HS What is Earth Science?

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Printed: December 25, 2012

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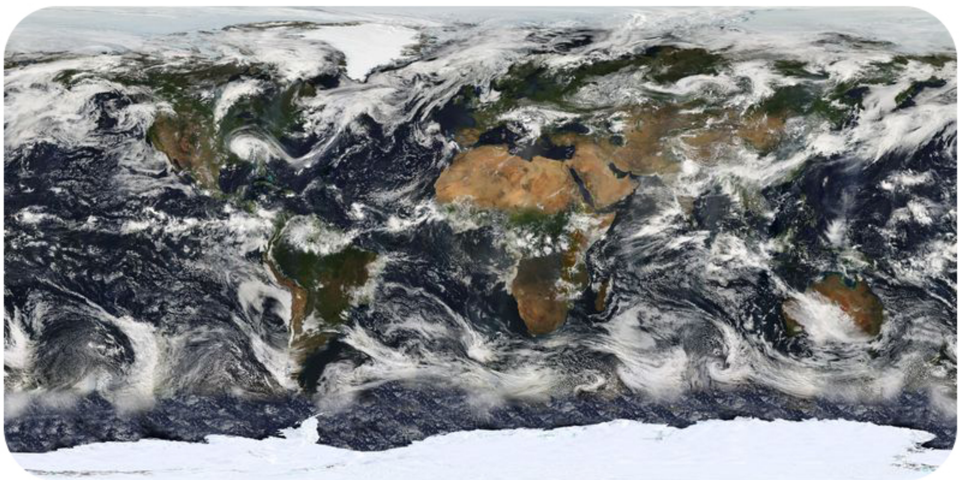
CHAPTER 1 HS What is Earth Science?

CHAPTER OUTLINE



Earth science is the study of our home planet and all of its components: its lands, waters, atmosphere, and interior. In this book, some chapters are devoted to the processes that shape the lands and impact people. Other chapters depict the processes of the atmosphere and its relationship to the planet's surface and all our living creatures. For as long as people have been on the planet, humans have had to live within Earth's boundaries. Now human life is having a profound effect on the planet. Several chapters are devoted to the effect people have on the planet. Chapters at the end of the book will explore the universe beyond Earth: planets and their satellites, stars, galaxies, and beyond.

The journey to better understanding Earth begins here with an exploration of how scientists learn about the natural world and introduces you to the study of Earth science.

1.1 The Nature of Science

Lesson Objectives

- Identify the goal of science.
- Explain the importance of asking questions.
- Describe how scientists study the natural world.
- Explain how and why scientists collect data.
- Describe the three major types of scientific models.
- Explain how a scientific theory differs from a hypothesis.
- Describe appropriate safety precautions inside and outside the science laboratory.

Vocabulary

- conceptual model
- control
- dependent variable
- hypothesis
- independent variable
- mathematical model
- model
- physical model
- scientific method
- theory

Introduction

Science is a path to gaining knowledge about the natural world. The study of science also includes the body of knowledge that has been collected through scientific inquiry.

To conduct a scientific investigation, scientists ask testable questions. To answer those questions, they make systematic observations and carefully collect relevant evidence. Then they use logical reasoning and some imagination to develop hypotheses and explanations. Finally, scientists design and conduct experiments based on their hypotheses.

Goal of Science

Scientists seek to understand the natural world. Scientists begin with a question and then try to answer the question with evidence and logic. A scientific question must be testable. It does not rely on faith or opinion. Our understanding of natural Earth processes help us to understand why earthquakes occur where they do and to understand the consequences of adding excess greenhouse gases to our atmosphere.

Scientific research may be done to build knowledge or to solve problems. Scientific discoveries may lead to technological advances. Pure research often aids in the development of applied research. Sometimes the results of pure research may be applied long after the pure research was completed. Sometimes something unexpected is discovered while scientists are conducting their research.

Some ideas are not testable. For example, supernatural phenomena, such as stories of ghosts, werewolves, or vampires, cannot be tested. Look at this website to see why astrology is not scientific: http://undsci.berkeley.edu/images/astrology_checklist.pdf.

