

## **Chapter 1: Introduction to Earth**

### **Learning Outcomes**

Learning Outcome 1.1 Distinguish the key concerns for geographers who study the world.

Learning Outcome 1.2 Analyze how geographers use science to explain and understand the natural environment.

Learning Outcome 1.3 Identify the four environmental “spheres” of Earth.

Learning Outcome 1.4 Illustrate how the concept of Earth Systems helps us to understand the interrelationships of the four environmental “spheres” of Earth.

Learning Outcome 1.5 Describe Earth’s relationships within the solar system.

Learning Outcome 1.6 Compare the size of Earth with the size of its surface features.

Learning Outcome 1.7 Determine the latitude of a location on Earth.

Learning Outcome 1.8 Determine the longitude of a location on Earth.

Learning Outcome 1.9 Locate a place given the latitude and longitude coordinates.

Learning Outcome 1.10 Explain how latitude and longitude together identify a location on Earth.

Learning Outcome 1.11 Summarize the factors that cause the annual change of seasons.

Learning Outcome 1.12 Describe the changes in the patterns of sunlight around Earth during the year.

Learning Outcome 1.13 Explain how time zones were established.

Learning Outcome 1.14 Describe how time zones are used to establish actual times around the world.

Learning Outcome 1.15 Discuss the relationship between time zones and the International Date Line.

## Chapter 1: Introduction to Earth

To ground the reader, Chapter One provides both a perspective on the field of geography and the Earth itself, orienting the reader as to physical geography's role in academic history and Earth's place in the universe. Chapter One also demonstrates how physical geography fits within the overall discipline of science through an examination of science as a field of learning, as well as how physical geography seeks to monitor both natural and human-induced global environmental change. Furthermore, Chapter One examines the basic physical characteristics of this planet and the functional relationship between Earth and its prime source of energy, the Sun. In addition, it examines the geographic grid as a system of accurate location for studying the distribution of geographic features over Earth's surface. It finishes with discussions on Earth's movements, the march of seasons, and telling time.

### TOPICS

#### Geography and Science

- Studying the World Geographically*
- Global Environmental Change*
- Globalization*
- The Process of Science*
- Numbers and Measurement Systems*

#### Environmental Spheres and Earth Systems

- Earth's Environmental Spheres*
- Earth Systems*
  - Closed Systems*
  - Open Systems*
  - Equilibrium*
  - Interconnected Systems*
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#### Earth and the Solar System

- The Solar System*
- Origins*
- The Planets*

#### The Size and Shape of Earth

- The Size of Earth*
- The Shape of Earth*

#### The Geographic Grid—Latitude and Longitude

- Great Circles*
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  - Descriptive Zones of Latitude*
  - Nautical Miles*
- Longitude*
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#### Earth–Sun Relations and the Seasons

*Earth Movements*

*Earth's Rotation on Its Axis*

*Earth's Revolution Around the Sun*

*Inclination of Earth's Axis*

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*The Annual March of the Seasons*

*June Solstice*

*September Equinox*

*December Solstice*

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*Seasonal Transitions*

*Latitude Receiving the Vertical Rays of the Sun*

*Day Length*

*Day Length in the Arctic and the Antarctic*

*Significance of Seasonal Patterns*

**Telling Time**

*Standard Time*

*International Date Line*

*Daylight Saving Time*

**CHAPTER OUTLINE**

**I. Geography and Science**

A. *Geography is a generalized discipline that has the face of planet Earth as its focus.*

1. Rooted in the Greek words for “earth description,” geography is the areal differentiation of Earth’s surface.

B. *Studying the World Geographically*

1. Geography has two main branches, Physical Geography and Cultural Geography:
  - a) **Physical Geography**—also known as environmental geography, looks at those Earth elements that are natural in origin;
  - b) **Cultural Geography**—also known as human geography, looks at elements of human endeavor.

C. *Geography's basic characteristics are as follows:*

1. It looks at how things differ from place to place.
2. It has no particular body of facts or objects it can call wholly its own.
3. It is a very broad field of inquiry and borrows its objects of study from related disciplines.
4. It is both a physical science and a social science because it combines characteristics of each and can be conceptualized as bridging the gap between the two.
5. The fundamental questions of geographic inquiry are:
  - a) “Why is What Where?”
  - b) “So What?”
6. It is interested in interrelationships; that is, examining how various factors (both physical and cultural) interrelate.
7. The subject matter of this book is physical geography.
8. The book will focus on the Earth’s physical elements, specifically:

- a) Their nature and characteristics, processes involved in their development, their distribution, and their interrelationships.
- 9. This book will also explore the ways humans have shaped the physical environment.
- D. *Global Environmental Change*
  - 1. This book focuses on both human-caused and natural processes that are currently altering the landscapes of the world.
  - 2. In this book, attention is paid to the accelerating impact of human activities on the global environment.
    - a) The text's focus boxes concentrate on this topic as well as sustainable energy.
- E. *Globalization*
  - 1. The process and consequences of an increasingly interconnected world
    - a) Connections between economics, cultures, and political systems
    - b) These also have environmental components
  - 2. Geography's global perspective and interest in both natural and human landscape allow geographers to offer insights into the world's most pressing problems.
- F. *The Process of Science*
  - 1. Science is described as a process that follows the scientific method:
    - a) Observe phenomena that stimulates a question or problem
    - b) Offer an educated guess (hypothesis) about the answer
    - c) Design an experiment to test the hypothesis
    - d) Predict the outcome of the experiment
    - e) Conduct the experiment and observe the outcome
    - f) Draw conclusions and formulate rules based on the experiment
  - 2. Science does not always exactly fit this methodology (i.e., data collection can be through observation) and therefore science is best thought of as a process for gaining knowledge.
    - a) Although the term "scientific proof" is used, science does not actually prove things, but rather eliminates alternative explanations.
    - b) Science is based on disproving these alternative explanations.
  - 3. In science, theories represent the highest order of understanding in a body of information.
    - a) Theories are logical and well-tested explanations encompassing numerous facts and observations.
  - 4. The acceptance of theories is based on evidence and not beliefs, nor the pronouncements of "authorities."
    - a) Theories are revised based on new observations and new evidence.
    - b) The scientific method is a self-correcting process based on the refining of scientific knowledge through peer review, which ensures that research and conclusions meet rigorous standards of scholarship.
    - c) New scientific evidence may make scientists change their minds, as well as lead to disagreement within the scientific community, but good science tends to take a cautious stance toward conclusions that are drawn.
      - (1) As such, scientists preface findings by stating that "the evidence suggests" or "the results most likely show."
      - (2) This apparent circumspection can lead to a misconception surrounding the validity of the scientific method on the part of the general public.

