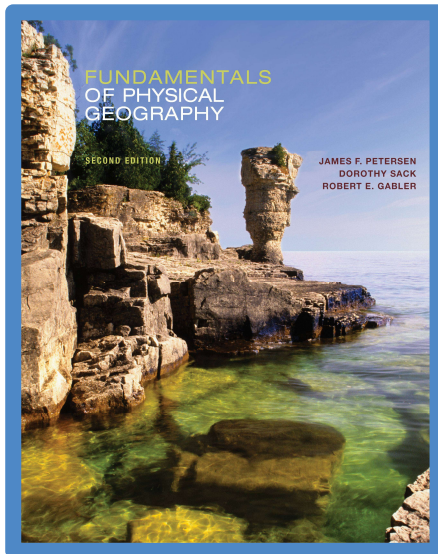


Fundamentals of Physical Geography 2e

Climate Classification: Tropical, Arid, and Mesothermal Climate Regions

7



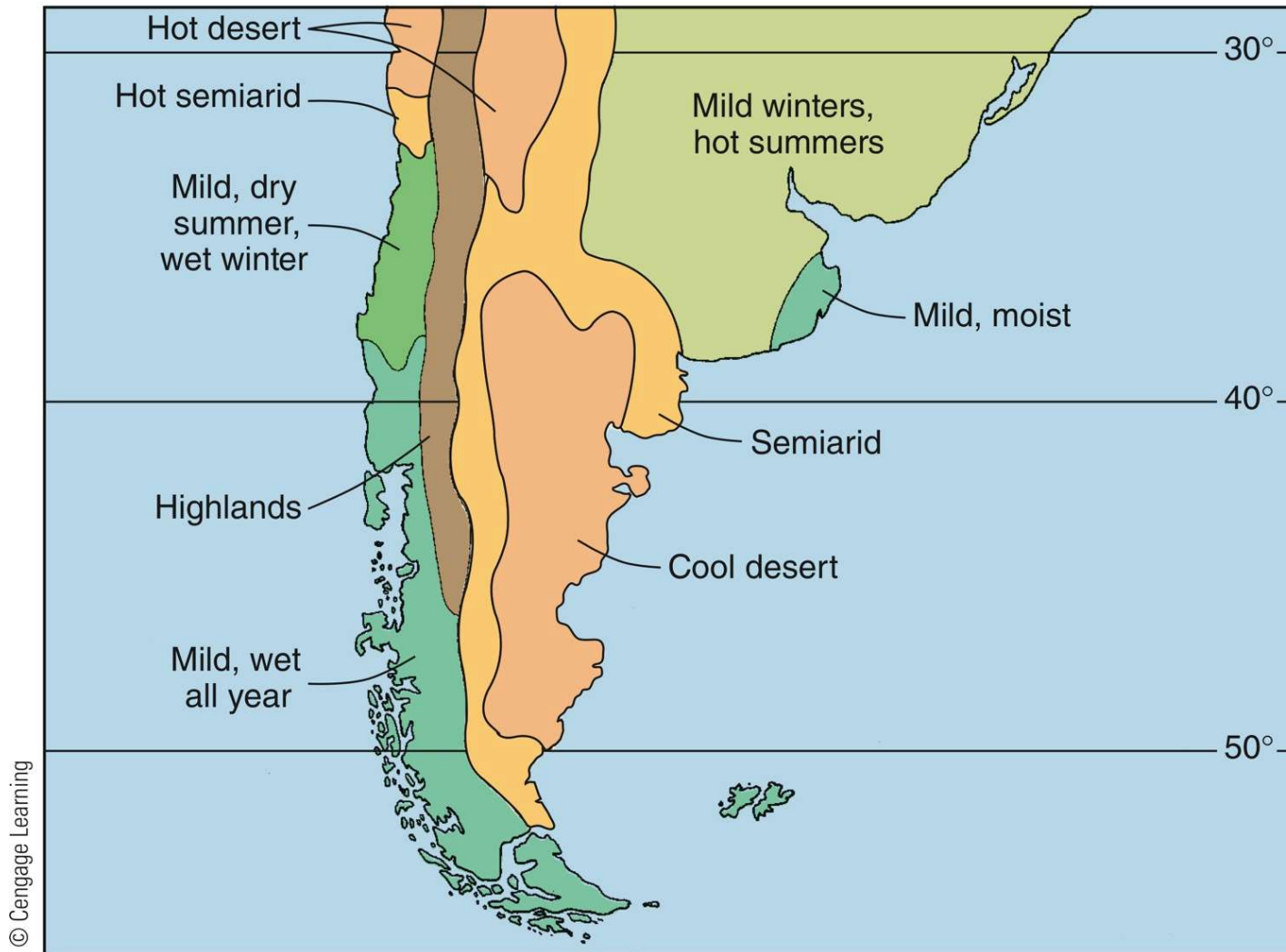
- ⌘ Peterson
- ⌘ Sack
- ⌘ Gabler

Classifying Climates

- Climate of a location or a region
 - Most common indicators
 - Temperature and precipitation
 - Thermometer
 - Galileo: early 1600s
 - Routine records: from mid 1800s and later
 - Global climates
 - First classification attempts using recorded data: early 20th century
 - Adequate records: thirty years or more

Classifying Climates (cont'd.)

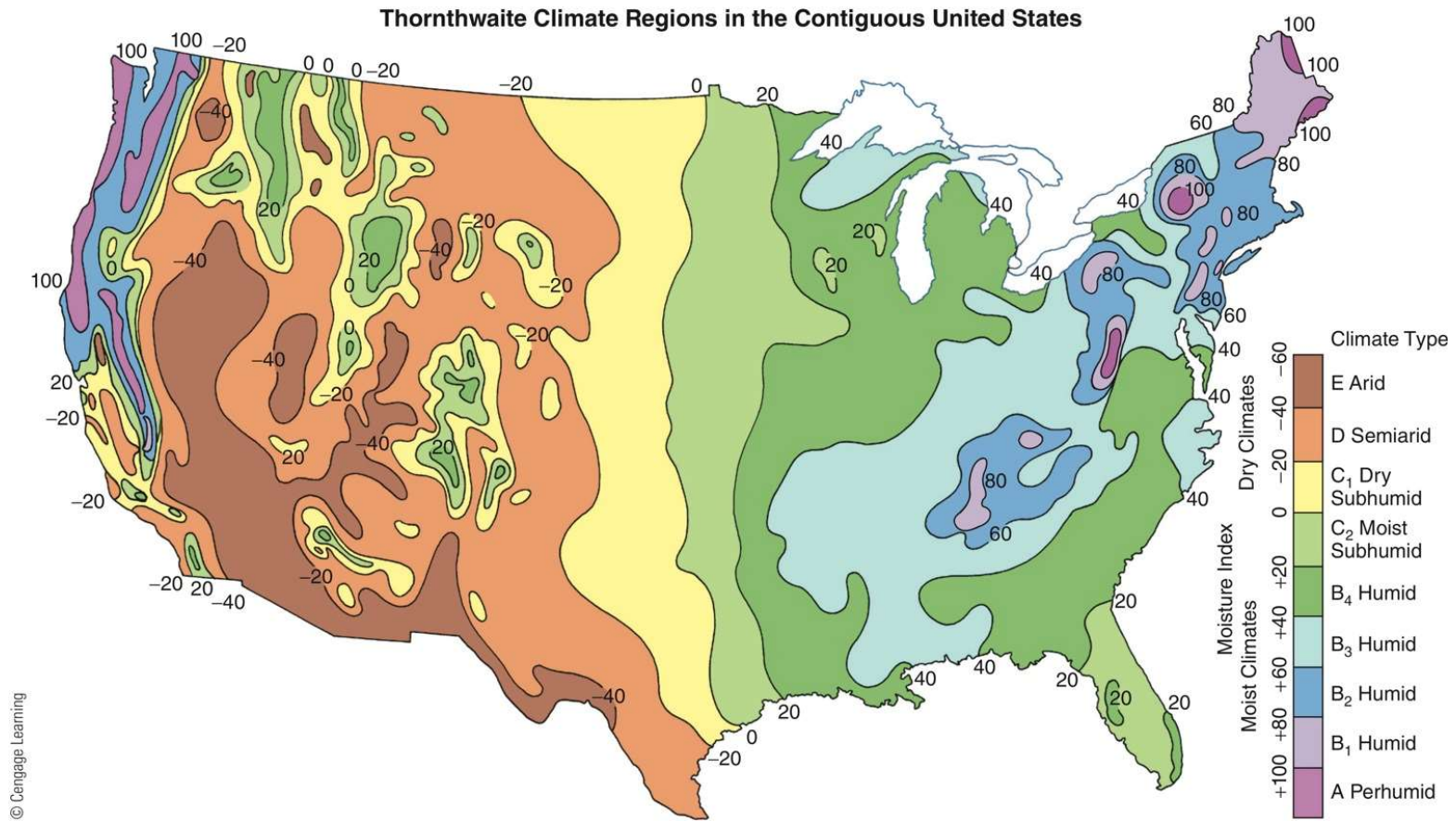
- Climate regions
 - Based on seasonal and annual similarities
 - Precipitation and temperature
 - Distinctions on a global scale requires:
 - Generalizations
 - Simplifications
 - Compromises



What causes the major climate changes along the 40°S latitude line from west to east across South America?

Classifying Climates (cont'd.)

- The Thornthwaite system
 - Moisture availability (or shortages)
 - Subregional scale
 - Based on:
 - Potential evapotranspiration (potential ET)
 - Transpiration
 - Actual evapotranspiration (actual ET)



What is the moisture index, and what is the Thornthwaite climate type for coastal California?

