus.” *Sky & Telescope* (August 1993): 22.
- Zimmerman, R. “Taking Venus by Storm.” *Astronomy* (October 2008): 66. On results from the Venus Express mission.

Mars

- Albee, A. “The Unearthly Landscapes of Mars.” *Scientific American* (June 2003): 44. Results from the Mars Global Surveyor and Mars Odyssey missions and an overview.
- Bell, J. “A Fresh Look at Mars.” *Astronomy* (August 2015): 28. Nice summary of recent spacecraft results and how they are revising our understanding of Mars.
- Bell, J. “Uncovering Mars’ Secret Past.” *Sky & Telescope* (July 2009): 22. How rovers and orbiters are helping us to understand Mars history and the role of water.
- Bell, J. “The Red Planet’s Watery Past.” *Scientific American* (December 2006): 62. Rovers are furnishing proof that ancient Mars was wet.
- Burnham, R. “Red Planet Rendezvous.” *Astronomy* (May 2006): 68. About Mariner Valley and a flyover film constructed from many still images.
- Christensen, P. “The Many Faces of Mars.” *Scientific American* (July 2005): 32. Results from the Rover mission; evidence that Mars was once wet in places.
- Lakdawalla, E. “The History of Water on Mars.” *Sky & Telescope* (September 2013): 16. Clear review of our current understanding of the role of water on Mars in different epochs.
- Malin, M. “Visions of Mars.” *Sky & Telescope* (April 1999): 42. A geological tour of the red planet, with new Mars Global Surveyor images.
- McEwen, A. “Mars in Motion.” *Scientific American* (May 2013): 58. On gullies and other surface changes.
- McKay, C. & Garcia, V. “How to Search for Life on Mars.” *Scientific American* (June 2014): 44. Experiments future probes could perform.
- Naeye, R. “Europe’s Eye on Mars.” *Sky & Telescope* (December 2005): 30. On the Mars Express mission and the remarkable close-up images it is sending.
- Talcott, R. “Seeking Ground Truth on Mars.” *Astronomy* (October 2009): 34. How rovers and orbiters are helping scientists understand the red planet’s surface.

Websites

- European Space Agency Mars Express Page: www.esa.int/Our_Activities/Sp...e/Mars_Express.
- European Space Agency Venus Express Page: www.esa.int/Our_Activities/Sp.../Venus_Express.
- High Resolution Imaging Science Experiment: http://hirise.lpl.arizona.edu/.
- Jet Propulsion Lab Mars Exploration Page: http://mars.jpl.nasa.gov/.
- Mars Globe HD app: https://itunes.apple.com/us/app/mars...376020224?mt=8.
- Mars Rover 360° Panorama: http://www.360cities.net/image/curio....10,26.50,70.0. Interactive.
- NASA Center for Mars Exploration: www.nasa.gov/mission_pages/ma...ain/index.html.
- NASA Solar System Exploration Mars Page: http://solarsystem.nasa.gov/planets/mars.
- NASA Solar System Exploration Venus Page: http://solarsystem.nasa.gov/planets/venus.
- NASA’s apps about Mars for phones and tablets can be found at: http://mars.nasa.gov/mobile/info/.
- NASA’s Magellan Mission to Venus: http://www2.jpl.nasa.gov/magellan/.
- Russian (Soviet) Venus Missions and Images: http://mentallandscape.com/C_CatalogVenus.htm.

- Venus Atlas app: https://itunes.apple.com/us/app/venu...317310503?mt=8.
- Venus Express Results Article: http://www.mpg.de/798302/F002_Focus_026-033.pdf.

Videos

- 50 Years of Mars Exploration: http://www.jpl.nasa.gov/video/details.php?id=1395. NASA's summary of all missions through *MAVEN*; good quick overview (4:08).
- Being a Mars Rover: What It's Like to be an Interplanetary Explorer: https://www.youtube.com/watch?v=nRpCOEsPD54. 2013 talk by Dr. Lori Fenton about what it's like on the surface of Mars (1:07:24).
- Magellan Maps Venus: www.bbc.co.uk/science/space/s...probe#p005y07s. BBC clip with Dr. Ellen Stofan on the radar images of Venus and what they tell us (3:06).
- Our *Curiosity*: https://www.youtube.com/watch?v=XczKXWvokm4. Mars *Curiosity* rover 2-year anniversary video narrated by Neil deGrasse Tyson and Felicia Day (6:01).
- Planet Venus: The Deadliest Planet, Venus Surface and Atmosphere: https://www.youtube.com/watch?v=HqFVxWfVtoo. Quick tour of Venus' atmosphere and surface (2:04).
- Planetary Protection and Hitchhikers in the Solar System: The Danger of Mingling Microbes: https://www.youtube.com/watch?v=6iGC3uO7jBI. 2009 talk by Dr. Margaret Race on preventing contamination between worlds (1:28:50).