- (3) However, this very circumspection spurs scientists to further seek knowledge and understanding.
  5. This text will present the fundamentals of physical geography as supported by scientific research and evidence.
  - G. *Numbers and Measurement Systems*
    1. This text offers measurements in both the **International System** of measurement, from the French *Système International* (abbreviated **SI**, sometimes called the “metric system”), and the traditional (or English) system. SI is an extension of the metric system, devised in the 1790s to provide simple and scientific standard units.
    2. SI to English conversions may be found in Tables 1-2 and 1-3, and in Appendix I.
- ## II. Environmental Spheres and Earth Systems
- A. *Earth’s Environmental Spheres*
    1. Earth’s surface is a complex interface where four spheres meet and, to some degree, overlap and interact. These four spheres provide important organizing concepts for the systematic study of Earth’s physical geography:
    2. **Lithosphere**
    3. **Atmosphere**
    4. **Hydrosphere**
      - a) A subcomponent of the hydrosphere that encompasses frozen water and snow is the **cryosphere**.
    5. **Biosphere**
  - B. *Earth Systems*
    1. System: a collection of things and processes connected together and operating as a whole.
  - C. *Closed Systems*
    1. Isolated from influences outside that system.
    2. Earth is a closed system in regard to matter, but not to energy.
  - D. *Open Systems*
    1. Matter and energy are freely exchanged.
    2. Most Earth systems are open.
  - E. *Equilibrium*
    1. When inputs and outputs are in balance over time
  - F. *Interconnected Systems*
    1. Many Earth systems are connected together.
      - a) For example, a glacier is connected to the hydrologic cycle, wind and pressure patterns, solar energy, and so on.
  - G. *Feedback Loops*
    1. Some systems produce outputs that reinforce change.
      - a) For example, the reduction in Arctic ice reduces reflectivity, which in turn allows more solar energy to be absorbed, which then causes more melting of Arctic ice, which further reduces reflectivity, and so on.
- ## III. Earth and the Solar System
- A. *The Solar System*
    1. The geographer’s concern with spatial relationships properly begins with the relative location of Earth in the universe.

- a) Solar system—system of eight planets (and dwarf planets, moons, comets, asteroids, meteors) revolving around the Sun; Earth is third.
  - b) Sun—medium-sized star that makes up more than 99.8 percent of the solar system's mass.
  - c) The Sun is one of perhaps 200 billion stars in the Milky Way Galaxy, which is one of hundreds of billions of galaxies in the universe.
- B. *Origins*
1. It is generally accepted that the universe began with the big bang some 13.7 billion years ago.
  2. Our solar system originated between 4.5 and 5 billion years ago.
  3. Earth's planetary orbit lies in nearly the same plane as all the other planets. (Pluto, which has lost its planetary status, is somewhat askew.)
    - a) Earth, like all the planets, revolves from west to east.
  4. Earth rotates from west to east on its own axis.
- C. *The Planets*
1. The terrestrial planets (the four inner planets—Mercury, Venus, Earth, and Mars) are smaller, denser, and less oblate and rotate on their axes more slowly than the Jovian planets.
    - a) Terrestrial planets are comprised mainly of mineral matter.
  2. The Jovian planets (the four outer—Jupiter, Saturn, Uranus, and Neptune) are larger, more massive, less dense, and more oblate than the terrestrial planets.
    - a) Jovian planets are comprised mostly of gas.
  3. In more recent years, more small-sized “Pluto-like” dwarf planets and comets have been discovered in our solar system beyond Neptune in the Kuiper Belt.
    - a) In June 2008 the International Astronomical Union reclassified Pluto and other similar objects in our solar system as “plutoids.”
- D. *The Size and Shape of Earth*
- E. Frame of reference determines whether one looks at Earth as being large or small.
1. Earth possesses a diameter of only 13,000 kilometers, which is negligible in comparison to the scale of the universe.
  2. In comparison to this diameter, Earth's relative relief is also quite small.
- F. *The Size of Earth*
1. Its surface varies by 19,883 meters (65,233 feet) in elevation from the highest mountain peak, Mt. Everest, at 8850 meters (29,035 feet) to the deepest ocean trench, Mariana Trench, -11,033 meters (-36,198 feet).
- G. *The Shape of Earth*
1. Earth is an oblate spheroid rather than a true sphere, though the variation from true sphericity is exceedingly minute, and so for most purposes it can properly be considered a sphere.
    - a) Greek scholars as early as the six century B.C. began believing Earth was a sphere, with several making independent calculations of its circumference that were all close to reality.
      - (1) Eratosthenes did so by observing the angle of the Sun's rays in Alexandria and Syene on the same day.
  2. Earth shape is affected by two main facts:
    - a) It bulges in midriff, because of pliability of Earth's lithosphere.

- (1) Therefore, its shape is an *oblate spheroid*.
- b) It has topographical irregularities.
- (1) In context of Earth's full dimensions, these variations are minute.

#### IV. The Geographic Grid—Latitude and Longitude

- A. A system of accurate location is necessary to pinpoint with mathematical precision the position of any spot on Earth's surface.
  - 1. The grid system is the simplest technique, using a network of intersecting lines.
  - 2. **Graticule**—the grid system for mapping Earth that uses a network of parallels and meridians (lines of latitude and longitude).
    - a) Four Earth features provide the set of reference points essential to establish the graticule as an accurate locational system.
      - (1) **North Pole, South Pole**, rotation axis, and equatorial plane (an imaginary plane passing through Earth halfway between the poles and perpendicular to rotation axis).
  - 3. **Equator**—the imaginary midline of Earth, where the *plane of the equator* intersects Earth's surface. Is the parallel of 0° latitude.
- B. *Great Circles*
  - a) **Great Circles** are the largest circle that can be drawn on a sphere; it must pass through the center of the sphere; it represents the circumference and divides the surface into two equal halves or hemispheres.
    - (1) *Circle of Illumination*—a great circle that divides Earth between a light half and a dark half.
  - b) Small circle—a plane that cuts through a sphere without passing through the center.
  - c) *Graticule*—the grid system of the Earth consisting of lines of latitude and longitude.
- C. *Latitude*
  - 1. **Latitude**—the distance measured north and south of the equator; it is an angular measurement, so is expressed in degrees, minutes, and seconds.
  - 2. **Parallel**—an imaginary line that connects all points of the same latitude; because they are imaginary, they are unlimited in number.
  - 3. Seven parallels are particularly significant:
    - a) Equator, 0°
    - b) Tropic of Cancer, 23.5° N
    - c) Tropic of Capricorn, 23.5° S
    - d) Arctic Circle, 66.5° N
    - e) Antarctic Circle, 66.5° S
    - f) North Pole, 90° N
    - g) South Pole, 90° S
- D. *Descriptive Zones of Latitude*
  - 1. Regions on Earth are sometimes described as falling within general bands of latitude.
    - a) Low latitude—generally between the equator and 30° N and S
    - b) Midlatitude—between about 30° N and S
    - c) High latitude—latitudes greater than about 60° N and S
    - d) Equatorial—within a few degrees of the equator

