APPENDIX 2

GLOBAL PHYSICAL GEOGRAPHY

This appendix provides an overview of planet earth as a habitable environment for humans and an account of 10 principal global environment regions.

A HABITABLE PLANET

The earth is a habitable planet for humans—the only such planet known to us. By *habitable*, we mean that physical processes and physical environments on this planet permitted the emergence and subsequent spread and growth of human life. Indeed, only a series of quite remarkable coincidences have made earth habitable for humans. The planet's distance from the sun, its axial tilt, its 24-hour rotation, and its "minor" variations in surface relief all combine to spread the sun's energy relatively evenly. The evolution of the earth required the presence of water to form oceans, an average surface temperature of 15°C (59°F), and the presence of a particular kind of atmosphere. Interestingly, the first life on earth evolved in water; the subsequent movement of life onto land converted the initial carbon dioxide atmosphere into an oxygen-rich one. This atmospheric transformation included the creation of the ozone layer (ozone is a form of oxygen) that prevents the penetration of ultraviolet rays that would sterilize the land surface. The oxygen-rich atmosphere also allowed the emergence of animal life.

From our earthbound perspective, the planet's surface is tremendously varied. The atmosphere is constantly changing; there are mountains as high as 8,854 m (29,048 feet) above sea level (Mount Everest), land areas 408 m (1,338 feet) below sea level (the shores of the Dead Sea), and known ocean depths of 10,927 m (35,849 feet) below sea level (south of the Mariana Islands in the Pacific Ocean). The planet frequently experiences dramatic changes—volcanic eruptions, earthquakes, tidal waves. On another level, all these variations and changes are insignificant. An accurate hand-sized model of the earth feels as smooth as a peach.

The earth is approximately spherical in shape, with an equatorial circumference of 40,067 km (24,897 miles) and a polar circumference of 40,000 km (24,855 miles). This shape is the result of gravity, the force that is also responsible for the tendency of the earth's surface area to be layered: a dense substance, rock, is at the bottom; a less dense substance, water, is often above the rock; and the least dense substance, air, is above the other two. Such an arrangement is crucial for human life, which has access to all three essential substances. The sphere moves in two ways. First, it rotates on its axis; one rotation defines a day. Second, it orbits the sun; one revolution defines a year.

Rotation

Rotation imposes a diurnal cycle on much of the life on earth. The end points of the axis of rotation are defined as the poles, north and south. Except for the poles, all locations on the earth's surface move as the earth rotates, and one circuit of the earth is a line of latitude. Because the earth is a sphere, the longest line of latitude lies midway between the poles: this is the equator. Lines from one pole to the other are lines of longitude. Unlike lines of latitude, these are not parallel, but they converge at the poles and are farthest apart at the equator. Lines of latitude are measured in degrees, with the equator defined as 0° and the poles therefore as 90°N and 90°S; lines of longitude are similarly measured in degrees, in this case from an arbitrary 0° line known as the prime meridian, which runs through the Greenwich Observatory in

London, England. The geographic grid commonly used to describe locations is based on latitude and longitude.

Revolution

Revolution produces seasonal climatic changes and variations in length of daylight. Figure A2.1 illustrates the four seasonal positions of the earth relative to the sun and introduces the terms *solstice* and *equinox*. The summer **solstice**—that is, when the hemisphere reaches maximum inclination towards the sun so that it is directly overhead at latitude 23.5°—occurs on 21 or 22 June in the northern hemisphere and on 21 or 22 December in the southern hemisphere. The winter solstice occurs on 21 or 22 December in the northern hemisphere and on 21 or 22 June in the southern hemisphere. On this date, the hemisphere reaches maximum inclination away from the sun. The two **equinoxes**, vernal and autumnal (spring and fall), are the halfway points between the solstices. On both occasions the axial inclination is at exactly 90° with respect to the sun.

solstice
Occurs twice each year when the sun is vertically overhead at the farthest distance from the equator, once 23.5°N and once 23.5°S of the equator; for example, when at 23.5°N, there is maximum daylight (longest day) in the northern hemisphere and minimum daylight (shortest day) in the southern hemisphere.

equinox
Occurs twice each year, in spring and fall, when the sun is vertically overhead at the equator; on this day the periods of daylight and darkness are both 12 hours long all over the earth.

A great deal of human activity is related to these global physical factors. Diurnal, seasonal, and annual cycles are basic to much social and economic organization. The durations of the day and year are defined by earth movements, while the month is defined by lunar movement around the earth. The hour, by contrast, is an arbitrary human division, as is the use of the equinoxes and solstices as the beginnings of seasons.

The Earth's Crust

The crust or outer layer of the earth is composed of rocks—aggregates of minerals—that have continued forming and changing for at least three billion years. The various rock types are usually classified as sedimentary (those that were formed at low temperatures on the earth's surface); igneous (those that solidified from a molten state); or metamorphic (those that have changed under high temperature and pressure).

One of the most important features of the earth's surface is that it is part land (29 per cent) and part water (71 per cent). The present distribution is the result of a long and ongoing process of movement by the lithosphere—the earth's crust and the uppermost mantle below the crust. The lithosphere is divided into six major and several minor plates that move relative to one another as a result of movements in the liquid mantle deep inside the earth. The continents quite literally float on this liquid mantle, with some four-fifths of their mass below the surface. The idea that the continents also move was suggested as long ago as the seventeenth century, when the English philosopher Francis Bacon (1561–1626) observed that