Scientists describe what they see, whether in nature or in a laboratory. Science is the realm of facts and observations. However, science does not make moral judgments, such as "It is bad that the volcano erupted" and opinions are not relevant to scientific inquiry. Scientists might enjoy studying tornadoes, but their opinion that tornadoes are exciting is not important to learning about them. Scientists increase our technological knowledge, but science does not determine how or if we use that knowledge. Scientists learned to build an atomic bomb, but scientists didn't decide whether or when to use it. Scientists have accumulated data on warming temperatures. Their models have shown the likely causes of this warming. But although scientists are largely in agreement on the causes of global warming, they can't force politicians or individuals to pass laws or change behaviors.

For science to work, scientists must make some assumptions. The rules of nature, whether simple or complex, are the same everywhere in the universe. Natural events, structures, and landforms have natural causes. Evidence from the natural world can be used to learn about those causes. The objects and events in nature can be understood through careful, systematic study. Scientific ideas can change if we gather new data or learn more. An idea, even one that is accepted today, may need to be changed slightly or be entirely replaced if new evidence is found that contradicts it. Scientific knowledge can withstand the test of time. Accepted ideas in science become more reliable as they survive more tests.

Scientific Method

You have probably learned that the **scientific method** is the way scientists approach their work. The scientific method is a series of steps that help to investigate a question. Scientists use data and evidence gathered from observations, experience, or experiments to answer their questions.

But scientific inquiry rarely proceeds in the same sequence of steps outlined by the scientific method. For example, the order of the steps might change because more questions arise from the data that is collected. Still, to come to verifiable conclusions, logical, repeatable steps of the scientific method must be followed, as seen in the **Figure** 1.1.

FIGURE 1.1
The basic sequence followed in the scientific method.

A flow chart of how science works that is much more accurate than the simple chart above is found here: http://undsci.berkeley.edu/lessons/pdfs/complex_flow_handout.pdf.

This video of *The Scientific Method Made Easy* explains scientific method succinctly and well **(1a, 1b, 1c, 1d, 1f, 1g, 1j, 1k - IE Stand)**: http://www.youtube.com/watch?v=zcavPAFiG14&feature=related (9:54).

MEDIA

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Questions

The most important thing a scientist can do is to ask questions.

- Why is the sky blue?
- Why does California have many earthquakes while Kansas does not?
- Why does Earth have so many varied life forms but other planets in the solar system do not?

Earth science can answer testable questions about the natural world. What makes a question impossible to test? Some untestable questions are whether ghosts exist or whether there is life after death.

A testable question might be about how to reduce soil erosion on a farm (**Figure** 1.2). A farmer has heard of a planting method called "no-till farming." Using this process eliminates the need for plowing the land. The farmer's question is: Will no-till farming reduce the erosion of the farmland?

FIGURE 1.2

Soil erosion on a farm.

Research

To answer a question, a scientist first finds out what is already known about the topic by reading books and magazines, searching the Internet, and talking to experts. This information will allow the scientist to create a good experimental design. If this question has already been answered, the research may be enough or it may lead to new questions.

Example: The farmer researches no-till farming on the Internet, at the library, at the local farming supply store, and elsewhere. He learns about various farming methods, as illustrated in the **Figure** 1.3. He learns what type of fertilizer is best to use and what the best crop spacing would be. From his research he learns that no-till farming can be a way to reduce carbon dioxide emissions into the atmosphere, which helps in the fight against global warming.

FIGURE 1.3
The farmer researches farming methods.

Hypothesis

With the information collected from background research, the scientist creates a plausible explanation for the question. This is a **hypothesis**. The hypothesis must directly relate to the question and must be testable. Having a hypothesis guides a scientist in designing experiments and interpreting data.

Example: The farmer's hypothesis is this: No-till farming will decrease soil erosion on hills of similar steepness as compared to the traditional farming technique because there will be fewer disturbances to the soil.

Data Collection

To support or refute a hypothesis, the scientist must collect data. A great deal of logic and effort goes into designing tests to collect data so the data can answer scientific questions. Data is usually collected by experiment or observation. Sometimes improvements in technology will allow new tests to better address a hypothesis.

Observation is used to collect data when it is not possible for practical or ethical reasons to perform experiments. Written descriptions are qualitative data based on observations. This data may also be used to answer questions. Scientists use many different types of instruments to make quantitative measurements. Electron microscopes can be used to explore tiny objects or telescopes to learn about the universe. Probes make observations where it is too dangerous or too impractical for scientists to go. Data from the probes travels through cables or through space to a computer where it is manipulated by scientists (**Figure** 1.4).