Classifying Climates (cont'd.)

- The Thornthwaite system

- Thornthwaite moisture index (MI)

$$MI = 100 \times \frac{P - \text{Potential } ET}{\text{Potential } ET}$$

where P = precipitation

- What does a negative index indicate?

Classifying Climates (cont'd.)

- The Köppen system
 - Most widely used climate classification
 - Based on regional patterns
 - Seasonal temperature and precipitation
 - Advantages
 - Long-term records
 - Temperature and precipitation directly impact humans, animals, vegetation, etc.
 - Visible association of vegetation with climate types

Classifying Climates (cont'd.)

- The Köppen system
 - Disadvantages
 - Relies on mean monthly (or annual) temperatures and precipitation
 - Precipitation effectiveness: does not permit detailed comparison of different locations
 - Does not account for other weather factors, e.g., winds, clouds, humidity, etc.

Classifying Climates (cont'd.)

- Simplified Köppen classification: six major climate categories (Table 7.1 and Appendix C)
 - (A) humid tropical climates
 - (C) humid mesothermal climates (mild winter)
 - (D) humid microthermal climates (cold winter)
 - (E) polar climates
 - (B) arid climates
 - (H) highland climates

NASA/Michael Studinger



(a)

Jim Petersen



(c)

National Scenic Byways/Photo by Dennis Adams



(b)

NASA/GSFC



(d)

National Scenic Byways



(a)

Natural Resources Conservation Service/Gene Alexander



(b)

Classifying Climates (cont'd.)

- Climate regions (Figure 7.5)
 - Region: similar internal characteristics; distinct from those of other areas
 - Boundary lines
 - Signify zones of transition between different climate regions

Classifying Climates (cont'd.)

- Climograph
 - Climate summarized in the form of a graph
 - Can be used to determine:
 - Köppen classification of a location
 - Specific temperature and rainfall regimes

Station: Nashville, Tenn.

Latitude: 36°N

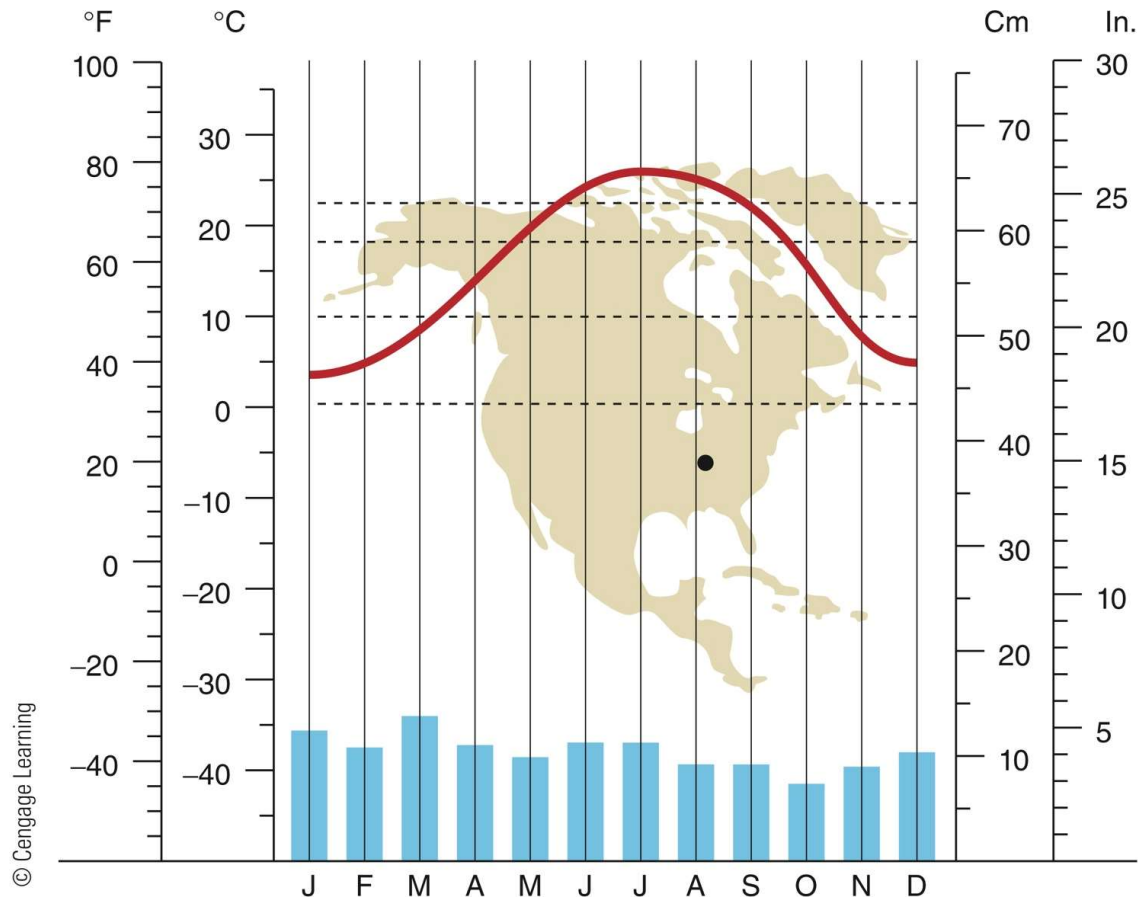
Type: Humid Subtropical (Cfa)

Longitude: 88°W

Av. annual prec.: 119.6 cm (47.1 in.)

Av. Annual temp.: 15.2°C (59.5°F)

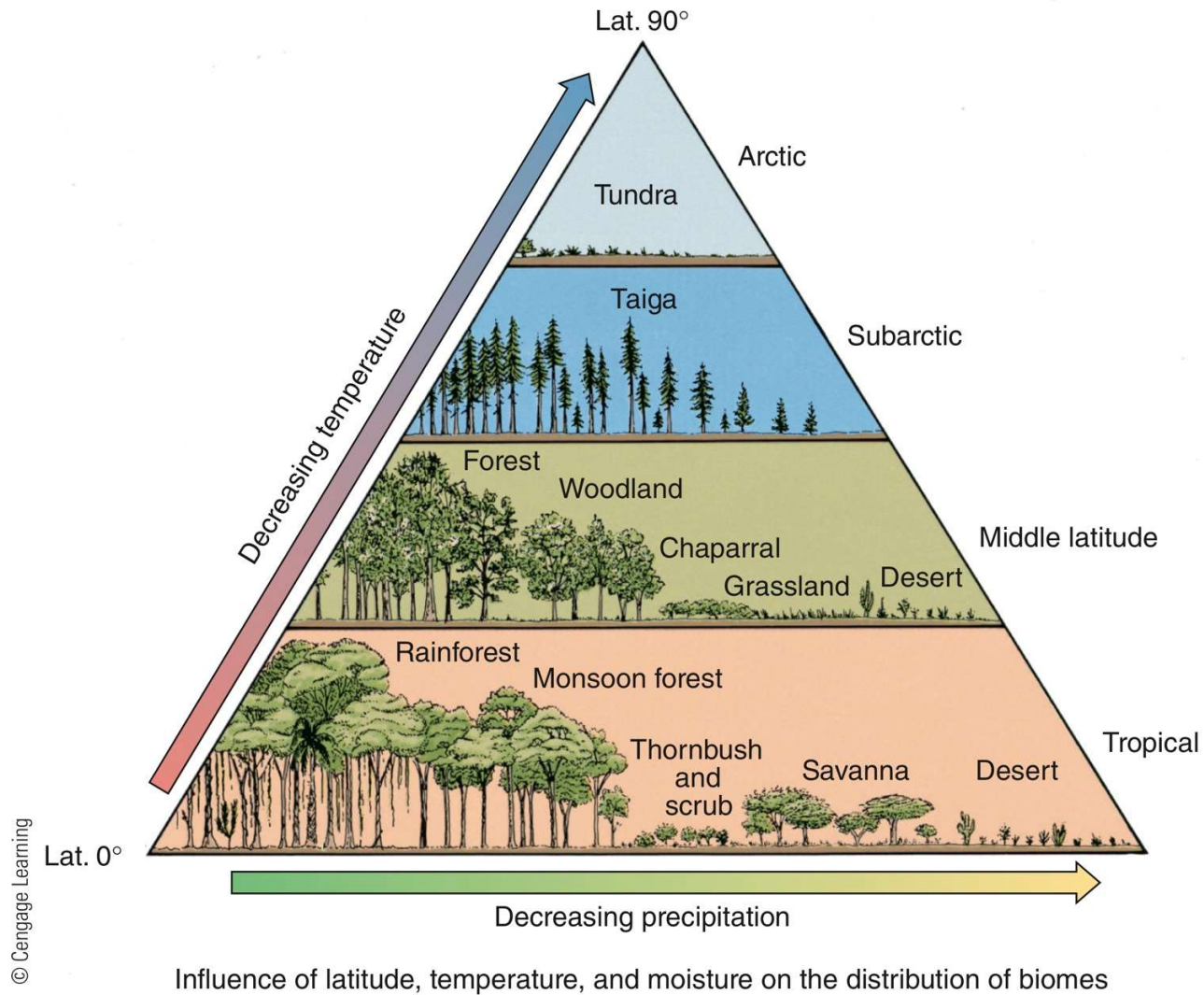
Range: 22.5°C (40.5°F)



What specific information can you read from the graph to classify Nashville's climate as humid subtropical in the Köppen system?

Classifying Climates (cont'd.)