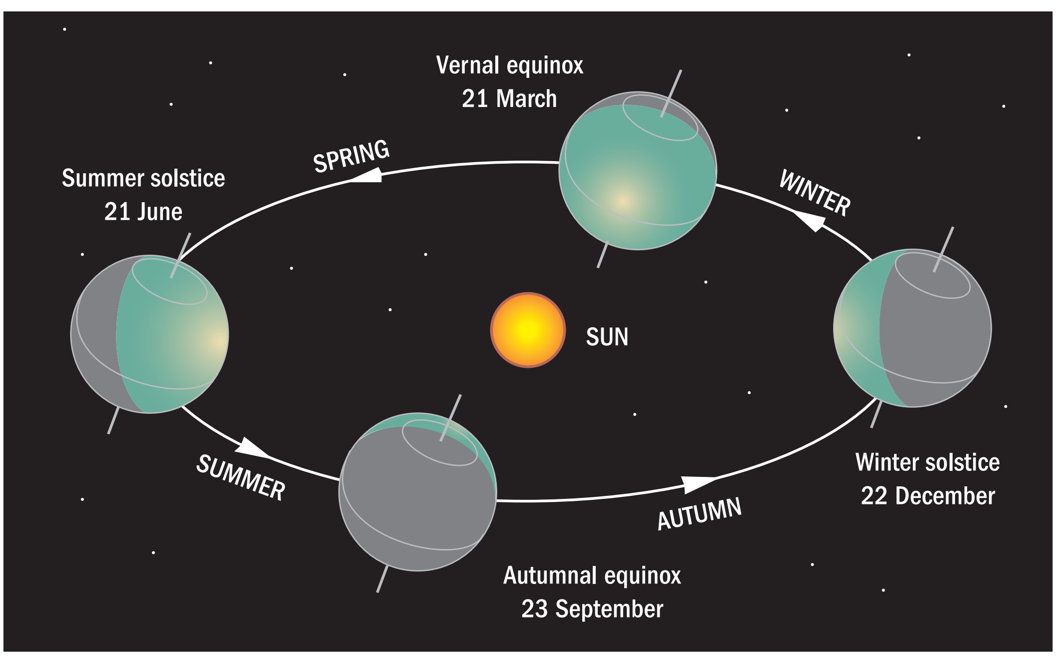

FIGURE A2.1 | The revolution of the earth around the sun the Atlantic coasts of South America and Africa fitted together like pieces of a jigsaw puzzle. Early scientific evidence was gathered by Alfred Wegener (1880–1930), a German meteorologist, but this idea of moving continents, known as **continental drift**, did not achieve scientific credibility until the 1960s. Figure A2.2 illustrates the positions of the continents since outward movements began roughly 225 million years ago (MYA). At the present time, the Atlantic Ocean is widening about 2 cm (0.75 inches) each year, Australia and Africa are moving northward, and parts of Africa and western North America may separate from their respective continents.

A second consequence of moving continents is the creation of mountain chains such as the Himalayas. When continents collide—as India and Asia did, perhaps 150 MYA—mountain chains are thrust upwards. The Appalachians are much older, resulting from a collision of North America and Africa perhaps 350 MYA.

Earthquakes are a third consequence; they occur when parts of the crust move over other parts as a result of movements in the liquid mantle. Once stress exceeds rock strength, an earthquake occurs. Such movements typically take place along fault lines (such as the San Andreas fault in California), which are lines of crustal weakness. Volcanoes also occur along lines of crustal weakness, often plate boundaries. A volcanic eruption involves liquid from the mantle (magma) being forced upwards and onto the earth's surface.

As already noted, approximately two-thirds of the earth's crust is covered by water. The physical landscape beneath is constantly changing, while the water itself is also involved in a series of movements. Waves are caused by wind; tides result from the gravitational pull of the moon (and, to a

continental drift
The idea that the present continents were originally connected as one or two land masses that separated and drifted apart.

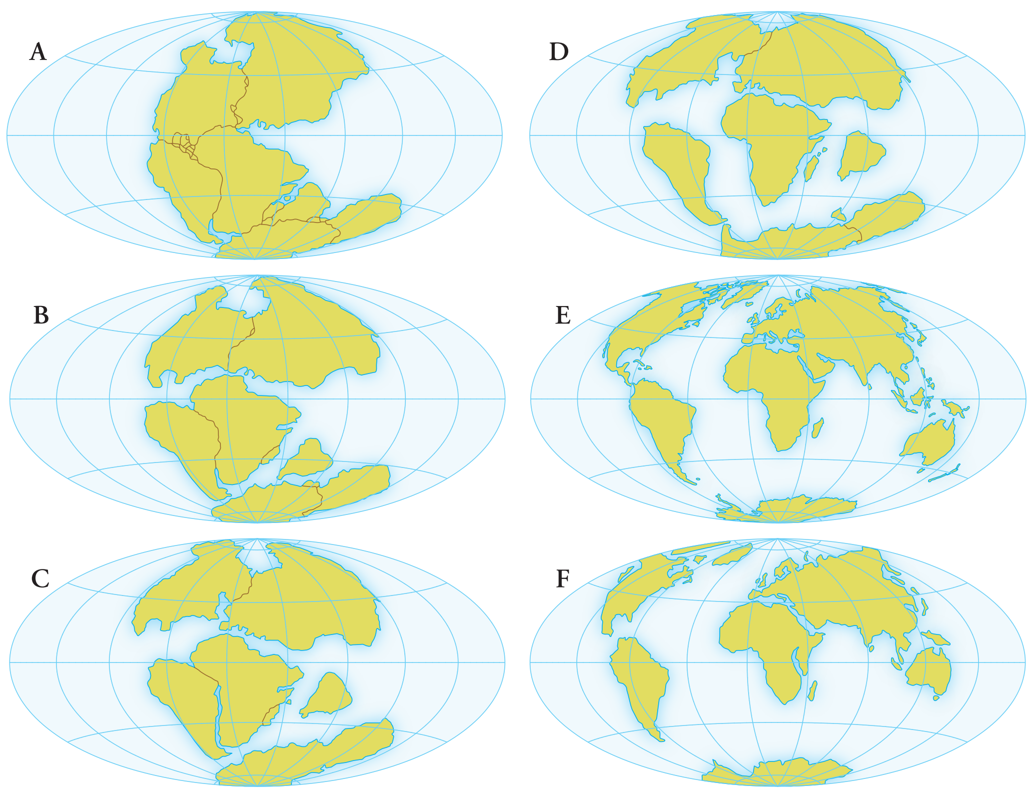

FIGURE A2.2 | **Moving continents**

In (A), beginning 222 MYA, there is one land mass, a super-continent called Pangaea. By 180 MYA (B), Pangaea is breaking up; Laurasia is moving north, and the southern land mass, Gondwanaland, is also breaking away. In (C), 135 MYA, the process continues, with the beginnings of the North and South Atlantic oceans. In (D), 65 MYA, Madagascar has separated from Africa and India is moving towards Asia, but Australia remains linked to Antarctica. Map (E) shows the present distribution of land and sea, and (F) shows a likely scenario 50 million years in the future: Australia continues to move north; East Africa is shifting farther east, California (west of the San Andreas fault) has separated from North America, and the Mediterranean Sea is shrinking as Africa moves north.

