Chapter 4

Global Climates and Biomes

Global Processes Determine Weather and Climate

- **Weather-** the short term conditions (scale of seconds to days of predication) of the atmosphere in a local area. These include temperature, humidity, clouds, precipitation, wind speed and atmospheric pressure.

- **Climate-** The average weather that occurs in a given region over a long period- typically several decades

- Regional differences in temp & precipitation collectively help determine which organism can survive, processes that affect this are 1. *Unequal heating of Earth's by Sun, 2. atmospheric convection currents, 3. rotation of Earth, 4.orbit around the Sun, 5. Ocean currents*

Earth's Atmosphere:

1. **Troposphere-** the layer closest to Earth's surface extending roughly 16 km (10 miles) above Earth.

2. **Stratosphere-** above the troposphere, this extends from roughly 16 to 50 km (10-31 miles, less dense than trop). Ozone layer is here (O_3) – absorbs most of the Sun's UV radiation.

3. **Mesosphere**

4. **Thermosphere –** ability to block harmful X-ray & UV radiation. Contains gas molecules that when hit with solar energy, begin to glow & produce light (Northern Lights)

5. **Exosphere**

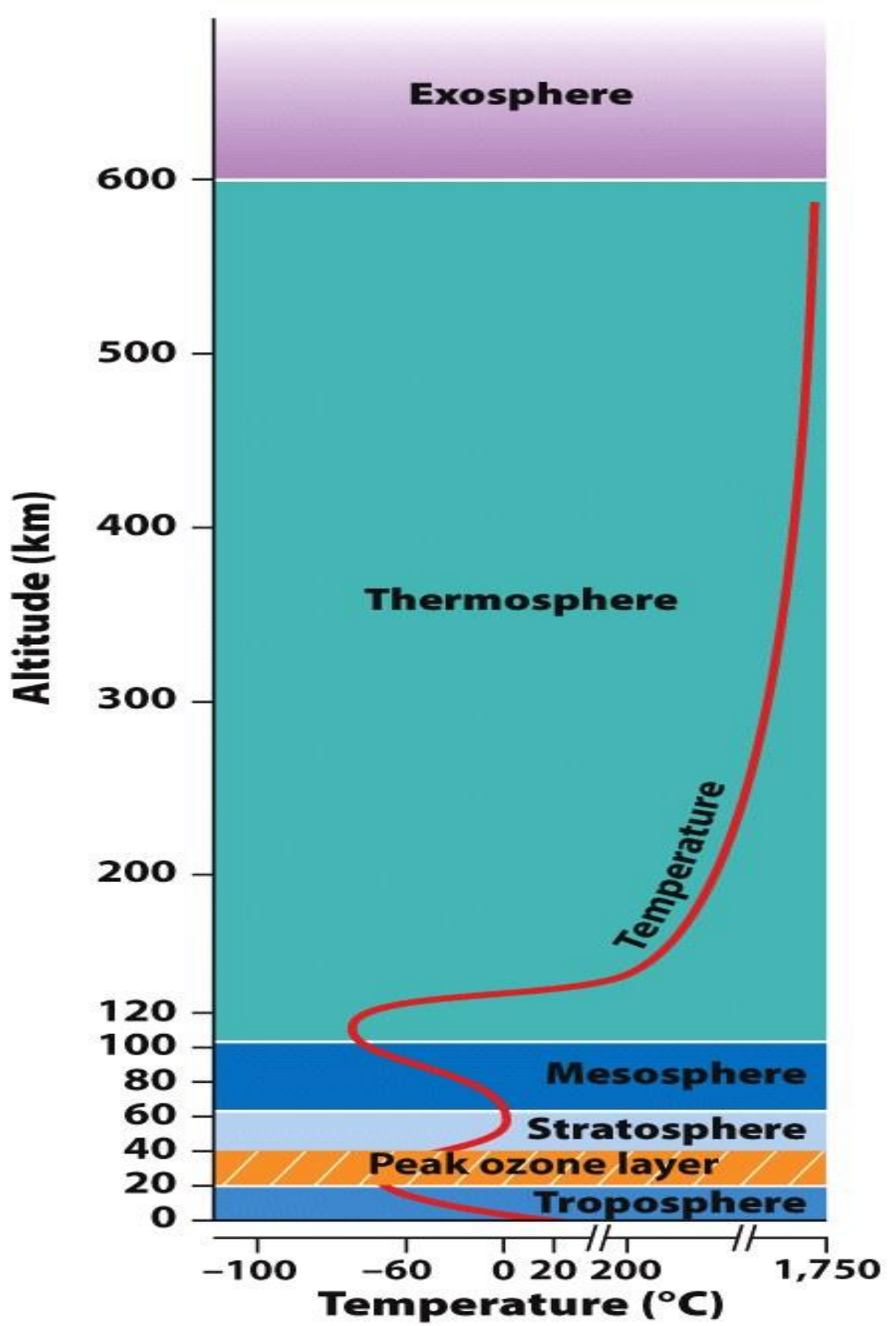


Figure 4.1
Environmental Science

1. Unequal Heating of Earth

- As the Sun's energy passes through the atmosphere and strikes land and water, it warms the surface of Earth. But this warming does not occur evenly across the planet.

(Ex). In the stratosphere, UV radiation reaches higher altitudes first and warms them, the higher altitudes are warmer than lower.

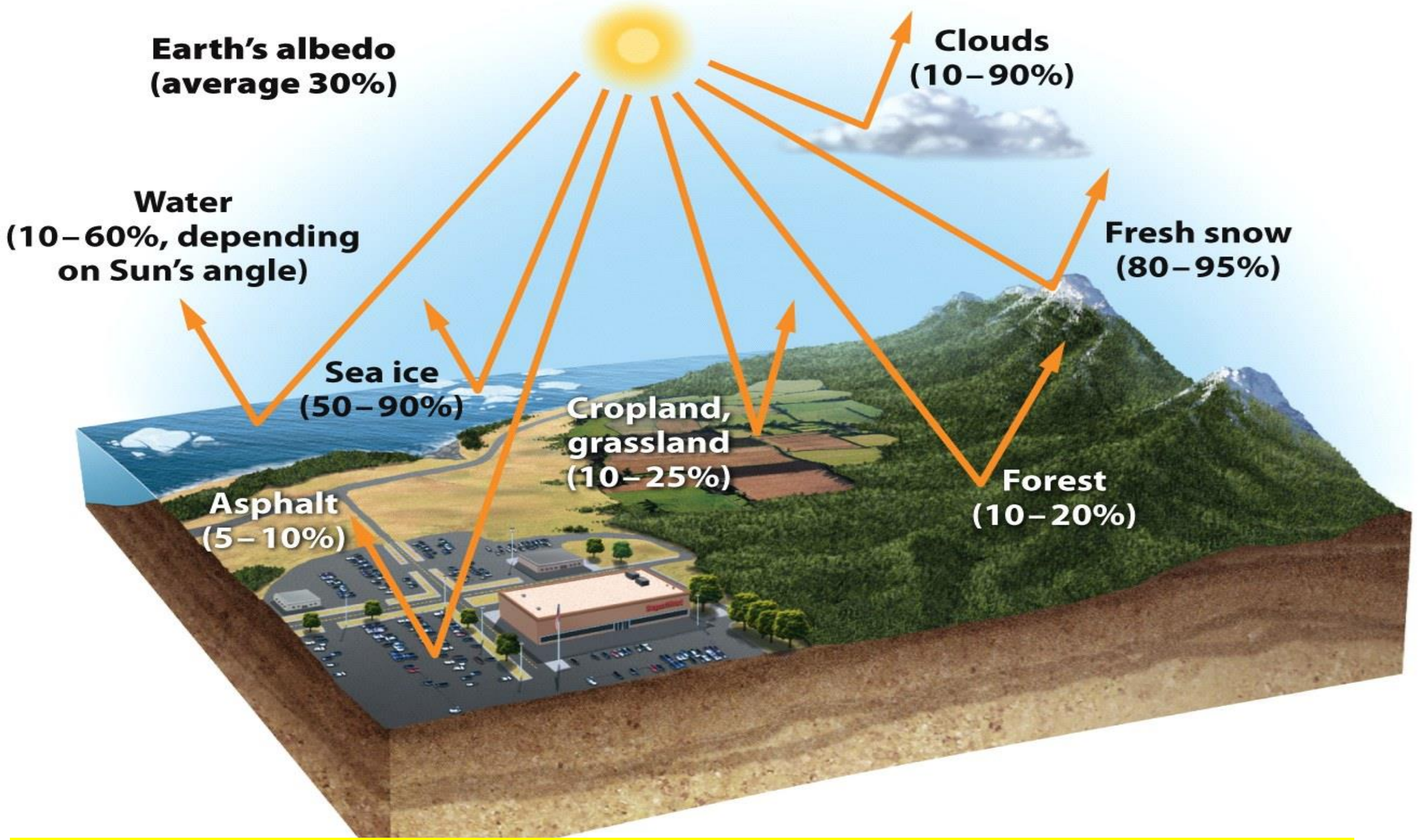
3 Primary causes of uneven warming patterns:

1. The variation in angle at which the Sun's rays strike (oblique angles vs right– near equator, travel shorter)

2. The amount of surface area over which the Sun's rays are distributed – based on the angle, regions may receive more solar energy per square meter (tropics)

3. Some areas of Earth reflect more solar energy than others. (Albedo)

Albedo effect – percentage of the incoming solar energy that is reflected



Higher the albedo of a surface, more energy is reflect = less is absorbed

White (higher albedo) vs. black surfaces

2. Atmospheric Convection Currents

Air has four properties that determines its movement due to unequal heating of Earth:

1. **Density-** less dense air rises, denser air sinks.

2. **Water vapor capacity-** warm air has a higher capacity for water vapor than cold air.

3. **Adiabatic heating or cooling-** as air rises in the atmosphere its pressure decreases and the air expands in volume (cooling). As air sinks, the pressure increases and the air decreases in volume (heating).

4. **Latent heat release-** when water vapor in the atmosphere condenses into liquid water and energy is released.

Formation of Convection Currents (move air around Earth w/o considering rotation on axis)

- Atmospheric convection currents are global patterns of air movement that are initiated by the unequal heating of Earth.

- Ex. In the tropics, warming of humid air, decrease in density…air begins to rise causing lower pressure (adiabatic cooling), cooling causes condensation allowing formation of clouds and precipitation (look at figure 4.6).

- **Intertropical convergence zone (ITCZ)-** the area of Earth that receives the most intense sunlight and where the ascending branches of the two Hadley cells converge (locations not fixed, based on Earth's rotations)

Formation of (Hadley cells) Convection Currents

- Hadley cells- the convection currents that cycle between the equator and 30˚ north and south.
- Intertropical convergence zone (ITCZ)
- Refer to the figure...

