BIOLOGICAL COMMUNITIES: THE BIOME CONCEPT

OUTLINE

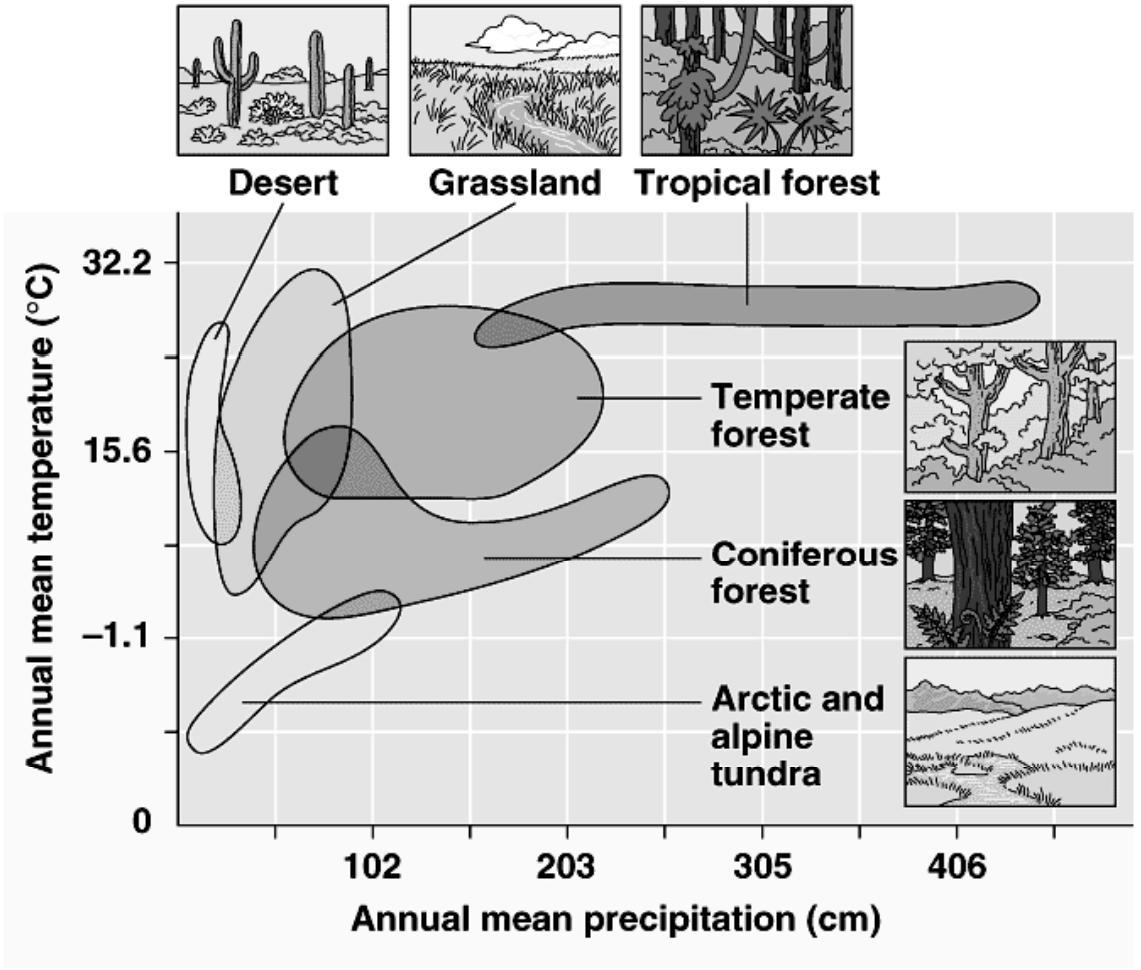
- Temperature, Atmospheric Circulation, and Precipitation
- Climate Diagrams
- Soil Horizons
- Terrestrial Biomes

OBJECTIVES

- What are large-scale distributions of plant life forms?
- aquatic
- terrestrial
- What is the proximal cause of their distribution?
- How does climate differ among biomes?
- Whittaker's scheme
- Walter's climagrams
- Do biomes and plant form and function converge in regions with similar climate?