Collaborative Group Activities

1. Your group has been asked by high NASA officials to start planning the first human colony on Mars. Begin by making a list of what sorts of things humans would need to bring along to be able to survive for years on the surface of the red planet.
2. As a publicity stunt, the mayor of Venus, Texas (there really is such a town), proposes that NASA fund a mission to Venus with humans on board. Clearly, the good mayor neglected to take an astronomy course in college. Have your group assemble a list of as many reasons as possible why it is unlikely that humans will soon land on the surface of Venus.
3. Even if humans would have trouble surviving on the surface of Venus, this does not mean we could not learn a lot more about our veiled sister planet. Have your group brainstorm a series of missions (pretend cost is no object) that would provide us with more detailed information about Venus' atmosphere, surface, and interior.
4. Sometime late in the twenty-first century, when travel to Mars has become somewhat routine, a very wealthy couple asks you to plan a honeymoon tour of Mars that includes the most spectacular sights on the red planet. Constitute your group as the Percival Lowell Memorial Tourist Agency, and come up with a list of not-to-be missed tourist stops on Mars.
5. In the popular book and film, called *The Martian*, the drama really begins when our hero is knocked over and loses consciousness as he is half buried by an intense wind storm on Mars. Given what you have learned about Mars' atmosphere in this chapter, have your group discuss how realistic that scenario is. (By the way, the author of the book has himself genially acknowledged in interviews and talks that this is a reasonable question to ask.)
6. Astronomers have been puzzled and annoyed about the extensive media publicity that was given the small group of "true believers" who claimed the "Face on Mars" was not a natural formation (see the Astronomy and Pseudoscience: The "Face on Mars" feature box in Section 10.5). Have your group make a list of the reasons many of the media were so enchanted by this story. What do you think astronomers could or should do to get the skeptical, scientific perspective about such issues before the public?
7. Your group is a special committee of scientists set up by the United Nations to specify how any Mars samples should be returned to Earth so that possible martian microbes do not harm Earth life. What precautions would you recommend, starting at Mars and going all the way to the labs that analyze the martian samples back on Earth?
8. Have your group brainstorm about Mars in popular culture. How many movies, songs or other music, and products can you think of connected with Mars? What are some reasons that Mars would be a popular theme for filmmakers, songwriters, and product designers?

Review Questions

1. List several ways that Venus, Earth, and Mars are similar, and several ways they are different.
2. Compare the current atmospheres of Earth, Venus, and Mars in terms of composition, thickness (and pressure at the surface), and the greenhouse effect
3. How might Venus' atmosphere have evolved to its present state through a runaway greenhouse effect?
4. Describe the current atmosphere on Mars. What evidence suggests that it must have been different in the past?
5. Explain the runaway refrigerator effect and the role it may have played in the evolution of Mars.

6. What evidence do we have that there was running (liquid) water on Mars in the past? What evidence is there for water coming out of the ground even today?
7. What evidence is there that Venus was volcanically active about 300–600 million years ago?
8. Why is Mars red?
9. What is the composition of clouds on Mars?
10. What is the composition of the polar caps on Mars?
11. Describe two anomalous features of the rotation of Venus and what might account for them.
12. How was the *Mars Odyssey* spacecraft able to detect water on Mars without landing on it?

Thought Questions

1. What are the advantages of using radar imaging rather than ordinary cameras to study the topography of Venus? What are the relative advantages of these two approaches to mapping Earth or Mars?
2. Venus and Earth are nearly the same size and distance from the Sun. What are the main differences in the geology of the two planets? What might be some of the reasons for these differences?
3. Why is there so much more carbon dioxide in the atmosphere of Venus than in that of Earth? Why so much more carbon dioxide than on Mars?
4. If the Viking missions were such a rich source of information about Mars, why have we sent the Pathfinder, *Global Surveyor*, and other more recent spacecraft to Mars? Make a list of questions about Mars that still puzzle astronomers.
5. Compare Mars with Mercury and the Moon in terms of overall properties. What are the main similarities and differences?
6. Contrast the mountains on Mars and Venus with those on Earth and the Moon.
7. We believe that all of the terrestrial planets had similar histories when it comes to impacts from space. Explain how this idea can be used to date the formation of the martian highlands, the martian basins, and the Tharsis volcanoes. How certain are the ages derived for these features (in other words, how do we check the ages we derive from this method)?
8. Is it likely that life ever existed on either Venus or Mars? Justify your answer in each case.
9. Suppose that, decades from now, NASA is considering sending astronauts to Mars and Venus. In each case, describe what kind of protective gear they would have to carry, and what their chances for survival would be if their spacesuits ruptured.
10. We believe that Venus, Earth, and Mars all started with a significant supply of water. Explain where that water is now for each planet.
11. One source of information about Mars has been the analysis of meteorites from Mars. Since no samples from Mars have ever been returned to Earth from any of the missions we sent there, how do we know these meteorites are from Mars? What information have they revealed about Mars?
12. The runaway greenhouse effect and its inverse, the runaway refrigerator effect, have led to harsh, uninhabitable conditions on Venus and Mars. Does the greenhouse effect always cause climate changes leading to loss of water and life? Give a reason for your answer.
13. In what way is the high surface temperature of Venus relevant to concerns about global warming on Earth today?
14. What is a dust devil? Would you expect to feel more of a breeze from a dust devil on Mars or on Earth? Explain.
15. Near the martian equator, temperatures at the same spot can vary from an average of –135 °C at night to an average of 30 °C during the day. How can you explain such a wide difference in temperature compared to that on Earth?

Figuring for Yourself

1. Estimate the amount of water there could be in a global (planet-wide) region of subsurface permafrost on Mars (do the calculations for two permafrost thicknesses, 1 and 10 km, and a concentration of ice in the permafrost of 10% by volume). Compare the two results you get with the amount of water in Earth's oceans calculated in Example 10.5.1.
2. At its nearest, Venus comes within about 41 million km of Earth. How distant is it at its farthest?
3. If you weigh 150 lbs. on the surface of Earth, how much would you weigh on Venus? On Mars?
4. Calculate the relative land area—that is, the amount of the surface not covered by liquids—of Earth, the Moon, Venus, and Mars. (Assume that 70% of Earth is covered with water.)
5. The closest approach distance between Mars and Earth is about 56 million km. Assume you can travel in a spaceship at 58,000 km/h, which is the speed achieved by the New Horizons space probe that went to Pluto and is the fastest speed so far of any space vehicle launched from Earth. How long would it take to get to Mars at the time of closest approach?