

INSTRUCTOR'S MANUAL

EARTH SCIENCE

FIRST EDITION

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Other Instructor Resources Available with *Earth Science*

Interactive Instructor's Guide

All of the materials found in this Instructor's Manual are available online, searchable by chapter, phrase, topic, or learning objective. The Interactive Instructor's Guide instantly provides multiple ideas for teaching: video clips, powerpoints, animations, and other class activities and exercises. This repository of lecture and teaching materials functions both as a course prep tool and as a means of tracking the latest ideas in teaching the Earth Science course.

To access the Interactive Instructor's Guide, to go <https://iig.wwnorton.com/earthscience/full>.

Smartwork5 Online Homework

The new Smartwork5 online assessment available for use with *Earth Science* features visual assignments with focused feedback. Because students learn best when they can interact with art as well as with text, Smartwork5 includes drag-and-drop figure-based questions, animation- and video-based questions, and What a Geologist Sees photo interpretations. Smartwork5 also provides questions based on real field explorations, via Geotours Google Earth exercises, and helps students check their knowledge as they go by working with reading-based questions and pre-made and easy-to-assign reading quizzes.

Designed to be intuitive and easy to use for both students and instructors, Smartwork5 makes it a snap to assign, assess, and report on student performance, and to keep the class on track. Smartwork5 now works with tablet and mobile environments, and also has single sign-on capability with your institution's learning management system.

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Norton Coursepacks for Campus Learning Management Systems

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To download the Norton Coursepack for your campus LMS, go to [the Earth Science Instructor's page](#).

Test Bank

The Test Bank, created by the same authors behind the Instructor's Manual, has been written to correlate to text learning objectives and to provide carefully vetted and well-rounded assessment. Every item in the test bank has been reviewed to ensure scientific reliability and to make sure it truly tests students' understanding of the most important topics in the text. Each chapter features 50 multiple-choice questions, 10 short-answer or essay questions that test student critical thinking and knowledge-application skills, and several art-based questions using modified images from the text. Each question is tied to sortable metadata fields including text section, learning objective, difficulty level, and Bloom's taxonomy.

To download the Test Bank in PDF, Word, RTF, or Examview formats, go to the [Earth Science Instructor's page](#).

PowerPoints

Several types of powerpoints are available, downloadable via [the Earth Science Instructor's page](#).

- Enhanced Art PowerPoints—Designed for instant classroom use, these slides utilize photographs and line art from the book in a form that has been optimized for use in the PowerPoint environment. The art has been relabeled and resized for projection formats. Think-Pair-Share questions, animation, and video slides help incorporate active learning into lecture.
- Labeled and Unlabeled Art PowerPoints—These include all art from the book formatted as JPEGs that have been prepasted into PowerPoints. We offer one set in which all labeling has been stripped and one set in which labeling remains. All art files for the text are also available in JPEG format for creating your own handouts and presentations
- Update PowerPoints—W. W. Norton & Company offers an update service that provides new PowerPoint slides, with instructor support, covering three recent geologic events for fall and spring semesters. These updates will help instructors keep their classes current, tying events in the news to core concepts from the text.
- Clicker questions for each chapter can be added as-needed to existing PowerPoint decks to check student comprehension in class.

Animations, Simulations, and Videos

Marshak's online resources are designed to be easy to use and visually appealing. Animations, interactive simulations, narrative art videos, and real-world videos cover the core topics and bring in-class presentations to life. The animations and videos may be accessed at no cost from [the Digital Landing Page](#). They are also available in the Coursepack and integrated into Smartwork5 assessment.

- Animations and interactive simulations are perfect for in-class lectures or student self-study use. Covering the most important topics, these 2-4 minute clips are available to help students better visualize and master key concepts and processes. Selected animations are also simulations, which include interactive tools that allow students to experiment with geologic variables.
- Narrative Figure Videos were written and narrated by Marshak himself. These videos bring textbook figures and supplementary photographs to life, helping students to better understand key concepts from the course.
- Real-World Videos are a streaming source of real world video content that exists on Norton's servers without advertising or broken links.