- e) Tropical—within the tropics (between 23.5° N and 23.5° S)
- f) Subtropical—slightly poleward of the tropics, generally around 25–30° N and S
- g) Polar—within a few degrees of the North or South Pole

E. *Nautical Miles*

- 1. The actual length of one degree of latitude varies according to where it is being measured on Earth, because of the polar flattening of Earth. Even with the variation, each degree has a north–south length of about 111 kilometers (69 miles).
- 2. A nautical mile is defined by the distance covered by one minute of latitude (1.15 statute miles, or 1.85 kilometers).

F. *Longitude*

- 1. **Longitude**—the distance measured east and west on Earth’s surface.
- 2. **Meridian**—imaginary line of longitude extending from pole to pole (aligned in a north–south direction), crossing all parallels at right angles. (It’s not to be confused with its other definition, the Sun’s highest point of the day.)
  - a) Meridians are not parallel to each other, except where they cross at the equator, where they are also the furthest apart.
    - (1) They close together northward and southward, converging at the poles.

G. *Establishing the Prime Meridian*

- 1. Established at an international conference in Washington, DC in 1883
- 2. The meridian passing through the Royal Observatory at Greenwich, England was selected because it was already used as a standard meridian by two-thirds of the world’s shipping lines.

H. *Measuring Longitude*

- 1. Longitude is measured from this meridian both east and west to a maximum of 180°.
- 2. The distance between any two meridians varies because they converge at the poles.
  - a) This variation is, however, predictable.

I. *Locating Points on a Geographic Grid*

- 1. The network of intersecting parallels and meridians creates a global reference grid that allows locations to be denoted and located with great precision.

V. **Earth-Sun Relations and the Seasons**

A. *Earth Movements*

- 1. The functional relationship between Earth and the Sun is vital because life on Earth is dependent on solar energy.
  - a) Two basic Earth movements are critical for continuously changing the geometric perspective between the two:
    - (1) Earth’s daily rotation on its axis;
    - (2) Earth’s annual revolution around the Sun.

B. *Earth’s Rotation on Its Axis*

- 1. Earth rotates toward the east on its axis, with one complete rotation taking 24 hours.
  - a) This eastward spin creates an illusion that the celestial bodies are rising in the east and setting in the west.
- 2. Although the speed of rotation varies from place to place, it is constant in any given place, so humans do not experience a sense of motion.



3. This rotation has several striking effects on the physical characteristics of Earth's surface:
  - a) There is an apparent deflection in the flow path of both air and water called the Coriolis effect, which deflects to the right in the Northern Hemisphere and to the left in the Southern Hemisphere.
  - b) Any point of the surface will pass through the increasing and decreasing gravitational pull of the Moon and the Sun.
  - c) Most important of all, there is a diurnal (daily) alternation of light and darkness, which in turn influences local temperatures, humidity, and wind movements.

C. *Earth's Revolution Around the Sun*

1. Tropical year—the time it takes Earth to complete one revolution around the Sun; for practical purposes it can be simplified to 365.25 days.
2. Earth's revolution is an ellipse, which varies the Earth–Sun distance.
  - a) The varying distance between Earth and the Sun is not an important determinant of seasonal temperature fluctuations.
    - (1) **Perihelion**—the point in an orbit that takes a planet nearest to the Sun (for Earth, it is 147,166,480 kilometers, or 91,455,000 miles, on January 3).
    - (2) **Aphelion**—the point in an orbit that takes a planet furthest away from the Sun (for Earth, it is 152,171,500 kilometers, or 94,555,000 miles, on July 4).

D. *Inclination of Earth's Axis*

1. **Plane of the ecliptic**—the imaginary plane that passes through the Sun and through every point of Earth's orbit around the Sun.
  - a) It is not perpendicular to Earth's rotation axis, which allows for seasons to occur.
2. **Inclination of Earth's axis**—the degree to which Earth's rotation axis is tilted (about 23.5° away from the perpendicular).

E. *Polarity of Earth's Axis*

1. **Polarity of the rotation axis**—also called **parallelism**; occurs because Earth's axis points toward Polaris, the North Star, no matter where Earth is in its orbit.
2. The combination of rotation, revolution, inclination, and polarity result in the seasonal patterns experienced on Earth.

F. *The Annual March of the Seasons*

1. During the year the changing relationship of Earth to the Sun results in variations in day length and in the angle at which the Sun's rays strike the surface of Earth. As a result of this, three conditions are noted in this section:
  - a) The latitude (or *subsolar point* or the *declination of the Sun*) receiving the vertical rays of the Sun.
  - b) The **solar altitude** at different latitudes.
  - c) The length of day at different latitudes.

2. *June Solstice*

- a) **June solstice**—on or about June 21, the North Pole is oriented most directly toward the Sun.
  - (1) On this day the direct rays of the Sun at noon strike perpendicular to the surface of the **Tropic of Cancer** (23.5° N).

