8.E: Earth as a Planet (Exercises)

For Further Exploration

Articles

Earth

Collins, W., et al. “The Physical Science behind Climate Change.” *Scientific American* (August 2007): 64. Why scientists are now confident that human activities are changing our planet’s climate.

Glatzmaier, G., & Olson, P. “Probing the Geodynamo.” *Scientific American* (April 2005): 50. Experiments and modeling that tell us about the source and reversals of Earth’s magnetic field.

Gurnis, M. “Sculpting the Earth from Inside Out.” *Scientific American*(March 2001): 40. On motions that lift and lower the continents.

Hartmann, W. “Piecing Together Earth’s Early History.” *Astronomy* (June 1989): 24.

Jewitt, D., & Young, E. “Oceans from the Skies.” *Scientific American*(March 2015): 36. How did Earth get its water after its initial hot period?

Impacts

Boslaugh, M. “In Search of Death-Plunge Asteroids.” *Astronomy (*July 2015): 28. On existing and proposed programs to search for earth-crossing asteroids.

Brusatte, S. “What Killed the Dinosaurs?” *Scientific American*(December 2015): 54. The asteroid hit Earth at an already vulnerable time.

Chyba, C. “Death from the Sky: Tunguska.” *Astronomy* (December 1993): 38. Excellent review article.

Durda, D. “The Chelyabinsk Super-Meteor.” *Sky & Telescope* (June 2013): 24. A nice summary with photos and eyewitness reporting.

Gasperini, L., et al. “The Tunguska Mystery.” *Scientific American* (June 2008): 80. A more detailed exploration of the site of the 1908 impact over Siberia.

Kring, D. “Blast from the Past.” *Astronomy* (August 2006): 46. Six-page introduction to Arizona’s meteor crater.

Websites

Earth

Astronaut Photography of Earth from Space: earth.jsc.nasa.gov/. A site with many images and good information.

Exploration of the Earth’s Magnetosphere: http://phy6.org/Education/Intro.html. An educational website by Dr. Daniel Stern.

NASA Goddard: Earth from Space: Fifteen Amazing Things in 15 Years: https://www.nasa.gov/content/goddard...gs-in-15-years. Images and videos that reveal things about our planet and its atmosphere.

U.S. Geological Survey: Earthquake Information Center: http://earthquake.usgs.gov/learn/

Views of the Solar System: http://www.solarviews.com/eng/earth.htm. Overview of Earth.

Impacts

B612 Foundation : https://b612foundation.org/. Set up by several astronauts for research and education about the asteroid threat to Earth and to build a telescope in space to search for dangerous asteroids.

Lunar and Planetary Institute: Introduction to Terrestrial Impact Craters: http://www.lpi.usra.edu/publications...esets/craters/. Includes images.

Meteor Crater Tourist Site: http://meteorcrater.com/.

NASA/Jet Propulsion Lab Near Earth Object Program: http://neo.jpl.nasa.gov/neo/.

What Are Near-Earth-Objects: http://spaceguardcentre.com/what-are-neos/. From the British Spaceguard Centre.

Videos

Earth

All Alone in the Night: http://apod.nasa.gov/apod/ap120305.html. Flying over Earth at night (2:30).

Earth Globes Movies (including Earth at night): astro.uchicago.edu/cosmus/projects/earth/.

Earth: The Operator's Manual: http://earththeoperatorsmanual.com/f...erators-manual. A National Science Foundation–sponsored miniseries on climate change and energy, with geologist Richard Alley (53:43).

PBS NOVA Videos about Earth: http://www.pbs.org/wgbh/nova/earth/. Programs and information about planet Earth. Click full episodes on the menu at left to be taken to a nice array of videos.

U. S. National Weather Service: http://earth.nullschool.net. Real Time Globe of Earth showing wind patterns which can be zoomed and moved to your preferred view.

Impacts

Chelyabinsk Meteor: Can We Survive a Bigger Impact?: https://www.youtube.com/watch?v=Y-e6xyUZLLs . Talk by Dr. David Morrison (1:34:48).

Large Asteroid Impact Simulation: https://www.youtube.com/watch?v=bU1QPtOZQZU. Large asteroid impact simulation from the Discovery Channel (4:45).

Meteor Hits Russia February 15, 2013: https://www.youtube.com/watch?v=dpmXyJrs7iU. Archive of eyewitness footage (10:11).

Sentinel Mission: Finding an Asteroid Headed for Earth: https://www.youtube.com/watch?v=efz8c3ijD_A. Public lecture by astronaut Ed Lu (1:08:57).