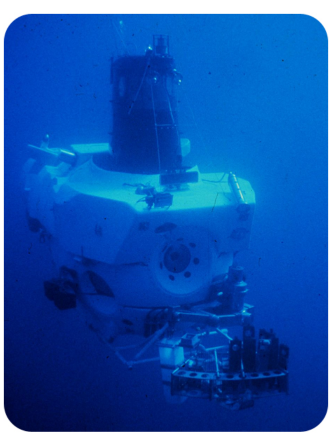

FIGURE 1.4
Scientists routinely travel to the bottom of the ocean in research submersibles to observe and collect samples.

Experiments may involve chemicals and test tubes, or they may require advanced technologies like a high-powered electron microscope or radio telescope. Atmospheric scientists may collect data by analyzing the gases present in gas samples, and geochemists may perform chemical analyses on rock samples.

A good experiment must have one factor that can be manipulated or changed. This is the **independent variable**. The rest of the factors must remain the same. They are the experimental **controls**. The outcome of the experiment, or what changes as a result of the experiment, is the **dependent variable**. The dependent variable "depends" on the independent variable.

Example: The farmer conducts an experiment on two separate hills. The hills have similar steepness and receive similar amounts of sunshine. On one, the farmer uses a traditional farming technique that includes plowing. On the other, he uses a no-till technique, spacing plants farther apart and using specialized equipment for planting. The plants on both hillsides receive identical amounts of water and fertilizer. The farmer measures plant growth on both hillsides (**Figure** 1.5).

FIGURE 1.5
A farmer takes careful measurements in the field.

In this experiment:

- What is the independent variable?
- What are the experimental controls?
- What is the dependent variable?

The independent variable is the farming technique—either traditional or no-till—because that is what is being manipulated. For a fair comparison of the two farming techniques, the two hills must have the same slope and the same amount of fertilizer and water. These are the experimental controls. The amount of erosion is the dependent variable. It is what the farmer is measuring.

During an experiment, scientists make many measurements. Data in the form of numbers is quantitative. Data gathered from advanced equipment usually goes directly into a computer, or the scientist may put the data into a spreadsheet. The data then can be manipulated. Charts and tables display data and should be clearly labeled.

Statistical analysis makes more effective use of data by allowing scientists to show relationships between different categories of data. Statistics can make sense of the variability in a data set. Graphs help scientists to visually understand the relationships between data. Pictures are created so that other people who are interested can see the relationships easily.

In just about every human endeavor, errors are unavoidable. In a scientific experiment, this is called experimental error. What are the sources of experimental errors? Systematic errors may be inherent in the experimental setup so that the numbers are always skewed in one direction. For example, a scale may always measure one-half ounce high. The error will disappear if the scale is recalibrated. Random errors occur because a measurement is not made precisely. For example, a stopwatch may be stopped too soon or too late. To correct for this type of error, many measurements are taken and then averaged.

If a result is inconsistent with the results from other samples and many tests have been done, it is likely that a mistake was made in that experiment and the inconsistent data point can be thrown out.

Conclusions

Scientists study graphs, tables, diagrams, images, descriptions, and all other available data to draw a conclusion from their experiments. Is there an answer to the question based on the results of the experiment? Was the hypothesis supported?

Some experiments completely support a hypothesis and some do not. If a hypothesis is shown to be wrong, the experiment was not a failure. All experimental results contribute to knowledge. Experiments that do or do not support a hypothesis may lead to even more questions and more experiments.

Example: After a year, the farmer finds that erosion on the traditionally farmed hill is 2.2 times greater than erosion on the no-till hill. The plants on the no-till plots are taller and the soil moisture is higher. The farmer decides to convert to no-till farming for future crops. The farmer continues researching to see what other factors may help reduce erosion.

Theory

As scientists conduct experiments and make observations to test a hypothesis, over time they collect a lot of data. If a hypothesis explains all the data and none of the data contradicts the hypothesis, the hypothesis becomes a **theory**.

A scientific theory is supported by many observations and has no major inconsistencies. A theory must be constantly tested and revised. Once a theory has been developed, it can be used to predict behavior. A theory provides a model of reality that is simpler than the phenomenon itself. Even a theory can be overthrown if conflicting data is discovered. However, a longstanding theory that has lots of evidence to back it up is less likely to be overthrown than a newer theory.