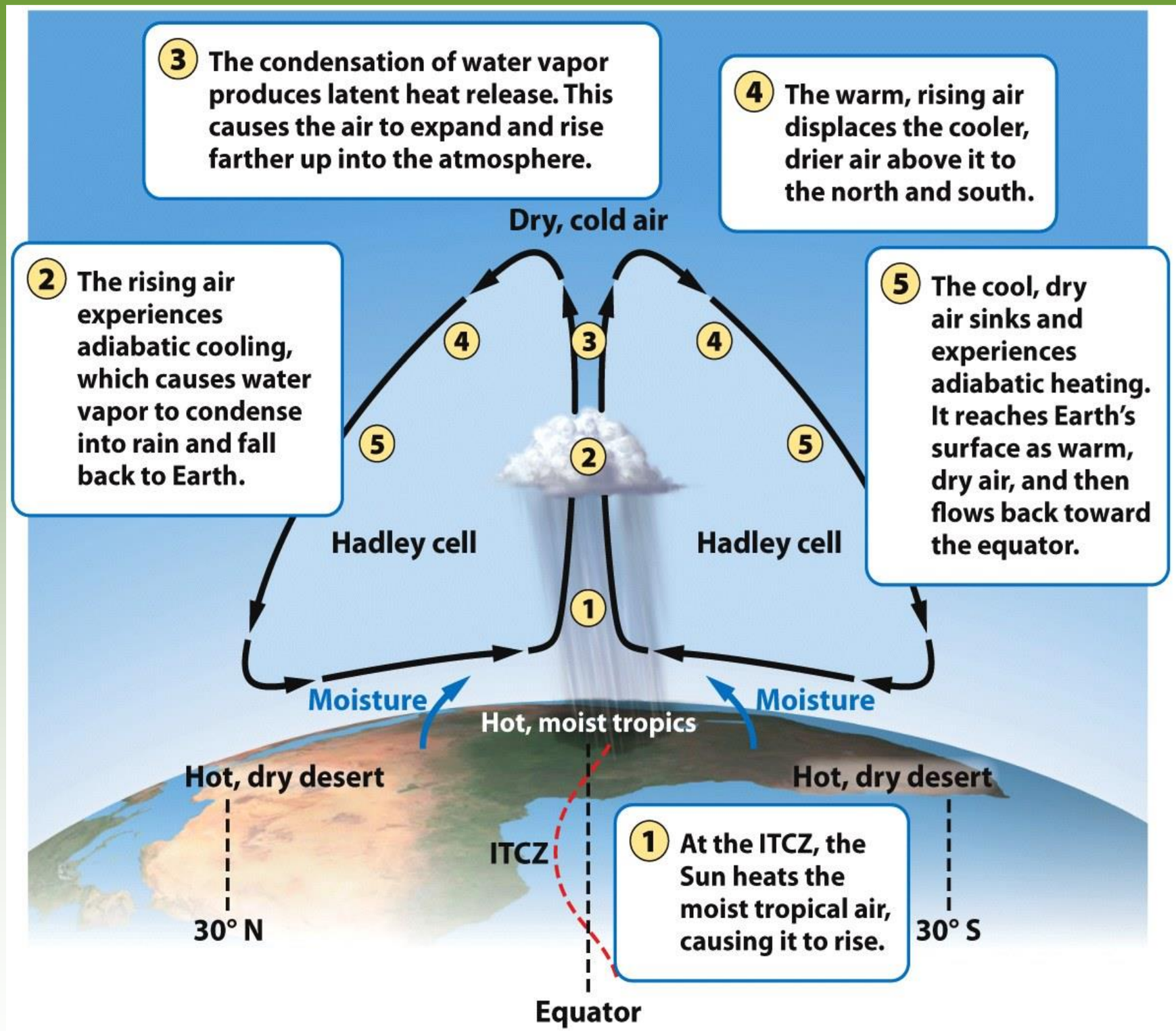


Figure 4.6
Environmental Science

3. Earth's Rotation and the Coriolis Effect

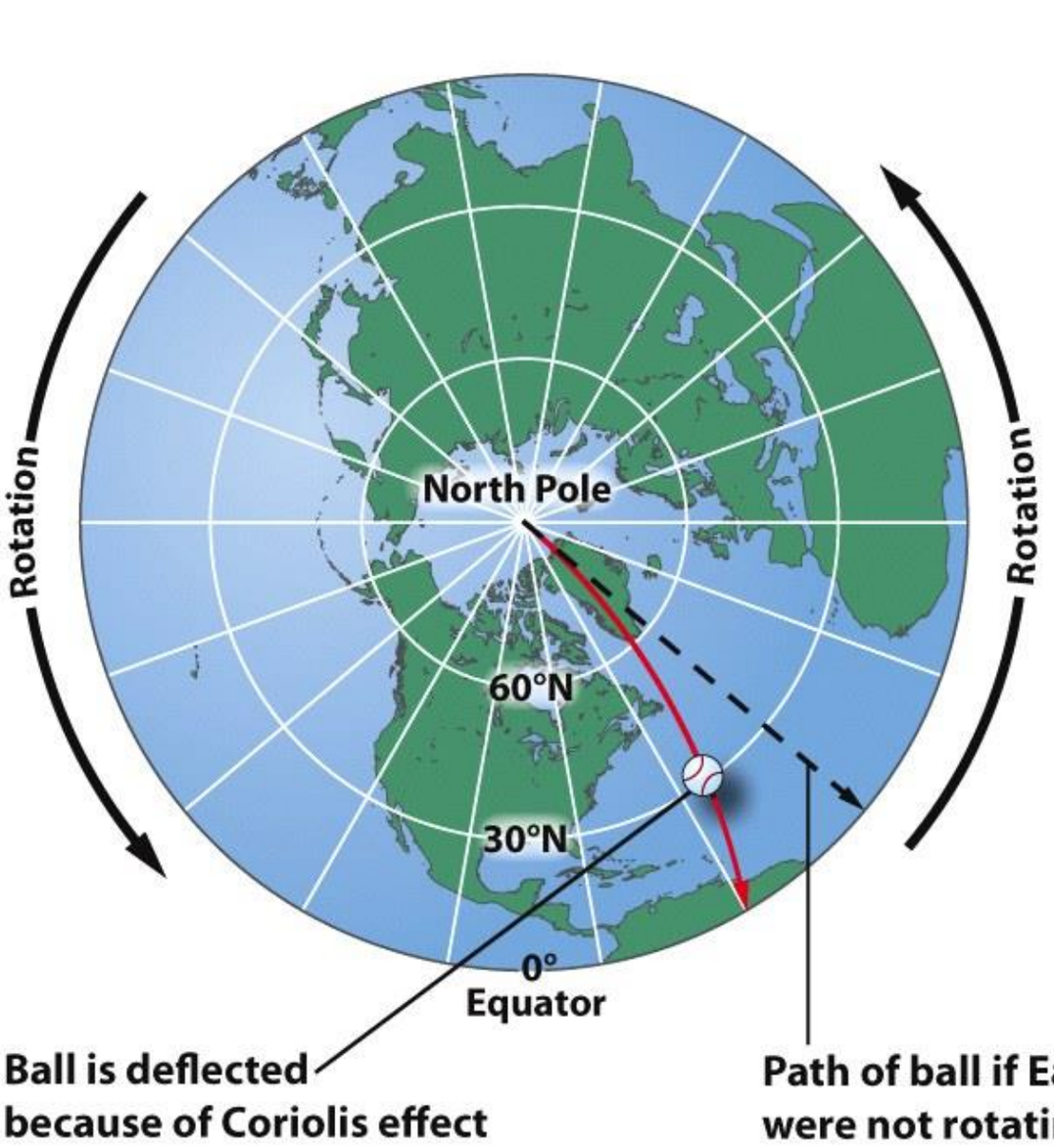
- Similar to Hadley cells, **Polar cells**- the convection currents that are formed by air that rises at 60˚ north and south and sinks at the poles (90˚ north and south)

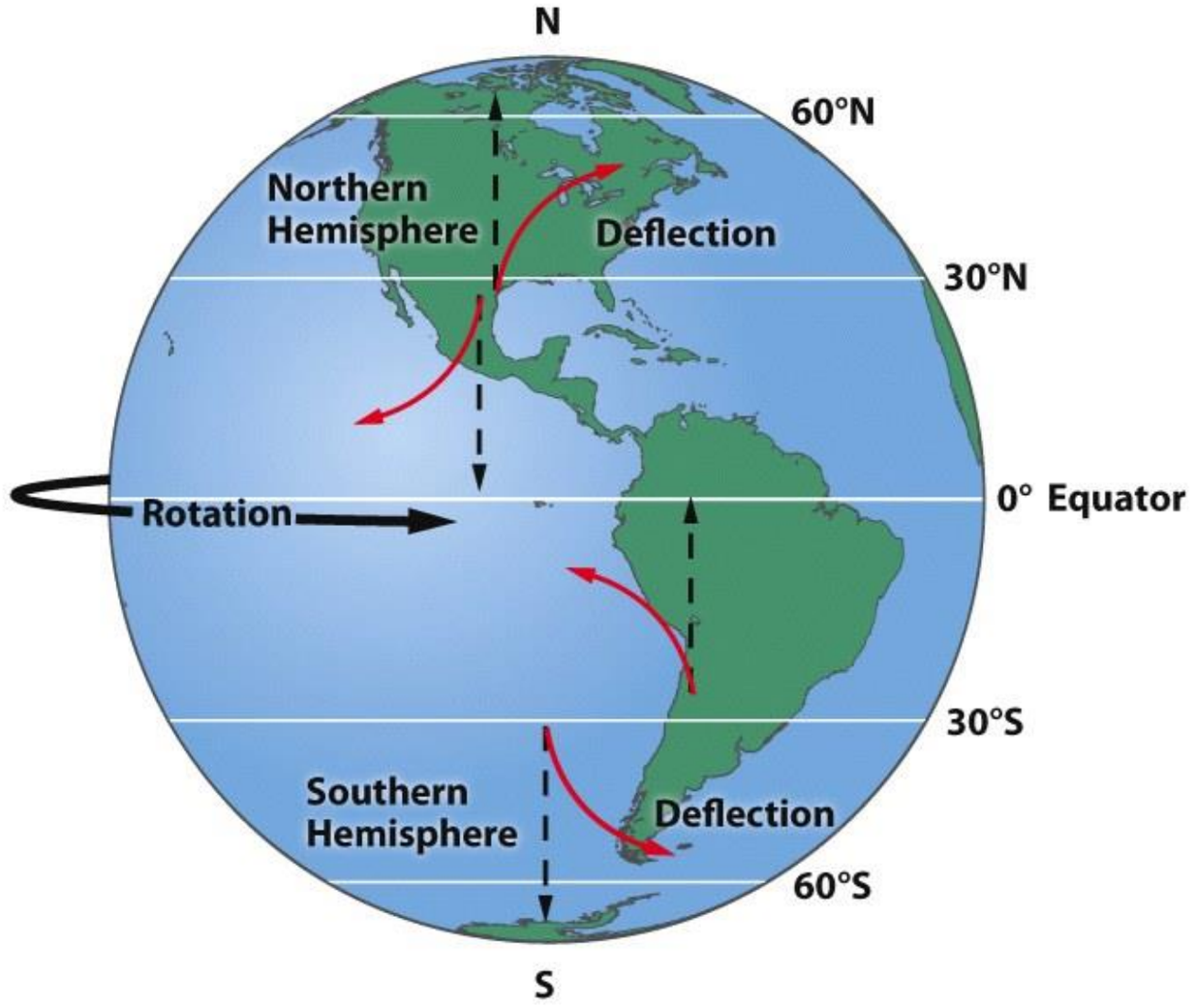
- Btwn Hadley and Polar cells, a third circulation can form. **Does not form distinct convection cells but is driven by the circulation of the neighboring cells.**

- This movement not only helps to distribute warm air away from the tropics and cold air away from the poles, but also allows a wide range of warm & cold air currents to circulate btwn 30* & 60*.

Earth's Rotation and the Coriolis Effect

- As Earth rotates, its surface moves much faster at the equator than in mid-latitude and polar regions.
- The faster rotation speeds closer to the equator cause a deflection of objects that are moving directly north or south.
- **Coriolis Effect**- the deflection of an object's path due to Earth's rotation.





All locations on Earth complete one revolution every 24hrs, the speed around the equator (1670km/hr) is faster due to the larger circumference vs. the poles (291km/hr)

A thrown baseball will not travel in a straight line (*physics – newton's 1st law*) due to the rotation of the Earth on the axis….**Coriolis Effect** – deflection (*w/o rotation, ball would travel in a straight line*)

- Due to the Coriolis Effect, air movement toward the equator is deflected to the WEST.

- Hadley cells cause north of the equator to produce winds along the Earth's surface come from the northeast (northeast trade winds)

- Cell south of the equator, produces wind that comes from the southeast (southeast trade winds)

- If Earth did not rotate, air w/in convection cell would simply move directly North & South and cycle back again.

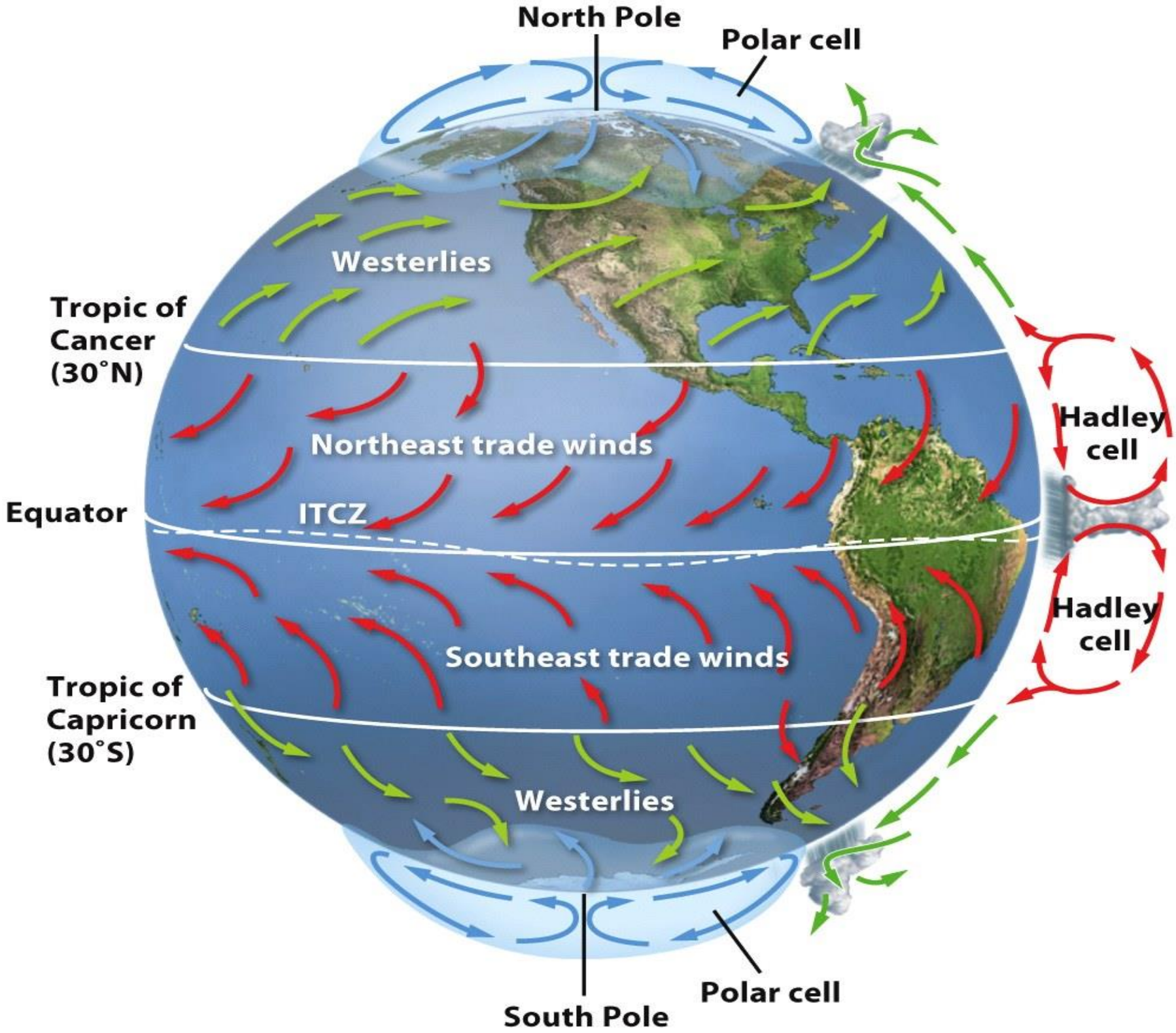


Figure 4.9
Environmental Science

The prevailing **winds** of the world are produced by a combination of atmospheric convection currents (Hadley-ITCZ, polar cells & cells btwn Hadley & polar) and the Coriolis effect.