Instructor USB

USB drives are available for instructors and contain the Test Bank, Animations and Simulations, Narrative Art Videos, Real World Videos, Enhanced Art Lecture Slides, labeled and unlabeled art from the book, the Instructor's Manual, and See For Yourself and GeoTours kmz files in one easy-to-access location. Request an Instructor USB via [the /instructor's page](#).

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Conversion Guide

Marshak/Rauber to Tarbuck/Lutgens/Tasa

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Prelude

Welcome To Earth Science!

Learning Objectives

By the end of the chapter students should be able to . . .

- A. describe the variety of subjects that an Earth Science course encompasses.
- B. evaluate whether a news story pertains to an aspect of Earth Science, and how.
- C. understand the concept of the Earth System and describe its key components.
- D. explain why studying our Universe can help us understand our home planet and to address practical issues.
- E. analyze an example of a scientific investigation.
- F. recall some of the key themes of Earth Science.

End of chapter question answers

Review Questions

1. What are the various subjects that an Earth Science course might cover?

Answer: Earth Science includes geology, oceanography, atmospheric science (meteorology and climate science), and astronomy.

2. Describe the different components of the Earth System. Name the three principal layers of the geosphere.

Answer: The Earth System includes the geosphere (the part of the Earth that starts at the solid surface and goes down to the center), hydrosphere (the liquid or solid water of the Earth), atmosphere (the layer of gas that surrounds the Earth), and the biosphere (all living organisms on Earth and the part of Earth where they live). The solid portion of the hydrosphere is sometimes considered a separate realm called the cryosphere. The geosphere is comprised of three principal layers: the crust, mantle, and core.

3. What are the various kinds of energy that play a role in driving the activity of the Earth System and causing aspects of the system to change over time? What is a “cycle” in the Earth System?

Answer: The Earth System is powered by both internal and external energy. Internal energy allows Earth to remain hot and relatively soft inside, and this drives plate motions and all of their associated consequences. External energy for the Earth System travels to the Earth from the Sun in the form of light, which helps heat the Earth System. External energy and gravity drive the wind and currents as well as transport thermal energy and materials from one location to another. A cycle in the Earth System involves materials passing among different parts of a given realm, or realms, over time.

4. Describe some of the ways you might use your understanding of Earth Science to address problems that you might face in your community.

Answer: Understanding Earth Science can help you address problems in your community in many ways. Understanding Earth Science can help you to understand weather patterns and climate. It can help you decide where to live—is the location you have selected safe from natural hazards like floods, landslides, or earthquakes? Earth Science can help you question whether your drinking water is safe. Knowledge of Earth Science can also help you know when to worry about natural hazards, and it can help you to better understand and formulate opinions about issues that have societal consequences, like climate change.

5. Explain the difference between cosmologic and geologic time. Imagine that a continent moves at 5 cm per year. How long would it take to move 2,000 km? What percentage of geologic time does this represent?

Answer: Cosmologic time describes intervals of time related to the events in the history of the Universe, whereas geologic time is used for intervals of time related to the history of the Earth. Cosmologic time covers a far greater time span than geologic time (13.8 billion years versus 4.54 billion years, respectively).

For a continent moving at 5 cm/yr to travel 2,000 km:

$$5 \text{ cm/yr} \times 1 \text{ km}/100,000 \text{ cm} = 5 \times 10^{-5} \text{ km/yr}$$

$$2,000 \text{ km} \div 5 \times 10^{-5} \text{ km/yr} = 40,000,000 \text{ years} = 40 \text{ million years (Ma)}$$

All of geologic time = 4.54 billion years (Ga)

$$40 \text{ Ma} \div 4.54 \text{ Ga} = 40,000,000 \text{ yr} \div 4,540,000,000 \text{ yr} = 0.88\% \approx 0.9\% \text{ of geologic time}$$

6. Name some of the practical applications of Earth Science. How can Earth Science help you understand sustainability and environmental issues?

Answer: Practical applications of Earth Science include deciding where to live, if your drinking water is safe, what the weather will be, when to worry about natural hazards, and how to interpret issues with social consequences. Earth science can help you to understand sustainability and environmental issues because it discusses the origin and supplies of natural resources allowing us to analyze whether we can continue to maintain or improve our standard of living without running out of resources. It also helps us to understand why many activities of society can impact environmental quality.