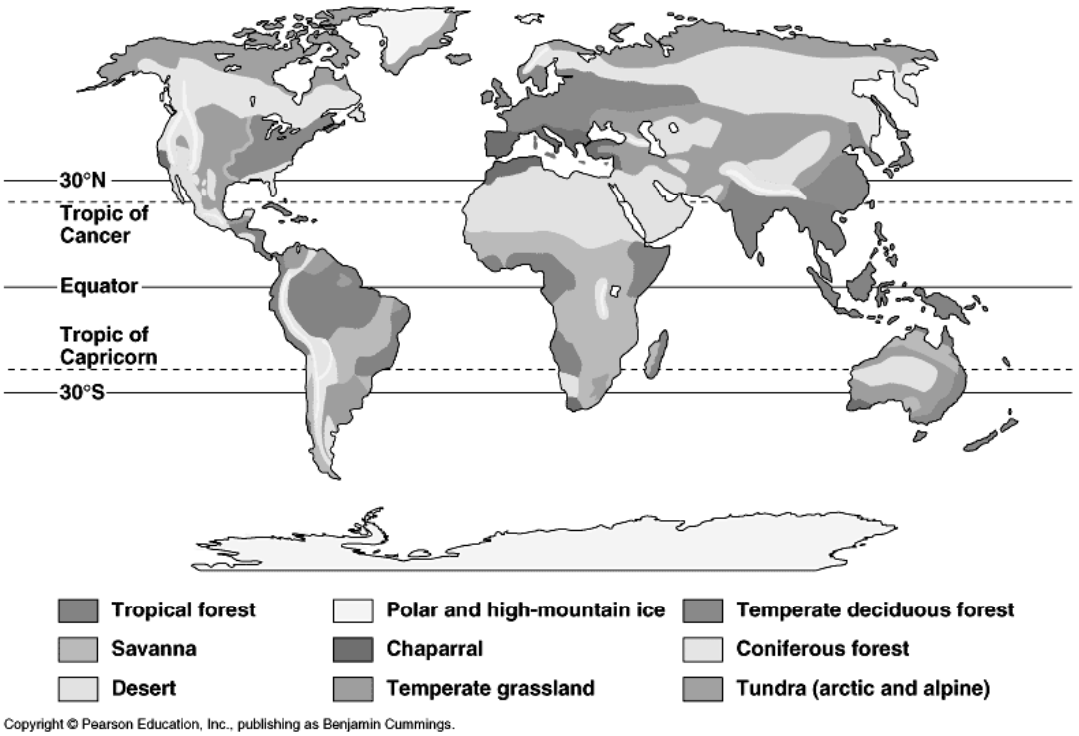
BIOMES

- Regions of the earth that are similar in organism type although the particular species differ
- Driven largely by climate – temp., water, seasonality
- Other factors – soil, topography