4. The Earth's axis of rotation is tilted 23.5°.

- The latitude that receives the most direct rays of the Sun and the most hours of daylight changes throughout the year as Earth rotates around the Sun **(season changes)**

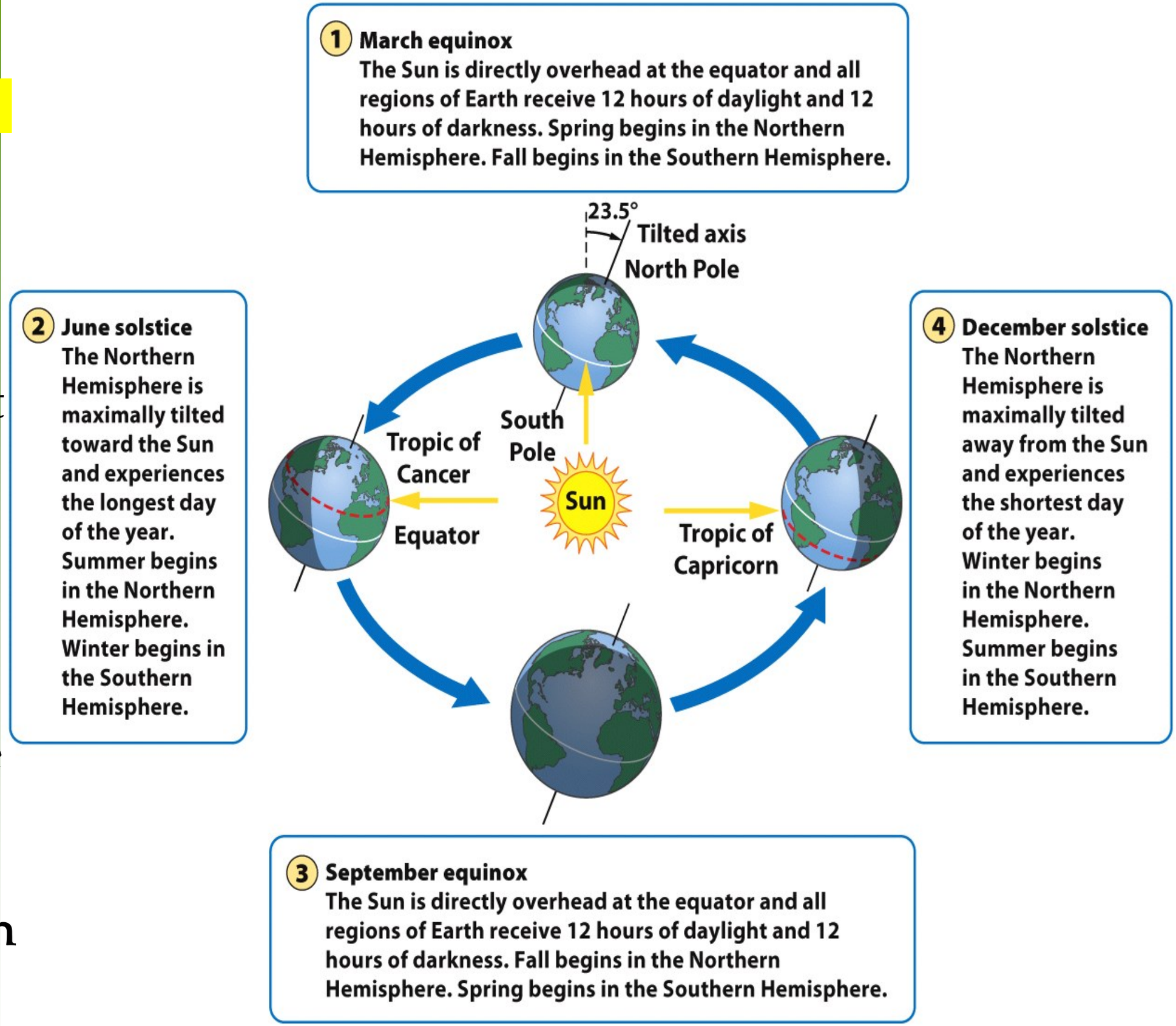


Figure 4.10
Environmental Science

SEASON CHANGES DUE TO LOCATION AND ROTATION

- At this point we have examined FOUR processes that influences Earth's weather and climate: (5 total)

1. Unequal heating of Earth

2. Atmospheric Convection currents

3. Rotation of Earth & Coriolis Effect

4. Earth's orbit around the Sun on a titled axis

5. Circulation of ocean waters, both at surface and deep oceans

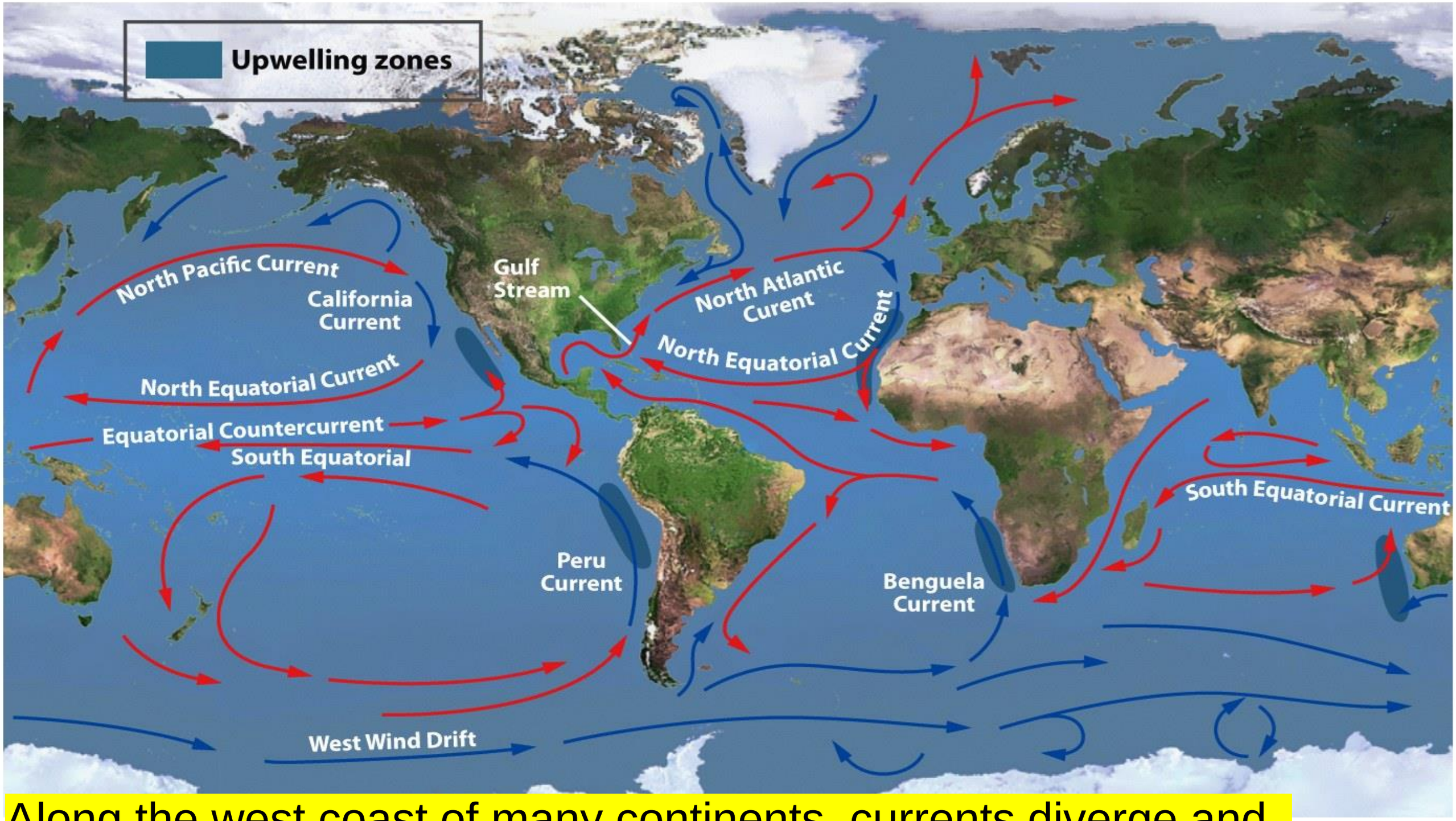
5. Ocean Currents

- **Ocean currents** are driven by a combination of temperature, gravity, prevailing winds, the Coriolis effect, and the locations of continents.

- Warm water, like warm air, expands and rises.

- **Gyres-** the large-scale patterns of water circulation. The ocean surface currents rotate in a clockwise direction in the Northern Hemisphere and a counterclockwise direction in the Southern Hemisphere.

Oceanic Circulation Patterns – clockwise circulation in Northern Hemisphere & counterclockwise circulation in the Southern Hemisphere.



Along the west coast of many continents, currents diverge and cause upwelling of deeper more fertile water

Upwelling

- **Upwelling-** as the surface currents separate from one another, deeper waters rise and replace the water that has moved away.

- This upward movement of water brings nutrients from the ocean bottom that supports the large populations of producers, which in turn support large populations of fish.

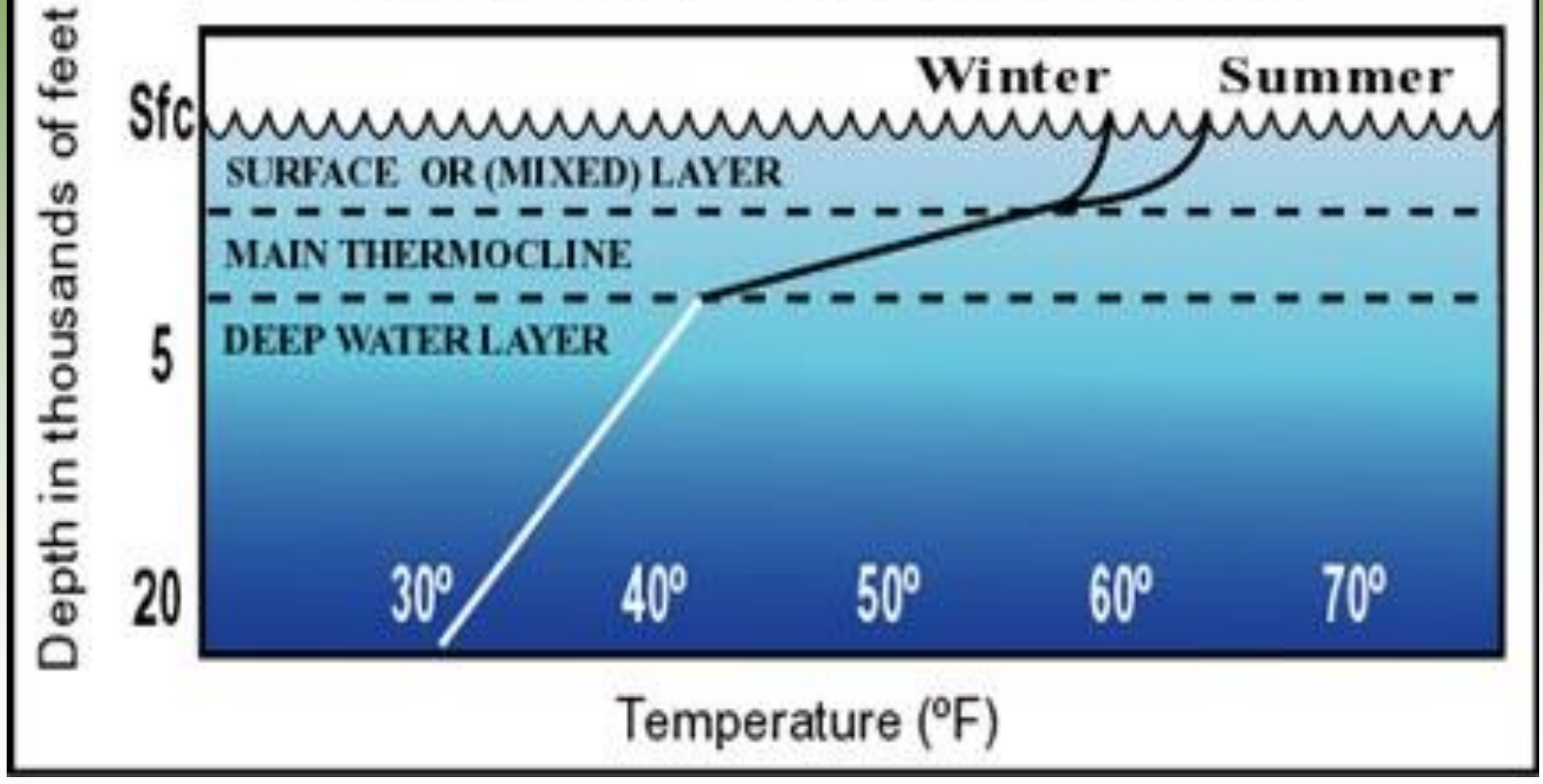
Thermohaline Circulation

- **Thermohaline circulation-** another oceanic circulation that drives the mixing of surface water and deep water.

- Scientists believe this process is crucial for moving heat and nutrients around the globe.

- Thermohaline circulation appears to be driven by surface waters that contain unusually large amounts of salt.

OCEAN TEMPERATURE PROFILE



Thermohaline Circulation

- 1. Some of the water that flows from the Gulf of Mexico to the North Atlantic freezes or evaporates, and the salt that remains behind increases the salt concentration of the water.

- 2. *This cold, salty water is relatively dense*, so it sinks to the bottom of the ocean, mixing with deeper ocean waters.

- These *two processes* create the movement necessary to drive a deep, cold current that slowly moves past Antarctica and northward to the northern Pacific Ocean.

1 Warm water flows from the Gulf of Mexico to the North Atlantic, where some of it freezes and evaporates.	**2** The remaining water, now saltier and denser, sinks to the ocean bottom.	**3** The cold water travels along the ocean floor, connecting the world's oceans.	**4** The cold, deep water eventually rises to the surface and circulates back to the North Atlantic.

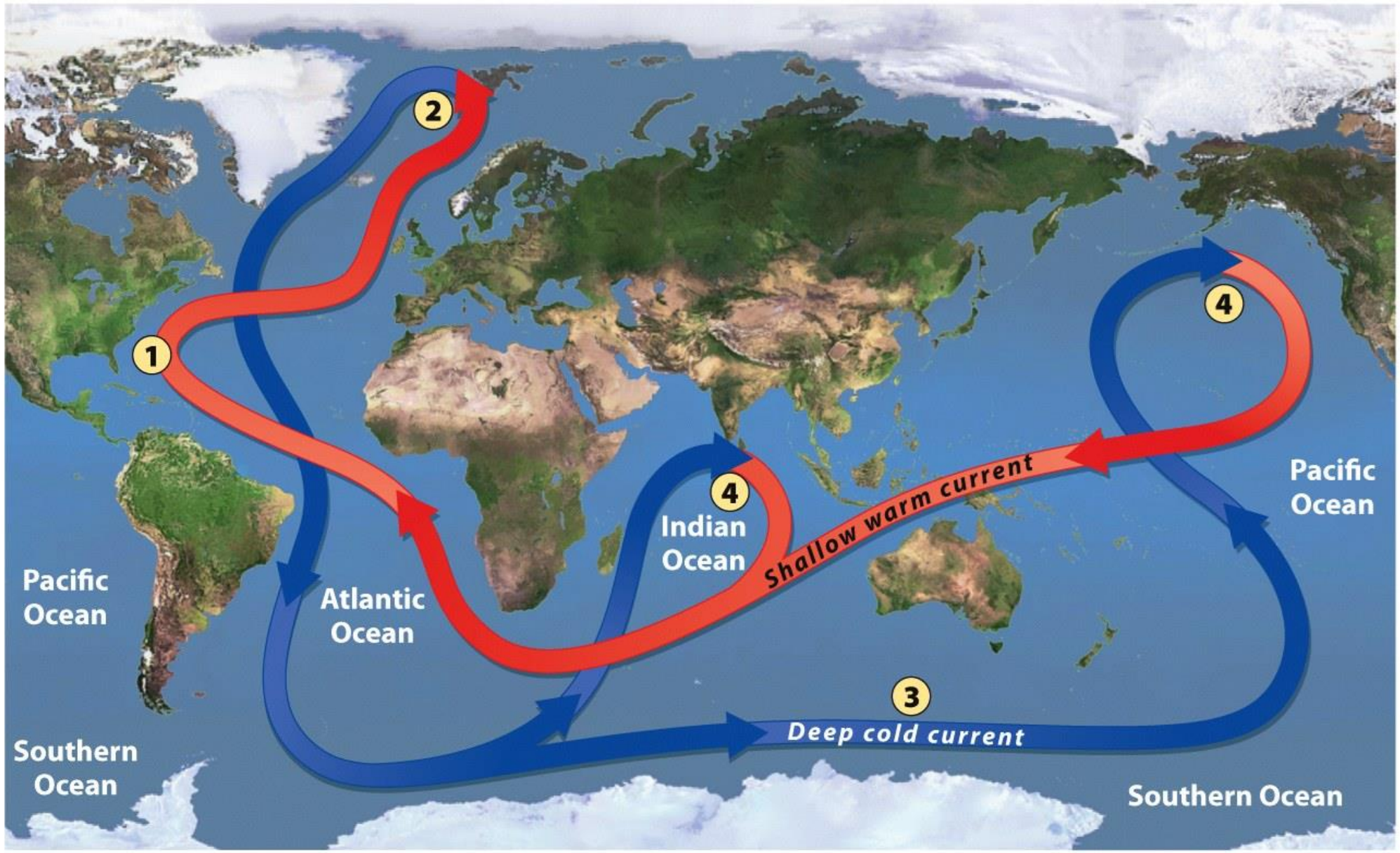


Figure 4.12
Environmental Science

Thermohaline Circulation – sinking of dense, salty water in the North Atlantic, drives a deep, Cold current moves slowly around the world

Heat Transport

- Ocean currents can affect the temperature of nearby landmasses.

