**Chapter 1**

# Introduction to Planet “Earth”

**Overview**

Chapter 1 is an introduction to Earth and its oceans, including a discussion of the history of ocean exploration. The scientific method is presented in this chapter so that students will have a framework for understanding the nature of scientific inquiry. Theories that describe the origin of the solar system, Earth, the atmosphere, and the oceans are presented in addition to a discussion of the origin of life on Earth. The chapter is completed with a presentation of the geologic time scale and radiometric age dating.

**Essential Concepts**

1.1 Compare the characteristics of Earth’s oceans.

1.2 Discuss how early exploration of the oceans was achieved.

1.3 Explain why oceanography is considered an interdisciplinary science.

1.4 Describe the nature of scientific inquiry.

1.5 Explain how Earth and the solar system formed.

1.6 Explain how Earth’s atmosphere and oceans formed.

1.7 Discuss why life is thought to have originated in the oceans.

1.8 Demonstrate an understanding of how old Earth is.

**Chapter Outline**

* 1. How Are Earth’s Oceans Unique?
		1. Earth’s Amazing Oceans

Squidtoons: How does the manta ray feed?

* + 1. How Many Oceans Exist on Earth?
		2. The Four Principal Oceans, Plus One

SmartFigure 1.2: Earth’s oceans

1.1.3.1 Pacific Ocean

1.1.3.2 Atlantic Ocean

1.1.3.3 Indian Ocean

1.1.3.4 Arctic Ocean

1.1.3.5 Southern Ocean, or Antarctic Ocean

 Web Animation: Earth’s Water and the Hydrologic Cycle

* + 1. Oceans versus Seas

1.1.4.1 Comparing the Oceans to the Continents

* 1. How Was Early Exploration of the Oceans Achieved?
		1. Early History
			1. Pacific Navigators

Diving Deeper 1.1 Historical Feature

How do sailors know where they are at sea? From stick charts to satellites

* + - 1. European Navigators
		1. The Middle Ages
		2. The Age of Discovery in Europe
		3. The Beginning of Voyaging for Science
		4. History of Oceanography . . . To Be Continued
	1. What Is Oceanography?
	2. What Is the Nature of Scientific Inquiry?
		1. Observations
		2. Hypothesis

SmartFigure 1.15: The scientific method

* + 1. Testing
		2. Theory
		3. Theories and the Truth
	1. How Were Earth and the Solar System Formed?
		1. The Nebular Hypothesis
		2. Proto-Earth

SmartFigure 1.19: The nebular hypothesis of solar system formation

Web Animation: The Nebular Hypothesis of Solar System Formation

* + 1. Density and Density Stratification
		2. Earth’s Internal Structure

SmartFigure 1.21: Comparison of Earth’s chemical composition and physical properties

* + - 1. Chemical Composition versus Physical Properties
			2. Chemical Composition
			3. Physical Properties

Web Animation: How Seismic Waves Reveal Earth’s Internal Layers

* + 1. Near the Surface
			1. Lithosphere
			2. Oceanic versus Continental Crust
			3. Asthenosphere
		2. Isostatic Adjustment

SmartTable 1.1 Comparing oceanic and continental crust

Web Animation: Isostatic Adjustment

* 1. How Were Earth’s Atmosphere and Oceans Formed?
		1. Origin of Earth’s Atmosphere
		2. Origin of Earth’s Oceans

Web Animation: Formation of Earth’s Oceans

* + - 1. The Development of Ocean Salinity
	1. Did Life Begin in the Oceans?
		1. The Importance of Oxygen to Life
		2. Stanley Miller’s Experiment
		3. Evolution and Natural Selection
		4. Plants and Animals Evolve

Diving Deeper 1.2 Historical Feature

The voyage of HMS Beagle: How it shaped Charles Darwin’s thinking about the theory of evolution

* + - 1. Photosynthesis and Respiration

SmartFigure 1.27: Photosynthesis and respiration are cyclic and complimentary processes that are fundamental to life on Earth

* + - 1. The Great Oxidation Event/Oxygen Crisis
			2. Changes to Earth’s Atmosphere
	1. How Old Is Earth?
		1. Radiometric Age Dating
		2. The Geologic Time Scale

Web Animation: Radioactive Decay

Essential Concepts Review

**Learning Outcomes**

Upon completion of this chapter, the student should be able to:

1. Describe the principal oceans of Earth, including the following:

 A. location

 B. relative size

 C. land forms that border the ocean

2. Name the deepest ocean trench and describe its exploration by humans.

3. Discuss early ocean exploration and include the contributions of:

 A. early Pacific islanders (4000 b.c.–900 a.d.)

B. the *Kon Tiki* voyage

 C. Phoenicians

 D. Greeks

 E. Romans

4. Describe the contributions to oceanic exploration during the Middle Ages and the Ming Dynasty, including the:

A. Arabs

 B. Vikings

 C. Ming Dynasty (1405–1433)

5. Elaborate on the contributions to oceanic exploration made by European explorers during the Renaissance (Age of Discovery), including:

 A. Prince Henry the Navigator

 B. Vasco da Gama

 C. Christopher Columbus

 D. John Cabot

 E. Vasco Nùñez de Balboa

 F. Ferdinand Magellan

G. Juan Sebastian del Caño

1. Discuss the contributions of James Cook to early ocean science.
2. List and describe the systematic steps of the **scientific method**.
3. Distinguish between a **hypothesis** and a **theory**.
4. Describe the formation of the **solar system** as outlined by the **nebular hypothesis**.
5. Compare and contrast **Proto-Earth** and modern Earth.
6. Describe **density stratification** in Earth and the resultant chemical structure, including the:
	1. **crust**
	2. **mantle**
	3. **core**
7. Describe the physical structure of Earth, including the:
8. **inner core**
9. **outer core**
10. **mesosphere**
11. **asthenosphere**
12. **lithosphere**
13. Distinguish between **continental crust** and **oceanic crust**, including location, chemical, and physical properties of the crust.
14. Differentiate between **isostatic adjustment** and **isostatic rebound**.
15. Describe the formation of Earth’s initial atmosphere.
16. Describe the formation of Earth’s oceans and discuss the origin of the salts in ocean water.
17. Discuss the implications of **Stanley Miller’s** experiment involving the simulation of primitive Earth’s atmosphere on the origin of life on Earth.
18. Discriminate between **evolution** and **natural selection.**
19. Define the following terms:
20. **autotroph**
21. **heterotroph**
22. **anaerobic**
23. **chemosynthesis**
24. **photosynthesis**
25. **respiration**
26. **endothermic (endergonic)**
27. **exothermic (exergonic)**
	1. Outline the effects of photosynthesis on primitive Earth’s atmosphere.
	2. Describe the process of **radiometric dating** and its implications estimating Earth’s age.

**Teaching Strategies**

Chapter 1 is a good starting point for any course. It is helpful to introduce students to all aspects of the oceans so that students understand how interdisciplinary the science of oceanography is. This chapter contains many general broad ideas, some of which are revisited in more detail in future chapters of the book. It is a good idea to not focus too narrowly on topics in this chapter that you will be covering more thoroughly later in the course. It is important to stress that, although the topics in Chapter 1 might seem broadly diverse, they are all related to the study of oceanography as a whole.

**Teacher’s Resources**

##### **Films**

* *Challenge of the Oceans* (McGraw-Hill), 29 minutes, DVD.
* *Scripps Institute of Oceanography: Understanding and Protecting the Planet* (University of California), 1 minute, [www.youtube.com/watch?v=jN-231KVKNY&index=4&list= PLHy4NEP75tDnzONfhyLh9GLXI2li43OD7](file:///C%3A%5CUsers%5Cumoorsa%5CDownloads%5Cwww.youtube.com%5Cwatch%3Fv%3DjN-231KVKNY%26index%3D4%26list%3D%20PLHy4NEP75tDnzONfhyLh9GLXI2li43OD7)
* *Planet Earth: The Blue Planet* (Program #2) (WQED, Pittsburgh, PBS), 58 minutes, <http://learner.org/resources/series49.html>
* *Bridging World History: Unit 10—Connections Across Water* (Oregon Public Broadcasting, 2004), 30 minutes. Discusses expansion of civilizations and trade using water routes. [www.learner.org/resources/series197.html](http://www.learner.org/resources/series197.html)
* *Life at Sea for NOAA Scientists and Crew* (NOAA), 2 minutes, <http://oceantoday.noaa.gov/lifeatsea/>