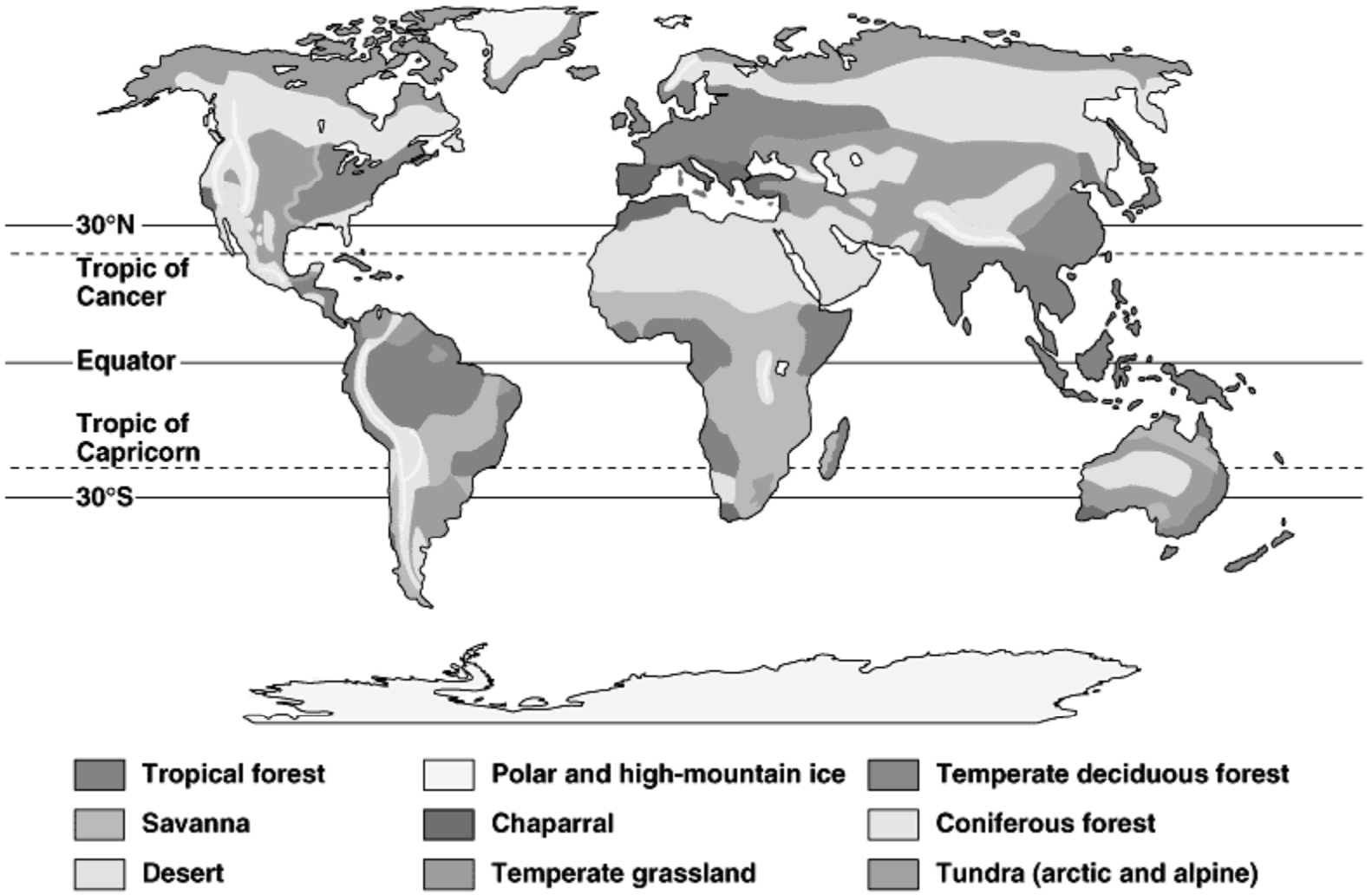


WORLD BIOMES – INTERACTIONS AMONG FACTORS

- Latitude
- Seasons
- Atmosphere and ocean circulation patterns
- Mountains



WORLD BIOMES

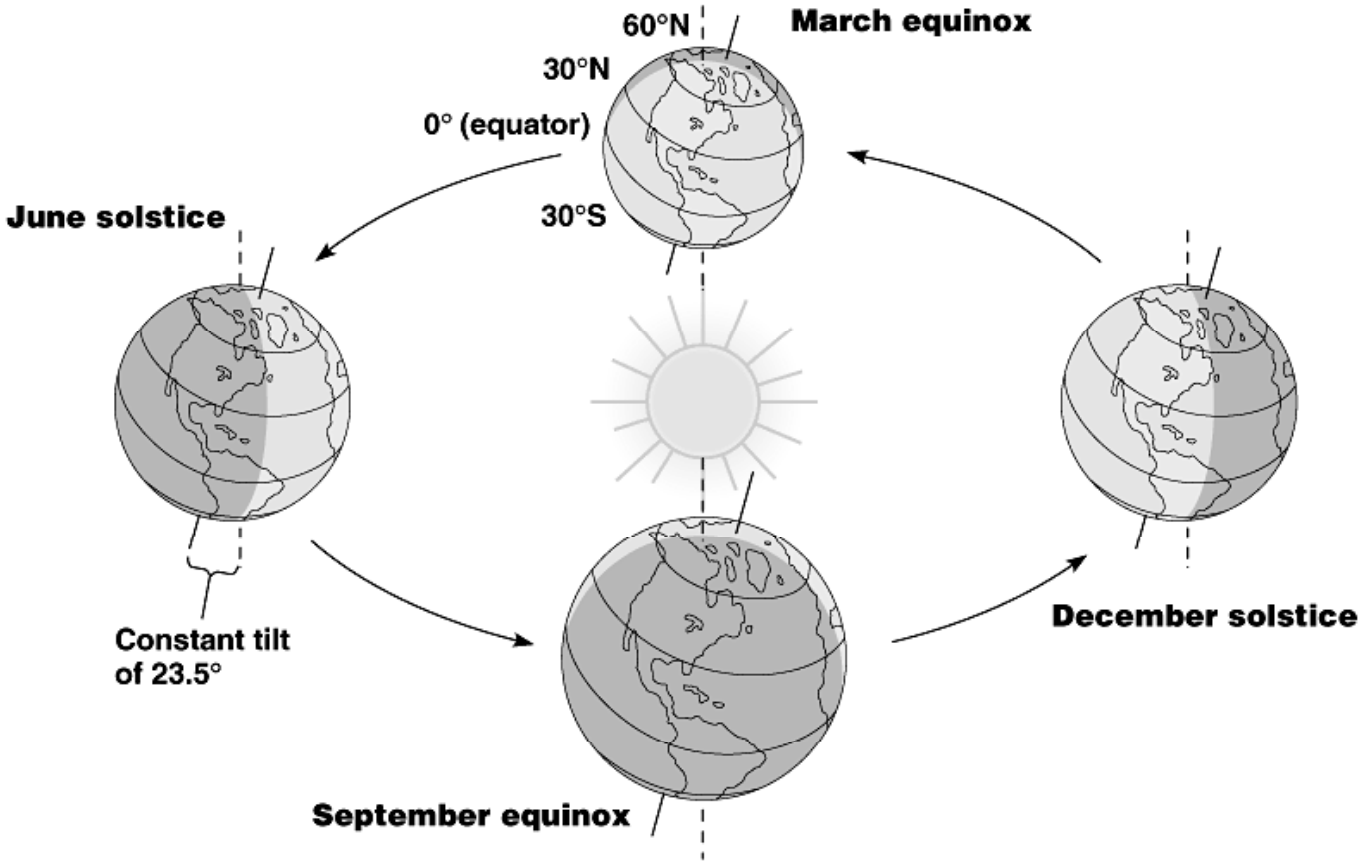


WHAT CAUSES THE SEASONS?

- ✖ It can NOT be the distance of the earth from the sun since the seasons are opposite in the northern and southern hemispheres.

TEMPERATURE

- seasons are caused by the tilt of the earth as it revolves about the sun



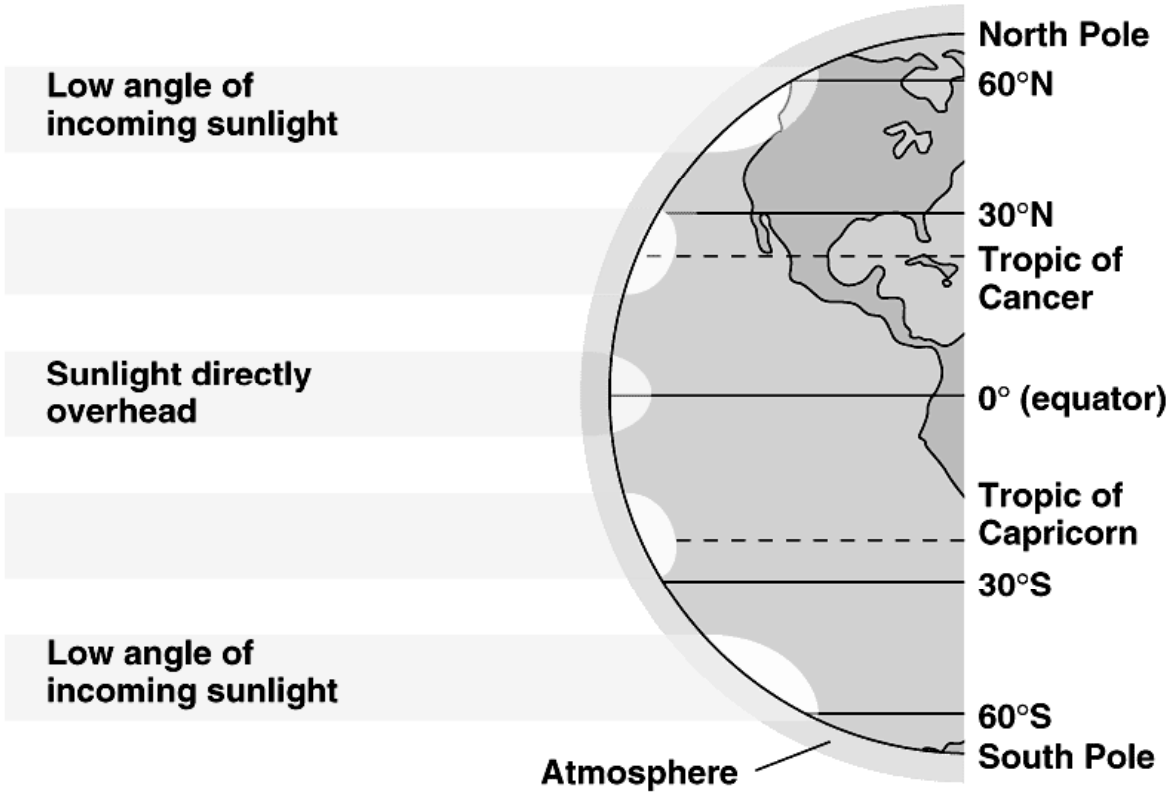
WHAT CAUSES THE SEASONS?