- (2) The day lengths are longer in the Northern Hemisphere on this day, and day lengths are shorter in the Southern Hemisphere.
  - (3) Day length is equal on the equator because the **circle of illumination** (the line dividing halfway between daylight and nighttime on Earth) bisects the equator evenly.
  - (4) **Arctic Circle**—the parallel of  $66.5^{\circ}$  north latitude; experiences 24 hours of light on this day.
  - (5) **Antarctic Circle**—the parallel of  $66.5^{\circ}$  south latitude; experiences 24 hours of darkness on this day.
3. *September Equinox* (also known as autumnal equinox)
    - a) Occurs on or about September 22 and all latitudes experience 12 hours of day and 12 hours of night. This is because all latitudes are bisected evenly by the circle of illumination.
    - b) The equinoxes represent the midpoints in the shifting of direct rays of the Sun between the Tropic of Cancer and the Tropic of Capricorn.
  4. *December Solstice*
    - a) **December solstice**—on or about December 21, the South Pole is oriented most directly toward the Sun.
      - (1) On this day the direct rays of the Sun at noon strike perpendicular to the surface of the **Tropic of Capricorn** ( $23.5^{\circ}$  S).
      - (2) The day lengths are longer in the Southern Hemisphere on this day, and day lengths are shorter in the Northern Hemisphere.
      - (3) Day length is equal on the equator because the circle of illumination (the line dividing halfway between daylight and nighttime on Earth) bisects the equator evenly.
      - (4) **Arctic Circle**—the parallel of  $66.5^{\circ}$  north latitude; experiences 24 hours of darkness on this day.
      - (5) **Antarctic Circle**—the parallel of  $66.5^{\circ}$  south latitude; experiences 24 hours of light on this day.
  5. *March Equinox* (also known as vernal equinox)
    - a) Occurs on or about March 20 and all latitudes experience 12 hours of day and 12 hours of night. This is because all latitudes are bisected evenly by the circle of illumination.
- G. *Seasonal Transitions*
- H. *Latitude Receiving the Vertical Rays of the Sun*
1. The vertical rays of the Sun can only strike between the Tropic of Cancer and the Tropic of Capricorn.
  2. Between the March equinox and the June solstice, the vertical rays of the Sun migrate northward until they reach the Tropic of Cancer.
  3. Latitudes north of the Tropic of Cancer never experience the vertical rays of the Sun, so the June solstice marks the day when they are at their highest angle.
  4. After the June solstice the vertical rays migrate south and the situation is similar in the Southern Hemisphere between the September equinox and the December solstice, with the Sun's vertical rays reaching their farthest point south at the Tropic of Capricorn on December 21.
- I. *Day Length*
1. Only at the equator is day length constant throughout the year.
  2. This shifting of the vertical rays of the Sun has a direct influence on day length.

3. Day length for a given hemisphere is longer as the vertical rays of the Sun approach the tropics within that hemisphere.
4. Day length will continue to lengthen and reach 12 hours during that hemisphere's equinox (when the vertical rays of the Sun are on the equator).
5. Day length will then continue to increase and reach its maximum during that hemisphere's solstice (when the direct rays of the Sun are at the tropic in that hemisphere).
6. Day length will then diminish as the direct rays of the Sun migrate back toward the equator and subsequently the tropic in the opposite hemisphere.

J. *Day Length in the Arctic and the Antarctic*

1. On the March equinox, the Sun rises at the North Pole and is continuously above the horizon until the following equinox in September.
2. Constant daylight extends southward to the Arctic Circle until the Sun's vertical rays reach their highest point on June 21.
3. Daylight begins to decrease northward toward the North Pole until the September equinox.
4. Between the September equinox and the March equinox, the North Pole is in continual darkness.
5. This overall pattern is reversed for the Southern Hemisphere with increasing daylight between the South Pole and the Antarctic Circle between the September and the March equinox.

K. *Significance of Seasonal Patterns*

1. Both day length and the angle at which the Sun's rays strike Earth are principal determinants of the amount of insolation received at any particular latitude.
2. Tropic latitudes are always warm/hot because they always have high Sun angles and consistent days close to 12 hours long.
3. Polar regions are consistently cold because they always have low sun angles.

VI. **Telling Time**

- A. It was difficult to compare time at different localities when transportation was limited to foot, horse, or sailing vessel. Thus there were no standard times; each community set its own time by correcting its clocks to high noon (meridian, not to be confused with meridian of longitude).

B. *Standard Time*

1. Use of local solar time created increasing problems with advent of telegraph and railroad; railroads stimulated development of a standardized time system.
2. An 1884 international conference divided world into 24 standard time zones, each extending over 15° of longitude (also determined prime meridian).
  - a) **Universal Time Coordinated (UTC)**—formerly **Greenwich Mean Time (GMT)**; a standardized time system that uses the local solar time of Greenwich (prime) meridian as its standard.
    - (1) In international waters, time zone boundaries are defined specifically and consistently;
    - (2) Over land areas, however, zone boundaries vary, sometimes undergoing great manipulation for political and economic convenience.

*C. International Date Line*

1. **International Date Line**—Along with prime meridian, provides the anchor for the framework of time zones. It is the line marking where new days begin and old days exit from surface of Earth.
  - a) Experiences a time difference of an entire day from one side of the line to the other.
  - b) Generally, the line falls on the 180th meridian except where it meanders to ensure two island groupings aren't split apart in their schedules (Aleutian Islands and South Pacific islands).
  - c) The extensive eastern displacement of the date line in the central Pacific is due to the widely scattered distribution of many of the islands of the country of Kiribati.

*D. Daylight Saving Time*

1. **Daylight Saving Time**—a practice by which clocks are set forward by an hour (or more) so as to extend daylight into the usual evening hours.
  - a) Created originally in Germany to help conserve electricity for lighting. Became U.S. national policy, though Arizona, Hawaii, and part of Indiana exempt themselves under the Uniform Time Act. Now gaining international acceptance.

**McKnight and Hess 11e Chapter 1 Learning Checks**

**Learning Check 1-1**

What are the differences between physical geography and cultural geography?

Physical geography deals with those elements of Earth that are natural in origin (such as landforms, weather, and climate), whereas cultural geography deals with elements of human endeavor (such as language, religion, and so on). For this reason, physical geography is sometimes referred to as environmental geography and cultural geography is sometimes referred to as human geography.

**Learning Check 1-2**

Why are physical geographers interested in globalization?

Outside of the realm of culture and economics, globalization also possesses environmental components (e.g., tropical rainforests decline because of the conversion of land to agriculture, climate change as a result of increased industrialization and consumption). Because of geography's global perspective and its interest in both the natural and human landscape, geographers are able to offer insights into many of the world's most pressing problems.

**Learning Check 1-3**

Why is the phrase "scientific proof" somewhat misleading?

Technically, science does not actually "prove" phenomena, but rather seeks to eliminate alternative explanations. Therefore, if something cannot be disproven via the scientific method, then it cannot be supported by science. However, just because something cannot be disproven does not mean that non-scientific causes of the phenomena are responsible, nor equally valid as

scientific explanations. Although there currently may not be a scientific explanation, in the light of new observations and evidence, one may eventually emerge.

#### **Learning Check 1-4**

Briefly define the lithosphere, atmosphere, hydrosphere, cryosphere, and biosphere.

Atmosphere—the gaseous envelope of air that surrounds Earth (*atmo* is Greek for “air”).

Hydrosphere—water in all its forms, with the oceans making up the majority of it (*hydro* is Greek for “water”).

Lithosphere—the solid, inorganic portion of Earth; it comprises the rocks of Earth’s crust and the mineral matter that overlies the solid bedrock (*litho* is Greek for “stone”).

Biosphere—all the living organisms of Earth (*bio* is Greek for “life”).

#### **Learning Check 1-5**

What does it mean when we say a system is in equilibrium?