- Climate and vegetation
 - Biomes: Earth's major terrestrial ecosystems
 - Major categories: forest, grassland, desert, and tundra
 - Climate: directly influences the distribution of biome types (Figure 7.7)
 - What are key factors in the location of biome types on a world regional scale?



What major biome dominates the wetter margins of all latitudes but the Arctic?

Humid Tropical Climate Regions (cont'd.)

NAME AND DESCRIPTION	CONTROLLING FACTORS	GEOGRAPHIC DISTRIBUTION	DISTINGUISHING CHARACTERISTICS	RELATED FEATURES
Tropical Rainforest				
Coollest month above 18°C (64.4°F); driest month with at least 6 cm (2.4 in.) of precipitation	High year-round insolation and precipitation of doldrums (ITCZ); rising air along trade wind coasts	Amazon R. Basin, Congo R. Basin, east coast of Central America, east coast of Brazil, east coast of Madagascar, Malaysia, Indonesia, Philippines	Constant high temperatures; equal length of day and night; lowest (2°C–3°C/3°F–5°F) annual temperature ranges; evenly distributed heavy precipitation; high amount of cloud cover and humidity	Tropical rainforest vegetation (selva); jungle where light penetrates; tropical iron-rich soils; climbing and flying animals, reptiles, and insects; slash-and-burn agriculture

Humid Tropical Climate Regions (cont'd.)

Topical Rainforest

DISTINGUISHING CHARACTERISTICS

RELATED FEATURES

Constant high temperatures; equal length of day and night; lowest (2°C–3°C/3°F–5°F) annual temperature ranges; evenly distributed heavy precipitation; high amount of cloud cover and humidity

Tropical rainforest vegetation (selva); jungle where light penetrates; tropical iron-rich soils; climbing and flying animals, reptiles, and insects; slash-and-burn agriculture

Humid Tropical Climate Regions (cont'd.)

NAME AND DESCRIPTION	CONTROLLING FACTORS	GEOGRAPHIC DISTRIBUTION
Tropical Monsoon		
Coollest month above 18°C (64.4°F); one or more months with less than 6 cm (2.4 in.) of precipitation; excessively wet during rainy season	Summer onshore and winter offshore air movement related to shifting ITCZ and changing pressure conditions over large landmasses; also transitional between rainforest and savanna	Coastal areas of southwest India, Sri Lanka, Bangladesh, Myanmar, southwest Africa, Guyana, Surinam, French Guiana, northeast and southeast Brazil

Humid Tropical Climate Regions (cont'd.)

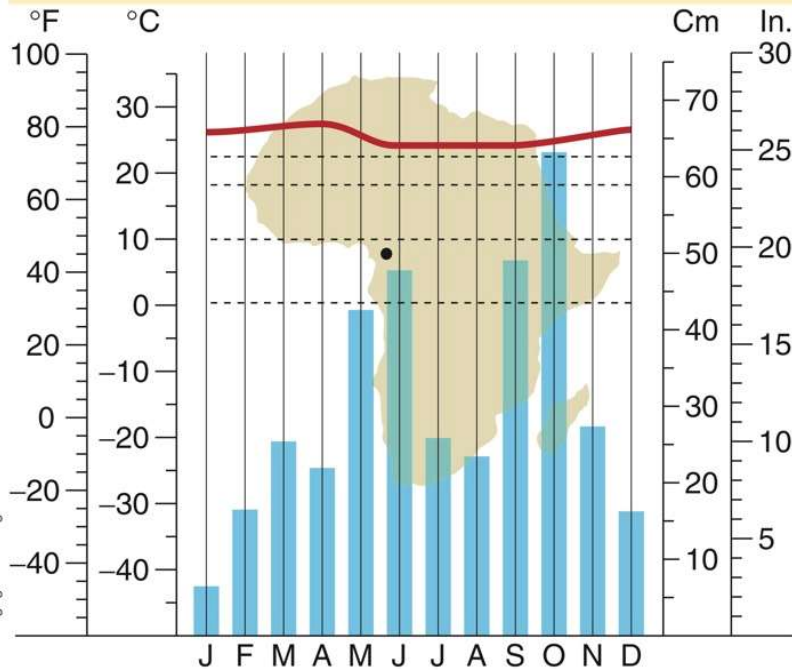
Topical Monsoon

DISTINGUISHING CHARACTERISTICS	RELATED FEATURES
Heavy high-sun rainfall (especially with orographic lifting), short low-sun drought; 2°C–6°C (3°F–10°F) annual temperature range, highest temperature just prior to rainy season	Forest vegetation with fewer species than tropical rainforest; grading to jungle and thorn forest in drier margins; iron-rich soils; rainforest animals with larger leaf-eaters and carnivores near savannas; paddy rice agriculture

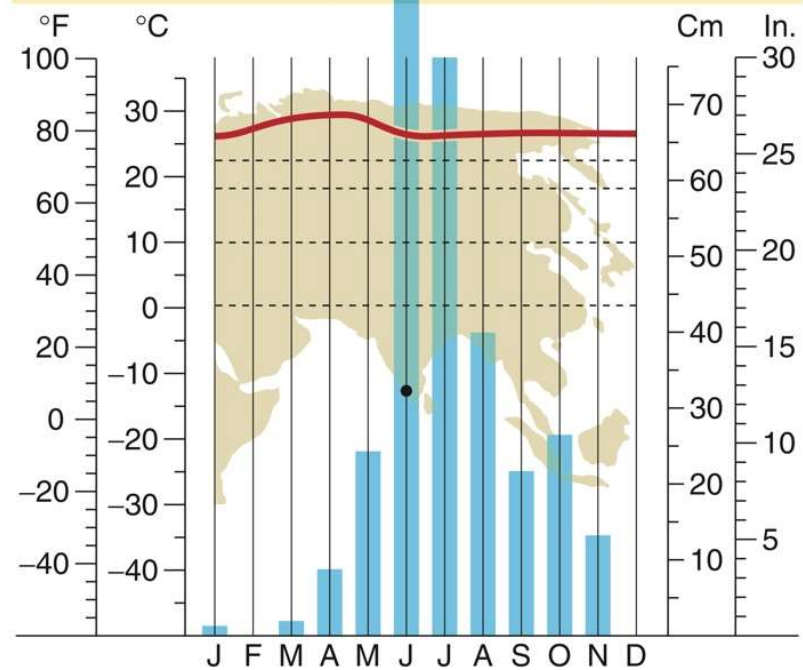
Humid Tropical Climate Regions (cont'd.)

- Compare and contrast a tropical rainforest climate and a tropical monsoon climate
 - Consistent vs. seasonal precipitation
 - Amount of precipitation; conditions along ITCZ
 - Consistency of high temperatures
 - Insolation and temperature
 - Annual temperature range
 - Rainforest climate: daily temperature range versus annual temperature range

Akassa, Nigeria
 5°N
 Precip.: 365 cm (143.8 in.)
 Av. temp.: 25.5°C (78°F)
 Range: 2.2°C (4°F)
 Tropical Rf (Af)
 6°E



Kozhikode, India
 11°N
 Precip.: 301 cm (118.6 in.)
 Av. temp.: 26.4°C (79.5°F)
 Range: 4°C (6.9°F)
 Tropical Mon. (Am)
 76°E



What information is most important as you compare the two stations?

Humid Tropical Climate Regions (cont'd.)

- Forest biomes
 - Varying appearance and composition
 - Tropical rainforests
 - Tropical savanna regions
- Tropical rainforests
 - Broad-leaf evergreens
 - Lianas
 - Epiphytes
 - Shallow root systems

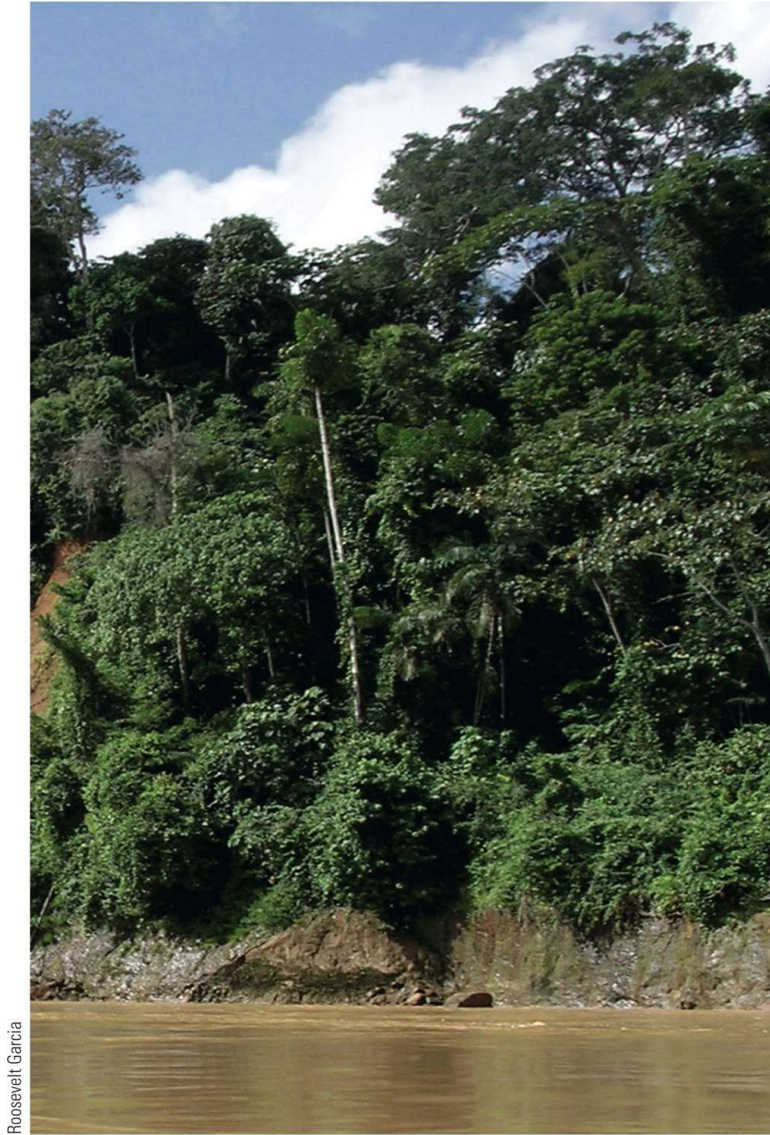


Sasan Saatchi NASA/JPL-Caltech

How many tree canopies (layers) can you see in this figure?