We know:

- Earth has elliptical orbit
- Earth is tilted on axis (23.5^{o})
- Seasons are opposite in northern and southern latitudes

TEMPERATURE

- Temperature is partly determined by the amount of solar radiation hitting an area
- Depends on latitude, angle of incidence

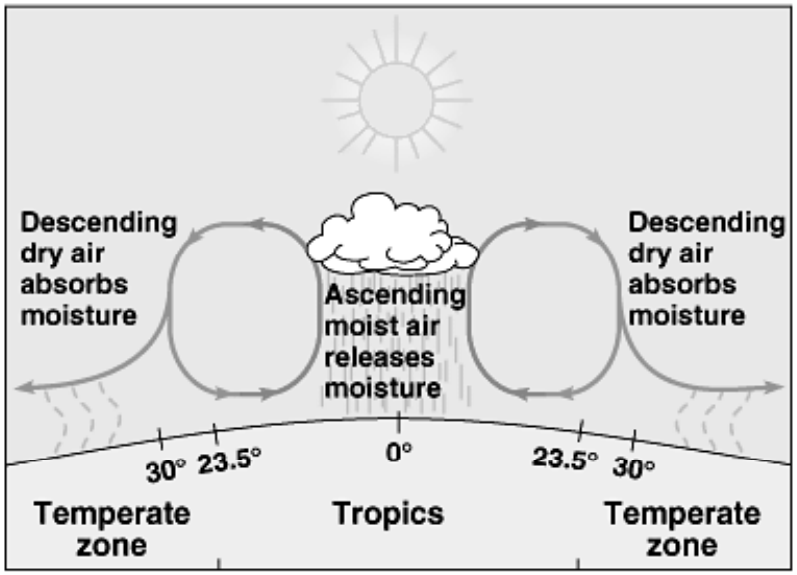


TEMPERATURE, ATMOSPHERIC CIRCULATION, AND PRECIPITATION

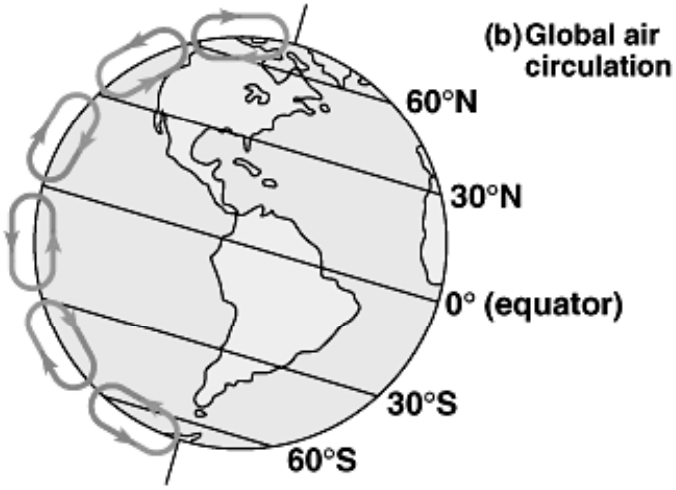
- Spherical shape and tilt of earth's axis cause uneven heating of earth's surface.
  - Drives air circulation patterns and consequently precipitation patterns.
    - Warm, moist air rises.
    - Cools, condenses, and falls as rain.
    - Cooler, dry air falls back to surface.
      - Rainforests found near equator.
      - Major deserts found near 30^{o} N / S.

SOLAR DRIVEN AIR CIRCULATION

- Warming air absorbs water and cooling releases water, causing more rain at some latitudes