When a system’s inputs and outputs are in balance over time, the conditions within a system remain the same and therefore it is in a state of equilibrium. For example through time, if the amount of precipitation (inputs) and melting (outputs) on a glacier are the same, then the glacier will neither advance nor retreat and it will be in equilibrium.

#### **Learning Check 1-6**

What is the difference between a positive feedback loop and a negative feedback loop?

Feedback is a system output that reinforces change in that system. Positive feedback encourages or advances change in a system. For example, if Arctic sea ice melts, its albedo (the reflectivity of a surface) is reduced and the region will absorb, rather than reflect, more incoming solar radiation. This will then increase temperatures, which will in turn melt more ice and further reduce albedo, allowing temperatures to increase even more, and this cycle, or loop, will continue. Negative feedback discourages or inhibits change in a system. For example, an increase in Arctic temperatures will cause more evaporation from ice and water surfaces and could increase cloud cover. The cloud cover would reflect more incoming solar radiation and cause surface temperatures to cool, which could then cause an increase in Arctic ice. In this example, the negative feedback has brought the system back into balance.

#### **Learning Check 1-7**

Contrast the characteristics of the terrestrial and Jovian planets in our solar system.

The four inner planets (the terrestrial planets) are smaller, denser, and less oblate (they are more nearly spherical) than the five outer planets.

The inner planets rotate more slowly on their axes.

The inner planets are composed principally of mineral matter, and they have, except for airless Mercury, diverse but relatively shallow atmospheres.

The outer planets seem to be composed entirely of gases, principally hydrogen, with dense and turbulent atmospheres; their chemical composition is similar to that of the Sun.

### **Learning Check 1-8**

What are the Earth's highest and lowest points, and what is the approximate elevation difference between them?

Earth's maximum relief (the difference between the highest and lowest points) is 19,883 meters, or 65,233 feet. This distance is miniscule compared to the 12,753-kilometer (7909-mile) diameter of Earth.

### **Learning Check 1-9**

What is a great circle? Provide an example of a great circle.

A great circle is the largest circle that can be drawn on a sphere; it represents the circumference of that sphere and divides its surface into two equal halves or hemispheres. Both the equatorial plane and the circle of illumination are great circles. They each pass through the center of Earth, bisecting it into two equal halves. The plane of the equator passes through Earth halfway between the poles and perpendicular to the axis of rotation. The circle of illumination is a great circle that divides Earth between a light half and a dark half. It divides Earth on an east–west orientation, whereas the plane of the equator divides it on a north–south orientation. Since the equatorial plane is based on the axis of rotation, it is fixed, whereas the circle of illumination, while always dividing Earth into two equal halves, shifts seasonally. Likewise, a plane passed through any meridian forms a great circle.

Any plane that is passed through a sphere and bisects the sphere into two unequal halves is known as a small circle. Any parallel, with the exception of the equator, is a small circle.

### **Learning Check 1-10**

Why are lines of latitude called parallels?

Because they are always evenly spaced and run parallel to each other and never converge.

### **Learning Check 1-11**

Are locations in North America described by east longitude or west longitude?

West longitude

### **Learning Check 1-12**

Distinguish between Earth's rotation and its revolution.

Rotation: Earth rotates toward the east on its axis, with one complete rotation taking 24 hours. This causes a diurnal (daily) alternation of light and darkness, which in turn influences local temperatures, humidity, and wind movements.

Revolution: Earth's revolution is an ellipse, which varies the Earth–Sun distance; however, the varying distance between Earth and the Sun is not an important determinant of seasonal temperature fluctuations.

**Learning Check 1-13**

Does the North Pole lean toward the Sun throughout the year? If not, how does the North Pole's orientation change throughout the year?

Earth's rotation axis is tilted, or inclined at 23.5 degrees, to the plane of the ecliptic. Likewise, Earth's axis possesses parallelism, which means that Earth's rotation axis is parallel to its orientation at all times—the axis always points toward Polaris, the North Star, no matter where Earth is in its orbit around the Sun.

**Learning Check 1-14**

What is the latitude of the vertical rays of the Sun on the June solstice?

23.5° north

**Learning Check 1-15**

How much does day length at the equator change throughout the year?

Day length is always 12 hours at the equator throughout the year.

**Learning Check 1-16**

On which days of the year do the vertical rays of the Sun strike the equator?

The equinoxes (September 22 and March 20)

**Learning Check 1-17**

For how many months of the year does the North Pole go without sunlight?

Six

**Learning Check 1-18**

What happens to the hour when crossing from one time zone to the next going from west to east?

It becomes an hour later

**Learning Check 1-19**

What happens to the day when crossing the International Date Line going from west to east?

It becomes a day earlier

## Chapter 1 Learning Review

After studying this chapter, you should be able to answer the following questions:

### KEY TERMS AND CONCEPTS

#### Geography and Science (p. 3)

1. Contrast **physical geography** and **cultural geography**.

Physical geography deals with those elements of Earth that are natural in origin (such as landforms, weather, and climate), whereas cultural geography deals with elements of human endeavor (such as language, religion, and so on). For this reason, physical geography is sometimes referred to as environmental geography and cultural geography is sometimes referred to as human geography.

2. If an idea cannot be disproven by some possible observation or test, can such an idea be supported by science? Explain.

No. Technically, science does not actually “prove” phenomena, but rather seeks to eliminate alternative explanations. Therefore, if something cannot be disproven via the scientific method, then it cannot be supported by science. However, just because something cannot be disproven does not mean that non-scientific causes of the phenomena are responsible, nor equally valid as scientific explanations. Although there currently may not be a scientific explanation, in the light of new observations and evidence, one may eventually emerge.

3. What is the approximate *English System* of measurement equivalent of one kilometer in the **International System (S.I.)**?

One kilometer in the English system = 0.62 (or ~2/3) miles.

#### Environmental Spheres and Earth Systems (p. 7)

4. Briefly describe the environmental “spheres”: **atmosphere**, **hydrosphere**, **cryosphere**, **biosphere**, and **lithosphere**.

**Atmosphere**—the gaseous envelope of air that surrounds Earth (*atmo* is Greek for “air”).

**Hydrosphere**—water in all its forms, with the oceans making up the majority of it (*hydro* is Greek for “water”).

**Cryosphere**—is a subcomponent of the hydrosphere that consists of water frozen as snow and ice.

**Lithosphere**—the solid, inorganic portion of Earth; it comprises the rocks of Earth’s crust and the mineral matter that overlies the solid bedrock (*litho* is Greek for “stone”).

**Biosphere**—all the living organisms of Earth (*bio* is Greek for “life”).



5. Contrast *closed systems* and *open systems*.

A closed system is one that is isolated from influences from outside that system. Closed systems permit energy to freely enter and escape, but prohibit matter from doing so. An open system is where energy and matter are exchanged freely across the system boundary.