7. This mine truck carries 100 tons of coal. Where does this resource, and others like it, come from?

Answer: Geologic resources, like coal, come from the Earth's crust, and are found in various places and concentrations throughout the world. Geologic processes, such as metamorphic, sedimentary, and igneous processes, are responsible for the concentration of minerals and rocks. Through geologic exploration, deposits of resources suitable for commercial exploitation, like coal, are extracted from the ground and put to use.



[Real World Videos](#)

SCIENCE FOR A CHANGING WORLD

Learning Objectives Covered:

- Pre.A: Describe the variety of subjects that an Earth Science course encompasses.
- Pre.C: Understand the concept of the Earth System and describe its key components.
- Pre.E: Analyze an example of a scientific investigation.

Length: 8:11

Summary: This video describes a brief history of the USGS and the significance of USGS's work and mission in today's world and its value in the past.

Classroom uses: This video helps students to understand the broad areas of science involved in studying the Earth System.

Discussion questions:

1. What are some of the major areas of Earth Science that the USGS supports?
2. What are some of the greatest challenges that the Earth System faces today?

HYDRAULIC FRACTURING: USING SCIENTIFIC METHODS TO EVALUATE TRADE-OFFS

Credit: Science 360 News (NSF)

Learning Objectives Covered:

- Pre.E: Analyze an example of a scientific investigation.

Length: 3:06

Summary: This video uses the example of hydraulic fracturing (fracking) to discuss how scientists turn data and information into useful knowledge that can guide environmental decisions. The video shows how several researchers are exploring fracking's potential impacts on water and air quality, human health, and energy sustainability.

Classroom Use: This video helps students to understand the importance of applying the scientific method to make objective decisions about important societal issues.

Discussion Questions:

1. What role does science play in determining the types of energy resources we use?
2. What are some of the questions that scientists are asking about hydraulic fracturing?

ARCTIC SEA ICE RETREAT

Credit: NASA Scientific Visualization Studio

Learning Objectives Covered:

- Pre.C: Understand the concept of the Earth System and describe its key components.

Length: 0:37

Summary: The cryosphere is an important Earth sphere. This animation shows the annual Arctic sea ice minimum from 1979 to 2015 with a superimposed graph showing the area of the minimum sea ice versus the year. The concentration and extent of sea ice in the Arctic has been on the decline since the 1980s.

Classroom Use: This video helps students to understand the importance of studying the cryosphere.

Discussion Questions:

1. Why is the cryosphere an important part of the Earth System?
2. What hypothesis might explain why Arctic sea ice has been declining over the past several decades?
3. What might happen to sea levels around the world if Arctic sea ice continues to decline? Remember that further decline means more liquid water enters the world's oceans.

THE ROLE OF HYDROGRAPHY IN THE NATIONAL MAP

Credit: USGS

Learning Objectives Covered:

- Pre.C: Understand the concept of the Earth System and describe its key components.

Length: 6:33

Summary: This video describes the National Hydrography Dataset component of The National Map, maintained by the USGS, that provides detailed information about surface water in the United States. This information is used by scientists and local water boards to determine changes to surface water supplies, the best use of water resources, and threats to these resources. Users of the National Hydrography Dataset discuss its role in water rights management in California, fisheries management in Michigan, and drinking water threat analysis around the country.

Classroom Use: This video helps students to understand the importance of studying the hydrosphere and how a central federal database helps in these efforts.

Discussion Questions:

1. Why is it important to analyze and understand the locations of water and its flow?
2. What is an example of an environmental problem that can be addressed by analyzing water flow data?
3. What types of data can be added to The National Map to make it even more useful for scientists?

Activity

USING EARTH SCIENCE IN DAILY LIFE

Learning Objectives Covered:

- Pre.A: Describe the variety of subjects that an Earth Science course encompasses.

Activity Type: Think-Pair-Share

Time in Class Estimate: 5 minutes

Recommended Group Size: 2–4 students

Classroom Procedures: Pose the question, “How have you used Earth Science in your life so far without knowing it?” Have students engage in a think-pair-share discussion for about 5 minutes with 1–3 of their immediate neighbors.