Collaborative Group Activities

1. If we can predict that lots of ground movement takes place along subduction zones and faults, then why do so many people live there? Should we try to do anything to discourage people from living in these areas? What inducement would your group offer people to move? Who would pay for the relocation? (Note that two of the original authors of this book live quite close to the San Andreas and Hayward faults. If they wrote this chapter and haven't moved, what are the chances others living in these kinds of areas will move?)
2. After your group reads the feature box on Alfred Wegener: Catching the Drift of Plate Tectonics in Section 8.2, discuss some reasons his idea did not catch on right away among scientists. From your studies in this course and in other science courses (in college and before), can you cite other scientific ideas that we now accept but that had controversial beginnings? Can you think of any scientific theories that are still controversial today? If your group comes up with some, discuss ways scientists could decide whether each theory on your list is right.
3. Suppose we knew that a large chunk of rock or ice (about the same size as the one that hit 65 million years ago) will impact Earth in about 5 years. What could or should we do about it? (The film *Deep Impact* dealt with this theme.) Does your group think that the world as a whole should spend more money to find and predict the orbits of cosmic debris near Earth?
4. Carl Sagan pointed out that any defensive weapon that we might come up with to deflect an asteroid *away* from Earth could be used as an offensive weapon by an unstable dictator in the future to cause an asteroid not heading our way to come toward Earth. The history of human behavior, he noted, has shown that most weapons that are built (even with the best of motives) seem to wind up being used. Bearing this in mind, does your group think we should be building weapons to protect Earth from asteroid or comet impact? Can we afford not to build them? How can we safeguard against these collisions?
5. Is there evidence of climate change in your area over the past century? How would you distinguish a true climate change from the random variations in weather that take place from one year to the next?

Review Questions

1. What is the thickest interior layer of Earth? The thinnest?
2. What are Earth's core and mantle made of? Explain how we know.
3. Describe the differences among primitive, igneous, sedimentary, and metamorphic rock, and relate these differences to their origins.
4. Explain briefly how the following phenomena happen on Earth, relating your answers to the theory of plate tectonics
    1. earthquakes

2. continental drift
3. mountain building
4. volcanic eruptions
5. creation of the Hawaiian island chain

5. What is the source of Earth's magnetic field?
6. Why is the shape of the magnetosphere not spherical like the shape of Earth?
7. Although he did not present a mechanism, what were the key points of Alfred Wegener's proposal for the concept of continental drift?
8. List the possible interactions between Earth's crustal plates that can occur at their boundaries.
9. List, in order of decreasing altitude, the principle layers of Earth's atmosphere.
10. In which atmospheric layer are almost all water-based clouds formed?
11. What is, by far, the most abundant component of Earth's atmosphere?
12. In which domain of living things do you find humankind?
13. Describe three ways in which the presence of life has affected the composition of Earth's atmosphere.
14. Briefly describe the greenhouse effect.
15. How do impacts by comets and asteroids influence Earth's geology, its atmosphere, and the evolution of life?
16. Why are there so many impact craters on our neighbor world, the Moon, and so few on Earth?
17. Detail some of the anthropogenic changes to Earth's climate and their potential impact on life.

Thought Questions

1. If you wanted to live where the chances of a destructive earthquake were small, would you pick a location near a fault zone, near a mid ocean ridge, near a subduction zone, or on a volcanic island such as Hawaii? What are the relative risks of earthquakes at each of these locations?
2. Which type of object would likely cause more damage if it struck near an urban area: a small metallic object or a large stony/icy one?
3. If all life were destroyed on Earth by a large impact, would new life eventually form to take its place? Explain how conditions would have to change for life to start again on our planet.
4. Why is a decrease in Earth's ozone harmful to life?
5. Why are we concerned about the increases in CO_2 and other gases that cause the greenhouse effect in Earth's atmosphere? What steps can we take in the future to reduce the levels of CO2 in our atmosphere? What factors stand in the way of taking the steps you suggest? (You may include technological, economic, and political factors in your answer.)
6. Do you think scientists should make plans to defend Earth from future asteroid impacts? Is it right to intervene in the same evolutionary process that made the development of mammals (including us) possible after the big impact 65 million years ago?

Figuring for Yourself

1. Europe and North America are moving apart by about 5 m per century. As the continents separate, new ocean floor is created along the mid-Atlantic Rift. If the rift is 5000 km long, what is the total area of new ocean floor created in the Atlantic each century? (Remember that 1 km = 1000 m.)
2. Over the entire Earth, there are 60,000 km of active rift zones, with average separation rates of 5 m/century. How much area of new ocean crust is created each year over the entire planet? (This area is approximately equal to the amount of ocean crust that is subducted since the total area of the oceans remains about the same.)
3. With the information from the previous exercise, you can calculate the average age of the ocean floor. First, find the total area of the ocean floor (equal to about 60% of the surface area of Earth). Then compare this with the area created (or destroyed) each year. The average lifetime is the ratio of these numbers: the total area of ocean crust compared to the amount created (or destroyed) each year.
4. What is the volume of new oceanic basalt added to Earth's crust each year? Assume that the thickness of the new crust is 5 km, that there are 60,000 km of rifts, and that the average speed of plate motion is 4 cm/y. What fraction of Earth's entire volume does this annual addition of new material represent?
5. Suppose a major impact that produces a mass extinction takes place on Earth once every 5 million years. Suppose further that if such an event occurred today, you and most other humans would be killed (this would be true even if the human species as a whole survived). Such impact events are random, and one could take place at any time. Calculate the probability that such an impact will occur within the next 50 years (within your lifetime).

6. How do the risks of dying from the impact of an asteroid or comet compare with other risks we are concerned about, such as dying in a car accident or from heart disease or some other natural cause? (Hint: To find the annual risk, go to the library or internet and look up the annual number of deaths from a particular cause in a particular country, and then divide by the population of that country.)
7. What fraction of Earth's volume is taken up by the core?
8. Approximately what percentage of Earth's radius is represented by the crust?
9. What is the drift rate of the Pacific plate over the Hawaiian hot spot?
10. What is the percent increase of atmospheric CO_2 in the past 20 years?
11. Estimate the mass of the object that formed Meteor Crater in Arizona.