- For example, England's average winter temperature is approximately 20 ° C (36°F) warmer than Newfoundland, Canada, which is located at a similar latitude.

Concern: Global warming is increasing air temp, accelerate the melting of the glaciers, which could make the waters less salty, thus less likely to sink...this could potential shut down thermohaline circulation!!

This will stop the transport of warm water to Western Europe, making it a COLDER place = consequence

El Nino-Southern Oscillation

(warm phase)

- Every 3 to 7 years, the interaction of the Earth's atmosphere and ocean cause surface currents in the tropical Pacific Ocean to reverse direction.

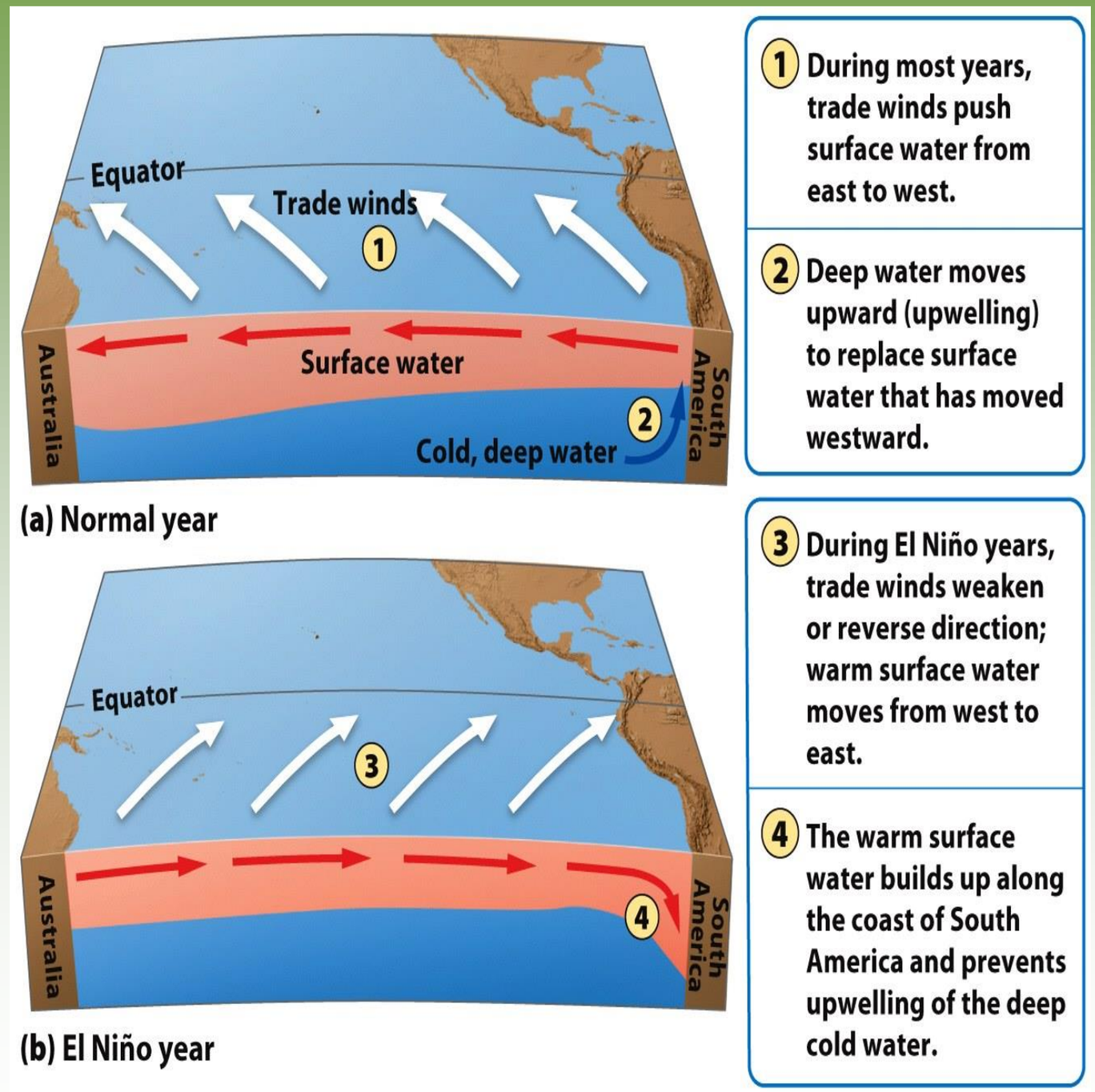


Figure 4.13
Environmental Science

El Nino-Southern Oscillation

- First, the *trade winds* *near South America* *weaken*.
- This weakening allows warm equatorial water from the western Pacific to move eastward toward the west coast of South America.
- The movement of warm water and air toward South America suppresses upwelling off the coast of Peru and decreases productivity there, reducing fish populations near the coast.
- These periodic changes in wind and ocean currents are collectively called the **EL Nino-Southern Oscillation, or ENSO**.
- **Globally, the impact of ENSO includes cooler and wetter conditions in the southeastern U.S.**

La Nina- (cool phase)

- Trade winds that blow west across the Tropical Pacific are STRONGER than normal.

- Increase in the upwelling off of South America

- Resulting in cooler-than-normal conditions across the Pacific northwest, and drier-and warmer-than-normal conditions in southern U.S…..increase number of Hurricanes and monsoons in India and Asia

- Winter temps are warmer than normal in southern U.S and cooler in northwest

Rain Shadows

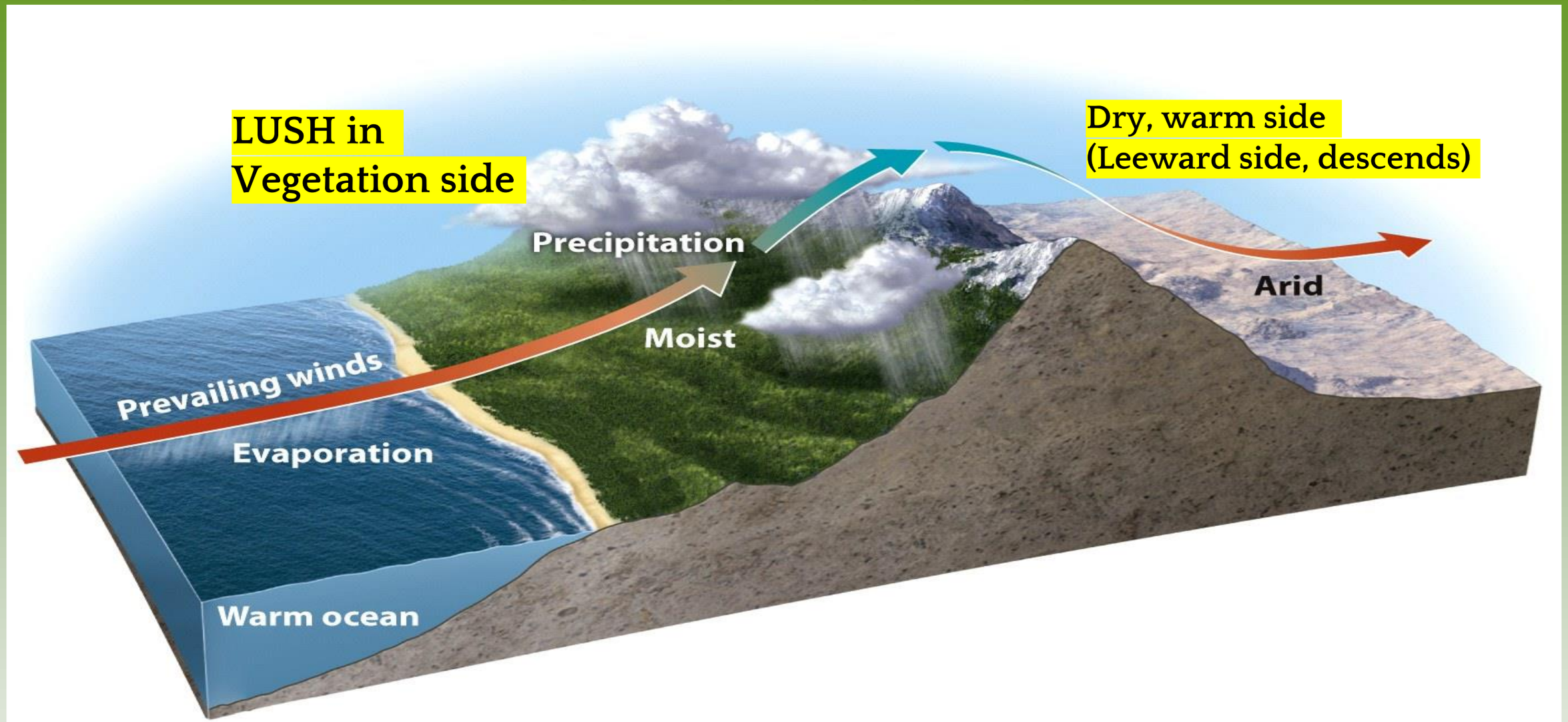


Figure 4.14
Environmental Science

Rain shadows occur where humid winds blowing inland from the ocean meet a mountain range

Wind-facing side of the mountains, air rise & cools and large amts of water vapor condenses to form clouds and precipitation

Other side of the mountains, cold, dry air descends, warm via adiabatic heating, causing much drier conditions.

Rain Shadows

- When air moving inland from the ocean that contains a large amount of water vapor meets the windward side of a mountain range (the side facing the wind), it rises and begins to experience adiabatic cooling.

- Because water vapor condenses as air cools, clouds form and precipitation falls.

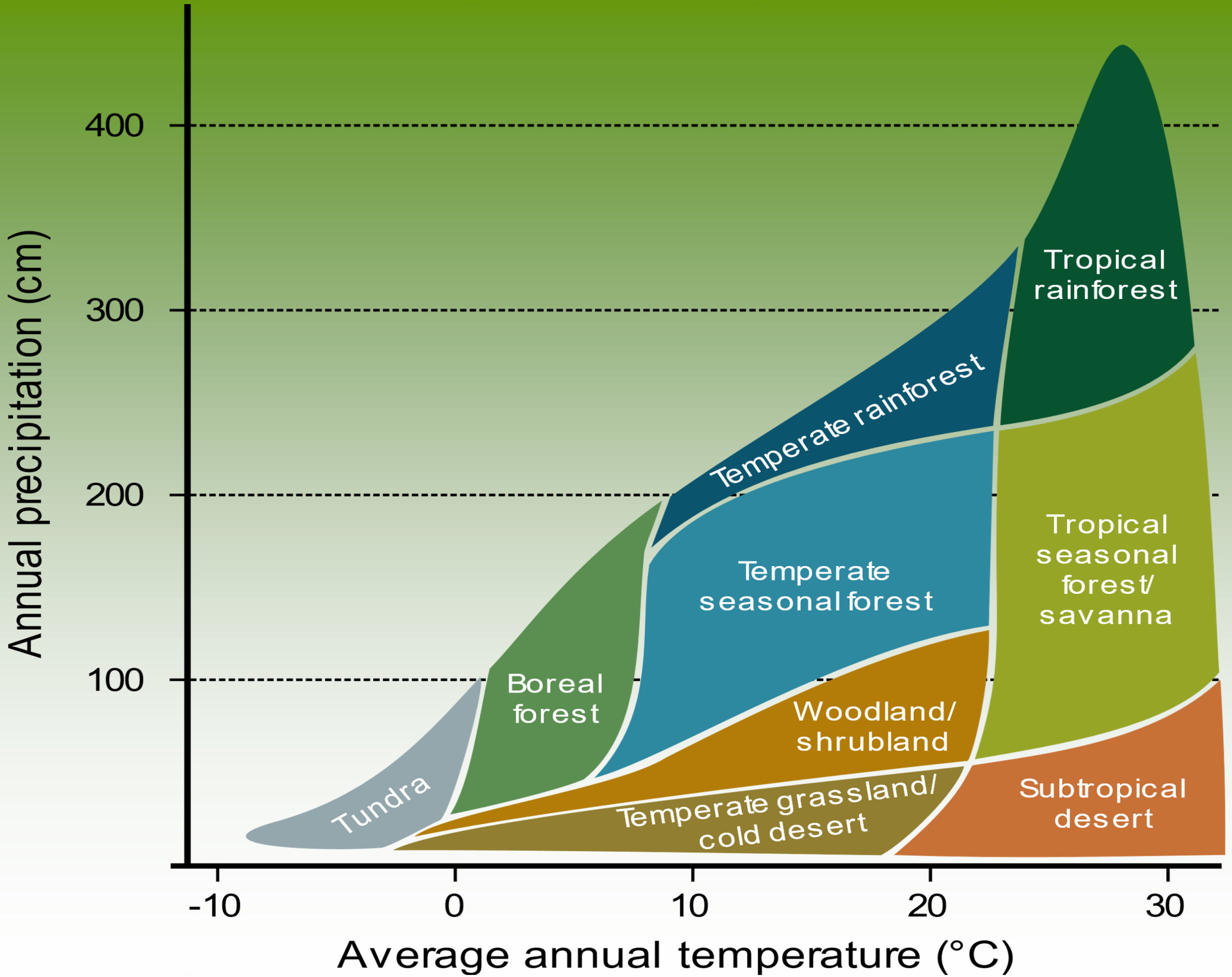
- The presence of the mountain range causes large amounts of precipitin to fall on its windward side.