Watch this video to understand the difference between hypothesis and theory **(1f - IE Stand.)**: http://www.youtube.com/watch?v=jdWMcMW54fA (6:39).

MEDIA

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An interactive animation of how Darwin used finches (**Figure** 1.6) to explain the origin of species using the Galapagos islands finches is found here: http://web.visionlearning.com/custom/biology/animations/darwin_finches_working.shtml.

Science does not prove anything beyond a shadow of a doubt. Scientists seek evidence that supports or refutes an idea. If there is no significant evidence to refute an idea and a lot of evidence to support it, the idea is accepted. The more lines of evidence that support an idea, the more likely it will stand the test of time. The value of a theory is when scientists can use it to offer reliable explanations and make accurate predictions.

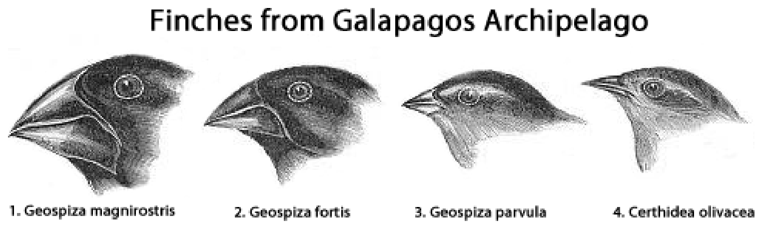

FIGURE 1.6
To explain how finches on the Galapagos islands had developed different types of beaks, Charles Darwin developed his theory of evolution by natural selection. Nearly 150 years of research has supported Darwin's theory.

Scientific Models

A system, such as Earth's surface or climate, can be very complex and can be difficult for scientists to work with. Instead, scientists may create **models** to represent the real system that they are interested in studying.

Models are a useful tool in science. They help scientists efficiently demonstrate ideas and create hypotheses. Models are used to make predictions and conduct experiments without all of the difficulties of using real-life objects. Could you imagine trying to explain a plant cell by only using a real plant cell or trying to predict the next alignment of planets by only looking at them? But models have limitations that should be considered before any prediction is believed or any conclusion is seen as fact.

Models are simpler than real life representations of objects or systems. One benefit to using a model is that it can be manipulated and adjusted far more easily than real systems. Models help scientists understand, analyze, and make predictions about systems that would be impossible to study without using models. The simplicity of a model, which makes it easier to use than the actual system, is also the reason why models have limitations. One problem with a simpler model is that it may not predict the behavior of the real system very accurately.

Scientists must validate their ideas by testing. If a model is designed to predict the future, it may not be possible to wait long enough to see if the prediction was accurate. One way to test a model is to use a time in the past as the starting point and then have the model predict the present. A model that can successfully predict the present is more likely to be accurate when predicting the future.

Many models are created on computers because only computers can handle and manipulate such enormous amounts of data. For example, climate models are very useful for trying to determine what types of changes we can expect as the composition of the atmosphere changes. A reasonably accurate climate model would be impossible on anything other than the most powerful computers.

There are three types of models used by scientists.

Physical Models

Physical models are physical representations of the subject being studied. These models are typically smaller and simpler than the thing they are modeling, but they contain some of the important elements. A map or a globe are physical models of Earth and are smaller and much simpler than the real thing (**Figure** 1.7).

Conceptual Models

A **conceptual model** ties together many ideas in an attempt to explain a phenomenon. A conceptual model uses what is known and must be able to incorporate new knowledge as it is acquired (**Figure** 1.8). For example, a lot of data supports the idea that the Moon formed when a Mars-sized planet hit Earth, flinging a great deal of debris and gas into orbit that eventually coalesced to create the Moon. A good working idea is a conceptual model.

FIGURE 1.7
The Unisphere in Queens, New York is a physical model of Earth but is very different from the real thing.

FIGURE 1.8
A collision showing a giant meteor striking the Earth.

Mathematical Models

A **mathematical model** is an equation or set of equations that takes many factors or variables into account. Mathematical models are usually complex and often cannot account for not all possible factors (**Figure** 1.9). These models may be used to predict complex events such as the location and strength of a hurricane.