Humid Tropical Climate Regions (cont'd.)

- Other regions with tropical rainforest climate
 - Jungle
 - Fertile soils for agricultural use
- Monsoon regions
 - Fewer plant species with some dominant
- How do animal species differ between monsoon regions and rainforests?



Roosevelt Garcia

Why is the vegetation so dense here, when it is more open inside the forest at ground level?

Humid Tropical Climate Regions (cont'd.)

- Human activity
 - Subsistence agriculture
 - Slash-and-burn: shifting cultivation
 - Commercial plantation agriculture
 - Tropics: wet-field (paddy) rice
 - South and Southeast Asia
 - Adequate food: dependent on climate

Humid Tropical Climate Regions (cont'd.)

NAME AND DESCRIPTION	CONTROLLING FACTORS	GEOGRAPHIC DISTRIBUTION
Tropical Savanna		
Coollest month above 18°C (64.4°F); wet during high-sun season, dry during lower-sun season	Alternation between high-sun doldrums (ITCZ) and low-sun subtropical highs and trades caused by shifting winds and pressure belts	Northern and eastern India, interior Myanmar and Indo-Chinese Peninsula; northern Australia; borderlands of Congo R. south central Africa; llanos of Venezuela, campos of Brazil; western Central America, south Florida, and Caribbean Islands

Humid Tropical Climate Regions (cont'd.)

Topical Savanna

DISTINGUISHING CHARACTERISTICS

Distinct high-sun wet and low-sun dry seasons; rainfall averaging 75–150 cm (30–60 in.); highest temperature ranges for humid tropical climates

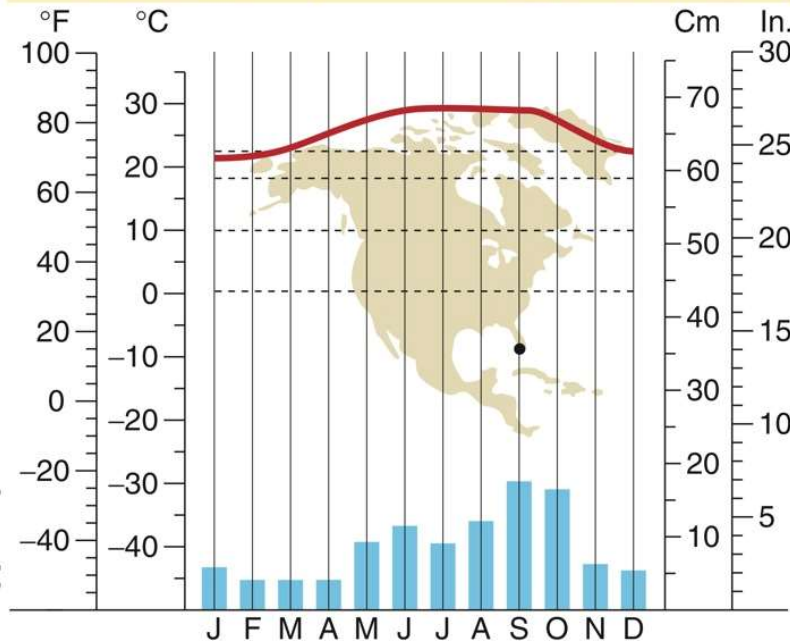
RELATED FEATURES

Grasslands with scattered, drought-resistant trees, scrub, and thorn bushes; poor soils for farming, grazing more common; large herbivores, carnivores, and scavengers

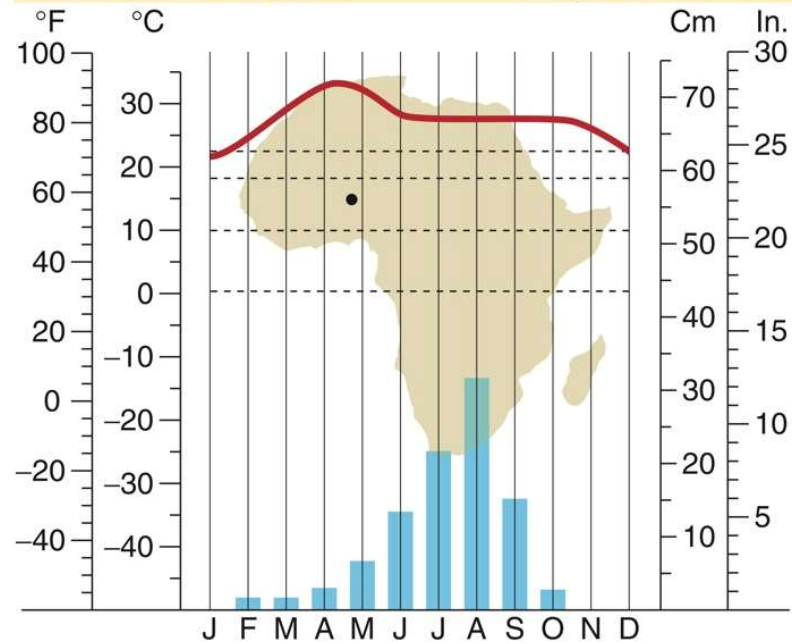
Humid Tropical Climate Regions (cont'd.)

- Savanna: transitional features
 - Situated between the rainforest climate and the semiarid steppe climate
 - Characteristics of both: rainy season and dry season
 - Temperature range
 - Vegetation: typical savanna
 - Mix of grassland and deciduous trees

Key West, Fla. Tropical Sav. (Aw)
 25°N 82°W
 Precip.: 97 cm (38.1 in.)
 Av. temp.: 25°C (77°F) Range: 7.5°C (13.5°F)



Kano, Nigeria Tropical Sav. (Aw)
 12°N 8°E
 Precip.: 86.5 cm (34 in.)
 Av. temp.: 26.7°C (80°F) Range: 9.5°C (17°F)

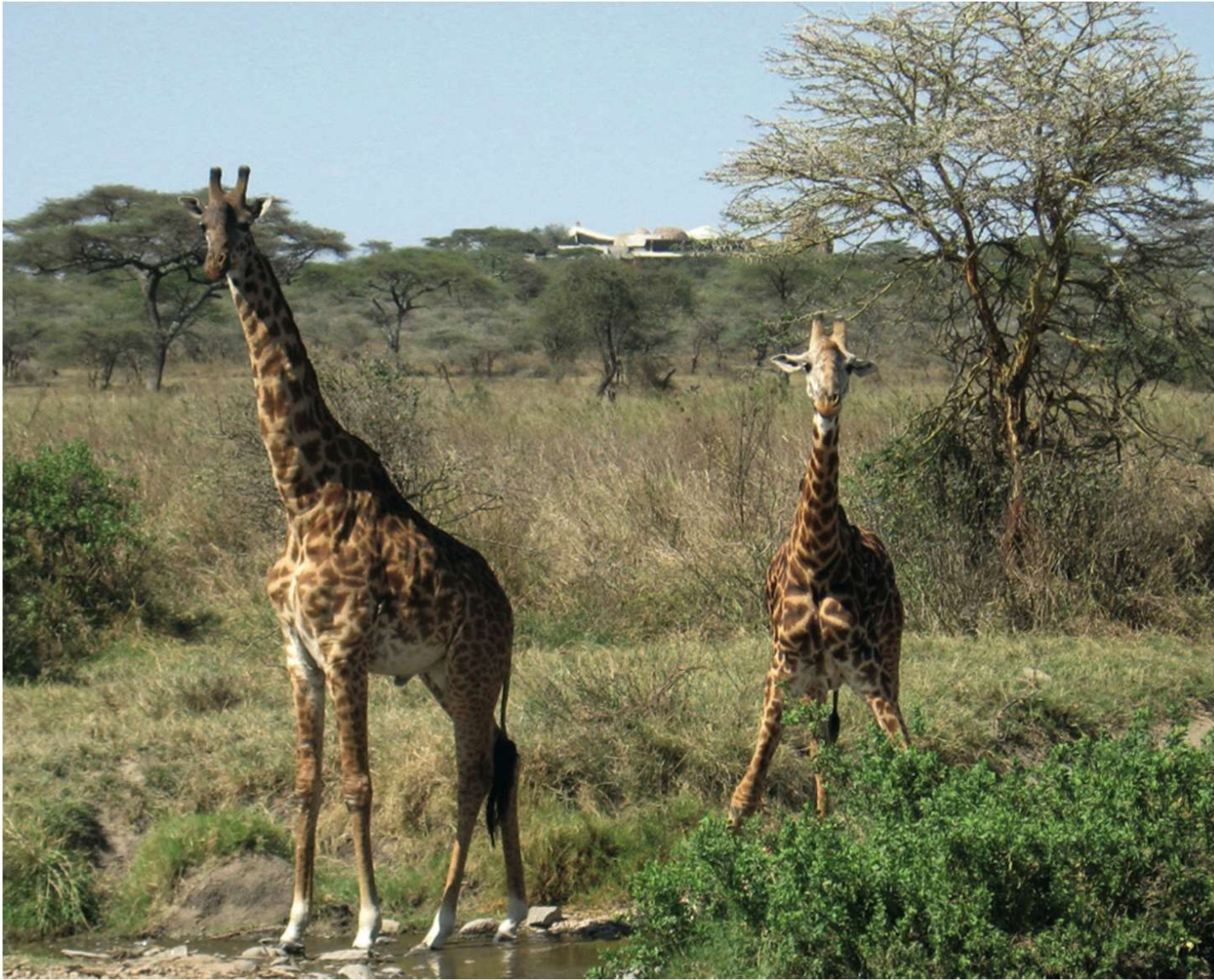


Consider the differences in climate and human use of the environment between Key West and Kano. Why is Key West, Florida, a rather atypical location for a savanna climate?