Answer Key: Every student will have used Earth Science in their life, with the most common application probably being a weather report. Other common uses include deciding where to live, where to travel, or what environmental causes to support. Stargazing could also be considered a use of Earth Science, as a student sees the stars as tiny points of light and understands that they are immensely far away, thereby understanding our context in the universe.

Reflection questions:

1. Why is the study of Earth Science increasingly important in today's society?
2. Whether or not you choose to pursue a career in Earth Science, how will the study of it impact your life?

Tarbuck Correlation Guide

| Marshak & Rauber | Tarbuck, Lutgens & Tasa, 14e |
|--|---|
| P.1 Introduction | n/a |
| P.2 What's in an Earth Science Course? | 1.1 What is Earth Science |
| P.3 Narrative Themes of This Book | n/a |
| P.4 Why Study Earth Science? | n/a |

Chapter 1

From The Big Bang To The Blue Marble

Learning Objectives

By the end of the chapter students should be able to . . .

- A. provide the scientific explanation for the origin of the Universe and the elements in it.
- B. describe how, according to the nebular theory, the Earth formed.
- C. interpret features that a space probe would detect when approaching the Earth from space.
- D. classify the great diversity of materials that the Earth contains.
- E. create a model of the basic internal layers of the Earth.

End of chapter question answers

Review Questions

1. How many planets does our Solar System contain, and what is the position of the Solar System in the Milky Way Galaxy?

Answer: There are eight planets in the Solar System. The Solar System is located near the outer edge of a curving arm of the Milky Way.

2. What is the difference between a nebula and a vacuum?

Answer: A vacuum is a volume that contains virtually no matter. A nebula is a visible cloud of gas and dust.

3. Explain the expanding Universe theory and its relationship to the Big Bang theory. According to the theory, when did the Universe form?

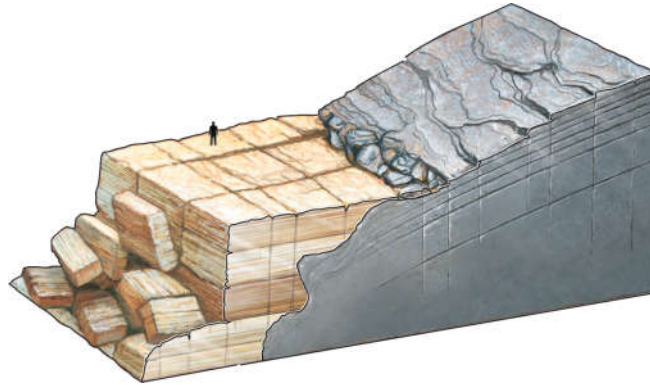
Answer: The expanding Universe theory proposed by Edwin Hubble states that distant galaxies are moving away from the Earth at great velocity, and thus the Universe is expanding much like a ball of rising raisin-bread dough. The Universe has been expanding since the Big Bang, the cataclysmic blast that is the origin of our physical Universe, which took place at about 13.8 Ga.

4. Distinguish between Big Bang nucleosynthesis and stellar nucleosynthesis. Why is it fair to say that we are all made of stardust?

Answer: In Big Bang nucleosynthesis, hydrogen atoms collided and underwent nuclear fusion to form helium atoms as well as tiny amounts of other atoms with small atomic numbers. During stellar nucleosynthesis, elements up to and including iron form inside stars as smaller nuclei fuse together to form larger ones. It is fair to say that we are all made of stardust since the mix of elements we find on Earth, including within our own bodies, comes from the hearts of extinct stars.

5. The image shows a nebula formed by a supernova explosion. How many elements does it contain?

Answer: The nebula in the image (the Crab Nebula) contains a wide array of elements: light elements such as hydrogen and helium (formed during Big Bang nucleosynthesis), heavier elements such as carbon through iron (formed during a star's later stages of life), and the heaviest elements such as iron through uranium (formed through conditions found in a supernova).