**Websites**

* [www.noaa.gov](file:///C%3A%5CUsers%5Cumoorsa%5CDownloads%5Cwww.noaa.gov) —National Oceanic and Atmospheric Administration
* <http://tos.org/>—The Oceanography Society
* <http://education.nationalgeographic.org/encyclopedia/oceanography/>—Oceanography from National Geographic

**Concept Check (Questions and Answers)**

***1.1 How Are Earth’s Oceans Unique?***

1. **How did the view of the ocean by early Mediterranean cultures influence the naming of planet “Earth”?**

*Early Mediterranean cultures envisioned that marginal bodies of water, similar to the Mediterranean Sea, surrounded most of the continents. The name “Earth” describes the portion of the planet that is inhabited by man in spite of the fact that the majority of the planet’s surface is covered by water. Our planet was named before ocean exploration began.*

1. **Although the terms *ocean* and *sea* are sometimes used interchangeably, what is the technical difference between an ocean and a sea?**

*In common use the terms “sea” and “ocean” are synonymous. Technically, seas are distinct from oceans in that:*

* + *Seas are smaller in size and are relatively shallow. (The Arctic Ocean would be a “sea” using these criteria.)*
	+ *Seas are variably salty, although the Caspian Sea in Asia is basically a very large freshwater lake.*
	+ *Seas are usually enclosed by land, although strong ocean currents can define an area (example: Sargasso Sea in the Atlantic Ocean).*
1. **Where is the deepest part of the ocean? How deep is it, and how does it compare to the height of the tallest mountain on Earth?**

*The deepest part of the ocean is the Challenger Deep region of the Mariana Trench, near Guam in the Pacific Ocean. It is 11,022 meters (36,161 feet) below sea level. In comparison, Mount Everest is the tallest mountain on Earth at 8850 meters (29,035 feet), which is 2172 meters (7126 feet) shorter than the Mariana Trench is deep.*

***1.2 How Was Early Exploration of the Oceans Achieved?***

1. **While the Arabs dominated the Mediterranean region during the Middle Ages, what were the most significant ocean-related events taking place in northern Europe?**

*The Vikings roamed the North Atlantic from the 8th to the 13th centuries. Erik the Red sailed to establish colonies in Baffin Island in 891, and his son, Leif Eriksson, visited Vineland (now Newfoundland, Canada) in 995.*

1. **Describe the important events in oceanography that occurred during the Age of Discovery in Europe.**

*During the 30-year period from 1492 to 1522 (the Age of Discovery), the western world came to realize the vastness of Earth’s oceans. Europeans explored the continents of North and South America. The circumnavigation of Earth was completed for the first time. Europeans discovered populations of indigenous peoples on other continents and islands. Bartholomeu Diaz, Vasco da Gama, Christopher Columbus, Vasco Nứñez de Balboa, and Ferdinand Magellan made important contributions to ocean exploration during the Age of Discovery.*

1. **List some of the major achievements of Captain James Cook.**

*During his three ocean voyages, Captain James Cook (1728–1779):*

* *Explored the southern oceans and charted the coasts of New Zealand and Australia.*
* *Was the first person to cross the Antarctic Circle in his search for a southern continent, Terra Australis.*
* *Discovered the Sandwich Islands and South George Island after failing to find the southern continent.*
* *Found a means of preventing scurvy, a disease resulting from Vitamin C deficiency.*
* *Proved the value of John Harrison’s chronometer to determine longitude.*
* *Determined the outline of the Pacific Ocean.*
* *Led the way in sampling subsurface water temperatures, measuring winds and ocean currents, sounding to estimate depth, and data collection on coral reefs.*
* *Discovered the Hawaiian Islands and looked for the Northwest Passage around North America.*

***1.3 What Is Oceanography?***

1. **What was the impetus for studying ocean processes that led to the great expansion of the science of oceanography?**

*Humans have always used the oceans for a variety of purposes. However, as scientists began to study how ocean geology, chemistry, and physics work with biology to create good fishing grounds, we have come to realize how much of an impact humans have on the ocean. The result is an expansion of the science of oceanography.*

1. **What are the four main disciplines or subfields of study in oceanography?**
* *Geological oceanography—studies sea floor structure, features, and change over time*
* *Chemical oceanography—studies chemical composition and properties of seawater; pollutants*
* *Physical oceanography—studies waves, tides, currents, ocean-atmosphere relationship, and transmission of light and sound in the oceans*
* *Biological oceanography—studies ocean life forms*
1. **What does it mean when oceanography is called an interdisciplinary science?**