Humid Tropical Climate Regions (cont'd.)

- Savanna potential
 - Unreliable rains
 - Deficient: drought and famine
 - Excessive: flooding
 - Animals: many different species
 - Herbivores, carnivores, scavengers

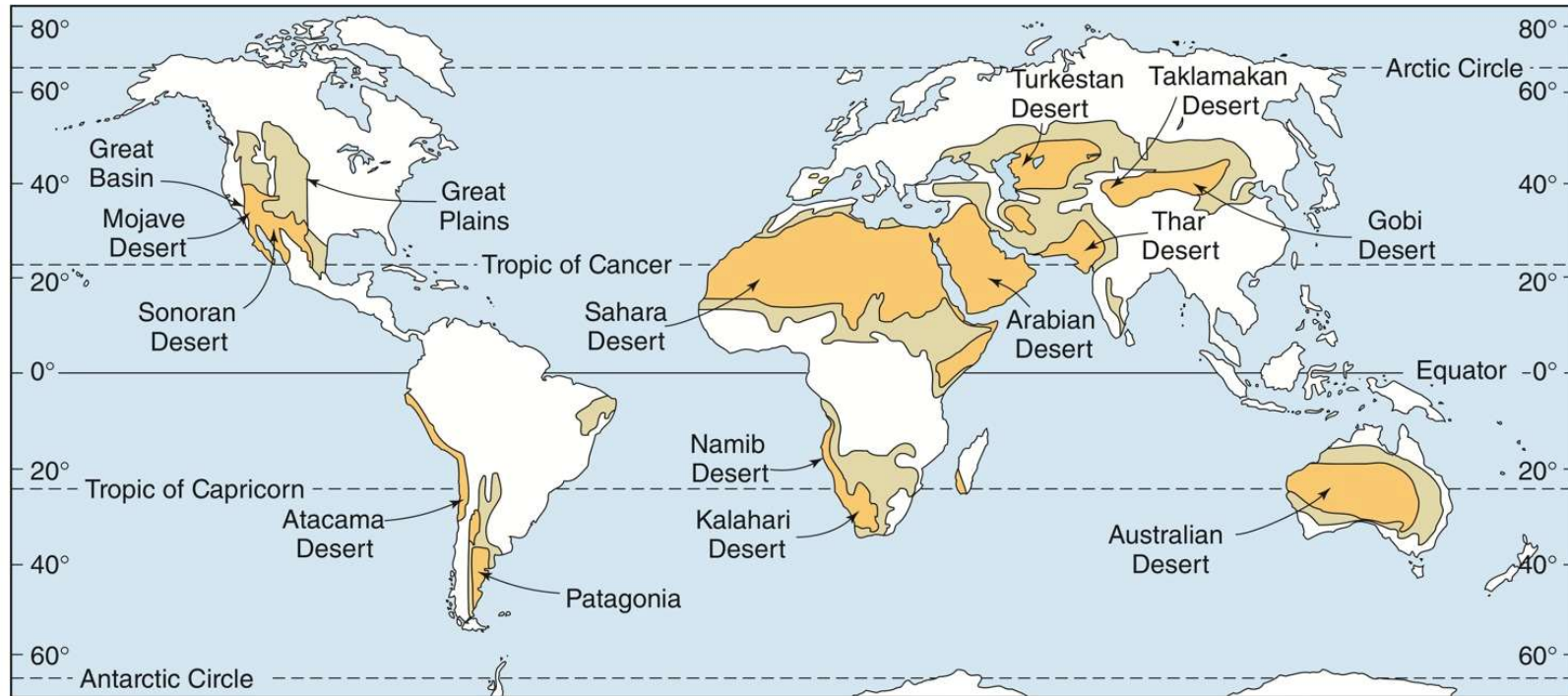
Courtesy of Norm Bettis



How is a giraffe's height so well adapted to the savanna environment?

Arid Climate Regions

- Two major types of locations
 - Centered on the Tropics of Cancer and Capricorn
 - 10° to 15° poleward and equatorward
 - Higher latitudes of continental interiors
- Central core: desert climate
 - Bounded on edges: semiarid steppe climates
- Why are deserts concentrated in the vicinity of the two tropic lines?



© Cengage Learning

Low-latitude and middle-latitude deserts (BWh, BWk)

Low-latitude and middle-latitude steppes (BSh, BSk)

What does a comparison of this map with the Map of World Population Density (inside back cover) suggest?

Arid Climate Regions (cont'd.)

- **Classification**
 - Desert climate
 - Precipitation is less than half the potential ET
 - Steppe climate
 - Precipitation is more than half but significantly less than total potential ET
- How does precipitation effectiveness distinguish between desert, steppe, or humid climates?

Arid Climate Regions (cont'd.)

NAME AND DESCRIPTION	CONTROLLING FACTORS	GEOGRAPHIC DISTRIBUTION
Desert		
Precipitation less than half of potential evapotranspiration; mean annual temperature above 18°C (64.4°F) (low-lat.), below (mid-lat.)	Descending, subsiding of subtropical highs; continentality often linked with rainshadow location	Coastal Chile and Peru, southern Argentina, southwest Africa, central Australia, Baja California and interior Mexico, North Africa, Arabia, Iran, Pakistan and western India (low-lat.); inner Asia and western United States (mid-lat.)

Arid Climate Regions (cont'd.)

Desert

DISTINGUISHING CHARACTERISTICS

Aridity; low relative humidity; irregular and unreliable rainfall; highest percentage of sunshine; highest diurnal temperature range; highest daytime temperatures; windy conditions

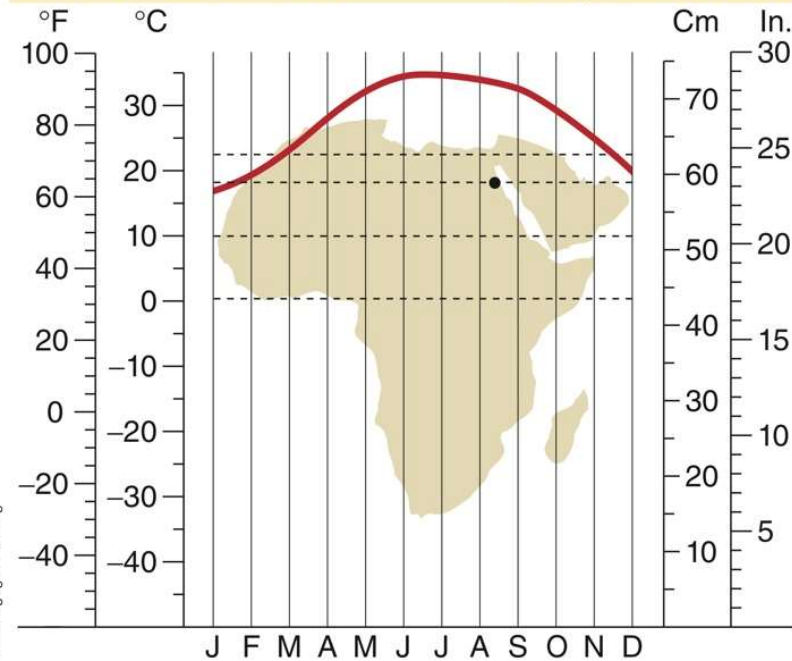
RELATED FEATURES

Xerophytic vegetation; often barren, rock, or sandy surface; desert soils; excessive salinity; usually small, nocturnal burrowing animals; nomadic herding

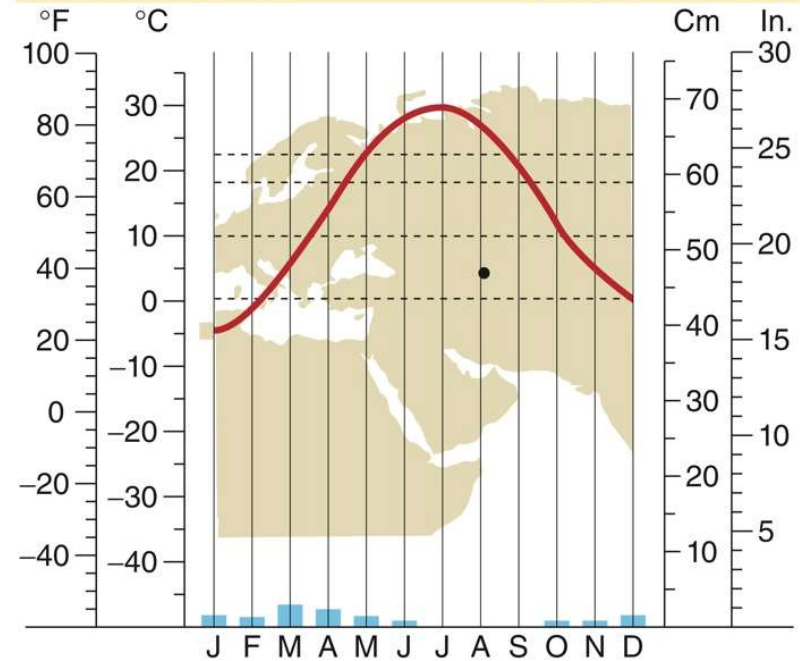
Arid Climate Regions (cont'd.)