6. Describe the steps in the formation of the Solar System according to the nebular theory.

Answer: First, a nebula forms, and gravity pulls the gas and dust of the nebula inward to form an accretionary disk. A protosun forms in the center of the disk. Dust concentrates in the inner part of the disk while volatiles are blown into the outer part of the disk by the solar wind, where they freeze into ice. Dust and ice particles collide and stick together, forming planetesimals that grow by continuous collisions. Gravity reshapes the proto-Earth and other planets into spheres and allows differentiation to take place.

7. Why isn't the Earth homogeneous, and why is it round?

Answer: Earth is heterogeneous and round because early in its formation it became large enough for its interior to become warm and soft. Gravity could then act on materials in the interior of the planet and cause them to flow. Materials separated into layers of different density, resulting in differentiation and producing a layered, heterogeneous Earth. Gravity also molded Earth into a rounded shape so that the force of gravity is nearly the same at all points on its surface.

8. What is the Earth's magnetic field? How does the magnetic field interact with the solar wind?

Answer: Earth's magnetic field is the region affected by the magnetic forces generated inside the Earth. Earth's magnetic field is a dipole; it has a north and south pole. The solar wind, which contains charged particles, warps the Earth's magnetic field into a huge teardrop pointing away from the Sun. Fortunately the magnetic field deflects most of the solar wind from Earth, acting like a shield.

9. What is the Earth's atmosphere composed of? Why would you die of suffocation if you were to jump from a jet?

Answer: Earth's atmosphere is the layer of gas that surrounds the Earth and is held in place by gravity. It is composed of 78% nitrogen, 21% oxygen, and 1% trace gases like carbon dioxide, methane, and argon. Air pressure—and thus the number of air molecules—decreases with increasing altitude. So if you were to jump out of a jet, which

typically flies at an altitude of 12–15 km, the air pressure would be so low that there would not be enough oxygen to breathe, and you would suffocate.

10. What is the proportion of land area to sea area on Earth? Is the seafloor completely flat? How about the land surface?

Answer: Water covers about 70% of the Earth's surface. Neither the land area nor the seafloor is completely flat.

11. Describe the major categories of materials constituting the geosphere.

Answer: The major categories of materials constituting the geosphere include melts (molten material), minerals (solid, naturally occurring substances with definable chemical compositions in which atoms are arranged in an orderly pattern), glasses (solids in which atoms are not arranged in an orderly pattern), sediments and soils (accumulations of loose mineral grains that are not stuck together), metals (solids composed of metallic atoms), and rocks (solid aggregates of mineral crystals or grains or of natural glass).

12. Distinguish among the various realms of the Earth System.

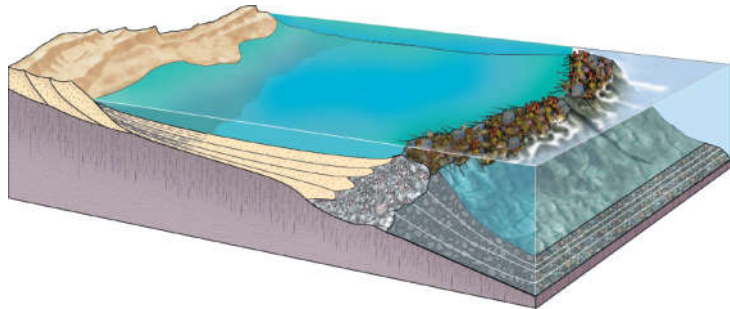
Answer: The Earth System is composed of a number of realms. The atmosphere is the layer of gas that surrounds the Earth. The hydrosphere includes both the liquid and frozen water on the planet. The geosphere is the solid Earth; it includes a variety of different materials. The biosphere consists of living organisms and the realm in which they can survive.

13. How do temperature and pressure change with increasing depth in the Earth?

Answer: Temperature and pressure both increase with depth in the Earth.

14. Label the principal layers of the Earth on the figure.

Answer: The Earth has three principal layers: 1) the thin, not-so dense crust, 2) a solid, high-density rock mantle, and 3) a very dense metal-alloy core.



15. What sources provide geologists with information about the character of the Earth's interior?

Answer: Scientists learn about Earth's interior by studying igneous rocks, pieces of asteroids, and by developing models of the interior. Additionally, geologists have been able to refine the image of the Earth's interior by measuring the speed and path of seismic waves that pass through the Earth from earthquakes.