*Oceanography often examines in detail all the different disciplines of oceanography. It covers all disciplines of science as they pertain to the oceans.*

***1.4 What Is the Nature of Scientific Inquiry?***

1. **Describe the steps involved in the scientific method.**
	1. *Observation: Ask Question*
	2. *Hypothesis: Make Generalization*
	3. *Test: Perform Experiment*
	4. *Theory: Draw Conclusion*
2. **What is the difference between a hypothesis and a theory?**

*A hypothesis is a tentative, testable statement, or an initial idea about a concept. A theory is a well-substantiated explanation of some aspect of the natural world that can incorporate facts, laws, logical inferences, and tested hypotheses. A hypothesis has not been extensively tested or observed, while a theory has.*

1. **Briefly comment on the phrase “scientific certainty.” Is it an oxymoron (a combination of contradictory words), or are scientific theories considered to be the absolute truth?**

*Knowledge about the natural world is constantly changing because we are always adding new observations and data to our knowledge base. As new data become available (frequently due to new technologies giving more detailed and accurate data), hypotheses, theories, and scientific facts are reexamined for consistency with the new information. As long as new data is being added, the nature of scientific truth will be subject to change. Thus, the phrase “scientific truth” is an oxymoron. Over time, scientific statements generally form a sequence of increasingly accurate statements, eventually coming to a point where they are no longer questioned. It is accurate to say that science arrives at that which is probably certain, based on available data.*

1. **Can a theory ever be so well established that it becomes a fact? Explain.**

*If an observation is repeatedly confirmed—that is, made so many times that it is assumed to be completely valid—then it can be called a scientific fact. As observations are made, humans attempt to sort out the observations to reveal underlying patterns. From these attempts to sort, humans develop hypotheses which predict certain occurrences which then lead to refinements of the hypotheses. If a hypothesis has been strengthened by additional observations and if it is successful in predicting additional phenomena, then it can be advanced to a theory.*

***1.5 How Were Earth and the Solar System Formed?***

1. **Discuss the origin of the solar system using the nebular hypothesis.**

*The nebular hypothesis (refer to Figure 1.12) suggests that bodies of the solar system formed from an enormous nebular cloud composed predominantly of hydrogen and helium with a small fraction of heavier elements. As the large dust cloud revolved around its rotational center, the Sun began to form due to the concentration of particles under gravitational forces. In the earliest stages, the volume of the Sun may have been equal to the diameter of our solar system today.*

*As the nebular matter that formed the Sun contracted, a small percentage of it was left behind in small eddies (similar to whirlpools in a stream). This material flattened itself into an increasingly compact disc. The disc became so compact that it became gravitationally unstable and broke apart into separate smaller clouds. These smaller clouds were the protoplanets and their orbiting satellites. These bodies became the modern day planets and their moons.*

1. **How was proto-Earth different from Earth today?**

*Proto-Earth was a large mass with perhaps a 1000 times greater diameter than the present Earth, and Proto-Earth was 500 times more massive than Earth today. Proto-Earth was devoid of life or oceans. It is believed that Proto-Earth was a homogenous planet with uniform composition throughout the planet. Proto-Earth had an atmosphere that was largely hydrogen and helium.*

1. **What is density stratification, and how did it change Proto-Earth?**

*Density stratification is a result of gravitational forces and results in the layering of materials as a function of density. The denser (heavier) material is found beneath the lower density (lighter) material. This caused Proto-Earth (and other protoplanets) to undergo internal rearrangement as the heavier materials migrated to the center to form a heavy core. The result is a layered Earth with the lowest density material on the surface and the greatest density material in the core.*

1. **What are some differences between the lithosphere and the asthenosphere?**

*The lithosphere is a thin, relatively cool, rigid layer that includes all of the crust and the topmost portion of the mantle that acts as a single unit floating on the asthenosphere. It is about 100 kilometers, or about 62 miles, thick. In contrast, the asthenosphere is a relatively thick, hot, highly viscous, plastic region of Earth. The asthenosphere corresponds to the upper mantle, and it is about 700 kilometers, or about 430 miles, thick. When force is applied to the lithosphere, it will fracture. When a gradual force is applied to the asthenosphere, it will deform without fracturing.*