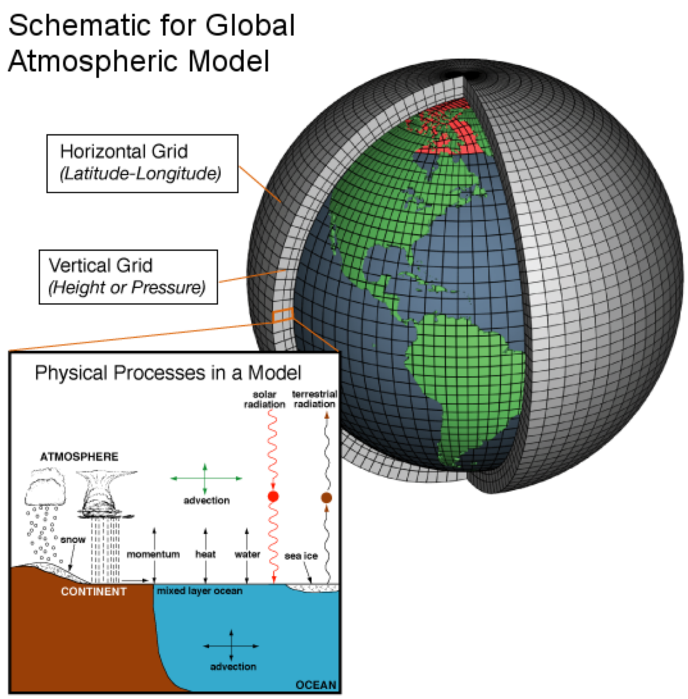

FIGURE 1.9
This climate model accounts for only a few factors in a small region of Earth. The best climate models are so complex that they must be created on supercomputers, and even they are simple compared to Earth's climate.

Modeling climate change is very complex because the model must take into account factors such as temperature, ice density, snow fall, and humidity. Many factors affect each other: If higher temperatures cause the amount of snow to decrease, the land surface is less able to reflect sunlight and temperature will increase more.

The Importance of Community in Science

Scientific discovery is best when it is the work of a community of scientists. For a hypothesis to be fully accepted, the work of many scientists must support it. The scientific process has built-in checks and balances. In general, the scientific community does a good job of monitoring itself. While new ideas are often criticized, if continued investigation supports them, they will eventually become accepted.

Although each scientist may perform experiments in her lab alone or with a few helpers, she will write up her results and present her work to the community of scientists in her field (**Figure** 1.10). Initially, she may present her data and conclusions at a scientific conference where she will talk with other scientists about those results.

Using what she's learned, she will write a professional paper to be published in a scientific journal (**Figure** 1.11). Before publication, several scientists will review the paper – called peer review – to suggest changes and then recommend or deny the paper for publication. Once it is published, other scientists in her field will learn about the work and will incorporate the results into their own research. They will try to replicate her results to prove whether the results are correct or incorrect. In this way, science builds toward a greater understanding of nature.

The scientific community controls the quality and type of research that is done by project funding. Most scientific research is expensive, so scientists must write a proposal to a funding agency, such as the National Science Foundation or the National Aeronautics and Space Administration (NASA), to pay for equipment, supplies, and salaries. Scientific proposals are reviewed by other scientists in the field and are evaluated for funding. In many fields, the funding rate is low and the money goes only to the most worthy research projects.

The scientific community monitors scientific integrity. During their training, students learn how to conduct good scientific experiments. They learn not to fake, hide, or selectively report data, and they learn how to fairly evaluate

FIGURE 1.10
High school students share their research results to NASA scientists at a poster session.

FIGURE 1.11
A peer-reviewed scientific journal.

data and the work of other scientists. Considering all the scientific research that is done, there are few incidences of scientific dishonesty, yet these are often reported with great vehemence by the media. Often this causes the public to mistrust scientists in ways that are unnecessary. Scientists who do not have scientific integrity are strongly condemned by the scientific community.

Safety in Science

Accidents happen from time to time in everyday life, and science is no exception. Indeed, scientists often work with dangerous materials and so scientists – and even science students - must be careful to prevent accidents (**Figure** 1.12). If there is an accident, scientists must be sure to treat any injury or damage appropriately.