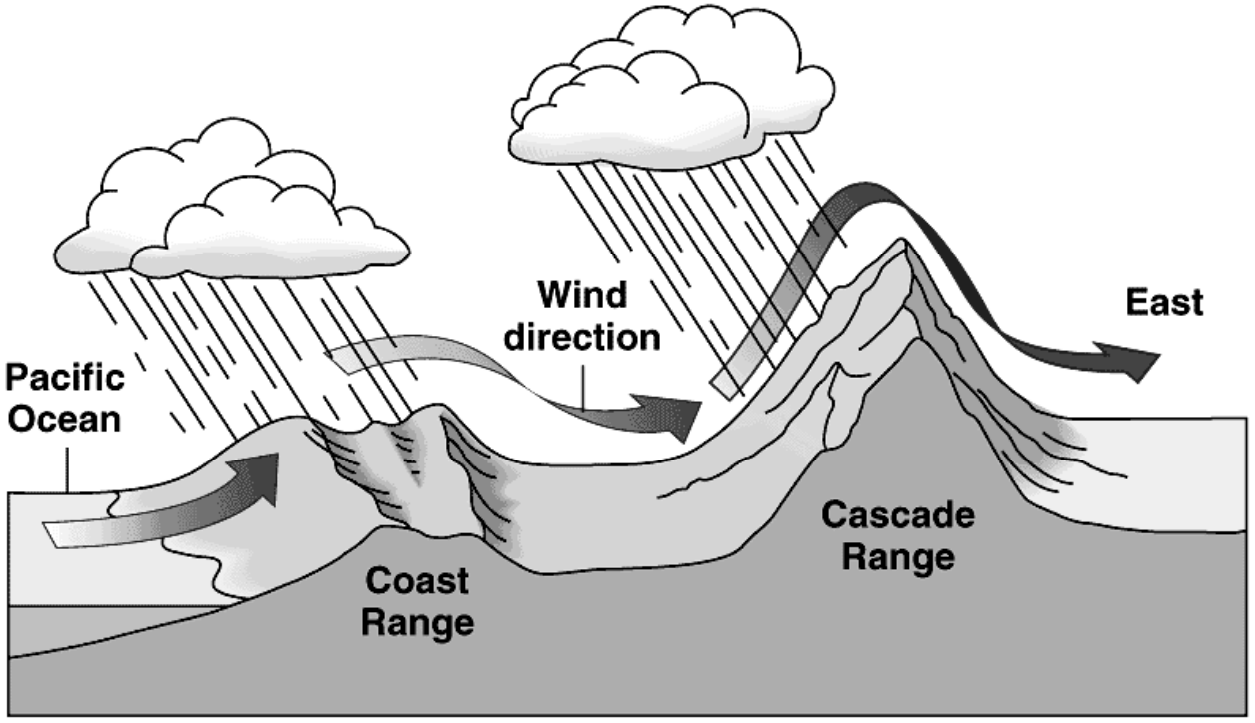


(a) Air circulation and precipitation near the equator



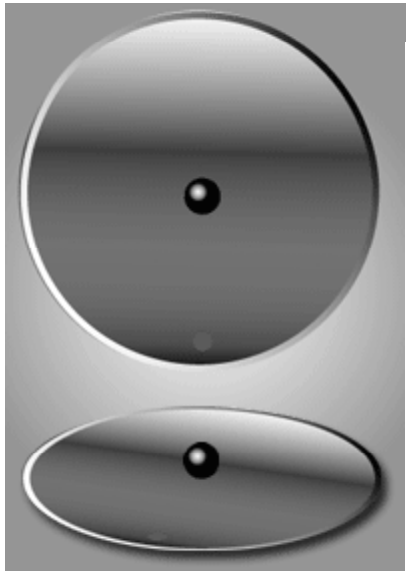
RAINSHADOWS

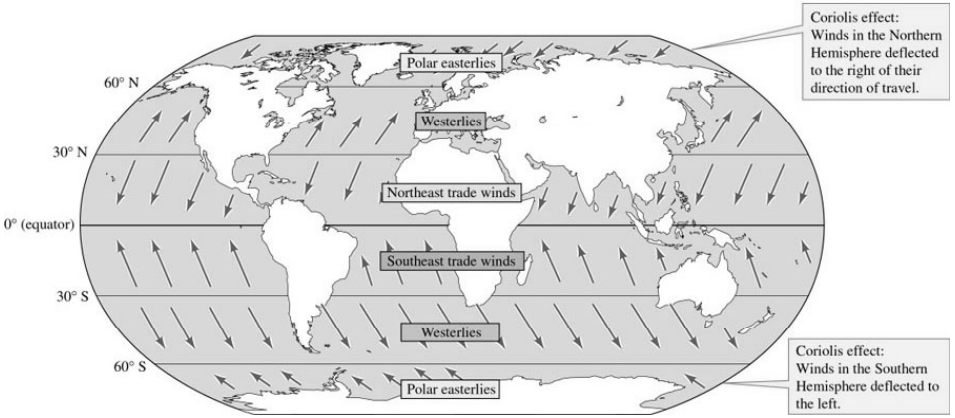
- Wind patterns interact with mountains to cause increased rain on windward sides, rain shadows on lee sides.