6. What does it mean when a system is in *equilibrium*?

A system is in equilibrium when the conditions within the system remain the same. These conditions occur when the system's inputs and outputs are in balance over time.

7. How does a *positive feedback loop* differ from a *negative feedback loop*?

Feedback loops are system outputs that reinforce change in the system. A positive feedback loop is change within a system that continues its progress in one direction. A negative feedback loop inhibits change within a system.

**Earth and the Solar System (p. 10)**

8. In what ways do the inner and outer planets (the terrestrial and Jovian planets) of our solar system differ from each other?

The four inner planets are smaller, denser, and less oblate (they are more nearly spherical) than the five outer planets.

The inner planets rotate more slowly on their axes.

The inner planets are composed principally of mineral matter, and they have, except for airless Mercury, diverse but relatively shallow atmospheres. The outer planets seem to be composed entirely of gases, principally hydrogen, with dense and turbulent atmospheres; their chemical composition is similar to that of the Sun.

9. Compare the size of Earth to that of its surface features and atmosphere.

Earth's maximum relief (the difference between the highest and lowest points) is 19,883 meters, or 65,233 feet. This distance is miniscule compared to the 12,753-kilometer (7909-mile) diameter of Earth. Likewise, although Earth's atmosphere extends 10,000 kilometers (6000 miles), more than 50 percent of its mass is compressed within 26 kilometers (16 miles) of Earth's surface.

10. Is Earth perfectly spherical? Explain.

For most purposes of study, Earth may be considered a sphere, although it is actually an oblate spheroid and not a true sphere. Because we are studying the physical aspects of Earth's geography, it is important to keep in mind that its shape is affected by (1) the pliability of Earth's lithosphere, which allows it to develop a bulge in the midriff, and (2) topographical irregularities in Earth's surface.

### The Geographic Grid—Latitude and Longitude (p. 13)

11. Define and explain the following terms: **latitude**, **longitude**, **parallel**, **meridian**, and **prime meridian**.

Latitude is an angular measurement of the number of degrees (from 0° to 180° east or west) east or west of the prime meridian where a given location on Earth lies.

Longitude is an angular measurement of the number of degrees (from 0° to 90° north or south) north or south of the equator a given location on Earth lies.

While both are imaginary lines, parallels actually run parallel to each other, so that the distance between two will not change. In contrast, meridians are only parallel where they cross at the equator; otherwise, their distances shift, with them closing in on each other the further north or south they go; they converge at the poles. They are aligned in a true north–south direction, whereas parallels run east–west.

The prime meridian is an imaginary north–south plane passing through Greenwich, England, and through Earth’s axis of rotation. The angle between this plane and a plane passed through any other point and the axis of Earth is a measure of longitude.

12. Latitude ranges from \_\_\_\_\_° to \_\_\_\_\_° north and south, while longitude ranges from \_\_\_\_\_° to \_\_\_\_\_° east and west.

Latitudes range from 0° to 90° north and south, while longitudes range from 0° to 180° east and west.

13. State the latitude (in degrees) for the following “special” parallels: **equator**, **North Pole**, **South Pole**, **Tropic of Cancer**, **Tropic of Capricorn**, **Arctic Circle**, and **Antarctic Circle**.

The North Pole is the latitude of 90° north.

The South Pole is the latitude of 90° south.

The equator is the parallel of 0° latitude and serves as the baseline from which all other parallels are measured (north and south latitudes).

The Tropic of Cancer marks the line (23.5° N latitude) of the farthest northern migration of the direct rays of the Sun (this coincides with the June solstice).

The Tropic of Capricorn marks the line (23.5° S latitude) of the farthest southern migration of the direct rays of the Sun (this coincides with the December solstice).

The Arctic Circle is the parallel of 66.5° north latitude. All parallels north of the Arctic Circle are illuminated during the June solstice, while they are in darkness during the December solstice.

The Antarctic Circle is the parallel of 66.5° south latitude. All parallels south of the Antarctic Circle are illuminated during the December solstice, while they are in darkness during the June solstice.

14. What is a **great circle**? A small circle? Provide examples of both.

A great circle is the largest circle that can be drawn on a sphere; it represents the circumference of that sphere and divides its surface into two equal halves or hemispheres. Both the equatorial plane and the circle of illumination are great circles. They each pass through the center of Earth, bisecting it into two equal halves. The plane of the equator passes through Earth halfway

between the poles and perpendicular to the axis of rotation. The circle of illumination is a great circle that divides Earth between a light half and a dark half. It divides Earth on an east–west orientation, whereas the plane of the equator divides it on a north–south orientation. Because the equatorial plane is based on the axis of rotation, it is fixed, whereas the circle of illumination, while always dividing Earth in two equal halves, shifts seasonally. Likewise, a plane passed through any meridian forms a great circle.

Any plane that is passed through a sphere and bisects the sphere into two unequal halves is known as a small circle. Any parallel, with the exception of the equator, is a small circle.

### Earth–Sun Relations (p. 17)

15. Describe and explain the four factors in Earth–Sun relations associated with the change of seasons: **rotation**, **revolution** around the Sun, **inclination of Earth’s axis**, and **polarity (parallelism) of Earth’s axis**.

Rotation: Earth rotates toward the east on its axis, with one complete rotation taking 24 hours. This causes a diurnal (daily) alternation of light and darkness, which in turn influences local temperatures, humidity, and wind movements.

Revolution: Earth’s revolution is an ellipse, which varies the Earth–Sun distance; however, the varying distance between Earth and the Sun is not an important determinant of seasonal temperature fluctuations.

Inclination of Earth’s axis: Earth’s axis is not perpendicular to the plane of the ecliptic (the imaginary plane that passes through the Sun and through every point of Earth’s orbit around the Sun), but rather is inclined at an angle of  $23.5^\circ$ . This inclination, in combination with the polarity of Earth’s axis, allows for seasons to occur.

Polarity of Earth’s axis, also called **parallelism**, occurs because Earth’s axis points toward Polaris, the North Star, no matter where Earth is in its orbit.

The combination of rotation, revolution, inclination, and polarity result in the seasonal patterns experienced on Earth.

16. Does the **plane of the ecliptic** coincide with the plane of the equator? Explain.

The plane of the ecliptic does not coincide with the equatorial plane because Earth’s rotation axis is not parallel to the plane of the ecliptic. Instead, Earth’s axis is tilted about  $23.5^\circ$  away from the perpendicular. This allows for the annual march of the seasons.