***1.6 How Were Earth’s Atmosphere and Oceans Formed?***

1. **Describe the origin of Earth’s oceans.**

*Evidence suggests that the oceans came from inside Earth by the process of outgassing. About four billion years ago, the surface of Earth cooled sufficiently to allow the water vapor being pumped into the atmosphere by volcanoes to condense and settle on Earth’s surface.*

1. **Describe the origin of Earth’s atmosphere. How is its origin related to the origin of Earth’s oceans?**

*Earth’s initial atmosphere was also outgassed from the interior along with the oceans, but its composition has changed through time.*

1. **Have the oceans always been salty? Why or why not?**

*Evidence suggests that the oceans have always been salty because many of the compounds eroded from surface rocks (where the ocean’s salinity originated) contain elements that comprise salt: chlorine, sodium, magnesium, and potassium.*

***1.7 Did Life Begin in the Oceans?***

1. **How does the presence of oxygen in our atmosphere help reduce the amount of ultraviolet radiation that reaches Earth’s surface?**

*Ultraviolet radiation is absorbed by oxygen in the form of ozone (O3) molecules in the upper atmosphere.*

1. **What was Stanley Miller’s experiment, and what did it help demonstrate?**

*Laboratory experiments by Stanley Miller in 1952 showed that exposing a mixture of compounds that were thought to exist in the early atmosphere (hydrogen, carbon dioxide, methane, ammonia, and water) to ultraviolet light plus an electrical spark (simulating the effect of lightning) will produce a large assortment of organic molecules that are the basis for life.*

1. **Earth has had three atmospheres (initial, early, and present). Describe the composition and origin of each one.**

*Earth’s initial atmosphere was composed of hydrogen and a small amount of helium. The atmosphere was outgassed from Earth’s interior, and it was replaced by the release of gases from the mantle by outgassing through volcanic activity to form an early atmosphere. These gases included water vapor, carbon dioxide, and smaller concentrations of other gases. The present atmosphere is composed mostly of nitrogen and oxygen gas. Atmospheric oxygen was produced by photosynthetic activity (or possibly outgassing from the mantle about 2.5 billion years ago). Oxygen began to be a significant constituent of Earth’s atmosphere about two billion years ago.*

***1.8 How Old Is Earth?***

1. **Describe how the half-life of radioactive materials can be used to determine the age of a rock through radiometric age dating.**

*Radioactive materials have a characteristic* ***half-life****, which is the time required for one-half of the atoms in a sample to decay to other atoms. The older the rock is, the more radioactive material will have been converted to decay product. Analytical instruments can accurately measure the amount of radioactive material and the amount of resulting decay product in rocks. By comparing these two quantities, the age of the rock can thus be determined.*

1. **What is the age of Earth? Describe the major events that demark the boundaries
between these time periods: (a) Precambrian/Proterozoic, (b) Paleozoic/Mesozoic,
(c) Mesozoic/Cenozoic.**

*Earth is 4.6 billion years old. (a) The boundary between the Precambrian and Proterozoic is marked by an explosion of life and the appearance of shelled organisms, particularly trilobites. (b) The Paleozoic/Mesozoic boundary saw one of the largest mass extinctions in Earth’s history, with 90% of marine species going extinct. (c) The Mesozoic/Cenozoic boundary is marked by the extinction of the dinosaurs and the subsequent rise of mammals.*

**Critical Thinking Questions (and Answers)**

* 1. **NASA has discovered a new planet that has an ocean. Using today’s technology, how would you propose studying that ocean, all that’s in it, and the sea floor beneath it? Assume an unlimited budget.**

Send autonomously operated vehicles containing onboard laboratory facilities, cameras, and other data collection devices to the new planet to make observations and return the data. This is assuming that the devices can reach the new planet in a reasonable period of time. Otherwise, using today’s technology the most we could hope to perform would be extreme distance observations using various forms of measurement of light waves and radio waves being transmitted from this newly discovered planet.