16. What is the Moho? Describe basic differences between continental crust and oceanic crust.

Answer: The Moho is the boundary between the base of the crust and the top of the mantle. Continental crust, the crust beneath most land, has a thickness that ranges between 25 and 70 km. Continental crust has an average composition similar to granite. Oceanic crust, the crust beneath the seafloor, has a thickness that ranges between 7 and

10 km. The oceanic crust is composed of basalt and gabbro and is covered by a thin layer of sediment

17. What is the mantle composed of? Is the mantle rigid and unmoving?

Answer: The mantle is composed of peridotite. It is a solid, but most of it is hot enough to be able to flow very slowly.

18. What is the core composed of? How do the inner and outer cores differ? Which produces the magnetic field?

Answer: The core is composed of iron alloy (a mix of iron with 4% nickel and up to 10% oxygen, silicon, or sulfur). The inner core is solid, whereas the outer core is molten. Flow in the outer core produces the Earth's magnetic field.

On Further Thought

19. Could a planet like the Earth have formed in association with a first-generation star?

Answer: A planet like Earth could not have formed in association with a first-generation star because the mix of elements we find on Earth contains heavier elements that form during stellar nucleosynthesis and supernova nucleosynthesis.

20. Why are the Jovian planets, which contain abundant gas and ice, farther from the Sun than the terrestrial planets?

Answer: During the formation of the Solar System, the early Sun generated a strong solar wind that melted ice particles (made up of volatile materials) in the inner part of the protoplanetary disk and blew their volatile materials to the outer part of the disk. As a result, dust (particles of refractory materials) concentrated in the inner rings of the protoplanetary disk and eventually formed the terrestrial planets. The volatile materials blown away by the solar wind refroze into ice in the outer rings of the disk, where they eventually formed the Jovian planets. Thus, the Jovian planets, those containing abundant gas and ice, are found farther from the Sun.

21. At highway speeds (100 km per hour), how long would it take for you to drive a distance equal to the thickness of continental crust? Of the entire mantle? From the base of the mantle to the core?

Answer: The Earth's radius is 6,371 km. Continental crust is between 25 and 70 km thick. The mantle is 2,885 km thick, and the distance from the base of the mantle to the center of the Earth is 3,471 km.

It would take 15–42 minutes to drive the equivalent of the continental crust.

$$25 \text{ km} \times 1 \text{ hour}/100 \text{ km} = 0.25 \text{ hours}$$

$$0.25 \text{ hr.} \times 60 \text{ minutes}/1 \text{ hour} = 15 \text{ minutes}$$

$$70 \text{ km} \times 1 \text{ hour}/100 \text{ km} = 0.7 \text{ hours}$$

$$0.7 \text{ hr.} \times 60 \text{ minutes}/1 \text{ hour} = 42 \text{ minutes}$$

It would take about 29 hours to drive the equivalent of the mantle.

$$2,885 \text{ km} \times 1 \text{ hour}/100 \text{ km} = 28.85 \text{ hours}$$

It would take about 35 hours to drive from the base of the mantle to the center of the Earth.

$$3,471 \text{ km} \times 1 \text{ hour}/100 \text{ km} = 34.71 \text{ hours}$$

[Real World Videos](#)

THE FAINT YOUNG STAR PARADOX: SOLAR STORMS MAY HAVE BEEN KEY TO LIFE ON EARTH

Learning objectives covered:

- 1B: Describe how, according to the nebular theory, the Earth formed.

Length: 1:29

Summary: This video describes how the energy from our young Sun—4 billion years ago—aided in creating molecules in Earth's atmosphere that allowed it to warm up enough to incubate life.

Classroom uses: This video can help students understand how the early Sun and Earth were much different than they are today. It also helps students understand the role the Sun played in creating Earth's atmosphere.

Discussion questions:

1. When it first formed billions of years ago, how did the Sun differ from today's Sun?
2. After the Earth first formed, what type of atmosphere did it have, if any?
3. How did the early Sun contribute to creating the Earth's early atmosphere?