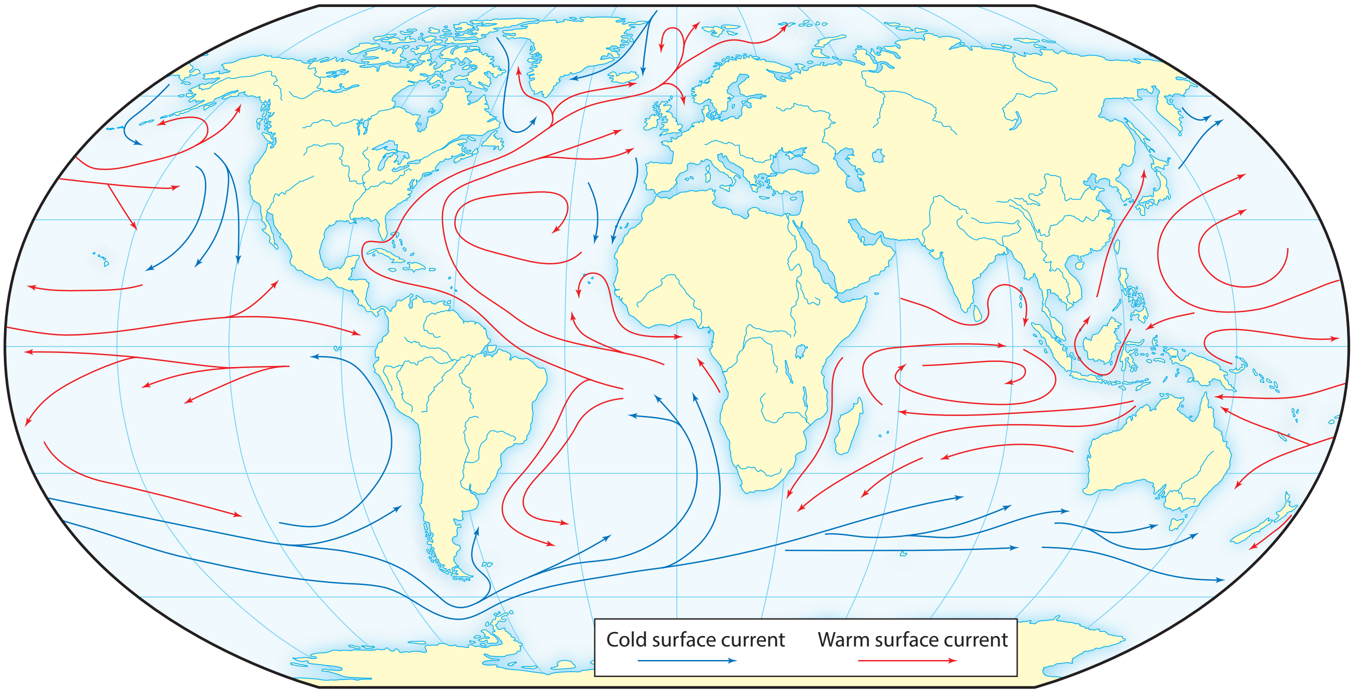

FIGURE A2.3 | The major ocean currents

The prevailing winds and the rotation of the earth combine to cause gyres (large whirlpools). These gyres move warm water away from the equator and cold water towards it. There are 5 major gyres and 30 major currents.

lesser extent, the sun). The most significant movements, however, are ocean currents (Figure A2.3). Warm water moves away from the equator and cold water moves towards the equator.

Some of the earth's water is in the form of ice—a leftover from the most recent glacial period. Most of this ice is in the Antarctic and Greenland continental sheets, which cover about 10 per cent of the land surface and reach thicknesses of several kilometres. As this ice gradually melts, the sea level rises. Some 20,000 years ago, the sea level was 100 m (328 feet) lower than today; the current rise is about 1 cm (0.39 inch) a year.

The physical processes and circumstances identified so far are global and/or long-term, but they are important to us. Understanding past migrations of life forms, for example, requires an appreciation of land movement and climatic change. One example of the possible long-term effects of a physical process—exacerbated by human activity—is the melting of all ice, which would result in a sea-level rise of 60 m (197 feet). Such a rise would flood many of the largest cities in the world.

The Physical Landscape

The physical landscape in which human activities take place (and which is continually modified by those activities) is a product of a series of processes. Crustal movement and the effects already noted are followed by weathering and gradational processes that combine to produce specific landforms. Weathering is the reduction in size of surface rock; gradation is the movement of surface material under the influence of gravity and typically involves water, ice, or wind. In addition to creating landforms, these processes combine with the activities of living organisms to create soil. Plant and animal life are, in a circular fashion, closely related to the landscapes created.

Weathering occurs when rock is mechanically broken and/or chemically altered. Temperature change is an important cause of mechanical weathering; water is the principal cause of chemical weathering. Rocks weakened in this way become especially susceptible to gradational processes. Water, ice, and wind can erode, move, and deposit material. Many of the earth's distinctive physical landscapes are clear evidence of these processes at work.

Water is probably the most important cause of gradation. A continuous transfer of water from sea to air to land to sea is taking place. River erosion creates V-shaped valleys and waterfalls, while river deposition creates flood plains and deltas. Seawater also affects land surfaces, and coastlines undergo constant change; cliffs are the result of erosion, beaches the result of deposition. Other parts of the earth's surface show the effects of ice and snow. During the most recent glacial period, ice covered an area approximately three times greater than that covered today, including Northern Europe and Canada. Areas formerly covered by ice show distinctive evidence both of erosion (e.g. U-shaped valleys) and of deposition (e.g. the low hills called drumlins). Wind erosion results either from wind-blown materials colliding with stable materials (as in sandblasting) or, more often, the wind's removal of loose particles from a surface. Sand dunes are among the best-known products of wind deposition of material. Each of these processes affects parts of the earth's surface at all times. Physical landscapes, then, are subject to continuous modification—almost fine-tuning. In principle, the eventual outcome, without crustal movement or climatic change, would be an almost featureless physical landscape.