Inside the Science Laboratory

If you work in the science lab, you may come across dangerous materials or situations. Sharp objects, chemicals, heat, and electricity are all used at times in earth science laboratories. By following safety guidelines, almost all accidents can be prevented or the damage can be minimized. For examples of safety equipment in the laboratory,

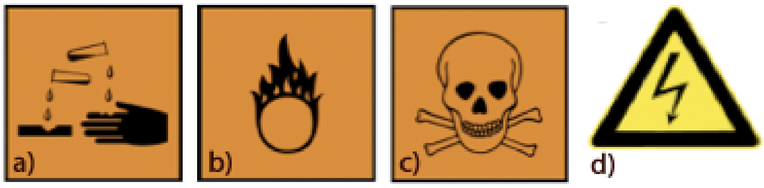

FIGURE 1.12
Safety symbols: A. corrosive, B. oxidizing agent, C. toxic, D. high voltage

refer to the **Figure** 1.13.

- Follow directions at all times.
- Obey safety guidelines given in lab instructions or by lab supervisor. A lab is not a play area.
- Use only the quantities of materials directed. Check with the person in charge before you deviate from the lab procedure.
- Tie back long hair. Wear closed toe shoes and shirts with no hanging sleeves, hoods, or drawstrings.
- Use gloves, goggles, or safety aprons when instructed to do so.
- Use extreme care with sharp or pointed objects like scalpels, knives, or broken glass.
- Never eat or drink anything in the science lab. Dangerous substances could be on the table tops.
- Keep your work area neat and clean. A messy work area could lead to spills and breakages.
- Clean and maintain materials like test tubes and beakers. Leftover substances could interact with other substances in future experiments.
- Be careful when you reach. Flames, heat plates, or chemicals could be below.
- Use electrical appliances and burners as instructed.
- Know how to use an eye wash station, fire blanket, fire extinguisher, or first aid kit.
- Alert the lab supervisor if something unusual occurs. An accident report may be required if someone is hurt; the lab supervisor must know if any materials are damaged or discarded.

FIGURE 1.13
Good safety practices must be followed in all laboratories.

Outside the Laboratory

Many Earth scientists work outside *in the field,* as shown in the **Figure** 1.14. Working outside requires additional precautions, such as:

- Wear appropriate clothing; for example, hiking boots, long pants, and long sleeves.
- Bring sufficient food and water, even for a short trip. Dehydration can occur rapidly.
- Have appropriate first aid available.
- Tell others where you are going, what you will be doing, and when you will be returning.
- Take a map with you. It is also a good idea to leave a copy of the map with someone at home.
- Be sure you have access to emergency services and some way to communicate. Keep in mind that not many field areas are too remote for cellular phones to be useful.
- Be sure that you are accompanied by a person familiar with the area or familiar with the type of investigation that you doing if you are new to field work.

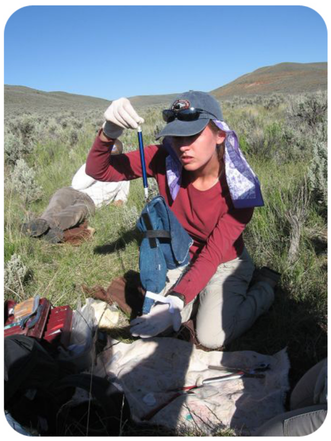

FIGURE 1.14
Outdoor excursions.

Lesson Summary

- The goal of science is to ask and answer testable questions.
- Scientists use a sequence of logical steps, called the scientific method, which involves making observations, forming a hypothesis, testing that hypothesis, and forming a conclusion.
- Physical, conceptual, and mathematical models help scientists to discuss and understand scientific information and concepts.
- A scientific theory is a hypothesis that has been repeatedly tested and has not been proven false.
- Safety in the laboratory as well as in the field are essential components of good scientific investigations.

Review Questions

1. Write a list of five interesting scientific questions. Is each one testable?
2. A scientist was studying the effects of oil contamination on ocean seaweed. He thought that oil runoff from storm drains would keep seaweed from growing normally, so he decided to do an experiment. He filled two aquarium tanks of equal size with water and monitored the dissolved oxygen and temperature in each to be sure that they were equal. He introduced some motor oil into one tank and then measured the growth of seaweed in each tank. In the tank with no oil, the average growth was 2.57 cm. The average growth of the seaweed in the tank with oil was 2.37 cm. Based on this experiment:
   (a) What was the question that the scientist started with?
   (b) What was his hypothesis?
   (c) Identify the independent variable, the dependent variable, and the experimental control(s).
   (d) What did the data show?

(e) Can he be certain of his conclusion? How can he make his conclusion firmer?