HOW PLANETS ARE BORN

Learning objectives covered:

- 1A: Provide the scientific explanation for the origin of the Universe and the elements in it.
- 1B: Describe how, according to the nebular theory, the Earth formed.

Length: 0:38

Summary: This animation shows how material around a young star is shaped into planets over billions of years.

Classroom uses: This animation can help students visualize how, over time, dust particles can combine to form pebbles, which evolve into mile-sized rocks, then into planetesimals, and finally into planets that orbit their star.

Discussion questions:

1. How does the nebular theory explain the formation of the Sun and planets?
2. Explain why the nebular theory is difficult to test directly.

RESEARCHERS DISCOVER THE EARTH'S INNER-INNER CORE

Learning objectives covered:

- 1E: Create a model of the basic internal layers of the Earth.

Length: First 1.01 minutes of video (of 3:58 total)

Summary: This video discusses the makeup and characteristics of the Earth's inner core.

Classroom uses: This video allows students to visualize the internal layering of the Earth and understand how we study these layers.

Discussion questions:

1. How does the Earth's inner core differ from the outer core?
2. What data do we use to understand the characteristics of the Earth's inner layers?

Activities

MATERIALS OF THE GEOSPHERE

Learning Objectives Covered:

- 1D: Classify the great diversity of materials that the Earth contains.

Activity Type: Think-Pair-Share

Time in Class Estimate: 5 minutes

Recommended Group Size: 2–4 students

Classroom Procedures: Pose the question, “What types of geosphere materials do you interact with on a daily basis? How?” Have students engage in a think-pair-share discussion for about 5 minutes with 1–2 of their immediate neighbors.

Answer Key: Students will have a variety of responses. Examples include rocks, minerals, sediment, soils, “dirt,” sand, silt, mud, etc.

Reflection question: Ask students to consider the diversity of materials necessary for life as we know it, and make connections to their own, everyday lives.

WATER AND THE HYDROSPHERE

Learning Objectives Covered:

- 1D: Classify the great diversity of materials that the Earth contains.

Activity Type: Think-Pair-Share

Time in Class Estimate: 5 minutes

Recommended Group Size: 2–4 students

Classroom Procedures: Pose the question, “We know that about 70% of the Earth’s surface is covered by water. Why then do we so frequently hear of drought being an issue?” Have students engage in a think-pair-share discussion for about 5 minutes with 1–2 of their immediate neighbors.

Answer Key: Only 3% of the hydrosphere is fresh water, and of that only a small proportion (< 1%) is readily available for consumption, mainly occurring as groundwater.

Reflection question: Why is ocean water not currently a viable resource for our water needs?

DIFFERENTIATION

Learning Objectives Covered:

- 1E: Create a model of the basic internal layers of the Earth.

Activity Type: Demonstration

Time in Class Estimate: 5–10 minutes

Recommended Group Size: whole class

Materials: empty water bottle with lid (labels removed so that it is fully transparent), water, oil, food coloring

Classroom Procedures: During lecture, discuss differentiation as it applies to Earth. Then, in a class demonstration, model the process of differentiation by pouring some water, oil, and a few drops of food coloring into an empty water bottle. Shake the bottle vigorously to produce a pseudo-homogenous mixture. Then let the oil and water separate—differentiate—into layers while students observe.

Reflection question: Following the demonstration, ask students to consider how the separation of the liquids in the bottle is similar to the differentiation that took place within the Earth. How is it different? (Hint: consider timeframes.)

Tarbuck Correlation Guide

| Marshak & Rauber | Tarbuck, Lutgens & Tasa, 14e |
|--|--|
| 1.1 Introduction | 1.1 What is Earth Science |
| 1.2 A Basic Image of the Universe | n/a (Chapter 24) |
| 1.3 Formation of the Universe and Its Elements | n/a (Chapter 24) |
| 1.4 Formation of the Earth | 1.3 Early Evolution of Earth |
| 1.5 The Blue Marble: Introducing the Earth | 1.4 Earth's Spheres 1.6 The Face of Earth |
| 1.6 A First Glance at the Earth's Interior | 1.5 A Closer Look at the Geosphere |