- The cold, dry air then travels to the other side of the mountain range (the leeward side), where it descends and experiences higher pressures, which cause adiabatic heating.

- This air is now war and dry and process arid conditions on the leeward side forming the region called **a rain shadow (2 sides of a mountain range view, lush in vegetation vs dry)**.

Variations in Climate Determine the Dominant Plant Growth Forms of **Terrestrial Biomes** *(categorized by plant growth forms)*

- Climate affects the distribution of species around the globe.
- Organisms possess distinct growth forms due to adaptations to local temperature and precipitation patterns.
- **Biomes-** The presence of similar plant growth forms in areas possessing similar temperature and precipitation patterns.


Annual precipitation (cm)
400
300
200
100
Tropical rainforest
Temperate rainforest
Tropical seasonal forest/ savanna
Temperate seasonal forest
Boreal forest
Woodland/ shrubland
Tundra
Temperate grassland/ cold desert
Subtropical desert
-10
0
10
20
30
Average annual temperature (°C)

Tundra

- Cold, treeless biome with low-growing vegetation. In winter, the soil is completely frozen.

- The tundra's growing season is very short, usually only about 4 months during summer.

- The underlying subsoil, known as **permafrost** is an impermeable, permanently frozen layer that prevents water from draining and roots from penetrating.

Tundra

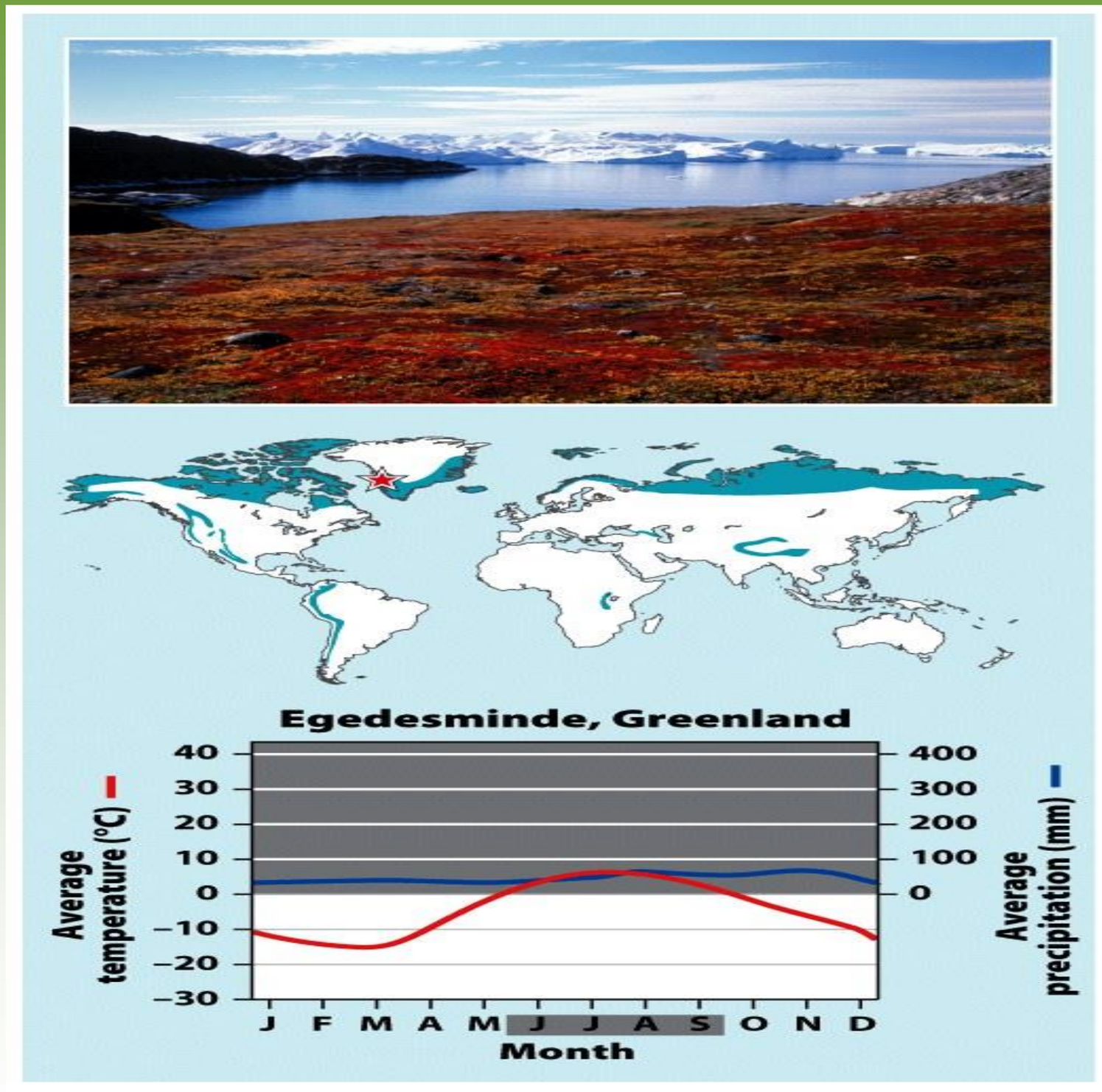


Figure 4.19
Environmental Science

Boreal Forest

- Forests made up primarily of coniferous (cone-bearing) evergreen trees that can tolerate cold winters and short growing seasons.
- Boreal forests are found between about 50˚ and 60˚ N in Europe, Russia and North America.
- This subarctic biome has a very cold climate, and plant growth is more constrained by temperature than precipitation.
- The soil is nutrient-poor due to slow decomposition.

Boreal Forest

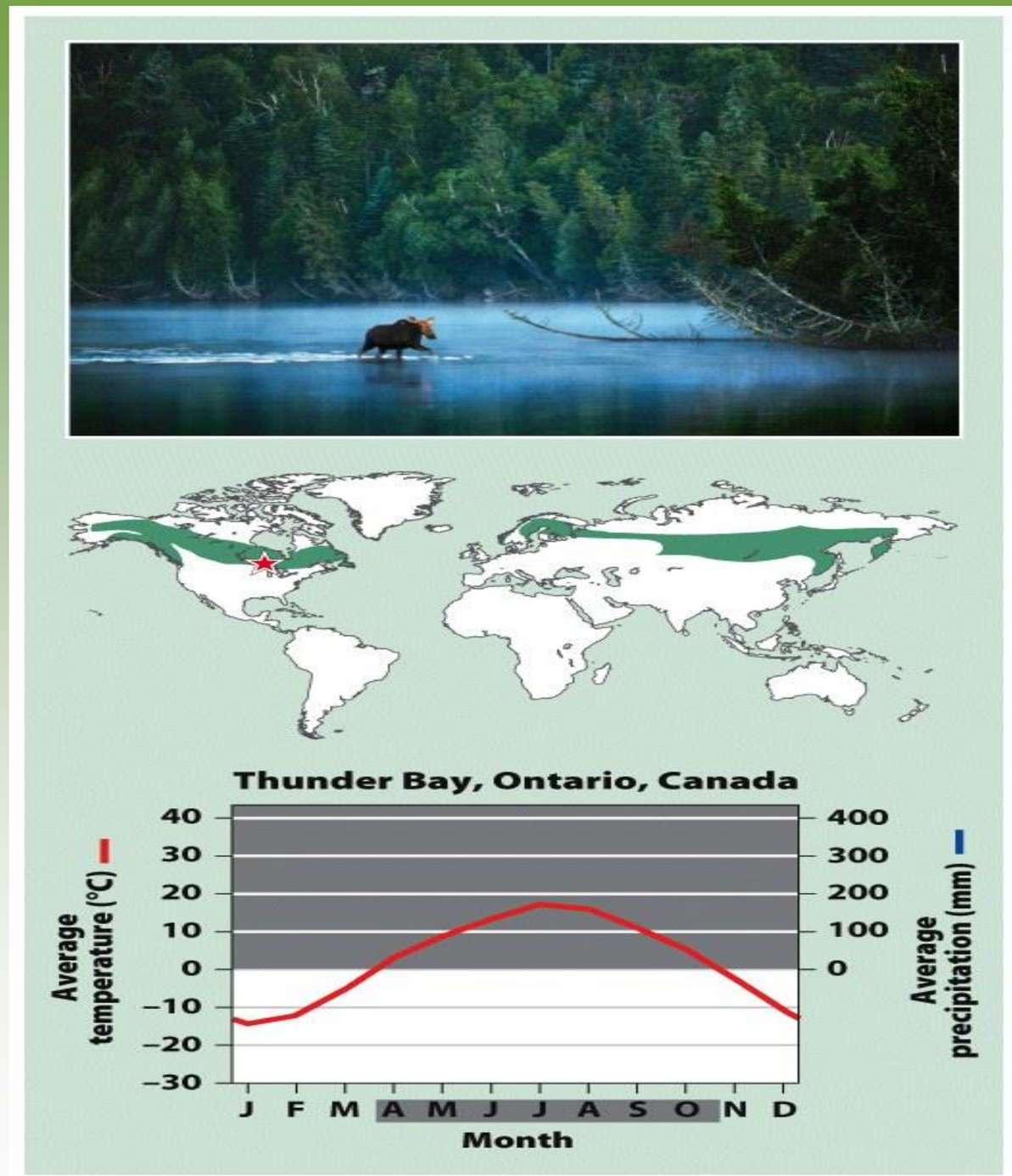


Figure 4.20
Environmental Science

Temperate Rainforest

Moderate temperatures and high precipitation typify the temperate rainforest.

The temperate rainforest is a coast biome and can be found along the west coast of North America from northern California to Alaska, in southern Chile, on the west coast of New Zealand, and on the island of Tasmania.

The ocean currents help moderate temperature fluctuations and provide a source of water vapor.

This biome has a nearly 12-month growing season where winters are rainy and summers are foggy.

The mild temperatures and high precipitation supports the growth of very large trees.

Temperate Rainforest

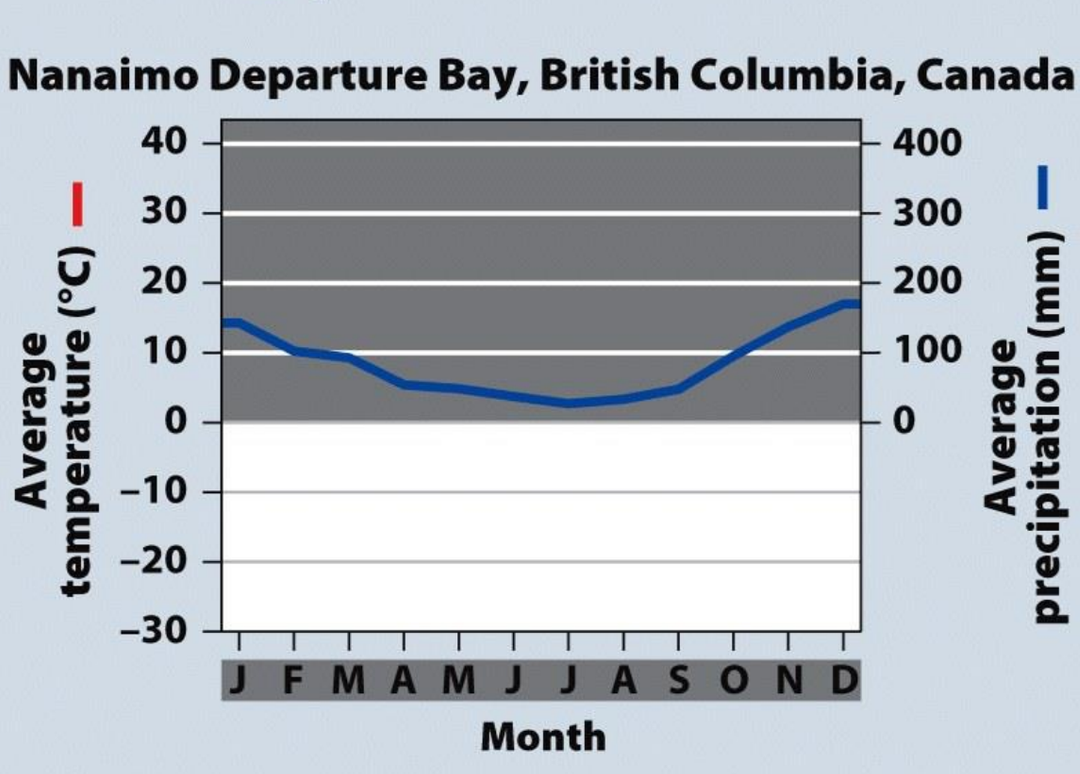


Figure 4.21
Environmental Science

Temperate Seasonal/deciduous Forest

- Receive over 1 m (39 inches) of precipitation annually.
- Found in the eastern United States, Japan, China, Europe, Chile and eastern Australia.
- Dominated by broadleaf deciduous trees such as beech, male, oak and hickory.
- Warmer summer temperatures favor decomposition so soils generally contain more nutrients than those of boreal forests.