17. On which day of the year is Earth closest to the Sun (**perihelion**)? Farthest from the Sun (**aphelion**)?

Because Earth travels on an elliptical orbit, it varies in its distance from the Sun. Earth is closest to the Sun, or at the perihelion, on January 3. When it is at this position, Earth is 147,166,180 kilometers (91,455,000 miles) from the Sun. Conversely, Earth is farthest from the Sun on July 4, at the aphelion, where it is 152,171,500 kilometers (94,555,000 miles) distant.

18. Provide the approximate date for the following special days of the year: **March equinox**, **June solstice**, **September equinox**, and **December solstice**.

March equinox: ~March 20

June solstice: ~June 21

September equinox: ~September 22

December solstice: ~December 21

19. What is the **circle of illumination**?

The edge of the sunlit hemisphere that is a great circle separating Earth into a light half and a dark half.

20. What is meant by **solar altitude**?

Solar altitude is the height of the Sun above the horizon. This altitude changes throughout the year.

21. Briefly describe Earth's orientation to the Sun during the Northern Hemisphere summer and the Northern Hemisphere winter.

During its summer, the Northern Hemisphere is orientated toward the Sun (because the pivotal axis is leaning toward the Sun). During this season, the direct rays of the Sun lie somewhere between 0° and 23.5° north latitude. During its winter, the Northern Hemisphere is orientated away from the Sun (because the pivotal axis is leaning away from the Sun). During this season, the direct rays of the Sun lie somewhere between 0° and 23.5° south latitude.

22. Beginning with the March equinox, describe the changing latitude of the vertical rays of the Sun throughout the year.

Between the March equinox and the June solstice, the vertical rays of the Sun migrate northward from the equator until they reach the Tropic of Cancer at 23.5° north latitude. Latitudes north of the Tropic of Cancer never experience the vertical rays of the Sun, so the June solstice marks the day when they are at their highest angle. After the June solstice, the vertical rays migrate south and the situation is similar in the Southern Hemisphere between the September equinox, when the vertical rays are at the equator again, and the December solstice, with the Sun's vertical rays reaching their farthest point south at the Tropic of Capricorn on December 21 at 23.5° south latitude.

23. In the midlatitudes of the Northern Hemisphere, on which day of the year is the Sun highest in the sky?

June 21

24. For the equator, describe the relative angle of the noon Sun above the horizon (the **solar altitude**) and the approximate number of daylight hours on the following days of the year: March equinox, June solstice, September equinox, and December solstice.

During the equinoxes, as with anywhere else on Earth, the day length will be approximately 12 hours because the circle of illumination evenly bisects all parallels. Likewise, the angle of the noon Sun will be  $90^\circ$  above the horizon. During the June solstice and the December solstice, the angle of the noon Sun will be  $66.5^\circ$  to the north horizon and  $66.5^\circ$  to the south horizon, respectively. This represents a small change in Sun angle at the equator throughout the year; therefore, the length of day varies little more than by 14 minutes during this period.

25. What is the longest day of the year (the day with the greatest number of daylight hours) in the mid-latitudes of the Northern Hemisphere? What is the longest day of the year in the mid-latitudes of the Southern Hemisphere?

The longest day of the year in the Northern Hemisphere is June 21 (the summer solstice for that hemisphere); the longest day of the year in the Southern Hemisphere is December 21 (the summer solstice for that hemisphere).

26. For the North Pole, describe the approximate number of daylight hours on the following days of the year: March equinox, June solstice, September equinox, and December solstice.

During the equinoxes, as with anywhere else on Earth, the day length will be approximately 12 hours at the North Pole because the circle of illumination evenly bisects all parallels. However, during the June solstice when the direct rays of the Sun are located at the Tropic of Cancer, the angle of the noon Sun will be  $23.5^\circ$ , and the day length will be 24 hours. Conversely, during the December solstice, when the direct rays of the Sun are located at the Tropic of Capricorn, the Sun will not appear above the horizon at the North Pole. Therefore, the angle of the noon Sun will be  $0^\circ$  and the day length will be 0 hours.

27. At the North Pole, for how many months of the year is there no sunlight at all?

Six

### **Telling Time (p. 21)**

28. What happens to the hour when crossing a **time zone** boundary moving from west to east?

As one travels across a time zone moving from west to east, it becomes an hour later.

29. What is meant by UTC (Universal Time Coordinated) and Greenwich Mean Time (GMT)?

UTC and GMT are essentially the same. They are standard time systems that use the prime meridian ( $0^\circ$  longitude) as the location from which all time on Earth is measured or determined.

30. What happens to the day when crossing the **International Date Line** moving from east to west?

As one travels across the International Date Line moving from east to west, it becomes a day later. For example, if one leaves Hawaii on a Thursday and flies to Japan, it would be Friday upon crossing the International Date Line.

31. When **daylight saving time** begins in the spring, you would adjust your clock from 2:00 A.M. to

3:00 A.M.

## STUDY QUESTIONS

1. Why are physical geographers interested in globalization of the economy?

Although globalization is most commonly associated with the cultural and economic realms of the world, globalization possesses environmental components as well. Likewise, because of geography's global perspective and its interest in both the natural and the human landscape, geographers are able to offer insight into many of the world's most pressing problems—problems too complex to address from a narrower perspective.

2. Why is a distance covered by  $1^\circ$  of longitude at the equator different from the distance covered by  $1^\circ$  of longitude at a latitude of  $45^\circ$  N?

Because the meridians converge at the poles, distances between them become shorter as one travels from the equator to the poles. The distance between  $1^\circ$  of longitude at the equator is approximately 111 kilometers, or 69 miles, and the distance then decreases to 0 kilometers, or 0 miles, at the poles.

3. What is the significance of *aphelion* and *perihelion* in Earth's seasons?

Aphelion is the point in Earth's revolution where it is farthest from the Sun (a distance of 152,171,500 km) and the perihelion is the point in Earth's revolution where it is closest to the Sun (a distance of 147,166,480 km). Earth is at the aphelion on July 4 and the perihelion on January 3.

4. In terms of the change of seasons, explain the significance of the Tropic of Cancer, the Tropic of Capricorn, the Arctic Circle, and the Antarctic Circle.

The Tropic of Cancer marks the line ( $23.5^\circ$  N latitude) of the farthest northern migration of the direct rays of the Sun (this coincides with the June solstice).

The Tropic of Capricorn marks the line ( $23.5^\circ$  S latitude) of the farthest southern migration of the direct rays of the Sun (this coincides with the December solstice).

The Arctic Circle is the parallel of  $66.5^\circ$  north latitude. All parallels north of the Arctic Circle are illuminated during the June solstice, while they are in darkness during the December solstice.

