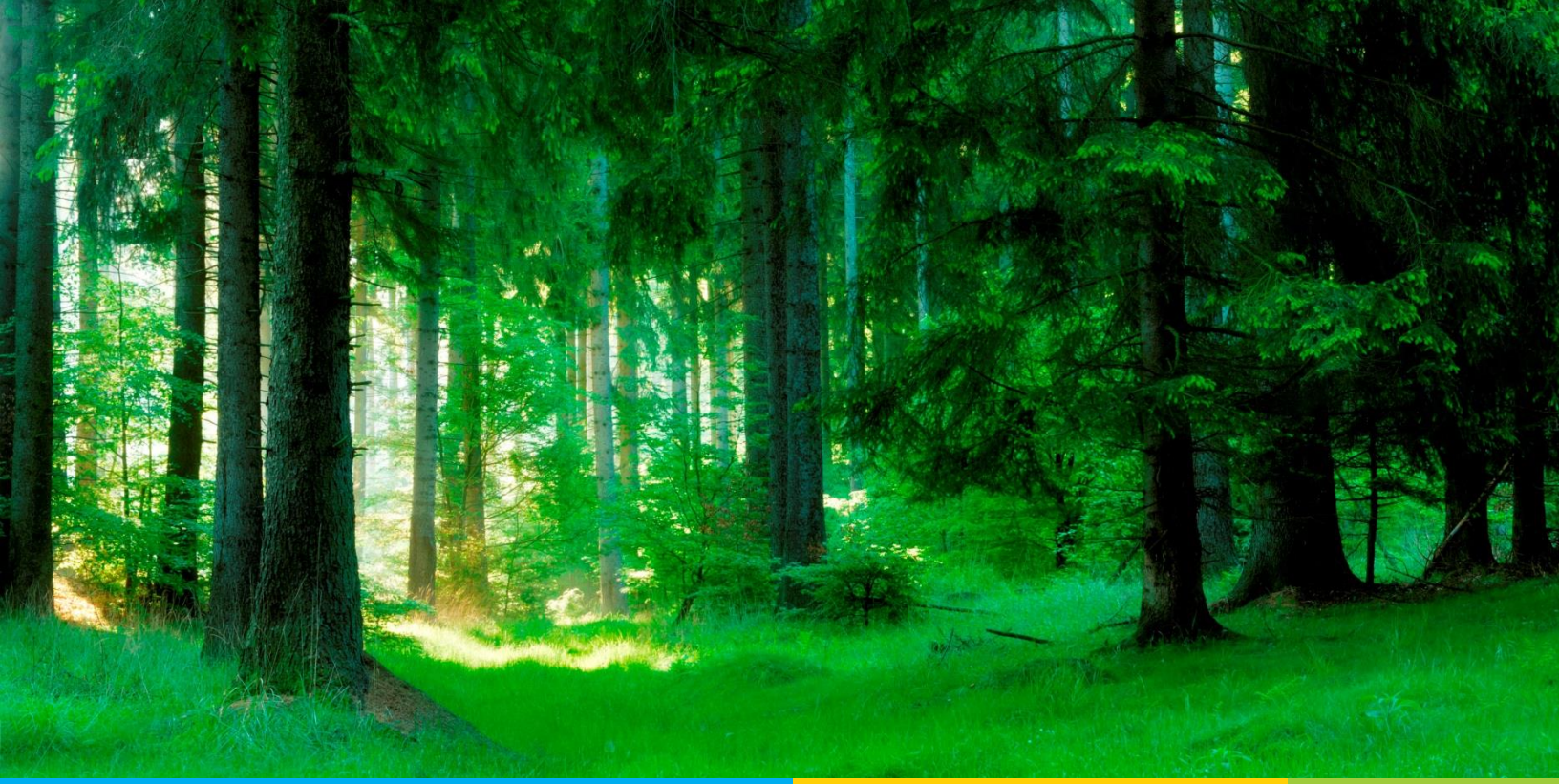

16 Global Climate

Learning Goals

After studying this chapter, students should be able to:

1. associate the world's six major vegetation biomes to climate (pp. 406–408);
2. describe methods for classifying climate (pp. 409–433);
3. apply the six climate controls to link the climate types of the world with their locations (pp. 404–406); and
4. provide reasons why Earth's climate has changed over time (pp. 433–438).