* 1. **Discuss the technological advantages that allowed sea-faring Arabs during the Middle Ages to dominate the Mediterranean Sea and trade with East Africa, India, and southeast Asia.**

*The Arabs retained knowledge of the early Phoenicians, Greeks, and Romans after the destruction of the Library of Alexandria in 415 a.d. These technologies included the ability to determine latitude by measuring one’s angle to the North Star in the northern hemisphere and accurate estimations of distances based on calculations of Earth’s circumference. The Arabs also took advantage of their knowledge of monsoon winds to plot out trade routes that corresponded with the wind.*

* 1. **Describe one of today’s ocean problems that encompasses at least two of the different disciplines in the multidisciplinary science that is oceanography.**

Answers will vary. One example could include a discussion of how increased carbon dioxide in the atmosphere is causing acidification of the oceans, and this acidification subsequently affects marine organisms.

* 1. **What is the difference between a fact and a theory? Can either (or both) be revised?**

*A scientific fact is an observation that has been repeatedly confirmed by independent testing (so many times that it is assumed to be valid). A theory is a well-substantiated explanation that incorporates facts, descriptive generalizations about the behavior of an aspect of the natural world (laws), logical inferences, and tested hypotheses. A theory is not an educated guess or a scientific hunch. A theory is an understanding that develops from extensive independent observation, experimentation, and data interpretation/reflection.*

*Facts and theories can be modified and/or revised as new data are collected and interpreted. Scientific facts are more likely to change with time and new technology than scientific theories.*

* 1. **Describe how the chemical composition of Earth’s interior differs from its physical properties. Include specific examples.**

*Figure 1.14 illustrates the distinction between Earth’s interior as a function of chemical and physical composition. If you consider the chemical composition of Earth, the interior can be divided into three layers: the crust, the mantle, and the core. The crust is the lowest density layer composed mostly of silicate minerals. The mantle below the crust is the largest layer and is composed of denser iron and magnesium silicate rock. The high-density core is predominately metal (mostly iron and nickel). In contrast, considering the physical characteristics of Earth, how the layers respond to temperature and pressure, Earth is composed of five layers: the lithosphere, the asthenosphere, the mesosphere, the outer core, and the inner core. The lithosphere is the outermost layer or brittle rock that fractures when pressure is applied. The asthenosphere is a plastic layer, it flows when a gradual force is applied. The mesosphere is below the asthenosphere (corresponds to the middle and lower mantle) and is rigid, due to the increased pressure at depth. The outer core below the mesosphere is liquid (capable of flow), and the inner core is rigid. Like the mesosphere, the pressure on the inner core produces a rigid layer incapable of flow when pressure is applied.*

* 1. **Compare the two ways in which Earth was supplied with enough water to have an ocean. Which is likely to have contributed most of the water on Earth?**

Research suggests that not all water came from inside Earth. Comets, being about half water, could be a source of Earth’s oceans. However, because outgassing releases mostly water vapor, this is considered the primary source of water on Earth, including supplying the oceans with water.

* 1. **How would you answer the accusation, made by some religious groups, that scientific theories such as Stanley Miller’s theory on the origin of life on Earth are inherently weak because it is a historic event that no one actually observed? Please explain your answer in detail.**

Answers will vary. Good answers will make note of the fact that scientists often make use of proxy data to infer past conditions and events that were not witnessed or recorded in any way. Scientists also make use of all available data to generate testable hypotheses and subsequent theories that are well-substantiated explanations of the natural world. Theories are not guesses, but have been extensively tested or subjected to repeated observation.

* 1. **Explain how radiometric age dating works. Why does the parent material never totally disappear completely, even after many half-lives?**

Radiometric age dating takes advantage of the fact that most rocks contain small amounts of radioactive isotopes of various elements. The half-life of these elements is the time it takes for half of the radioactive isotope to decay into other atoms. Older rocks will have more of the radioactive materials converted to the decay product. It is important to know the half-life of the isotope in the rock you are dating, and then compare the quantity of radioactive isotope to the quantity of resulting decay products in rocks. The parent material never disappears completely because the rate of decay is exponential. The rate of decay of radioactive parent will approach, but never reach, zero.