Our physical environment is much more than the distribution of landforms. Soils, vegetation, and climate are additional components of a physical environment. Figures A2.4, A2.5, A2.6, and A2.7 provide general outlines of global landforms, soils, vegetation, and climate, respectively. Figure A2.4 maps the major cordilleran *belts*—the backbones of the continents. The slope and ruggedness of local landforms in particular are major considerations in human decisions about the location of economic activities, such as agriculture, industry, and transport.

Soil types are distributed in a systematic fashion (Figure A2.5). There are close general links both to climate and to natural vegetation; these are two of the most important determinants of soil type. Soils are important for their agricultural potential and for their capacity to support buildings. Much of the European migration to the New World was closely tied to the availability of soils suitable for commercial agriculture; in the late nineteenth century, many settlers found suitable grassland soils in Canada, Argentina, and Australia.

Figure A2.6 maps the global distribution of natural vegetation. The four principal types are grassland, forest, desert scrub, and tundra. Much

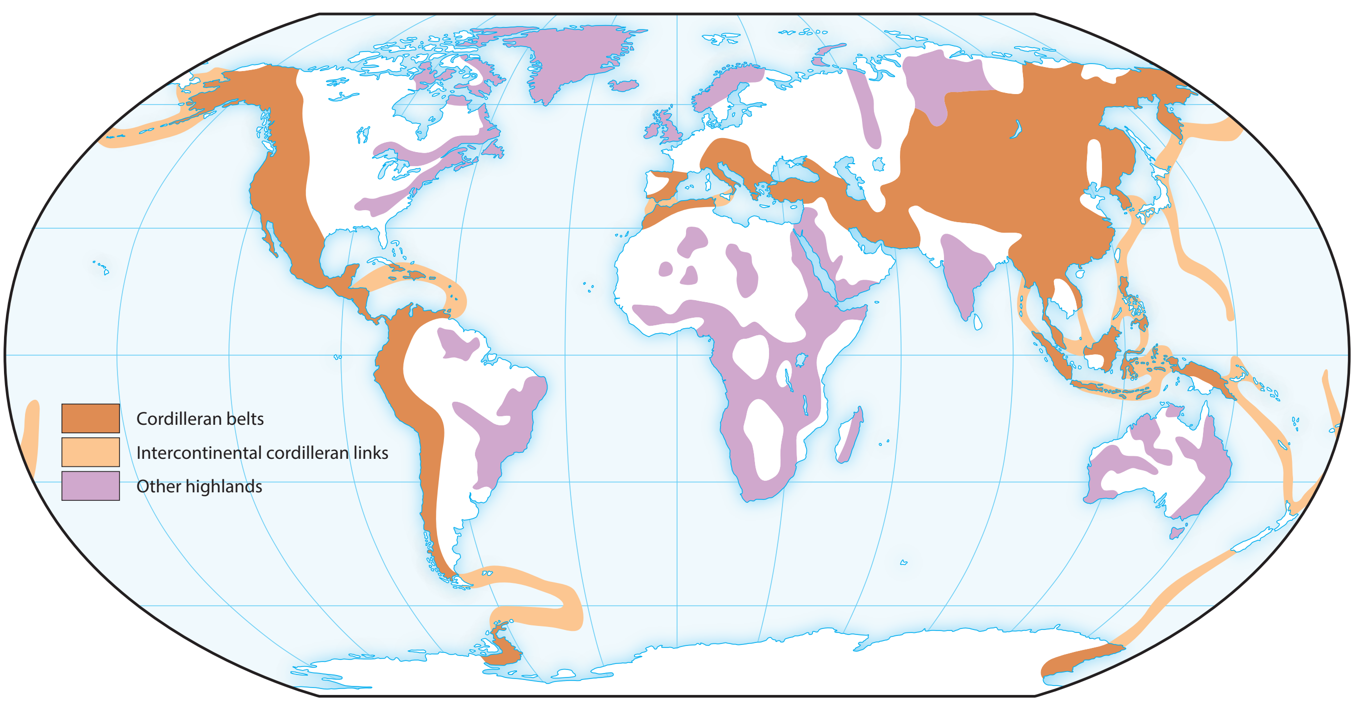

FIGURE A2.4 | Global cordilleran belts

The backbones of the continents, these cordilleran belts also extend through ocean areas.

Source: Adapted from Scott, R. C. 1989. *Physical Geography*. St Paul, MN: West Publishing, 295.

