7.E: Other Worlds - An Introduction to the Solar System (Exercises)

For Further Exploration

Articles

Davidson, K. "Carl Sagan's Coming of Age." *Astronomy.* (November 1999): 40. About the noted popularizer of science and how he developed his interest in astronomy.

Garget, J. "Mysterious Microworlds." *Astronomy.* (July 2005): 32. A quick tour of a number of the moons in the solar system.

Hartmann, W. "The Great Solar System Revision." *Astronomy*. (August 1998): 40. How our views have changed over the past 25 years.

Kross, J. "What's in a Name?" *Sky & Telescope*. (May 1995): 28. How worlds are named.

Rubin, A. "Secrets of Primitive Meteorites." *Scientific American*. (February 2013): 36. What meteorites can teach us about the environment in which the solar system formed.

Soter, S. "What Is a Planet?" *Scientific American*. (January 2007): 34. The IAU's new definition of a planet in our solar system, and what happened to Pluto as a result.

Talcott, R. "How the Solar System Came to Be." *Astronomy*. (November 2012): 24. On the formation period of the Sun and the planets.

Wood, J. "Forging the Planets: The Origin of our Solar System." *Sky & Telescope*. (January 1999): 36. Good overview.

Websites

Gazetteer of Planetary Nomenclature: http://planetarynames.wr.usgs.gov/. Outlines the rules for naming bodies and features in the solar system.

Planetary Photojournal: http://photojournal.jpl.nasa.gov/index.html. This NASA site features thousands of the best images from planetary exploration, with detailed captions and excellent indexing. You can find images by world, feature name, or mission, and download them in a number of formats. And the images are copyright-free because your tax dollars paid for them.

The following sites present introductory information and pictures about each of the worlds of our solar system:

- NASA/JPL Solar System Exploration pages: http://solarsystem.nasa.gov/index.cfm.
- National Space Science Data Center Lunar and Planetary Science pages: http://nssdc.gsfc.nasa.gov/planetary/.
- Nine [now 8] Planets Solar System Tour: www.nineplanets.org/.
- Planetary Society solar system pages: www.planetary.org/explore/spa...opics/compare/.
- Views of the Solar System by Calvin J. Hamilton: http://www.solarviews.com/eng/homepage.htm.

Videos

Brown Dwarfs and Free Floating Planets: When You Are Just Too Small to Be a Star: https://www.youtube.com/watch?v=zXCDsb4n4KU. A nontechnical talk by Gibor Basri of the University of California at Berkeley, discussing some of the controversies about the meaning of the word "planet" (1:32:52).

In the Land of Enchantment: The Epic Story of the Cassini Mission to Saturn: https://www.youtube.com/watch?v=Vx135n8VFxY. A public lecture by Dr. Carolyn Porco that focuses mainly on the exploration of Saturn and its moons, but also presents an eloquent explanation of why we explore the solar system (1:37:52).

Origins of the Solar System: www.pbs.org/wgbh/nova/space/o...ar-system.html. A video from PBS that focuses on the evidence from meteorites, narrated by Neil deGrasse Tyson (13:02).

To Scale: The Solar System: https://www.youtube.com/watch?t=84&v=zR3Igc3Rhfg. Constructing a scale model of the solar system in the Nevada desert (7:06).

Collaborative Group Activities

1. Discuss and make a list of the reasons why we humans might want to explore the other worlds in the solar system. Does your group think such missions of exploration are worth the investment? Why?

2. Your instructor will assign each group a world. Your task is to think about what it would be like to be there. (Feel free to look ahead in the book to the relevant chapters.) Discuss where on or around your world we would establish a foothold and what we would need to survive there.
3. In the There's No Place Like Home feature in Section 7.2, we discuss briefly how human activity is transforming our planet's overall environment. Can you think of other ways that this is happening?
4. Some scientists criticized Carl Sagan for "wasting his research time" popularizing astronomy. To what extent do you think scientists should spend their time interpreting their field of research for the public? Why or why not? Are there ways that scientists who are not as eloquent or charismatic as Carl Sagan or Neil deGrasse Tyson can still contribute to the public understanding of science?
5. Your group has been named to a special committee by the International Astronomical Union to suggest names of features (such as craters, trenches, and so on) on a newly explored asteroid. Given the restriction that any people after whom features are named must no longer be alive, what names or types of names would you suggest? (Keep in mind that you are not restricted to names of people, by the way.)
6. A member of your group has been kidnapped by a little-known religious cult that worships the planets. They will release him only if your group can tell which of the planets are currently visible in the sky during the evening and morning. You are forbidden from getting your instructor involved. How and where else could you find out the information you need? (Be as specific as you can. If your instructor says it's okay, feel free to answer this question using online or library resources.)
7. In the Carl Sagan: Solar System Advocate feature in Section 7.1, you learned that science fiction helped spark and sustain his interest in astronomy. Did any of the members of your group get interested in astronomy as a result of a science fiction story, movie, or TV show? Did any of the stories or films you or your group members saw take place on the planets of our solar system? Can you remember any specific ones that inspired you? If no one in the group is into science fiction, perhaps you can interview some friends or classmates who are and report back to the group.
8. A list of NASA solar system spacecraft missions can be found at http://www.nasa.gov/content/solar-missions-list. Your instructor will assign each group a mission. Look up when the mission was launched and executed, and describe the mission goals, the basic characteristics of the spacecraft (type of instruments, propellant, size, and so on), and what was learned from the mission. If time allows, each group should present its findings to the rest of the class.
9. What would be some of the costs or risks of developing a human colony or base on another planetary body? What technologies would need to be developed? What would people need to give up to live on a different world in our solar system?