TEMPERATURE, ATMOSPHERIC CIRCULATION, AND PRECIPITATION

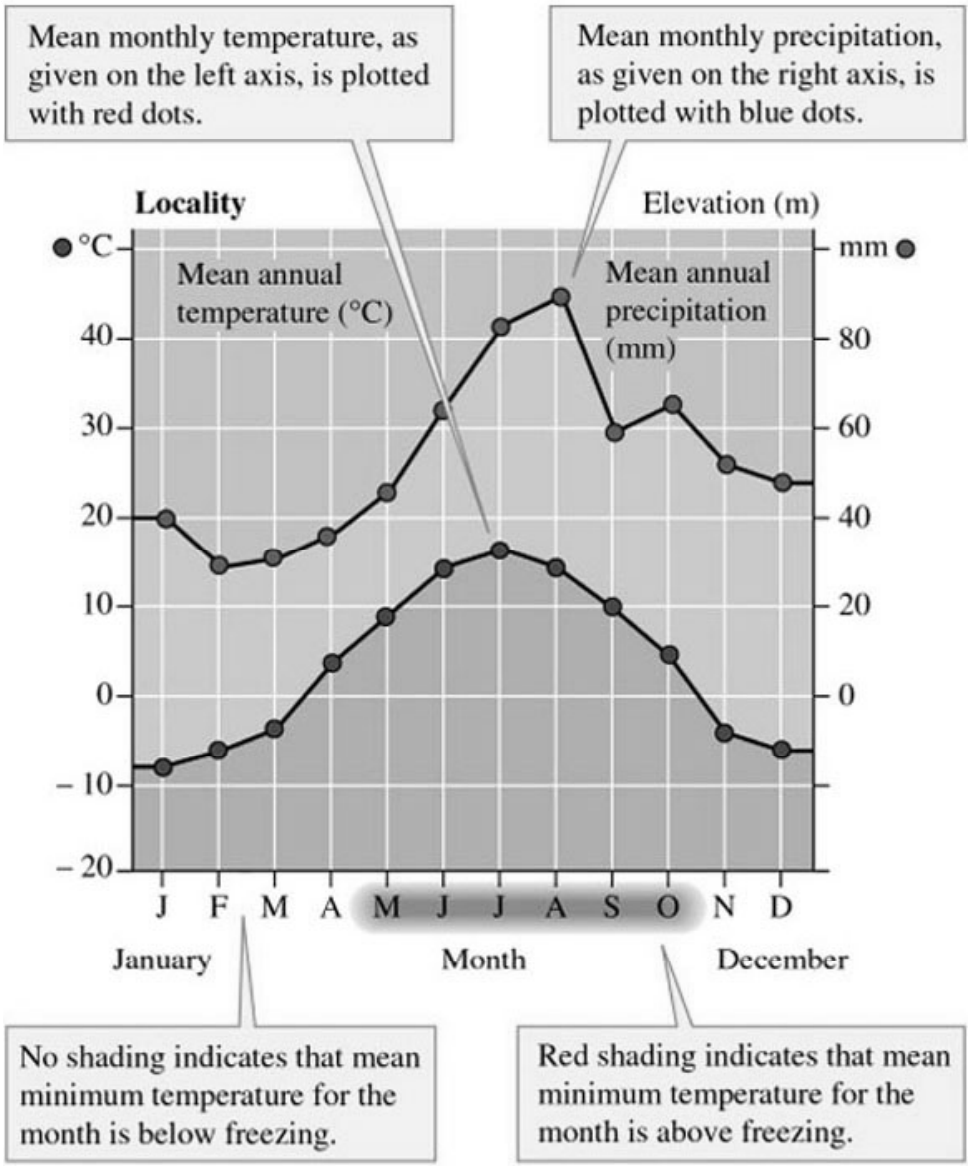
- Coriolis effect causes apparent deflection of winds clockwise in the N hemisphere and counterclockwise in the S hemisphere.





CLIMATE DIAGRAMS

Developed by Heinrich Walter



Adequate plant growth can occur when precipitation line is above temperature

SOIL : FOUNDATION OF TERRESTRIAL BIOMES

- Soil is a complex mixture of living and non-living material.
  - Classification based on vertical layering (soil horizons).
    - Profile provides a snapshot of soil structure in a constant state of flux.

SOIL HORIZONS

- O horizon: Organic Layer freshly fallen organic material - most superficial layer.
- A horizon: Mixture of minerals, clay, silt and sand.
- B horizon: Clay, humus, and other materials leached from A horizon - often contains plant roots.
- C horizon: Weathered parent material.

SOIL PROFILE

Soil horizons

O — Organic horizon. Upper layer contains loose, somewhat fragmented plant litter. Litter in lower layer is highly fragmented.

A — Mineral soil mixed with some organic matter. Clay, iron, aluminum, silicates, and soluble organic matter are gradually leached from A horizon.