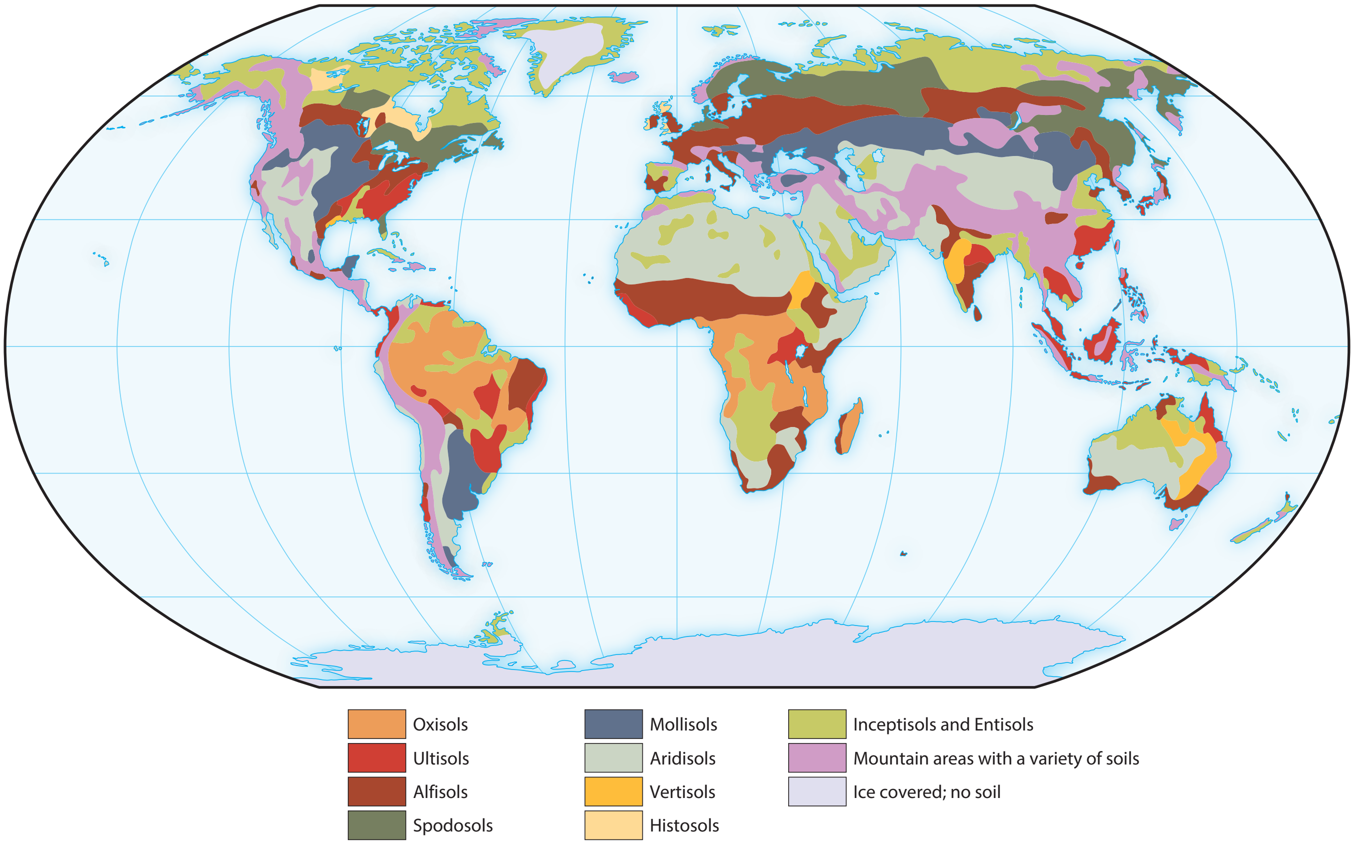

FIGURE A2.5 | Global distribution of soil types

Oxisols are typical of tropical rain forests and are deep soils but not inherently fertile: if the natural vegetation is removed, the soil is soon impoverished. Ultisols, in the humid tropics, are low in fertility. Alfisols, dispersed throughout low- and mid-latitude forest/grassland transition areas, are of moderate to high fertility. Spodosols are associated with the northern forests of North America and Eurasia; low fertility is typical. Mollisols, associated with middle-latitude grasslands, are often very fertile. Aridisols, located in areas of low precipitation, lack water. Vertisols, limited to areas of alternate wet and dry seasons, may be very fertile. Histosols are most common in northern areas of North America and Eurasia; they are composed of partially decayed plant material, usually waterlogged, and typically fertile for only water-tolerant plants. Inceptisols and entisols are immature soils found in environments that are poorly suited to soil development.

Source: Adapted from Scott, R. C. 1989. *Physical Geography*. St Paul, MN: West Publishing, 276–7.

of the history of agriculture is intimately tied to their distribution. In circumstances of limited agricultural technology, for example, forested areas can be a significant barrier.

Climate is the characteristic weather of an area over an extended period of time and can be usefully summarized by referring to mean monthly and annual statistics of temperature and precipitation. These means reflect latitude. Figure A2.7 makes it clear that climatic distributions are generally linked to latitude. Three low-latitude, two subtropical, three mid-latitude, and three high-latitude climates are mapped, along with one highland climate. Low-latitude climates are characteristically hot; the distinguishing feature of each is precipitation. The two subtropical climates are less hot, and again the distinguishing feature is precipitation. The three low-latitude climates lack any significant seasonality. The subtropical and mid-latitude climates vary according to the degree of continentality (distance from ocean) and, of course, latitude. All five of these climates have seasonal variations. Proximity to oceans tends to increase precipitation and reduce temperature variations. The three high-latitude climates are cold most of the year and have low precipitation. Finally, highland climates display many local variations, since temperature and precipitation are affected by altitude in addition to latitude.