- Desert climates: land of extremes
 - Up to 90% of insolation reaches surface
 - World's greatest diurnal temperature ranges
 - Low-latitude deserts
 - What accounts for high annual temperature ranges in middle-latitude deserts?

Aswan, Egypt
 24°N
 Precip.: <.25 cm (0.1 in.)
 Av. temp.: 27°C (80.5°F)
 Range: 17°C (31°F)
 Low-lat. Desert (BWh)
 33°E

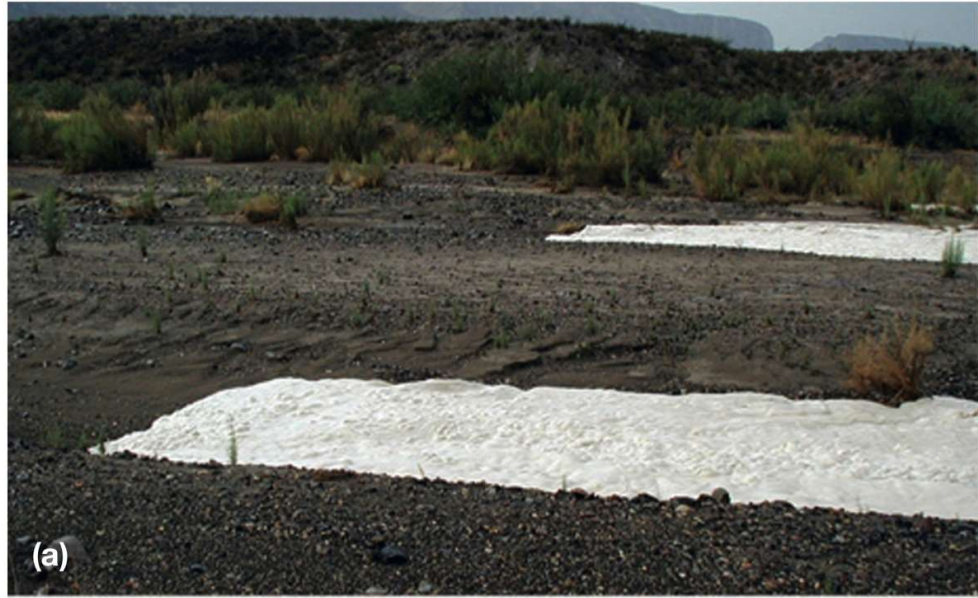


Turtkul, Uzbekistan
 41°N
 Precip.: 7.5 cm (3 in.)
 Av. temp.: 13°C (55°F)
 Range: 34°C (61°F)
 Mid-lat. Desert (BWk)
 61°E



Considering the serious limitations of desert climates, why do some people choose to live in desert regions?

What factors could cause floodwaters to rise so rapidly in a desert environment?



Jim Petersen



Jim Petersen

Arid Climate Regions (cont'd.)

- Desert climates: adaptations by plants and animals
 - Xerophytic plants
 - Non-xerophytic plants: short-lived annuals
 - Short complete life cycle
 - Nocturnal animals
 - Evolutionary adaptations
 - Humans
 - Hunters and gatherers, nomadic herders, and subsistence farmers



Jim Petersen

What physical characteristics of cacti help them to survive the heat, drought, and evaporation rates of the desert?

Arid Climate Regions (cont'd.)

- Desertification
 - Expansion of deserts: accelerated by humans
 - Serious lack of rain
 - Consequences
 - Vegetation dies; erosion occurs; soil loss
 - What are examples of contributing human activity?
 - Habitation: threats to humans and wildlife

The Environmental Perspective



The Environmental Perspective

Arid Climate Regions (cont'd.)

NAME AND DESCRIPTION	CONTROLLING FACTORS	GEOGRAPHIC DISTRIBUTION
Steppe		
Precipitation more than half but less than potential evapo-transpiration; mean annual temperature above 18°C (64.4°F) (low-lat.), below (mid-lat.)	Same as deserts; usually transitional between deserts and humid climates	Peripheral to deserts, especially in Argentina, northern and southern Africa, Australia, central and southwest Asia, and western United States

Arid Climate Regions (cont'd.)

Steppe

DISTINGUISHING CHARACTERISTICS

Semiarid conditions, annual rainfall distribution similar to nearest humid climate; temperatures vary with latitude, elevation, and continentality

RELATED FEATURES

Dry savanna (tropics) or short grass vegetation; highly fertile black and brown soils; grazing animals in vast herds; predators and small animals; ranching and dry farming

Arid Climate Regions (cont'd.)

- Steppe climates
 - Share common characteristics with deserts
 - Controlling factors: continentality, rain-shadow location, subtropical high pressure systems, or some combination
 - Potential ET exceeds the precipitation
 - Precipitation: unpredictable and varies widely
 - Low- and middle-latitude locations

Arid Climate Regions (cont'd.)

- Steppe and natural vegetation
 - Annual rainfall (10–20 inches)
 - Supports significant vegetation: ground cover, dry savanna type, grasslands, sagebrush, etc.
- A dangerous appeal
 - Overgrazing
 - Agricultural practices
 - Dust Bowl (1930s)
 - Importance of maintaining ecological balance

Mesothermal Climate Regions

- Regions with moderate temperatures (Understanding Map Content 7.2 and Figure 7.5)
 - Mediterranean climate
 - Humid subtropical climate
 - Marine west coast climate

Mesothermal Climate Regions (cont'd.)

NAME AND DESCRIPTION	CONTROLLING FACTORS	GEOGRAPHIC DISTRIBUTION
Mediterranean		
Warmest month above 10°C (50°F); coldest month between 18°C (64.4°F) and 0°C (32°F); summer drought; hot summers (inland), mild summers (coastal)	West coast location between 30° and 40°N and S latitudes; alternation between subtropical highs in summer and westerlies in winter	Central California; central Chile; Mediterranean Sea borderlands, Iranian highlands; Cape Town area of South Africa; southern and southwestern Australia

Mesothermal Climate Regions (cont'd.)

Mediterranean

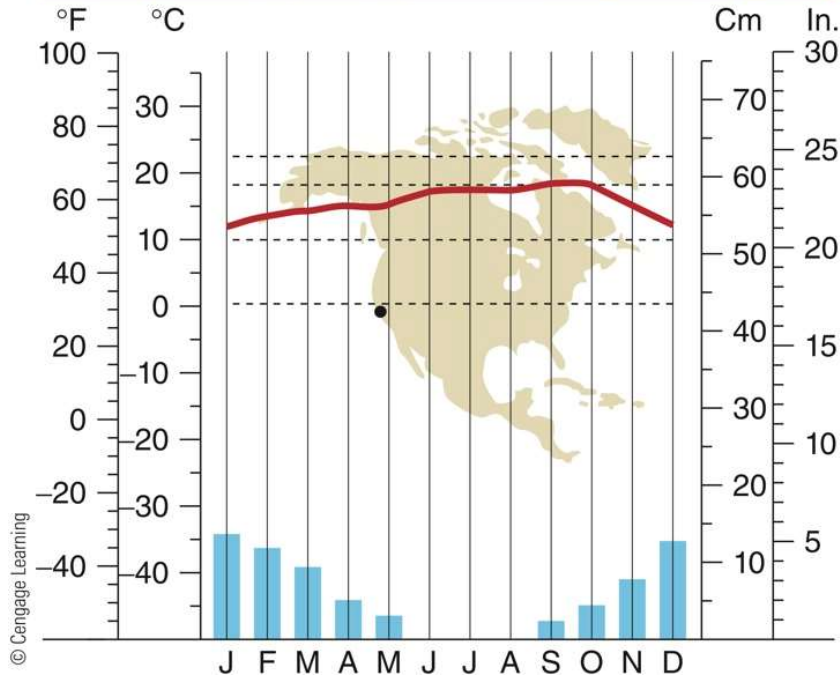
DISTINGUISHING CHARACTERISTICS

Mild, moist winters and hot, dry summers inland with cooler, often foggy coasts; high percentage of sunshine; high summer diurnal temperature range; frost danger

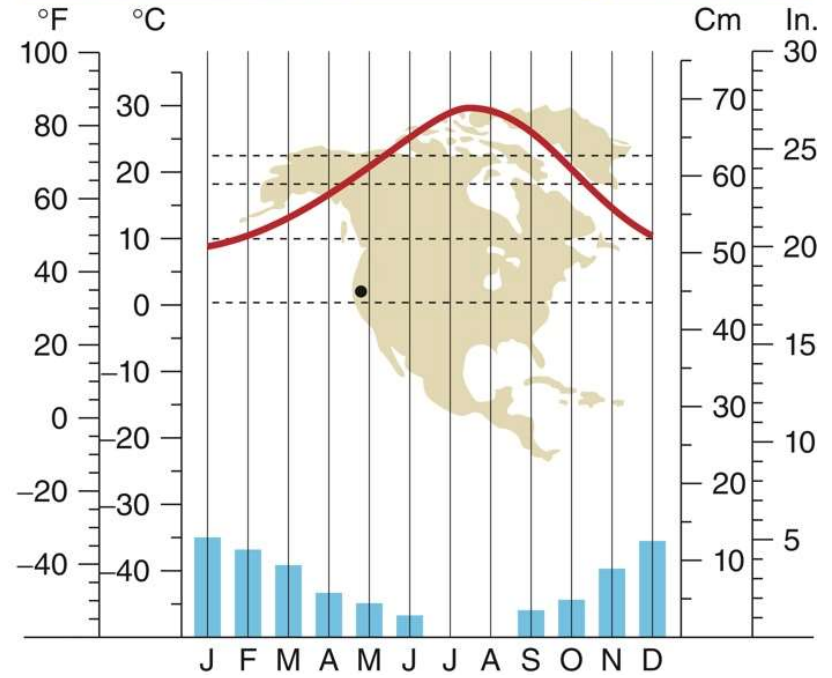
RELATED FEATURES

Sclerophyllous vegetation; low, tough brush (chaparral); scrub woodlands; varied soils, erosion in Old World regions; winter-sown grains; olives, grapes, vegetables, citrus, irrigation

San Francisco, Ca. Coastal Medit. (Csb)
 38°N 122°W
 Precip.: 56 cm (22.1 in.)
 Av. temp.: 13.6°C (56.5°F) Range: 6.5°C (12°F)



Red Bluff, Ca. Inland Medit. (Csa)
 40°N 122°W
 Precip.: 62 cm (24.3 in.)
 Av. temp.: 17°C (62.5°F) Range: 20°C (36°F)



In what way do these climographs differ? What causes the differences?