3. Explain three types of scientific models. What is one advantage and one disadvantage of each?
4. Identify or design five of your own safety symbols, based on your knowledge of safety procedures in a science laboratory.
5. Design your own experiment based on one of your questions from question 1 above. Include the question, hypothesis, independent and dependent variables, and safety precautions. You may want to work with your teacher or a group.

Further Reading / Supplemental Links

- An extremely good and detailed explanation of what science is and how it is done: http://undsci.berkeley.edu/article/0_0_0/us101contents_01.
- BrainPOP features in-depth discussions of scientific inquiry, including text and movies: http://www.brainpop.com/science/.
- An example of the use of scientific method to study greenhouse gases and tree growth is found here: http://forest.mtu.edu/kidscorner/face_nf.html. Or one to study the relationship of foot pain to the weather: http://www.brooklyn.cuny.edu/bc/ahp/AVC/SciMeth/VCB_SM_HP.html.

Points to Consider

- What types of models have you had experience with? What did you learn from them?
- What situations are both necessary and dangerous for scientists to study? What precautions do you think they should use when they study them?
- How does the scientific meaning of the word theory differ from the common usage? Can you find an example in the media of where the word was used incorrectly in a scientific story? The misuse of the word theory is rampant in the media and in daily life.

1.2 Earth Science and Its Branches

Lesson Objectives

- Define and describe Earth science as a general field with many branches.
- Identify the field of geology as a branch of Earth science dealing with the solid Earth.
- Describe oceanography as a branch of Earth science that has several subdivisions that deal with the various aspects of the ocean.
- Define meteorology as a branch of Earth science that deals with the atmosphere.
- Understand that astronomy is an extension of Earth science that examines other parts of the solar system and universe.
- List some of the other branches of Earth science, and how they relate to the study of the Earth.

Introduction

Earth science is made of many branches of knowledge concerning all aspects of the Earth system. The main branches are geology, meteorology, climatology, oceanography, and environmental science. Astronomy uses principles understood from Earth to learn about the solar system, galaxy, and universe.

Overview of Earth Science

Only recently have humans begun to understand the complexity of our planet Earth. We have only known for a few hundred years that Earth is just a tiny part of an enormous galaxy, which in turn is a tiny part of an even greater universe.

Earth science deals with any and all aspects of the Earth: its lands, interior, atmosphere, and oceans. In all its wonder, Earth scientists seek to understand the beautiful sphere on which we live, shown in **Figure** 1.15.

Earth is a very large, complex system or set of systems, so most Earth scientists specialize in studying one aspect of the planet. Since all of the branches of Earth science are connected, these researchers work together to answer complicated questions. The major branches of Earth science are described below.

Geology

Geology is the study of the Earth's solid material and structures and the processes that create them. Some ideas geologists might consider include how rocks and landforms are created or the composition of rocks, minerals, or various landforms. Geologists consider how natural processes create and destroy materials on Earth, and how humans can use Earth materials as resources, among other topics.

Geology has many branches, only a few of which are described in **Figure** 1.16. As you learn about each branch of geology, think of an interesting question that you might like to try to answer.

Oceanography

The study of water and its movements, distribution and quality is hydrology. Oceanography is more than just the hydrology of the oceans. Oceanography is the study of everything in the ocean environment, which covers about

FIGURE 1.15
Earth as seen from Apollo 17.

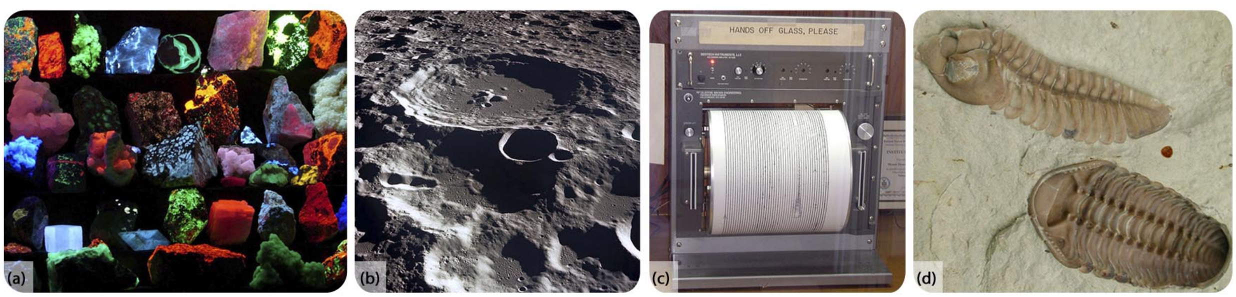

FIGURE 1.16
(a) Mineralogists study the composition and structure of minerals and may look for valuable minerals. (b) Planetary geologists study the geology of other planets. Lunar geologists study the Moon. (c) Seismologists study earthquakes and the geologic processes that create them. They monitor earthquakes worldwide to protect people and property. (d) Scientists interested in fossils are paleontologists.