**Active Learning Exercises**

**1.1 If all Earth’s glaciers melted, sea level would rise by about 70 meters (230 feet). Since the average height of the continents is only 840 meters (2756 feet), a rise in sea level of this magnitude would seriously impact human activities, especially in low-lying areas. Based on your knowledge of worldwide geography, which areas of the globe would most likely be affected? Be sure to include major population centers that would be under water. Assess these impacts, and discuss as a group.**

Southeast Asia would most notably be impacted, particularly islands in the Pacific Ocean; there are island nations that have already been abandoned due to sea level rise. Low-lying countries such as Bangladesh have already experienced problems with just monsoonal flooding, so any sea level rise could impact the livelihoods and homes of some of the world’s poorest people. Any coastal cities would be adversely impacted, especially those on low-lying continental shelves. Miami, New York, and Amsterdam would be cities that would notably be under water, their billions of residents displaced by rising tides.

**1.2. Make a list of the 10 essential items you’d need to take with you on a month-long boat expedition to study the ocean (exclude clothes, personal items, and food). Compare and discuss your list with another student in class. How would your list of 10 essential items be different if you created it during the beginning of voyaging for science in the 1700s?**

Items might include a cell phone, computer or tablet, books, mp3 players, headphones, magazines, radio communication, electronic navigational equipment, sunscreen, hats, sunglasses, wetsuits, swimsuits, SCUBA equipment, scientific equipment such as salinometers, and games. In the 1700s, modern technological equipment would not have been available, nor would most of the items on the list above. Early voyagers might have brought a compass, a sextant, and perhaps books, paper, and a pen and inkwell.

**1.3. With another student in class, make a list of all the types of careers you would be qualified for with a degree in oceanography or marine science. Consider your instructor as an example of someone who works in oceanography or marine science.**

College professor, marine biologist, physical oceanographer, geologist, marine chemist, military officer, environmental scientist, fishery biologist, and many others.

**1.4. With another student in class, discuss if you believe nature is simple enough for humans to understand. Give reasons why or why not. If not, do you think it is still reasonable for scientists to make this assumption in applying the scientific method in their work?**

Viewpoints will vary. On the one hand, science assumes nature is consistent and predictable. In that sense, nature is simple and therefore should be easy enough for humans to understand. Conversely, there are aspects of the natural world that are inexplicable and complex, that require complicated mathematical functions to explain. Scientists take various paths to arrive at knowledge, and these paths may not necessarily be dependent upon following the scientific method in its raw form, but rather makes use of available information, observation, and experimentation.

**1.5. The nebular hypothesis of solar system formation is a scientific hypothesis. Based on your understanding of the scientific method, describe to another student in class how sure of this hypothesis you think scientists really are. Why would scientists have this level of certainty?**

Students should be able to distinguish between a hypothesis and a theory. A hypothesis is not a well-substantiated explanation, whereas a theory is and has been extensively tested and/or subject to repeated observations. Based on this, it would appear that scientists are not certain as to the nebular hypothesis. However, this is an area of scientific exploration that does not readily lend itself to testing or observation; therefore, despite the fact that this is a hypothesis, it is generally accepted by the scientific community.

**1.6. With another student in class, describe in your own words how Earth’s oceans became salty.**

Earth’s surface is made of minerals. These minerals, when dissolved and eroded into the oceans, will add elements to Earth’s oceans that will render them salty.

**1.7. With another student in class, discuss which of these two statements has more validity: (1) the greatest environmental crisis of all time was the build-up of toxic oxygen in Earth’s atmosphere 2 billion years ago, or (2) humans are causing the greatest environmental crisis of all time.**

Answers will vary with student’s perspective. The build-up of oxygen altered the nature of the planet, but it was a very long time ago before the presence of life. A more human-centric approach will argue that humans are causing the greatest environmental crisis, since it is impacting life as we know it today. Interpretation of the term “environmental” can mean from a planetary point of view or from the perspective of how it impacts our current Earth.

**1.8 Working as a team, construct a representation of the geologic time scale using an appropriate quantity of any substance (other than dollar bills or toilet paper, which are used as examples in Mastering Oceanography Web Diving Deeper 1.2). Be sure to indicate some of the major changes that have occurred on Earth since its origin, such as “Origin of Earth,” “Origin of oceans,” “Earliest known life forms,” “Dinosaurs die out” and “Age of humans.”**

Student answers will vary, but it is important to stress accurate calculation of scale. The toilet paper model works because it makes it possible to see how events that are far apart are relative to each other. Although it does not make use of a substance, a depiction of the time scale using a sidewalk, measuring tape, and chalk, will also give an accurate representation of how these major events relate to each other in both time and magnitude.