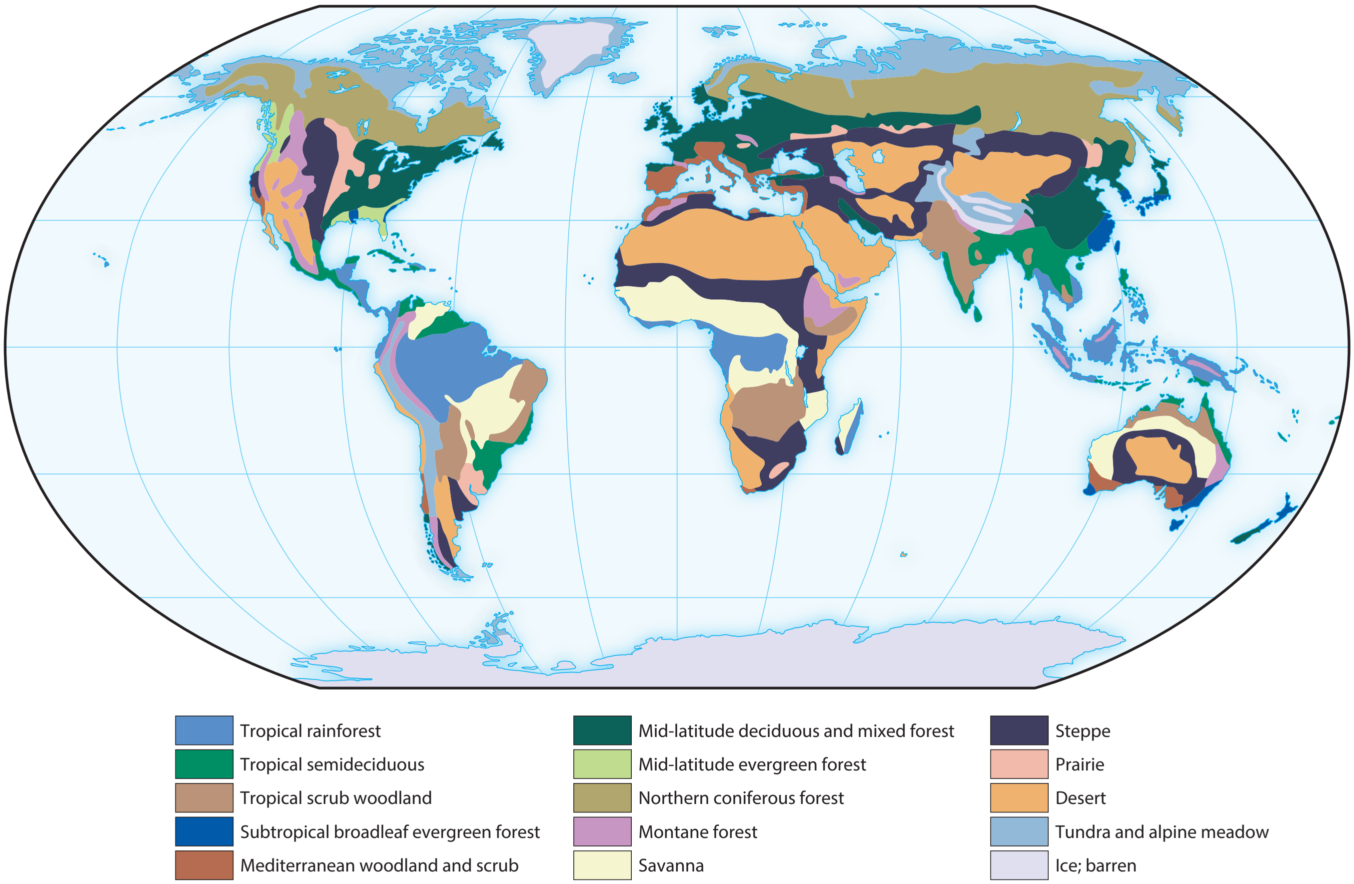

FIGURE A2.6 | Global distribution of natural vegetation

Differences in forest types are related to climate. Forests become less dense and have fewer species as they move northward or southward from the equator. Deciduous trees dominate the middle latitudes, evergreens the higher latitudes. Savanna, steppe, and prairie are composed chiefly of grasses. Desert vegetation is closely linked with an arid climate. Tundra vegetation is the most cold-resistant.

Source: Adapted from Scott, R. C. 1989. *Physical Geography*. St Paul, MN: West Publishing, 232–3.

GLOBAL ENVIRONMENTS

The preceding section highlighted a wide variety of physical processes and environments. These processes often have an intimate relationship to human activities but do not in any sense determine them. Although we need to be aware of physical factors at all levels, we must not assume any causal relationships. As this book demonstrates, we humans make the decisions—albeit with many physical factors in mind! This section presents a brief summary of the major global environments (Figure A2.8), integrating much of the material above in a more applied human context. The notion of global environmental regions is useful here. Indeed, those regions are closely correlated with climatic regions in particular. Humans have favoured certain environments and have made changes to all areas they have settled in.

Tropical Rain Forests

These areas are located close to the equator and experience high rainfall—typically exceeding 2,000 mm (78 inches) per annum—and high

Guenter Guni/iStockphoto

Evergreen cloud forest on the slopes of Mt Ruwenzori on the border of Uganda and DR of Congo. Mt Ruwenzori (5,114 metres) is the third highest mountain in Africa.