Summary

1. Six factors control the distribution of climate types around the world. Latitude influences temperatures and seasonality through its control over sun angle and day length. Effects of the distri-

bution of land and water account for the fact that coastal locations have lower daily and annual temperature ranges than do inland locations; these differences arise because water has a moderating effect on temperature. Ocean currents control temperatures and precipitation because warm ocean currents warm, moisten, and destabilize the air above, while cold ocean currents have the opposite effect. The major pressure systems of the Earth's general circulation control precipitation. The equatorial low (ITCZ) and the subpolar lows (mid-latitude cyclones) bring precipitation; the subtropical highs and the polar highs bring clear skies. Prevailing winds also control climate; as a result, windward coasts are wetter, and have lower annual and daily temperature ranges, than leeward coasts. Finally, mountains have a strong control on the distribution of precipitation, as they force air to release its moisture on their windward sides, leaving their leeward sides dry. Mountains also control temperature because temperature decreases with altitude.

2. Forests require warmth and abundant moisture. Grasslands grow where moisture is more limited. Savanna grows in the tropics in places with a seasonal drought that lasts several months. Shrublands are an adaptation to locations with hot, dry summers. Desert vegetation is adapted to conserve moisture. Tundra vegetation occurs at high latitudes where temperatures are too low to support forests.

3. There are three types of climate classification systems. *Applied* systems group climates for specific purposes. *Genetic* systems group climates based on their common causes. *Empiric* systems group climates based on climatic data, usually temperature and precipitation. Köppen's system is an example of an empiric climate classification system that sets boundaries for climate regions based on mean monthly temperature and precipitation values.

4. Tropical climates are hot due to their low-latitude locations. The precipitation regimes of these climates are influenced by the movement of the ITCZ and the subtropical highs. Places that are always affected by the ITCZ are wet year round, places that are always affected by the subtropical highs are dry year round, and places that are affected by both have wet and dry seasons. Tropical monsoon climates have a very wet season and a short dry season due to seasonal shifts in the winds. In the tropics, prevailing easterly winds make east coasts wetter than west coasts. The hottest, the wettest, and the driest places on Earth are located in the tropics.

5. Mid-latitude climates have warm and cold seasons. Continental locations experience greater seasonal differences in temperature than do marine locations. Most precipitation comes from mid-latitude cyclones. Some locations experience dry summers due to the poleward shift of these storms at that time. Prevailing westerly winds make west coasts wetter and milder than east coasts. Most dry mid-latitude climates form on the lee sides of mountains. The largest annual temperature ranges on Earth occur in the mid-latitudes.

6. Polar climates are always cold and have large annual temperature ranges. Precipitation is low because the air is cold and the pressure is normally high.

7. Earth's climate has changed over time. Evidence indicates that there have been at least four ice ages and that these ice ages have been interrupted by warm periods in which there has been no ice on Earth. Such long-term climate changes have been linked to the gradually increasing output of the sun, along with changes in the planetary albedo and greenhouse effect. Both the latter sets of changes have been associated with the actions of plate tectonics and the evolution of life. Climate changes occurring over periods of tens of thousands of years are caused by variations in Earth's orbit and appear to be amplified by feedback effects. Over time periods of years, climate change results from variations in the sun's output, volcanic eruptions, and climate oscillations.

Key Terms

Chaparral The name given to the shrubland vegetation of California. (p. 424)

Climate controls Characteristics of a location that combine to create the climate of that location. (p. 404)

Permafrost A subsurface layer of soil and rock material that remains frozen throughout the year. (p. 407)

Potential evaporation The amount of evaporation that would occur if moisture were unlimited. (p. 413)

Sclerophyll Woody plants with small, waxy leaves. (p. 406)

Answers to Selected Review Questions (p. 441)

1. **What are some examples of how each climate control influences climate?**

   Latitude influences temperatures and seasonality through its control on sun angle and day length. The distribution of land and water accounts for the fact that coastal locations have lower daily and annual temperature ranges because of the moderating effect that water has on air temperatures. Ocean currents affect both temperature and precipitation since warm ocean currents warm, moisten, and destabilize the air above while cold ocean currents have the opposite effect. Pressure systems control precipitation. The equatorial low and the subpolar lows bring precipitation while the subtropical highs and the polar highs bring clear skies. Prevailing winds can affect both temperature and precipitation. As a result of prevailing winds, places on Canada's west coast are wetter and have lower temperature ranges than places on Canada's east coast. Mountains control the distribution of precipitation as they force air to rise and release moisture on their windward sides, leaving their leeward sides dry. Mountains also control temperature because temperature decreases with altitude.

3. **How do genetic climate classification systems differ from empiric climate classification systems?**

   Genetic climate classification systems group climates based on their common causes. In empiric climate classification systems, climates are grouped based on mean monthly temperature and precipitation values.

5. **How are wet-dry tropical climates different from tropical monsoon climates?**

   The wet season in wet-dry tropical climates is shorter and brings much less precipitation than the wet season in tropical monsoon climates.