Temperate Seasonal/deciduous Forest

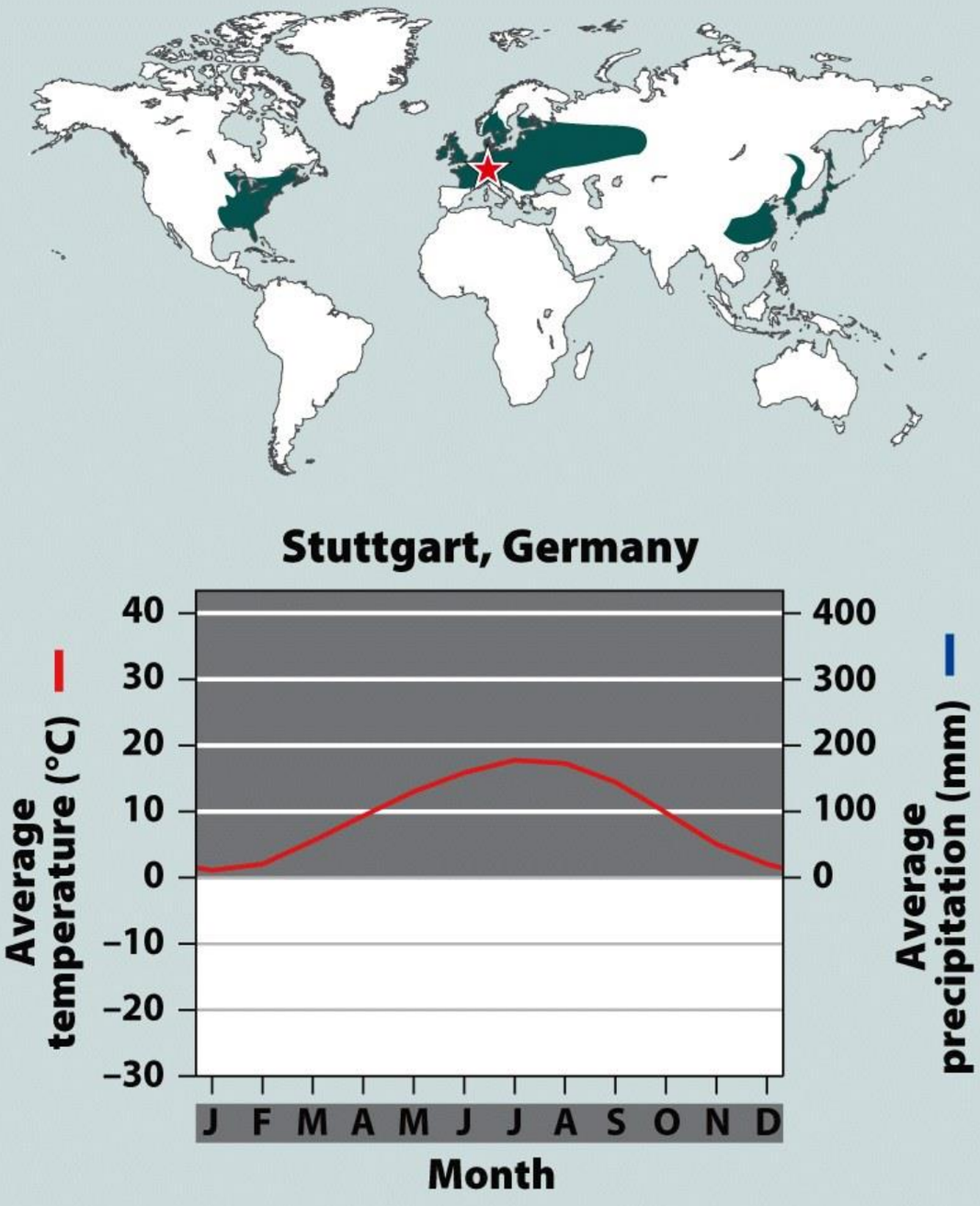


Figure 4.22
Environmental Science

Woodland/Shrubland

- Found on the coast of southern California, southern Australia, southern Africa and in the area surrounding the Mediterranean Sea.
- Hot, dry summers and mild, rainy winters are characteristic of this biome.
- There is a 12-month growing season, but plant growth is constrained by low precipitin in summer and by relatively low temperatures in winter.
- Wildfires are common and plants of this biome are well adapted to both fire and drought.

Woodland/Shrubland

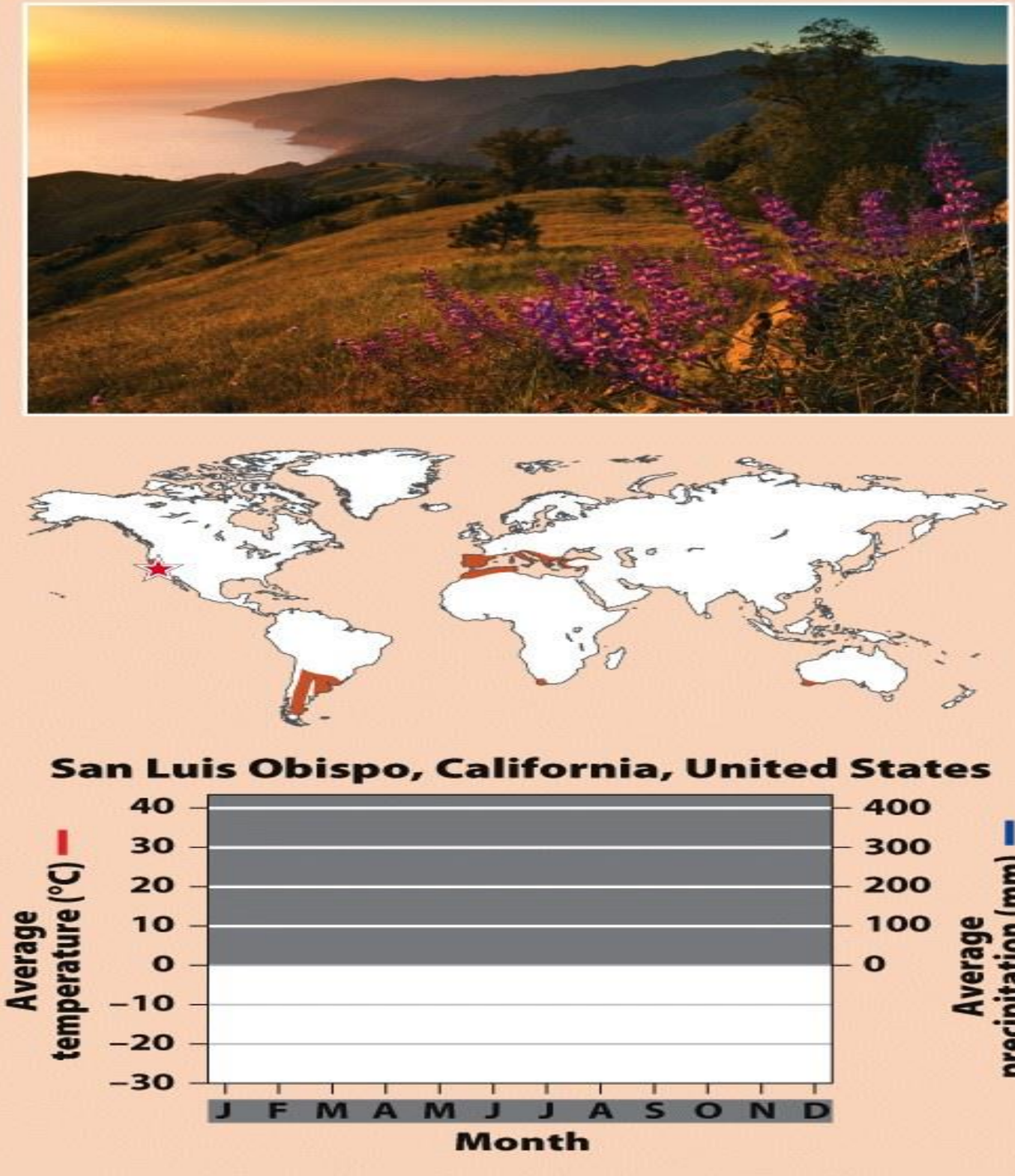


Figure 4.23
Environmental Science

Temperate Grassland/Cold Desert/Prairies

- This biome has the lowest average annual precipitation of any temperate biome.
- These are found in the Great Plains of North America, in South America, and in central Asia and eastern Europe.
- Cold, harsh winters and hot, dry, summers characterize this biome.
- Plant growth is constrained by both insufficient precipitation in summer and cold temperatures in winter.
- Plants include grasses and non woody flowering plants that are well adapted to wildfires and frequent grazing by animals.

Temperate Grassland/Cold Desert/Prairies

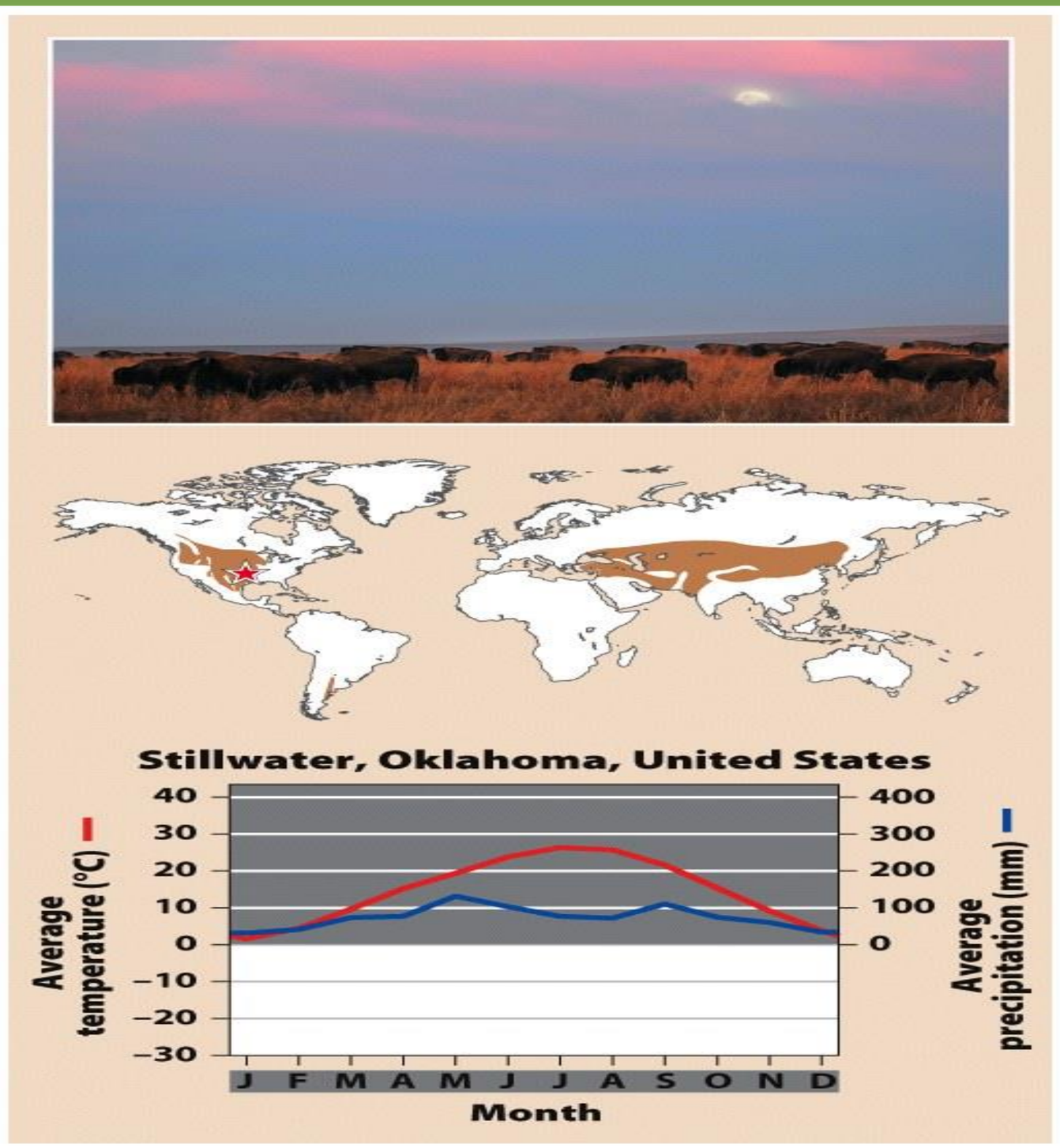


Figure 4.24
Environmental Science

Tropical Rainforest

- In the tropics, average annual temperatures exceed 20°C.
- This biome is located approximately 20° N and S of the equator.
- They are found in Central and South America, Africa, Southeast Asia, and northeastern Australia.
- Precipitation occurs frequently and this biome is warm and wet with little temperature variation.
- Tropical rain forests have more biodiversity per hectare than any other terrestrial biome and contain up to two-thirds of Earth's terrestrial species.

Tropical Rainforest

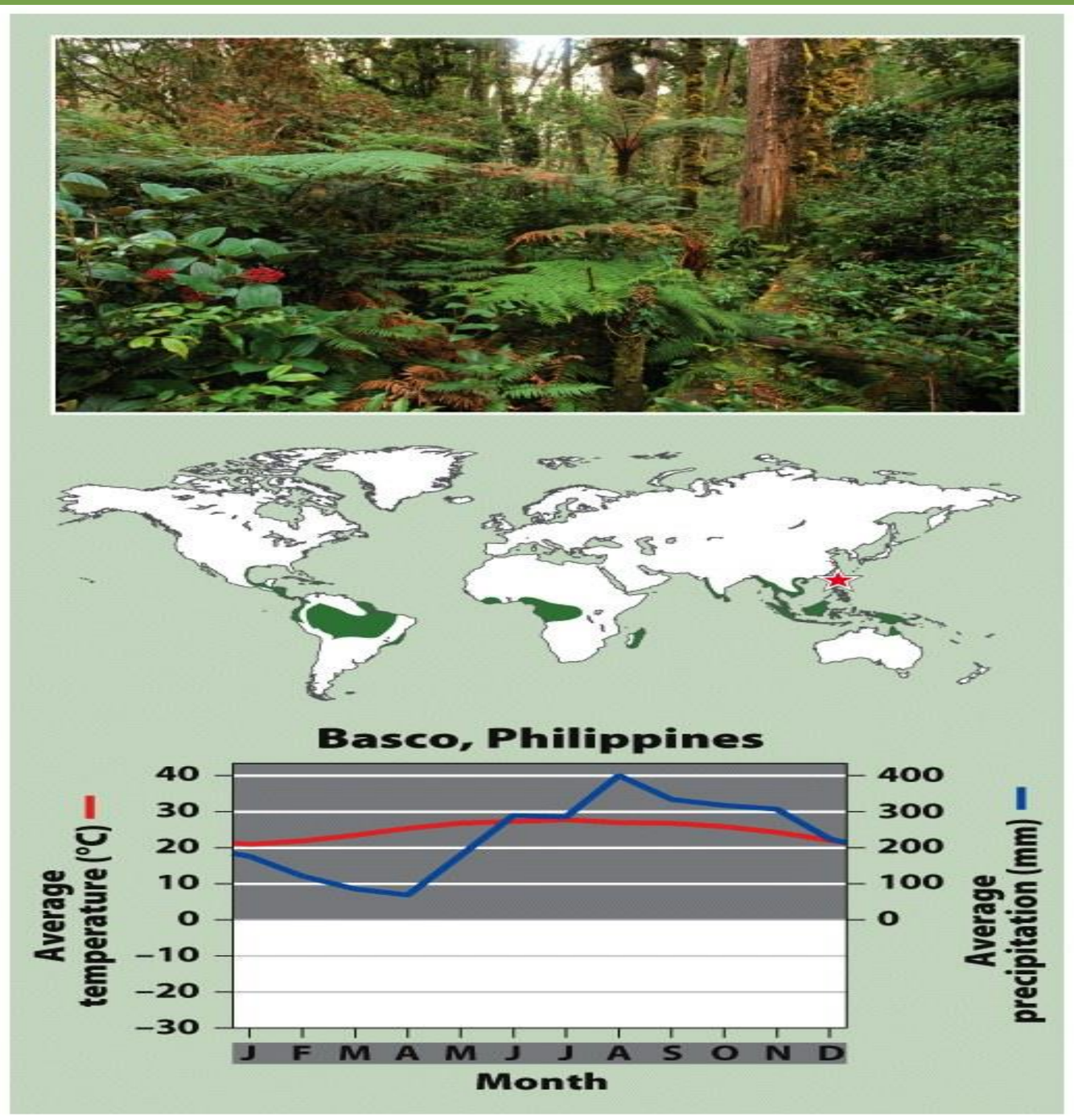


Figure 4.25
Environmental Science

Tropical Seasonal Forest/Savanna

- Warm temperatures and distinct wet and dry seasons characterize this biome.
- Tropical seasonal forests are common in much of Central America, on the Atlantic coast of South America, in southern Asia, in northwestern Australia, and in sub-Saharan Africa.
- Soil in this biome is fairly fertile and can be farmed due to high decomposition rates, but the low amount of precipitation constrains plants from using the soil nutrients that are released.