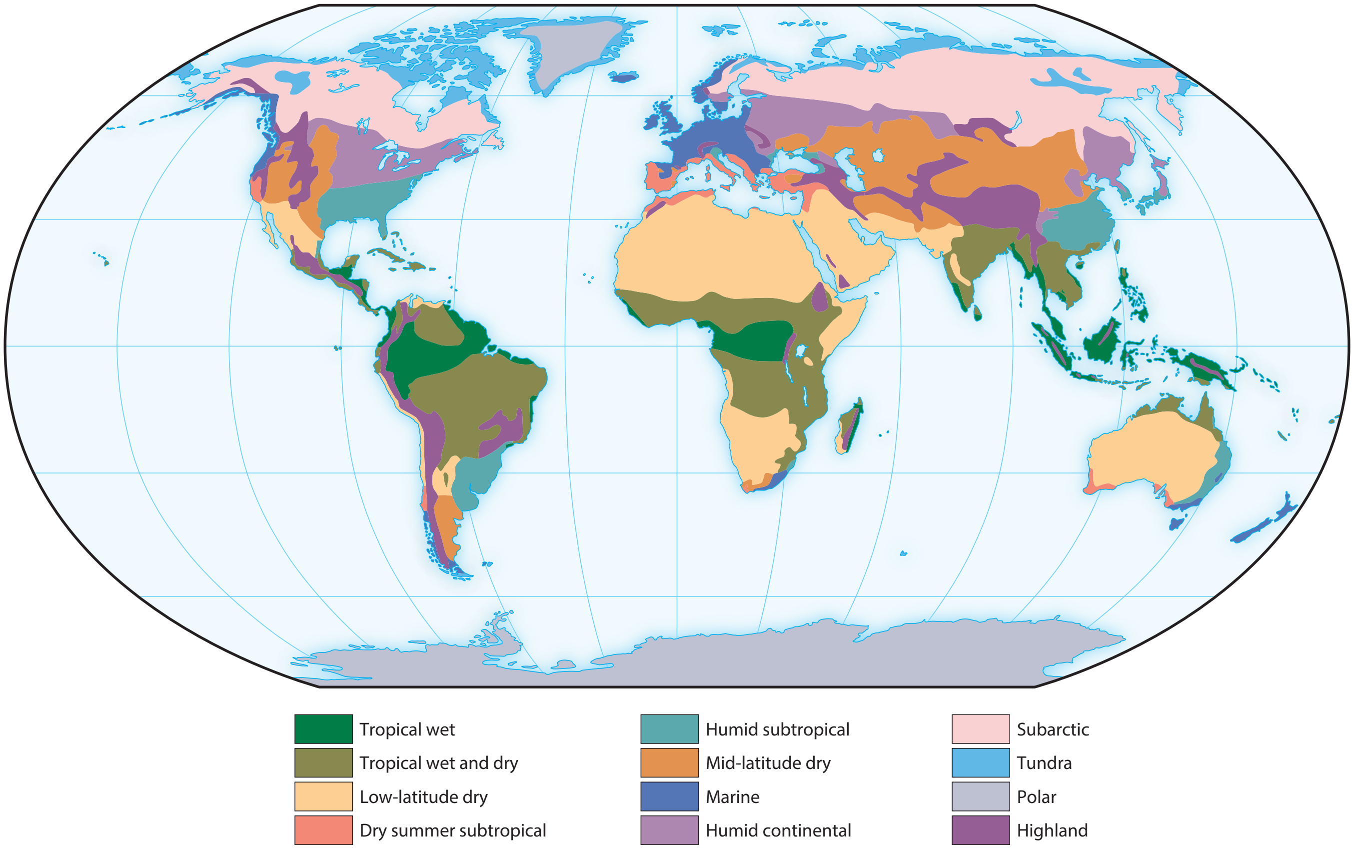

FIGURE A2.7 | Global distribution of climate

These types of climate, distinguished on the basis of moisture and temperature, are derived from the Köppen classification. Tropical wet, tropical wet and dry, and low-latitude dry climates may be grouped as low-latitude climates; dry summer subtropical, humid subtropical, mid-latitude dry, marine, humid, and continental climates as mid-latitude climates; and subarctic, tundra, and polar climates as high-latitude climates.

Source: Adapted from Scott, R. C. 1989. *Physical Geography*. St Paul, MN: West Publishing, 158–9.

temperatures—24°C to 30°C (75°F to 86°F). They lack seasonal variation. Broad-leaf trees dominate, and the vegetation is dense and highly varied.

Dirk Ott/iStockphoto

Flooded fields around Inle Lake in the monsoon area of Burma.

Nevertheless, once the vegetation is removed, the soil is characteristically shallow and easily eroded. Tropical rain forests have not become major agricultural regions. Among the economically valuable products of rain forests are mahogany and rubber, as well as numerous starchy food plants, such as manioc, yams, and bananas.

Monsoon Areas

Monsoon areas are characterized by marked seasonality, especially an extended dry season and heavy rainfall. Rainfall may be as high as 2,000 cm (780 inches) in some areas. The typical natural vegetation is deciduous forest, but all monsoon areas have been changed dramatically as a result of human activity. Agriculture has been practised for a long time, with rice as the basic crop in many such areas. Population densities are usually high.

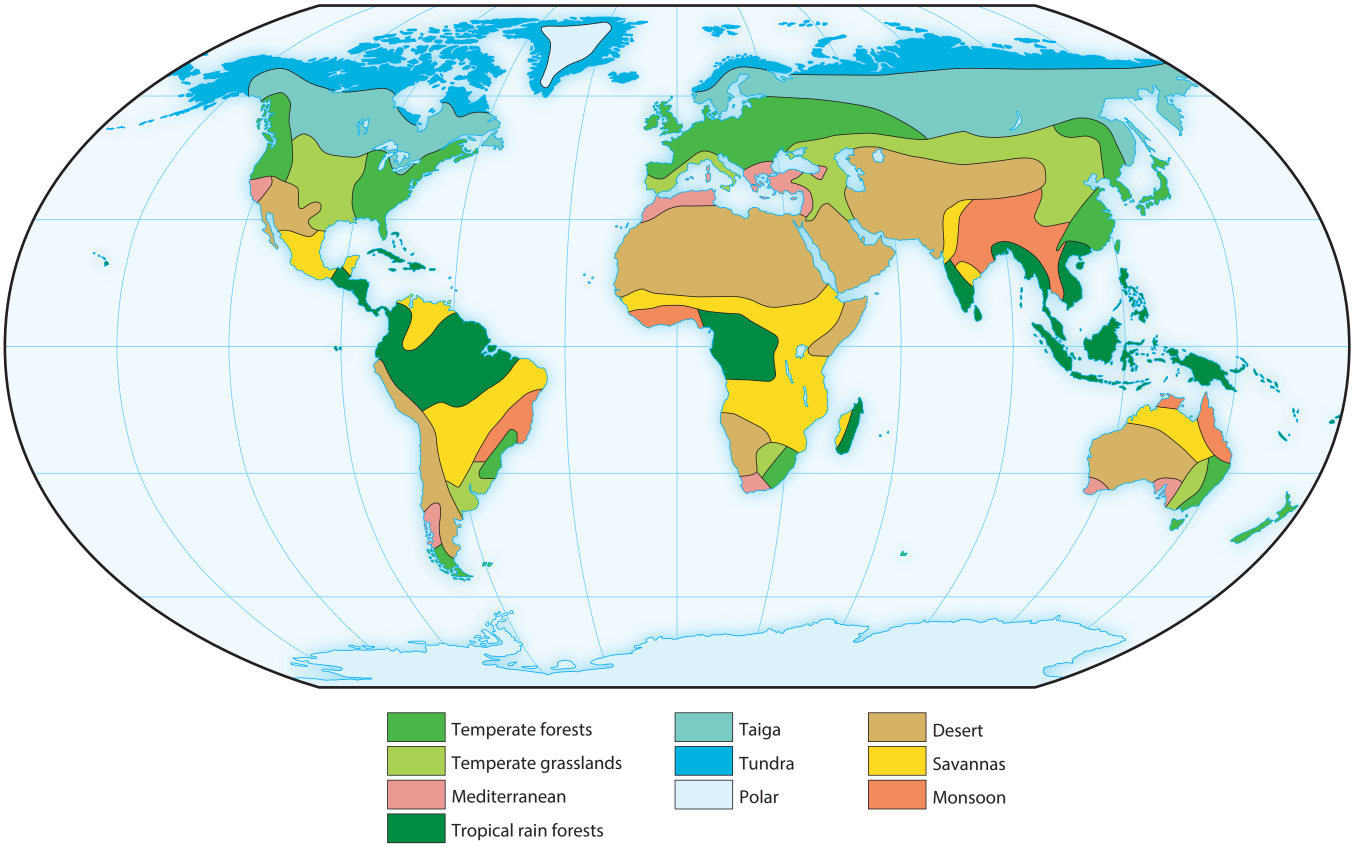

FIGURE A2.8 | Generalized global environments
Climate is clearly a key consideration in many human decisions, but weather is also important. Weather can have a major impact on agricultural yields. Atypical or violent weather can cause floods or droughts, and hurricanes—vast tropical storms—can cause serious damage to populated land areas.