7. **How are Mediterranean climates, moist subtropical climates, and marine west coast climates similar to and different from one another?**

All three of the climates are moist with mild winters. Mediterranean climates have dry summers. Moist subtropical climates do not have a dry season. Marine west coast climates do not have a dry season and are colder than both Mediterranean and moist subtropical climates.

9. What climate controls produce "D" climates??

Latitude and pressure systems (polar highs) produce D climates.

11. In what climate types are prevailing winds important?

Prevailing winds are important in wet equatorial climates. Tropical east coasts are likely to be wetter than tropical west coasts due to the prevailing easterly winds. Where trade winds blow toward mountainous coasts, large amounts of rain are produced. Prevailing winds are important in subtropical desert and steppe climates where rain-shadows are found on the west sides of mountain ranges. Tropical monsoon climates are found in areas where prevailing winds shift seasonally from a moist onshore flow during the high-sun season to a dry offshore flow during the low season. Prevailing winds are also important in marine west coast climates. Winds blowing off of oceans bring a moderated climate to west coast regions in the mid-latitudes as opposed to east coast regions. Prevailing winds are important in mid-latitude desert and steppe climates where rain-shadows are found on the east sides of mountain ranges.

13. What climate types occur in Canada?

Polar tundra, subarctic, moist continental, mid-latitude steppe, Mediterranean, and marine west coast all occur in Canada.

15. What role have feedback effects played in the climate changes that have occurred through Earth's history?

It is thought that the carbonate–silicate cycle operating in combination with plate tectonics contributed to the changing amount of carbon dioxide in the atmosphere. Feedbacks could then have amplified on going changes. Positive feedbacks might have operated to reduce the amount of carbon dioxide in the atmosphere once cooling began, and to increase the amount of carbon dioxide in the atmosphere when the climate began to warm again. For example the ice-albedo feedback; this feedback would likely have contributed to at least some of the necessary amplification because it operates to accelerate both glacial advance and glacial retreat.

17. What is the iron hypothesis? How might it be used to explain the relationship between temperature and carbon dioxide over the last 800,000 years?

The iron hypothesis describes a positive feedback loop that strengthens glacial cycles triggered by orbital changes by affecting the amount of carbon dioxide in the atmosphere. The Earth is drier and windier during the colder glacial cycles, resulting in an increase of windblown dust. Dust is often coated in iron, which is an important nutrient. It is thought that the dust supplies iron to the oceans and stimulates the growth of phytoplankton, which in turn remove carbon dioxide from the atmosphere through photosynthesis. When phytoplankton die they sink to the ocean floor, carrying the carbon with them, effectively removing it from the atmosphere for the long term which amplifies the cooling. When an orbital change triggers a warming of the planet,

this feedback loop operates in reverse - phytoplankton growth slows, and atmospheric carbon dioxide levels increase.

Study Questions

For suggested answers, see below.

1. How are heating degree days calculated? What is the importance of calculating total annual HDD for a location?

2. Why are dry climates more difficult to define than the other four? What is potential evaporation and how does it change depending on climate?

3. Why do subtropical deserts have the greatest daily range in temperature of any climate type?

4. What are the differences in the vegetation between the marine west coast climates of North America and the marine west coast climates of Europe?

5. Why are there no Group D climates in the southern hemisphere?

Answers to Study Questions

1. For each day of the year that the average temperature is below 18°C, the temperature is subtracted from 18°C. When all such values are obtained, they are added together to give the HDD for a particular location. The total annual HDD gives an idea of the heating requirements of buildings. (p. 411)

2. They are difficult to define because dryness is not a function of precipitation alone. For moisture deficits to occur, potential evaporation must exceed precipitation. Potential evaporation is the amount of evaporation that would occur if moisture were unlimited. It is much higher in hot climates than it is in cold climates. Therefore, to determine whether a climate is dry or not, both temperature and precipitation must be taken into account. (p. 413)

3. Daytime maximum temperatures in subtropical deserts are very high due to high sun angles and clear skies. Because the surface is dry, little energy is used for evaporation. At night, the clear skies and low humidity mean that absorption of longwave radiation leaving the surface is minimal, so temperatures drop rapidly overnight. (p. 421)

4. In the marine west coast climates of North America, the natural vegetation is temperate rainforest. These needleleaf evergreen forests contain trees such as Douglas fir, western red cedar, Sitka spruce, and western hemlock. These trees are better adapted to colder temperatures. In the marine west coast climates of Europe, the natural vegetation is temperate deciduous forest. These forests contain trees such as oaks, birches, elms, maples, and beeches. (pp. 427–428)

5. There are no Group D climates in the southern hemisphere because there are no large continents between the latitudes of 40° and 60° S. (p. 428)