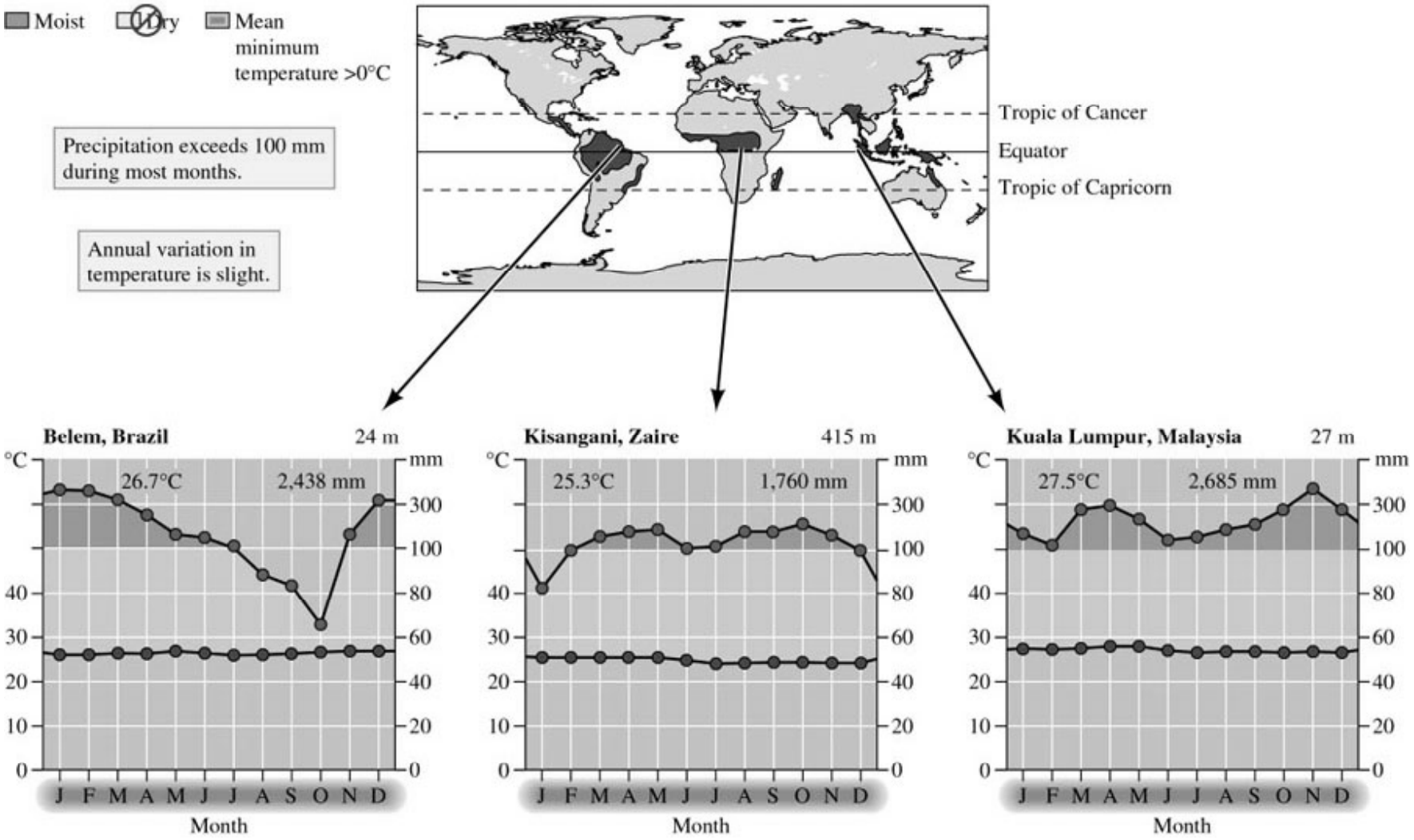
B — Depositional horizon. Materials leached from A horizon are deposited in B horizon. Deposits may form distinct banding patterns.

C — Weathered parent material. The C horizon may include many rock fragments. It often lies on bedrock.

TROPICAL RAINFORESTS

- Most occur within 10^{o} latitude of equator.
- Little temperature variation between months.
- Annual rainfall of 2,000 - 4,000 mm relatively evenly distributed.
  - + Quickly leaches soil nutrients.
  - + Mycorrhizae help gather nutrients.
- Organisms add vertical dimension.
- Harbor staple foods and medicines for world's human populations - increasingly exploited.