Savannas

Savannas are located to the north and south of the tropical rain forests. They have a distinctive climate: a very wet season and a very dry season. The natural vegetation is a combination of trees and grassland. Africa has the most extensive savanna areas, which are rich in animal species. To date, most savannas are relatively undeveloped economically, but they offer great promise for increases in animal and crop yields. Important grain crops include sorghum in Africa and wheat in Asia.

Deserts

A desert area has low and infrequent rainfall, perhaps as low as 100 mm (4 inches) per annum and perhaps no rain for 10 years. Areas are typically defined as arid if they receive less than 255 mm (10 inches) of rain per annum and as semi-arid if they receive less than 380 mm (15 inches). There are hot, cold, sandy, and rocky deserts. In all deserts, water is a crucial consideration in human activities. Irrigation and nomadic pastoralism are two human responses to desert environments.

Mediterranean Areas

There are only a few Mediterranean environments. They are characterized by long, hot, dry summers

Lucyna Koch/iStockphoto

Savanna, Naukluft, Namibia.


Xebeche/iStockphoto

Desert, Argentina (Patagonia).


akrp/iStockphoto

Mediterranean area, Provence-Alpes-Côte d'Azur, France.


Вадим Орлов/iStockphoto

Temperate grassland, rural Russia.

and warm, moist winters. The typical location is on the western side of a continent in a temperate latitude. Evergreen forests are the usual natural vegetation, although human activity means that scrub land prevails today. Important crops, especially in the Mediterranean proper, are wheat, olives, and grapes.

Temperate Forests

A temperate climate predominates in much of Europe and eastern North America. This climate is characterized by a distinct seasonal cycle, fertile soils, and a natural vegetation composed primarily of mixed deciduous trees. The seasonal cycle gives this area its distinctive character. The many animals and plants have adapted to the variations in heat, moisture, food, and light. Annual loss and growth of leaves is an especially striking adaptation that affects all other forest life forms. Particularly since the beginnings of agriculture, these areas have been attractive to and significantly altered by humans, and they are now dominated by agriculture, industry, and urbanization. These changes began in Europe about 7,000 years ago, in Asia about 6,000 years ago, and in North America about 1,000 years ago. Indeed, the removal of forest cover has been so dramatic that today there is a general recognition of the need to preserve and even expand the remaining forests.

Temperate Grasslands

North American prairies, Russian steppes, South African veld, and Argentine pampas are four of the large temperate grasslands. Located in continental interiors, they have insufficient rainfall for forest cover and tend to show great annual temperature variations. Such grasslands were once occupied by particular large migrating herbivores such as the bison (North America); antelopes, horses, and asses (Eurasia); and pampas deer (South America). After remaining almost devoid of humans until the late seventeenth century, these grasslands became the granaries of the world in the twentieth century. Their soils are typically suited to grains; wheat became dominant in most areas.

Boreal Forests

Boreal forests, often called taiga, are located only in the northern hemisphere—in North America and Eurasia. Their winters are long and cold, their summers brief and warm, and precipitation is limited. The natural vegetation is evergreen forest. Agriculture is very limited, and the major economic importance of taiga consists in forest products and minerals.

Tundra

Located north of the boreal forest, this area experiences long, cold winters; temperatures average −5°C (23°F) and there are few frost-free days. Perennially frozen ground—permafrost—is characteristic and presents a severe challenge to human activities. Only a few plants and animals have adapted to this environment because the land has been exposed for only about 8,000 years, since the last retreat of ice caps. There has been little time for soil to form.

Polar Areas

Polar conditions prevail in both hemispheres and are best represented by the Greenland and Antarctic ice sheets. Antarctica is a continental land mass under an ice sheet that reaches thicknesses of 4,000 m (more than 13,000 feet). These areas lack vegetation and soil and have proven hostile to human settlement and activity. Indigenous inhabitants of these areas lived in close relationship to the physical environment, subsisting on hunting and fishing. In recent years non-indigenous inhabitants have greatly increased in number, particularly because of the discovery of oil.

These brief descriptions of 10 global environments make no attempt to describe all areas. Nor do all areas within a particular environment have

Dougall Photography/iStockphoto

Boreal forest, Prince Albert National Park, Saskatchewan.

kalimf/iStockphoto

Temperate mixed deciduous forest of lower Great Lakes–St Lawrence Valley region.

Philip Dearden

Tundra, Herschel Island, Yukon.

Philip Dearden

Polar region, Ellesmere Island.

uniform characteristics. Regions merge into one another; the tropical rain forest merges into savanna and then into desert, for example. Rarely are there clear, sharp divisions. As a result, many areas are difficult to classify. This outline emphasizes that the earth comprises many environments with which humans have to cope. All these environments have been affected by human activities, and all need to be considered in any attempt to comprehend our human use of the earth.

Suggested Readings

de Blij, H. J., P. O. Muller, R. S. Williams Jr, C. T. Conrad, and P. Long. 2009. *Physical Geography: The Global Environment*, 2nd Canadian edn. Toronto: Oxford University Press.

A detailed, comprehensive text on physical geography; very readable, well illustrated, and student-friendly throughout.

Trenhaile, A. S. 2009. *Geomorphology: A Canadian Perspective*, 4th edn. Toronto: Oxford University Press.

A textbook presenting a systematic explanation of Canada's landforms.

On the Web

Canada

www.nrcan.gc.ca

The home page of Natural Resources Canada, on which you can find the Geological Survey of Canada, offering a wide variety of information on physical geography and links to relevant provincial and territorial websites.

United States

www.usgs.gov

The US Geological Survey site includes clear overviews of physical geographic landscapes; offers a good account of the application of GIS technologies.