Grasses and scattered deciduous trees are common.

Tropical Seasonal Forest/Savanna

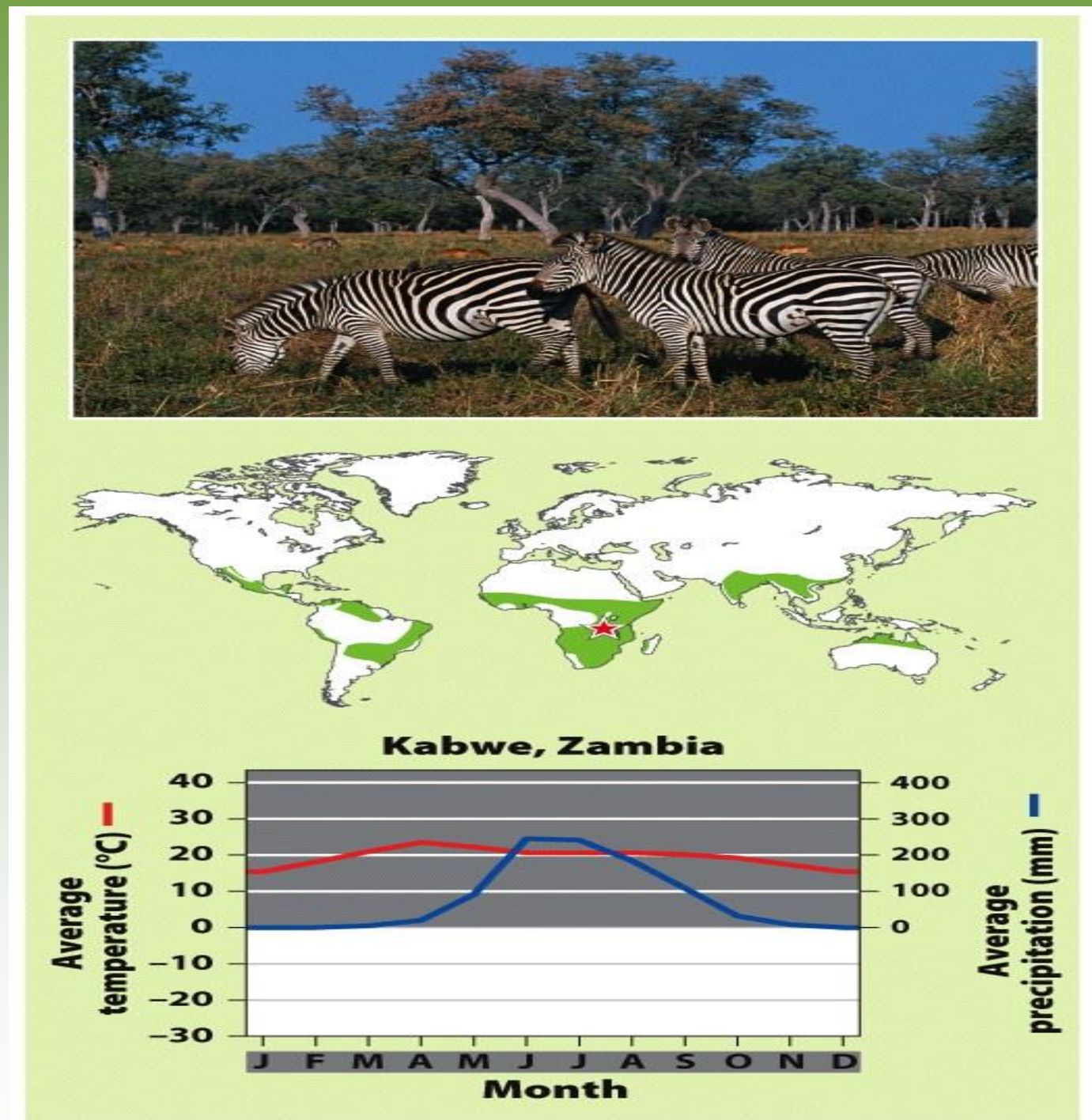


Figure 4.26
Environmental Science

Subtropical Desert

- This biome is found at 30˚ N and S with hot temperatures and extremely dry conditions.

- The Mojave Desert in the southwestern United States, the Sahara in Africa, the Arabian Desert of the Middle East and the Great Victoria Desert of Australia are all subtropical deserts.

- Cacti, euphorbs and succulent plants are well adapted to this biome.

- Annual plants – live for a few months, grow rapidly during periods of rain. Perennial – live for many years (slow) and experience growth spurts in rain

Subtropical Desert

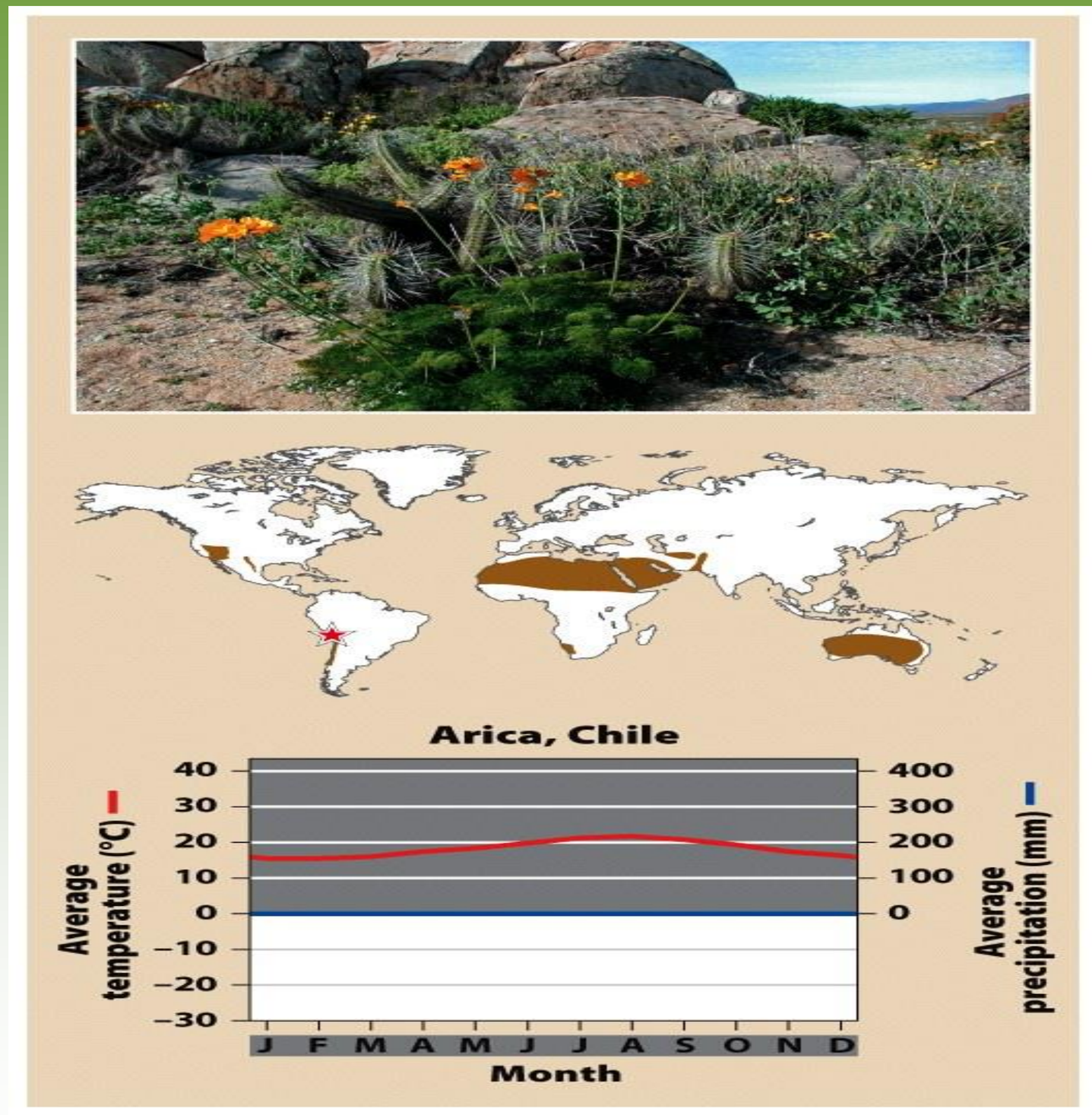


Figure 4.27
Environmental Science

Aquatic Biomes are Categorized by *Salinity, Depth, and Water Flow*

Two Broad categorize:

1. **Fresh water** – streams, rivers, lakes, wetlands
2. **Marine (salt) water** – shallow marine areas, estuaries, coral reefs (open oceans)

Temp determines what species can survive in a particular aquatic habitat (not used to categorize)

Streams and Rivers

- Flowing fresh water that may *originate* from *underground springs* or as *runoff from rain or melting snow.*

- **Streams** are typically narrow and carry relatively small amounts of water.

- **Rivers** are usually wider and carry larger amounts of water.

- **Rapids** – fast moving streams/rivers that have stretches of turbulent waters. Water & Air mix, allowing large amts of oxygen dissolved in water. Supporting fish such as trout or salmon (need large amt of oxygen rich water.

Figure 4.28
Environmental Science

Lakes and Ponds

- Standing water that some of which is too deep to support emergent vegetation.
- Lakes are larger than ponds but there is no clear point at which a pond is considered large enough to be called a lake.

Lake George, Adirondack Park, New York

Figure 4.29a
Environmental Science

Lakes and Ponds

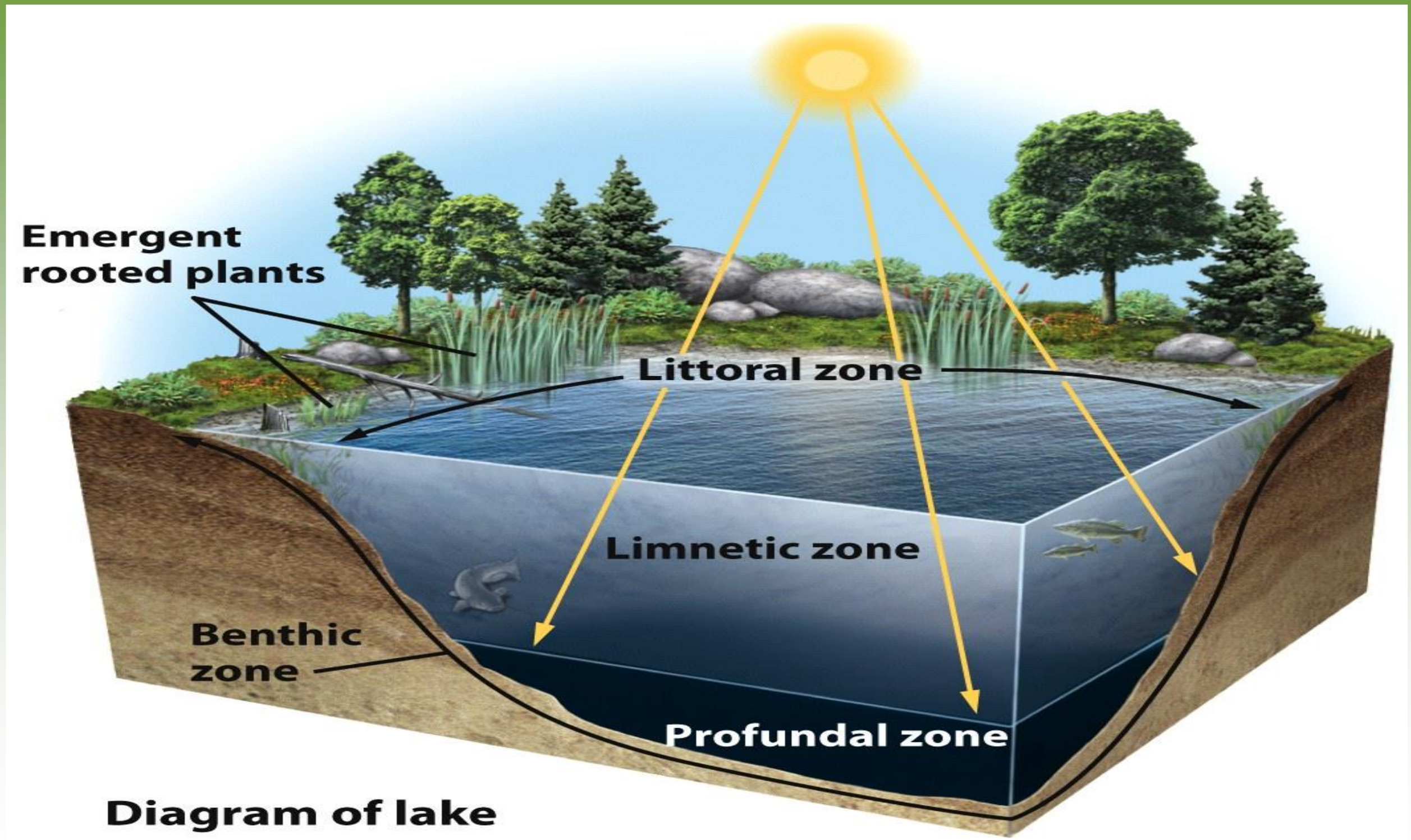


Figure 4.29b
Environmental Science

Lakes and Ponds – Too deep for emergent vegetation (plants rooted to the bottom and emerge above) to grow

- **Littoral zone**- the shallow area of soil and water near the shore where algae and emergent rooted plants grow.

- **Limnetic zone**- open water, where rooted plants can no longer survive. Phytoplankton (floating algae) are the only photosynthetic organisms. This zone extends to as deep as sunlight can penetrate.

- **Profundal zone**- the zone where sunlight cannot penetrate and therefore *producers cannot survive*.

- **Benthic zone**- the muddy bottom of a lake or bond beneath the limnetic and profundal zone.