Review Questions

1. Venus rotates backward and Uranus and Pluto spin about an axis tipped nearly on its side. Based on what you learned about the motion of small bodies in the solar system and the surfaces of the planets, what might be the cause of these strange rotations?
2. What is the difference between a differentiated body and an undifferentiated body, and how might that influence a body's ability to retain heat for the age of the solar system?
3. What does a planet need in order to retain an atmosphere? How does an atmosphere affect the surface of a planet and the ability of life to exist?
4. Which type of planets have the most moons? Where did these moons likely originate?
5. What is the difference between a meteor and a meteorite?
6. Explain our ideas about why the terrestrial planets are rocky and have less gas than the giant planets.
7. Do all planetary systems look the same as our own?
8. What is comparative planetology and why is it useful to astronomers?
9. What changed in our understanding of the Moon and Moon-Earth system as a result of humans landing on the Moon's surface?
10. If Earth was to be hit by an extraterrestrial object, where in the solar system could it come from and how would we know its source region?
11. List some reasons that the study of the planets has progressed more in the past few decades than any other branch of astronomy.
12. Imagine you are a travel agent in the next century. An eccentric billionaire asks you to arrange a "Guinness Book of Solar System Records" kind of tour. Where would you direct him to find the following (use this chapter and Appendix F and Appendix G):
    1. the least-dense planet
    2. the densest planet
    3. the largest moon in the solar system

4. excluding the jovian planets, the planet where you would weigh the most on its surface (Hint: Weight is directly proportional to surface gravity.)
5. the smallest planet
6. the planet that takes the longest time to rotate
7. the planet that takes the shortest time to rotate
8. the planet with a diameter closest to Earth's
9. the moon with the thickest atmosphere
10. the densest moon
11. the most massive moon

13. What characteristics do the worlds in our solar system have in common that lead astronomers to believe that they all formed from the same "mother cloud" (solar nebula)?
14. How do terrestrial and giant planets differ? List as many ways as you can think of.
15. Why are there so many craters on the Moon and so few on Earth?
16. How do asteroids and comets differ?
17. How and why is Earth's Moon different from the larger moons of the giant planets?
18. Where would you look for some "original" planetesimals left over from the formation of our solar system?
19. Describe how we use radioactive elements and their decay products to find the age of a rock sample. Is this necessarily the age of the entire world from which the sample comes? Explain.
20. What was the solar nebula like? Why did the Sun form at its center?

Thought Questions

1. What can we learn about the formation of our solar system by studying other stars? Explain.
2. Earlier in this chapter, we modeled the solar system with Earth at a distance of about one city block from the Sun. If you were to make a model of the distances in the solar system to match your height, with the Sun at the top of your head and Pluto at your feet, which planet would be near your waist? How far down would the zone of the terrestrial planets reach?
3. Seasons are a result of the inclination of a planet's axial tilt being inclined from the normal of the planet's orbital plane. For example, Earth has an axis tilt of 23.4° (Appendix F). Using information about just the inclination alone, which planets might you expect to have seasonal cycles similar to Earth, although different in duration because orbital periods around the Sun are different?
4. Again using Appendix F, which planet(s) might you expect not to have significant seasonal activity? Why?
5. Again using Appendix F, which planets might you expect to have extreme seasons? Why?
6. Using some of the astronomical resources in your college library or the Internet, find five names of features on each of three other worlds that are named after real people. In a sentence or two, describe each of these people and what contributions they made to the progress of science or human thought.
7. Explain why the planet Venus is differentiated, but asteroid Fraknoi, a very boring and small member of the asteroid belt, is not.
8. Would you expect as many impact craters per unit area on the surface of Venus as on the surface of Mars? Why or why not?
9. Interview a sample of 20 people who are not taking an astronomy class and ask them if they can name a living astronomer. What percentage of those interviewed were able to name one? Typically, the two living astronomers the public knows these days are Stephen Hawking and Neil deGrasse Tyson. Why are they better known than most astronomers? How would your result have differed if you had asked the same people to name a movie star or a professional basketball player?
10. Using Appendix G, complete the following table that describes the characteristics of the Galilean moons of Jupiter, starting from Jupiter and moving outward in distance.

Table A

Moon	Semimajor Axis (km^3)	Diameter	Density (g/cm^3)
Io			
Europa			
Ganymede			
Callisto			

This system has often been described as a mini solar system. Why might this be so? If Jupiter were to represent the Sun and the Galilean moons represented planets, which moons could be considered more terrestrial in nature and which ones more like gas/ice giants? Why? (Hint: Use the values in your table to help explain your categorization.)

Figuring for Yourself

1. Calculate the density of Jupiter. Show your work. Is it more or less dense than Earth? Why?
2. Calculate the density of Saturn. Show your work. How does it compare with the density of water? Explain how this can be.
3. What is the density of Jupiter's moon Europa (see Appendix G for data on moons)? Show your work.
4. Look at Appendix F and Appendix G and indicate the moon with a diameter that is the largest fraction of the diameter of the planet or dwarf planet it orbits.
5. Barnard's Star, the second closest star to us, is about 56 trillion (5.6×10^{12}) km away. Calculate how far it would be using the scale model of the solar system given in Overview of Our Planetary System.
6. A radioactive nucleus has a half-life of 5×10^8 years. Assuming that a sample of rock (say, in an asteroid) solidified right after the solar system formed, approximately what fraction of the radioactive element should be left in the rock today?