Mesothermal Climate Regions (cont'd.)

- Mediterranean
 - Warm, dry summers; mild, moist winters
 - Moderate-summer and hot-summer subtypes
 - Year-round fog: coastal locations
 - Rainy winter season
 - Special adaptations
 - Vegetation: sclerophyllous
 - Chaparral: low, scrubby bushes; western U.S.
 - Common tree species: needle-leaf pines
 - Why are the most productive areas lowlands?

Mesothermal Climate Regions (cont'd.)

NAME AND DESCRIPTION	CONTROLLING FACTORS	GEOGRAPHIC DISTRIBUTION
Humid Subtropical		
Warmest month above 10°C (50°F); coldest month between 18°C (64.4°F) and 0°C (32°F); hot summers; generally year-round precipitation, winter drought (Asia)	East coast location between 20° and 40°N and S latitudes; humid onshore (monsoonal) air movement in summer, cyclonic storms in winter	Southeastern South America; coastal southeast South Africa and eastern Australia; eastern Asia from northern India through south China to southern Japan

Mesothermal Climate Regions (cont'd.)

Humid Subtropical

DISTINGUISHING CHARACTERISTICS

High humidity; summers like humid tropics; frost with polar air masses in winter; precipitation 63–250 cm (25–100 in.), decreasing inland; monsoon influence in Asia

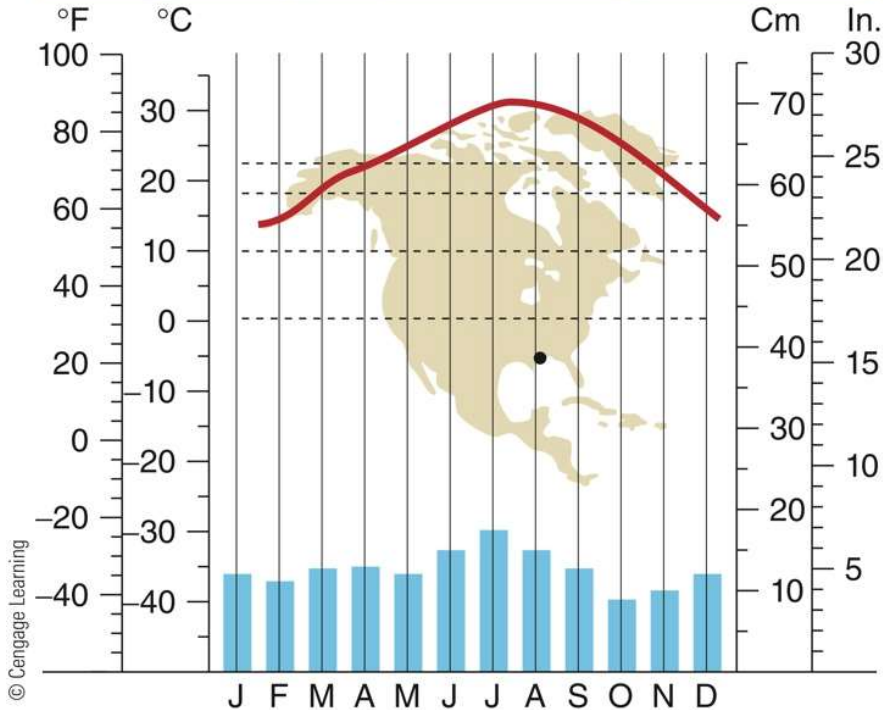
RELATED FEATURES

Mixed forests, some grasslands, pines in sandy areas, soils productive with regular fertilization; rice, wheat, corn, cotton, tobacco, sugarcane, citrus

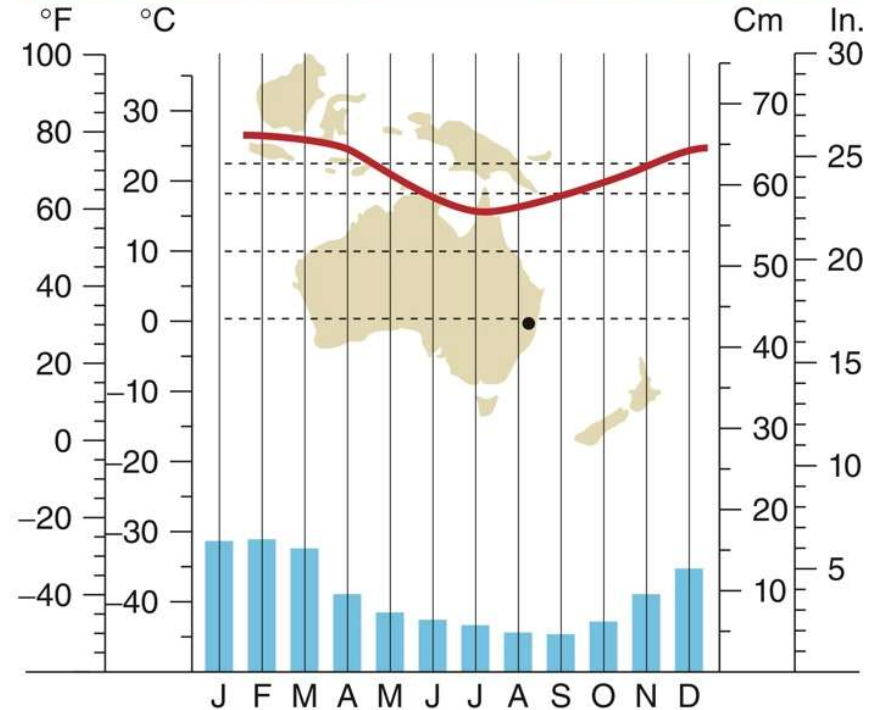
Mesothermal Climate Regions (cont'd.)

- Humid subtropical
 - Extends inland from continental east coasts between 15° and 20° and 40°N and S latitude
 - Mild winters; hot summers
 - Wet year-round
 - Winter: cyclonic storms
 - Summer: convectional activity and tropical storms
 - Frost is uncommon
 - High humidity

New Orleans, La. Humid Subt. (Cfa)
 30°N 90°W
 Precip.: 146 cm (57.4 in.)
 Av. temp.: 21°C (69.5°F) Range: 16°C (28.5°F)



Brisbane, Australia Humid Subt. (Cfa)
 27°S 153°E
 Precip.: 113.5 cm (44.7 in.)
 Av. temp.: 20.5°C (69°F) Range: 10°C (18.5°F)



What hemispheric characteristics are shown in these graphs?

Mesothermal Climate Regions (cont'd.)

- Humid subtropical: productive climate
 - Abundant vegetation
 - Forests
 - Diverse wildlife: animals, birds, swamp species
 - Agricultural value: grasslands and subsistence crops
 - Commercial importance: lumber and resinous products
 - Livestock



How has the physical landscape of central Florida been changed by human occupancy?

© Robert Essel NYC/CORBIS



Why is rice a preferred crop in Japan?

Mesothermal Climate Regions (cont'd.)

NAME AND DESCRIPTION

CONTROLLING FACTORS

GEOGRAPHIC DISTRIBUTION

Marine West Coast

Warmest month above 10°C (50°F); coldest month between 18°C (64.4°F) and 0°C (32°F), year-round precipitation; mild to cool summers

West coast location under the year-round influence of the westerlies; warm ocean currents along some coasts

Coastal Oregon, Washington, British Columbia, and southern Alaska; southern Chile; interior South Africa; southeast Australia and New Zealand; northwest Europe

Mesothermal Climate Regions (cont'd.)