Freshwater Wetlands

- Aquatic biomes that are submerged or saturated by water for at least part of each year, but shallow enough to support emergent vegetation.

- Support species of plants that specialized to live in submerged or saturated soils.

- Freshwater wetlands in general are the most productive biomes on the planet.

- Filter pollutants from water, recharging the groundwater with clean water.

- This biome only makes up 5% of the nations land area.
- More than half of the freshwater wetlands area in the U.S. have been drained for agriculture or development or to eliminate breeding grounds for mosquitos

Wetlands include swamps, marshes, and bogs

Figure 4.30a
Environmental Science

Swamp

Figure 4.30b
Environmental Science

Marsh

Figure 4.30c
Environmental Science

Bog

Salt Marshes

- Found along the coast in temperate climates and contain non woody emergent vegetation (ex. Cattail). Not acidic

- The salt marsh is one of the most productive biomes in the world.

- Many marshes are found in ***estuaries***, which are areas along the coast where fresh water of rivers mixes with salt water in oceans

Figure 4.31
Environmental Science

Mangrove Swamps

- Found along tropical and subtropical coasts and contain trees whose roots are submerged in water.

- Mangrove trees are salt tolerant and help protect the coastlines from erosion and storm damage.

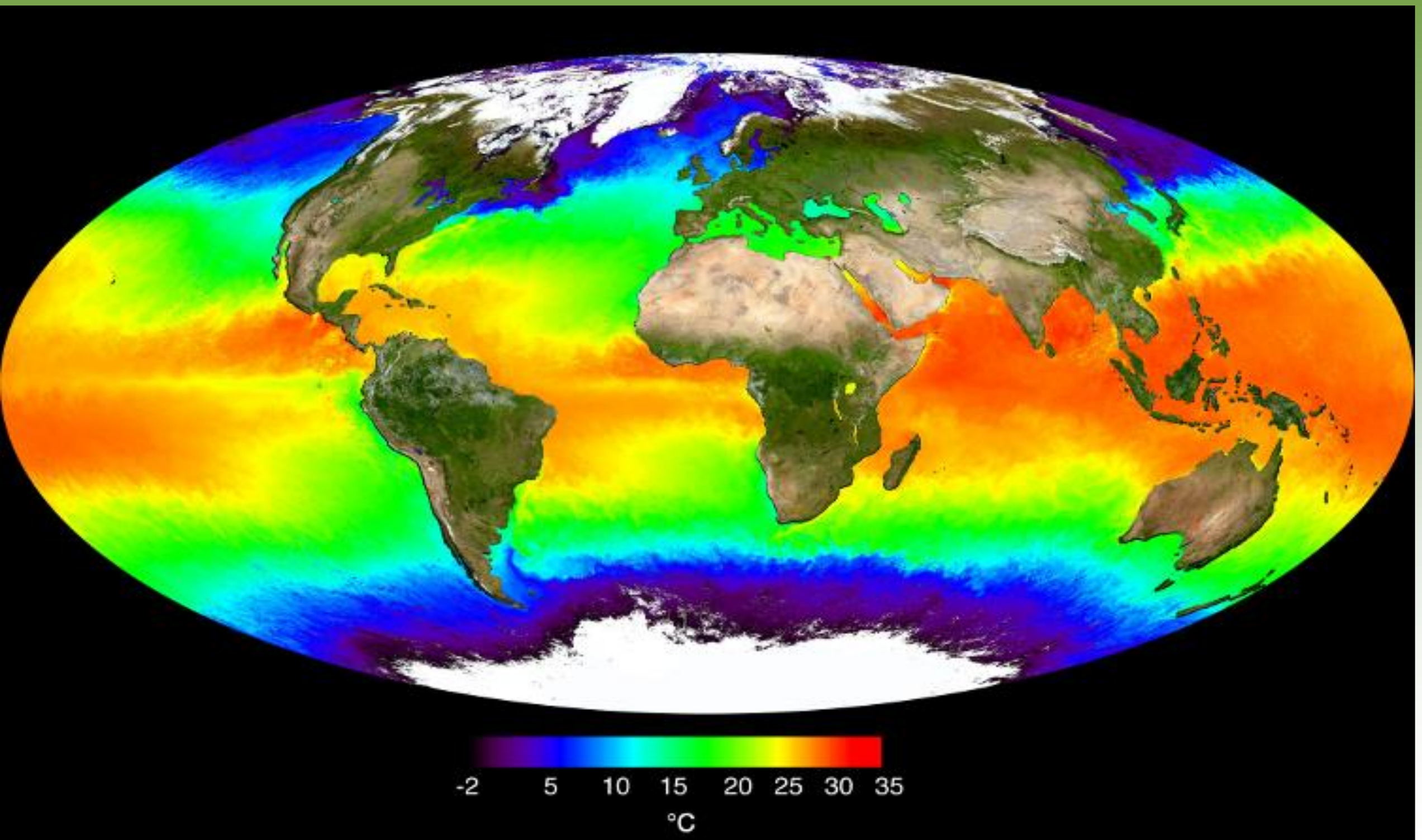
- Salt-tolerant provide habitat for marine organism.

Figure 4.32
Environmental Science

Bogs

- Very acidic wetlands, typically contain sphagnum moss, shrubs and spruce trees.

Aquatic temp. zones



Intertidal Zone

- Narrow band of coastline that exists between the levels of high tide (*stable condition when submerged*) and low tide (*harsh conditions organisms are exposed to direct sunlight, high temps, & desiccation –dryness).*

- Waves that crash onto the shore in this biome can make it a challenge for organisms to hold on and not get washed away.

Figure 4.33
Environmental Science

Coral Reefs

- Coral are tiny organisms that secrete a layer of limestone, form a external skeleton (where animal live, mutualistic, algae live within the coral's tissue and coral get sugars from the photosynthetic algae)
- Found in warm, shallow waters beyond the shoreline.
- Earth's most diverse marine biome even though coral reefs are found in water that is relatively poor in nutrients and food.

- **Coral bleaching-** when the algae inside the coral dies,. soon after, the coral will die leaving just the limestone skeleton, which develops the coral reef (habitat)

- Scientists believe this is due to a combination of disease and environmental change.

- Environmental changes can include lower ocean pH, abnormally high water temps.

- Without the corals, the entire coral reef biome is endangered.

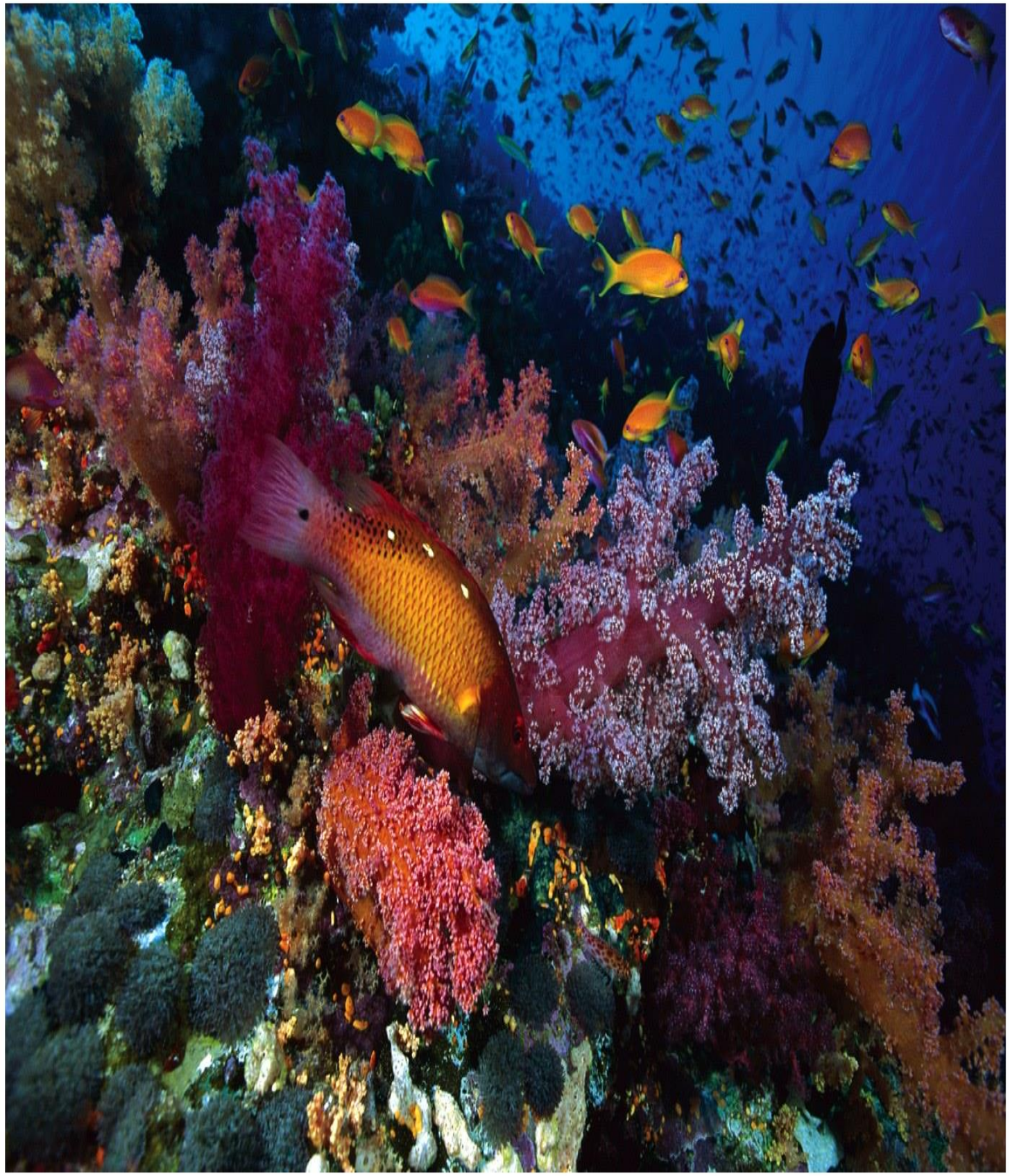


Figure 4.34
Environmental Science

The Open Ocean

- The depth that sunlight can penetrate in the open ocean is dependent on the amount of sediment and algae suspended in the water.

- **Photic zone-** the zone that receives enough light to allow photosynthesis to occur.

- **Aphotic zone-** the deeper water that lacks sufficient light for photosynthesis.

- **Bioluminescence** – generate own light to help feed in dark waters

- **Chemosynthesis**- The process that occurs in the aphotic zone when some species of bacteria use methane and hydrogen sulfide to generate energy.

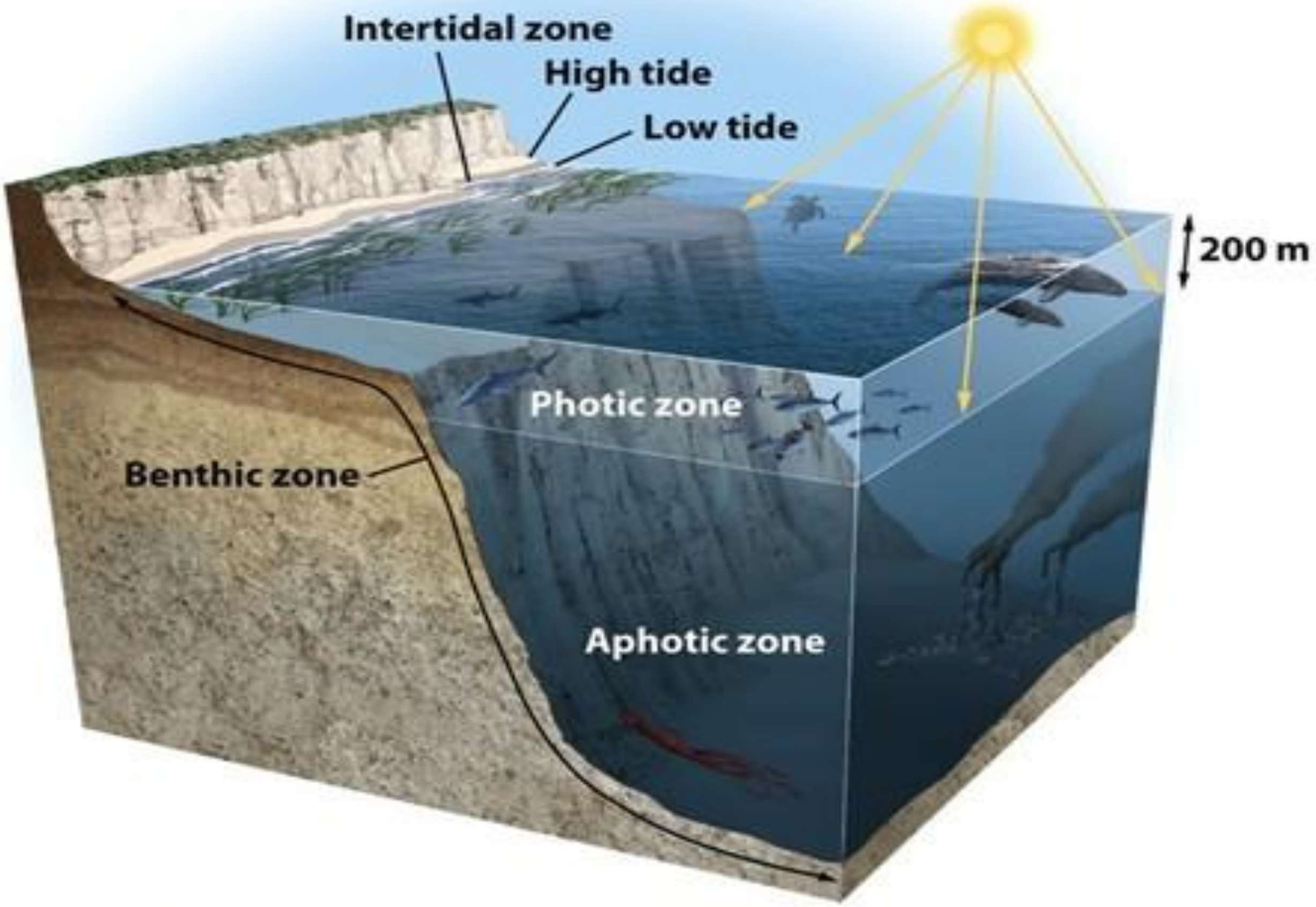


Figure 4.35 **The open ocean.** The open ocean can be separated into several distinct zones.

- Regional variations in global climate of aquatic and terrestrial biomes, have a major effect of on the types of organisms that can live in different parts of the world.

- **Terrestrial biome**, temp and precipitation affect the rate of decomposition and the productivity of the soil.

- **Aquatic biomes**, differences in water flow, depth, and salinity describes why certain species live in certain regions of the world.