70% of the Earth's surface (**Figure** 1.17). Recent technology has allowed people and probes to venture to the deepest parts of the ocean, but still much of the ocean remains unexplored.

Marine geologists learn about the rocks and geologic processes of the ocean basins. An animation of underwater high-resolution sonar can be found here: http://oceanexplorer.noaa.gov/explorations/02fire/logs/jul06/media/abefly.html. Marine biologists study life in the oceans.

FIGURE 1.17
Physical oceanographers study the movements of ocean water such as currents, waves, and tides.

Climatology and Meteorology

Meteorology includes the study of weather patterns, clouds, hurricanes, and tornadoes. Using modern technology such as radars and satellites, meteorologists are getting more accurate at forecasting the weather all the time (**Figure** 1.18 here).

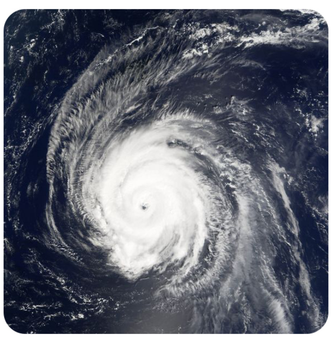

FIGURE 1.18
Meteorologists forecast major storms to save lives and property.

Climatologists study the whole atmosphere, taking a long-range view. Climatologists can help us better understand how and why climate changes (**Figure** 1.19).

Environmental Science

Environmental scientists study the effects people have on their environment, including the landscape, atmosphere, water, and living things (**Figure** 1.20 here).

Astronomy

Astronomers are interested in outer space and the physical bodies beyond the Earth. They use telescopes to see things far beyond what the human eye can see. Astronomers help to design spacecraft that travel into space and send back information about faraway places or satellites (**Figure** 1.21 here).

FIGURE 1.19
Carbon dioxide released into the atmosphere is causing the global climate to change.

FIGURE 1.20
Every action people take has some effect on Earth's environment.

Lesson Summary

- The study of Earth science includes many different fields, including geology, meteorology, oceanography, and astronomy.
- Each type of Earth scientist investigates the processes and materials of the Earth and beyond as a system.

Review Questions

1. What are three major branches of Earth science?

FIGURE 1.21
The Hubble Space Telescope.

2. What branch of science deals with stars and galaxies beyond the Earth?
3. List some important functions of Earth scientists.
4. What is the focus of a meteorologist?
5. An astronomer has discovered a new planet. On the planet, she sees what appears to be a lava flow. With what type of scientist might she consult to help her figure it out?
6. An ecologist notices that an important coral reef is dying off. He believes that it has to do with some pollution from a local electric plant. What type of scientist might help him analyze the water for contamination?
7. Design an experiment that you could conduct in any branch of Earth science. Identify the independent variable and dependent variable. What safety precautions would you have to take?

Further Reading / Supplemental Links

- BrainPOP features in depth discussions of many topics in earth systems including text and movies: http://www.brainpop.com/science/earthsystem/.
- USGS Online Lectures: Lectures 60-90 minutes long delivered by experts covering an enormous range of Earth science topics can provide detail on topics of interest to students and teachers. They can be found at http://education.usgs.gov/common/video_lectures.html.

Points to Consider

- Why is Earth science important?
- Which branch of Earth science would you most like to explore?
- What is the biggest problem that humans face today? Which Earth scientists may help us to solve the problem?
- How do the other branches of science impact Earth science?

- D. Sodipodi. *[A. http://en.wikipedia.org/wiki/File:Hazard_C.svg; B. http://en.wikipedia.org/wiki/File:Hazard_O.svg; C. http://en.wikipedia.org/wiki/File:Hazard_T.svg; D. http://en.wikipedia.org/wiki/File:High_voltage_warning.svg]*. A. Public Domain; B. Public Domain; C. Public Domain; D. CC-BY-SA 2.5.
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