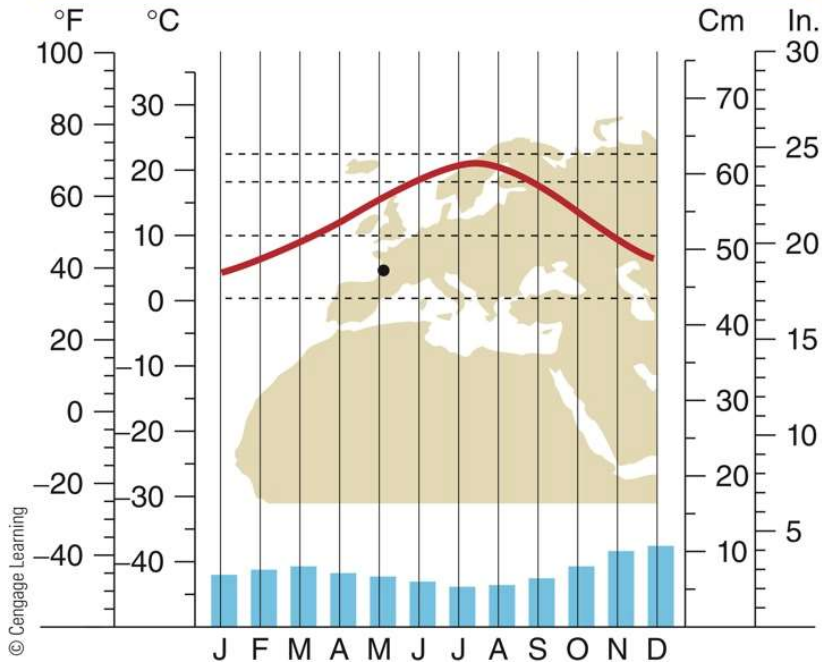
Marine West Coast

DISTINGUISHING CHARACTERISTICS	RELATED FEATURES
Mild winters, mild summers, low annual temperature range; heavy cloud cover, high humidity; frequent cyclonic storms, with prolonged rain, drizzle or fog; 3- to 4-month frost period	Naturally forested, green year-round; soils require fertilization; root crops, deciduous fruits, winter wheat, rye, pasture and grazing animals; coastal fisheries

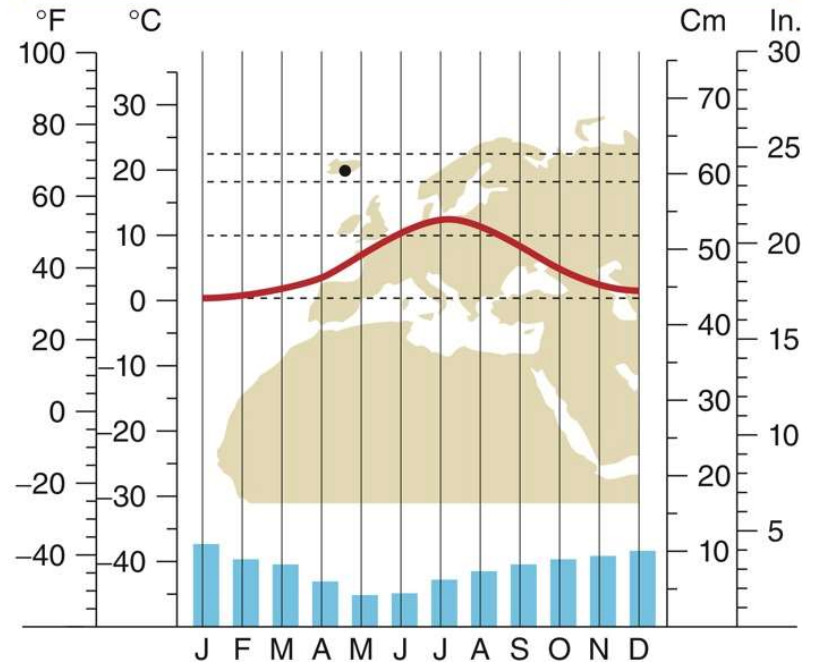
Mesothermal Climate Regions (cont'd.)

- Marine west coast
 - Proximity to the sea and prevailing onshore winds
 - Known as the temperate oceanic climate
 - Middle-latitude (between 40° and 65°)
 - Year-round precipitation
 - Continuously influenced by the westerlies
 - Mild to cool summers

Bordeaux, France
 45°N
 Precip.: 83 cm (32.7 in.)
 Av. temp.: 12.5°C (55°F)
 Range: 15°C (27.5°F)
 Marine W.C. (Cfb)
 1°W

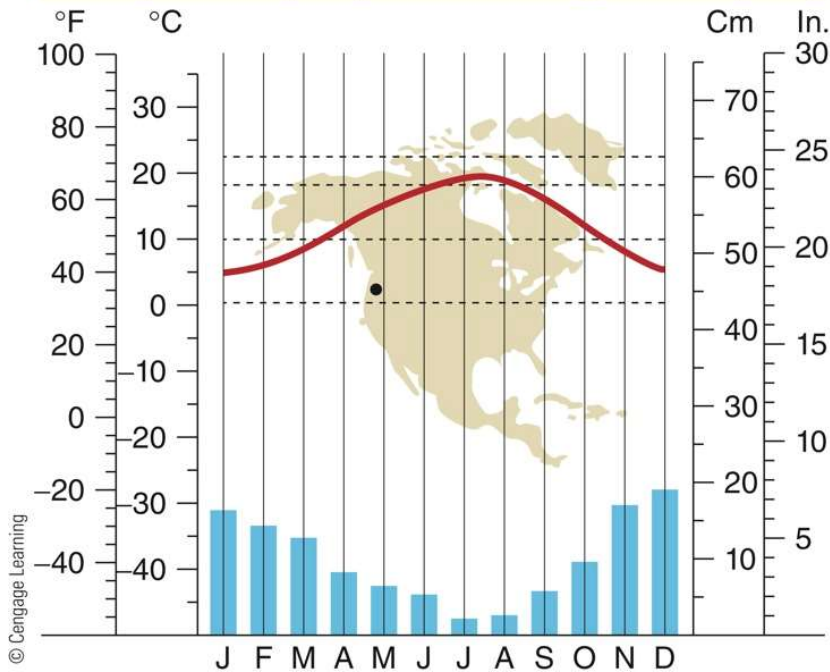


Reykjavik, Iceland
 64°N
 Precip.: 86.1 cm (33.9 in.)
 Av. temp.: 5.2°C (41.5°F)
 Range: 11.5°C (21°F)
 Marine W.C. (Cfc)
 23°W

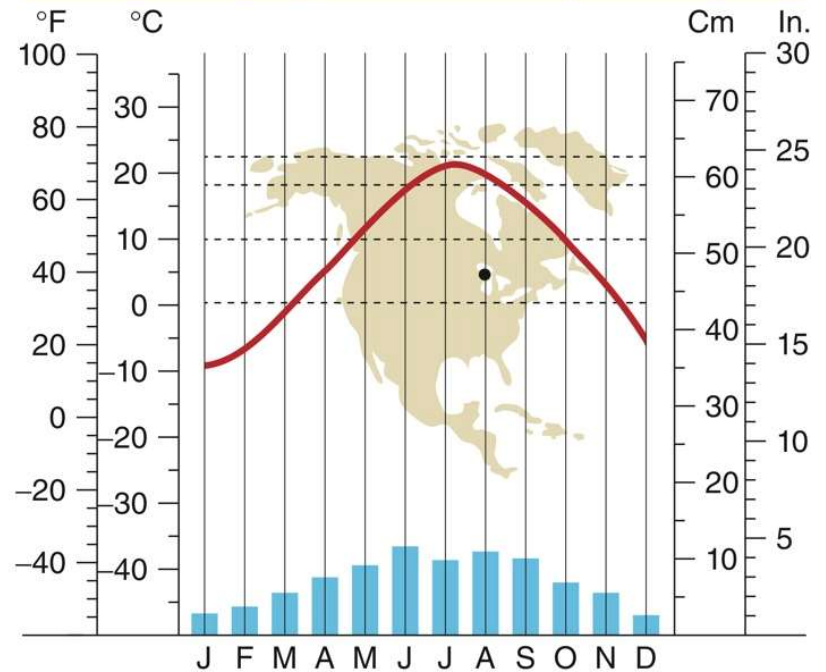


What wind or pressure system would influence the precipitation decrease during the summer?

Portland, Oregon Marine W.C. (Cfb)
 46°N Precip.: 106 cm (41.8 in.) 122°W
 Av. temp.: 11.5°C (53°F) Range: 15.5°C (28°F)



Eau Claire, Wisconsin Humid Cont. M.S. (Dfb)
 45°N Precip.: 76 cm (30 in.) 92°W
 Av. temp.: 8°C (46°F) Range: 31.5°C (57°F)



How do you explain these differences?

Mesothermal Climate Regions (cont'd.)

- Marine west coast
 - What examples provide evidence of oceanic influences?
 - Clouds and precipitation
 - Advection fog
 - Cyclonic storms and frontal systems
 - Precipitation: impact of local topography, e.g., fjord coasts vs. lowlands



Courtesy of Richard Earl

In what other areas of the world are fjords common?

Mesothermal Climate Regions (cont'd.)

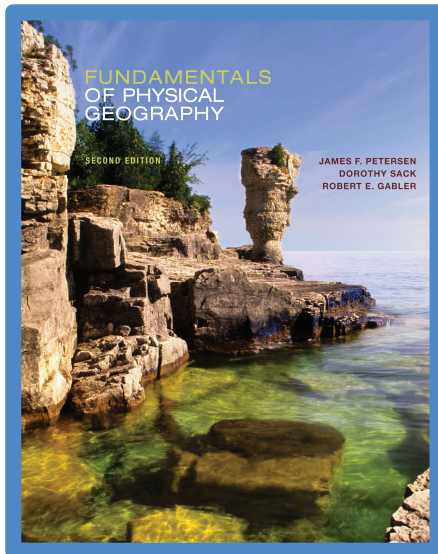
- Marine west coast
 - Resource potential
 - Agriculture: many different crops
 - Needle-leaf evergreen trees
 - Conifers

Fundamentals of Physical Geography 2e

Climate Classification: Tropical, Arid, and Mesothermal Climate Regions

7

<end of chapter>



- ⌘ Peterson
- ⌘ Sack
- ⌘ Gabler