The Antarctic Circle is the parallel of  $66.5^\circ$  south latitude. All parallels south of the Antarctic Circle are illuminated during the December solstice, while they are in darkness during the June solstice.

5. Is the noon Sun ever directly overhead in Madison, Wisconsin (43° N)? If not, on which day of the year is the noon Sun *highest* in the sky there, and on which day is it lowest?

No. Outside of the tropics, the noon Sun is never directly overhead. In the Northern Hemisphere, the noon Sun will always be the highest in the sky on the summer solstice (June 21) and lowest in the sky on the winter solstice (December 21). This is just the opposite for all locations in the Southern Hemisphere.

6. What would be the effect on the annual march of the seasons if Earth's axis was *not* inclined relative to the plane of the ecliptic?

There would be no seasonality on Earth.

7. What would be the effect on the annual march of the seasons if the North Pole was always leaning toward the Sun?

The Northern Hemisphere would receive a surplus of energy and would possess a hotter climate and the Southern Hemisphere would receive a deficit of energy and possess a colder climate.

8. If Earth's axis was tilted only 20° from perpendicular, what would the latitudes of the Tropic of Cancer and Arctic Circle become?

20° north and south latitudes

9. Why are standard time zones 15° of longitude wide?

Time zones are one hour divisions of Earth's rotation. Earth takes 24 hours to make one complete rotation. Earth is 360° in circumference.  $360^\circ/24 \text{ hours} = 15^\circ$

10. Most weather satellite images are "time-stamped" using UTC or "Zulu" time (UTC expressed using 24-hour or military time) instead of the local time of the region below. Why?

As a way to standardize the times at which such images were taken. Because it is the same number of minutes after the hour in all standard time zones, we usually need to know only the correct time at Greenwich meridian to know exact local time.

## EXERCISES

1. Using formulas found in Appendix I (p. A-1), make the following conversions between the International System (S.I.) and English systems of measurements:

a. 12 centimeters = \_\_\_\_\_ inches:  $12 \times 0.3937 = 4.72 \text{ inches}$

b. 140 kilometers = \_\_\_\_\_ miles:  $140 \times 0.6214 = 87.5 \text{ miles}$

c. 12,000 feet = \_\_\_\_\_ meters:  $12,000 \times 0.3048 = 3657.6$  meters

d. 3 quarts = \_\_\_\_\_ liters:  $3 \times 0.946 = 2.838$  liters

e. 5 kilograms = \_\_\_\_\_ pounds:  $5 \times 2.2046 = 11.02$  pounds

f.  $10^{\circ} \text{ C} = \text{_____}^{\circ} \text{ F}$ :  $(10^{\circ} \text{ C} \times 1.8) + 32 = 50^{\circ} \text{ F}$

2. Using a world map or globe, estimate the latitude and longitude of both New York City and Sydney, Australia. Be sure to specify if these locations are north or south latitude, and east or west longitude.

New York:  $40.7142^{\circ} \text{ N}$ ,  $74.0064^{\circ} \text{ W}$

Sydney:  $33.8683^{\circ} \text{ S}$ ,  $151.2086^{\circ} \text{ E}$

3. The solar altitude (the angle of the noon Sun above the horizon) can be calculated for any latitude on Earth for any day of the year by using the formula  $\text{SA} = 90^{\circ} - \text{AD}$ , where SA is the “solar altitude” and AD is the “arc distance” (the difference in latitude between the declination of the Sun and the latitude in question). Use the analemma (Figure 1.29) to determine the declination of the Sun, and then calculate the solar altitude at the following locations on the day given:

a. Beijing, China ( $40^{\circ} \text{ N}$ ) on November 25th

$$90^{\circ} - (40^{\circ} + 21^{\circ}) = 29^{\circ}$$

b. Nairobi, Kenya ( $1^{\circ} \text{ S}$ ) on September 25th

$$90^{\circ} - (1^{\circ} - 1^{\circ}) = 90^{\circ}$$

c. Fairbanks, Alaska ( $65^{\circ} \text{ N}$ ) on July 10th

$$90^{\circ} - (65^{\circ} - 22^{\circ}) = 47^{\circ}$$

4. Using the map of North American time zones (Figure 1.32) for reference, if it is 5:00 P.M. standard time on Thursday in New York City ( $41^{\circ} \text{ N}$ ,  $74^{\circ} \text{ W}$ ), what is the day and time in Los Angeles ( $34^{\circ} \text{ N}$ ,  $118^{\circ} \text{ W}$ )?

2:00 P.M.

5. Using the map of world time zones (Figure 1.31) for reference, if it is 11:00 A.M. UTC (Universal Time Coordinated, or Greenwich Mean Time), what is the standard time in Seattle ( $48^{\circ} \text{ N}$ ,  $122^{\circ} \text{ W}$ )?

3:00 A.M.



### **Answers to Seeing Geographically Chapter 1 (p. 3)**

#### **Questions:**

This is a natural color, composite satellite image of Earth created by NASA. In the image can you see any indications of human presence? What might explain the differences in the color of land areas? What might explain the differences in the color of ocean areas?

#### **Answers:**

Human presence is indicated by the night-sky lights over Asia, especially visible in the Indian sub-continent along the east coast. Land areas differ in color because of differences in vegetation cover, with this variation especially notable over Australia, with reds and oranges in the central Australian deserts contrasting with the lush green colors of tropical and subtropical vegetation along Australia's northern and eastern coasts. Ocean colors vary with water depth primarily, with shallower water on coasts appearing brighter blue, with darker blue in deeper waters.

### **Answers to Seeing Geographically Chapter 1 (p. 29)**

#### **Questions:**

Look again at the image of Earth at the beginning of the chapter (p. 2). What evidence can you see of each of Earth's "spheres" in this image? What is the approximate latitude and longitude of the center of the image? Based on the position of the circle of illumination, is it early morning or late afternoon in Beijing, China? Generally, how do the clouds look different in the tropics compared with the clouds at higher latitudes?

#### **Answers:**

The atmosphere is visible via the variety of clouds across the globe. The cryosphere is visible in the ice cover in Antarctica at the bottom of the image. The biosphere is illustrated by the greens of terrestrial vegetation. The lithosphere is best seen in the bare rocks of the central Australian desert region. The hydrosphere, represented by the oceans, dominate the image. Nearly the entire Earth from pole to pole is illustrated, indicating that the latitude of the center of the image is approximately along the equator, 0 degrees. The longitude of the center of the image is approximately 125 degrees East. Earth rotates west to east, so China is entering the sphere of illumination, indicating that it is early morning in Beijing. Tropical clouds appear as puffy, cumulus clouds, whereas thinner cirrus and cirrocumulus clouds dominate the southern high latitudes toward Antarctica.