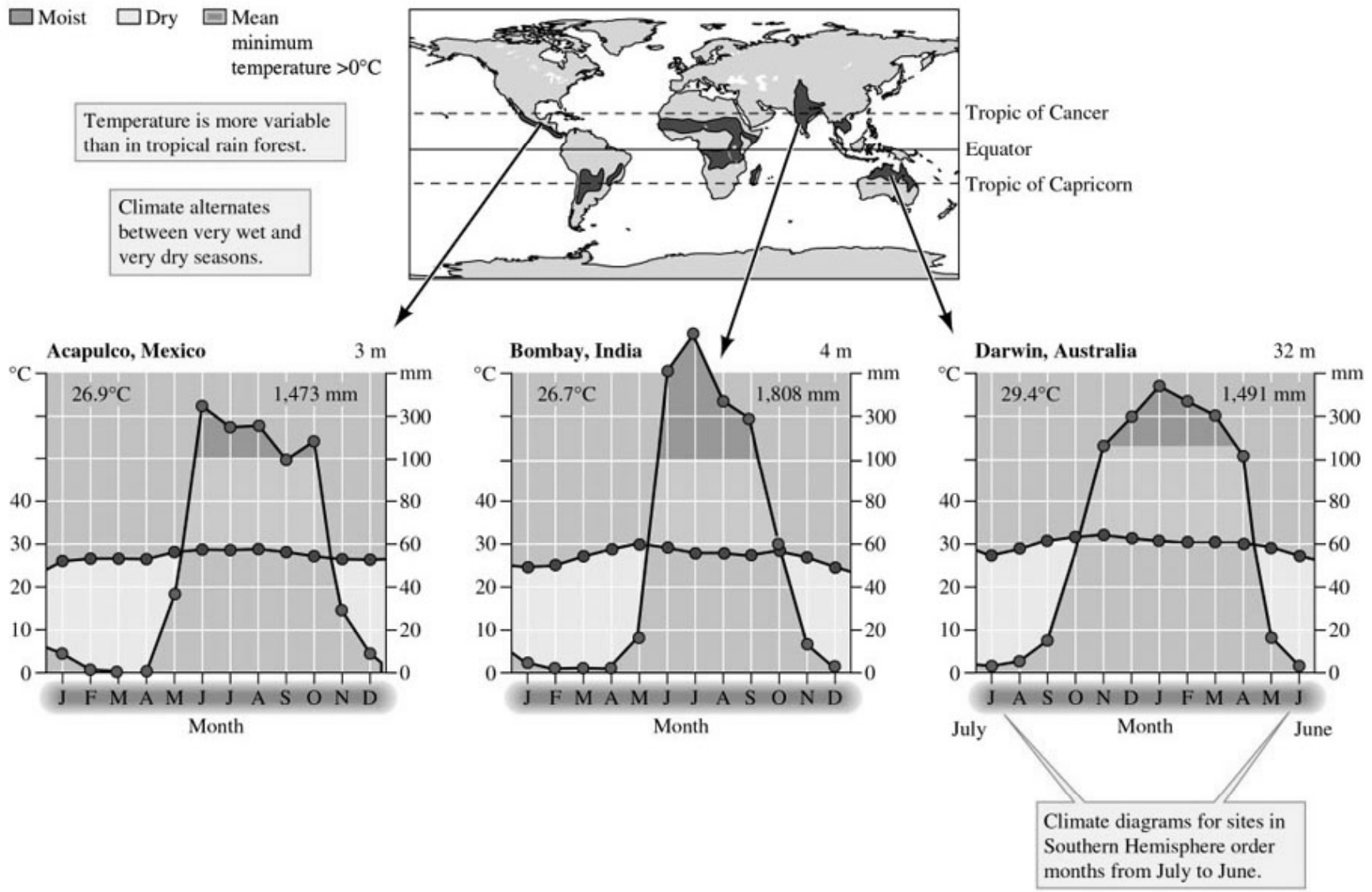
TROPICAL RAINFORESTS



TROPICAL DRY FOREST

- Usually located between 10^{o} - 25^{o} latitude.
- Climate more seasonal than tropical rainforest.
- Soils generally richer in nutrients, but vulnerable to erosion.
- Shares many animal and plant species with tropical rainforests.
- Heavily settled by humans with extensive clearing for agriculture.

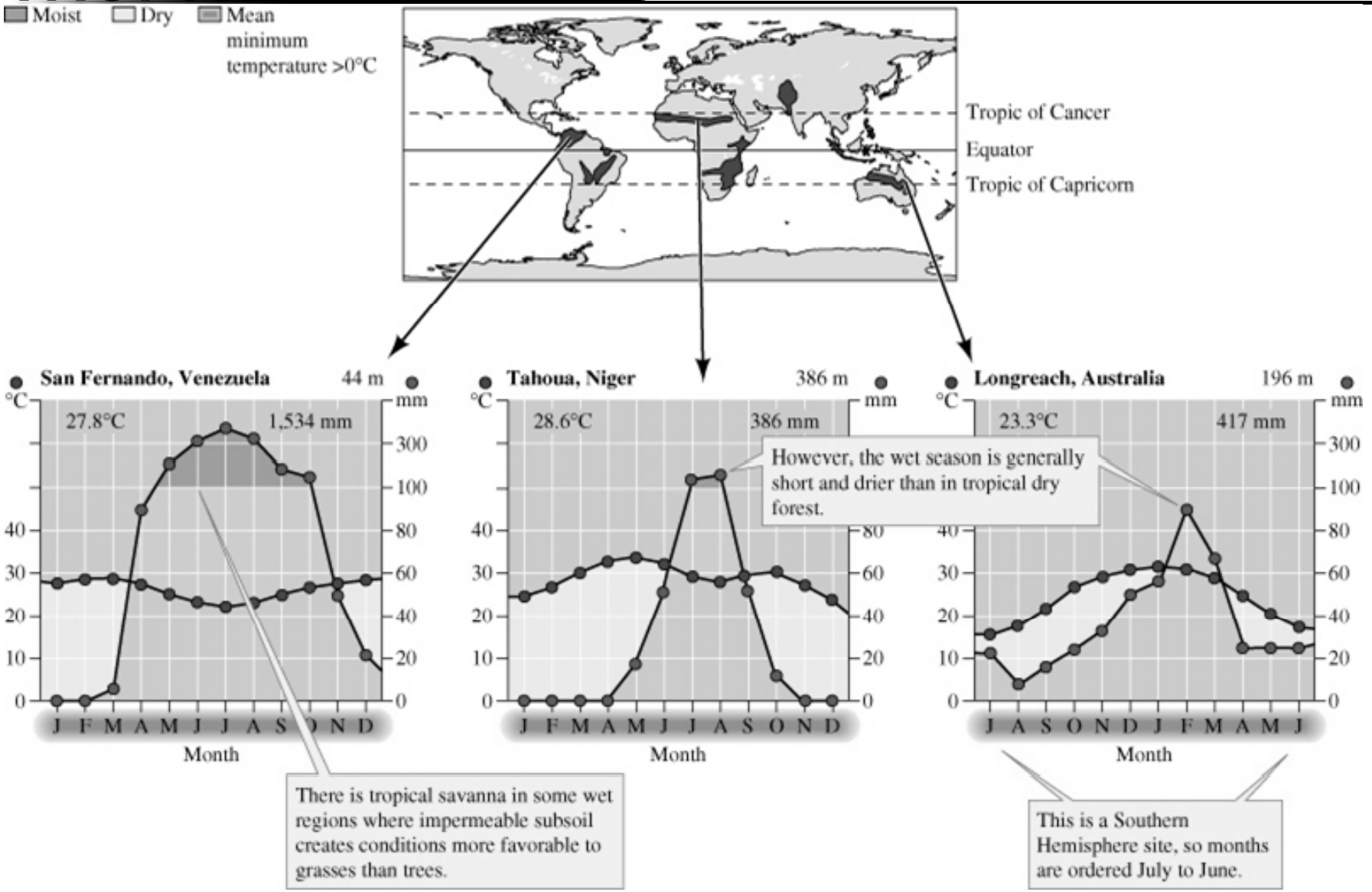
TROPICAL DRY FOREST



TROPICAL SAVANNA

- Most occur north and south of tropical dry forests within 10^{o} - 20^{o} of the equator.
- Climate alternates between wet / dry seasons.
  - Drought associated with dry season leads to lightning-caused wildfires.
- Soils have low water permeability.
  - Saturated soils keeps trees out.
- Landscape is more two-dimensional with increasing pressure to produce livestock.

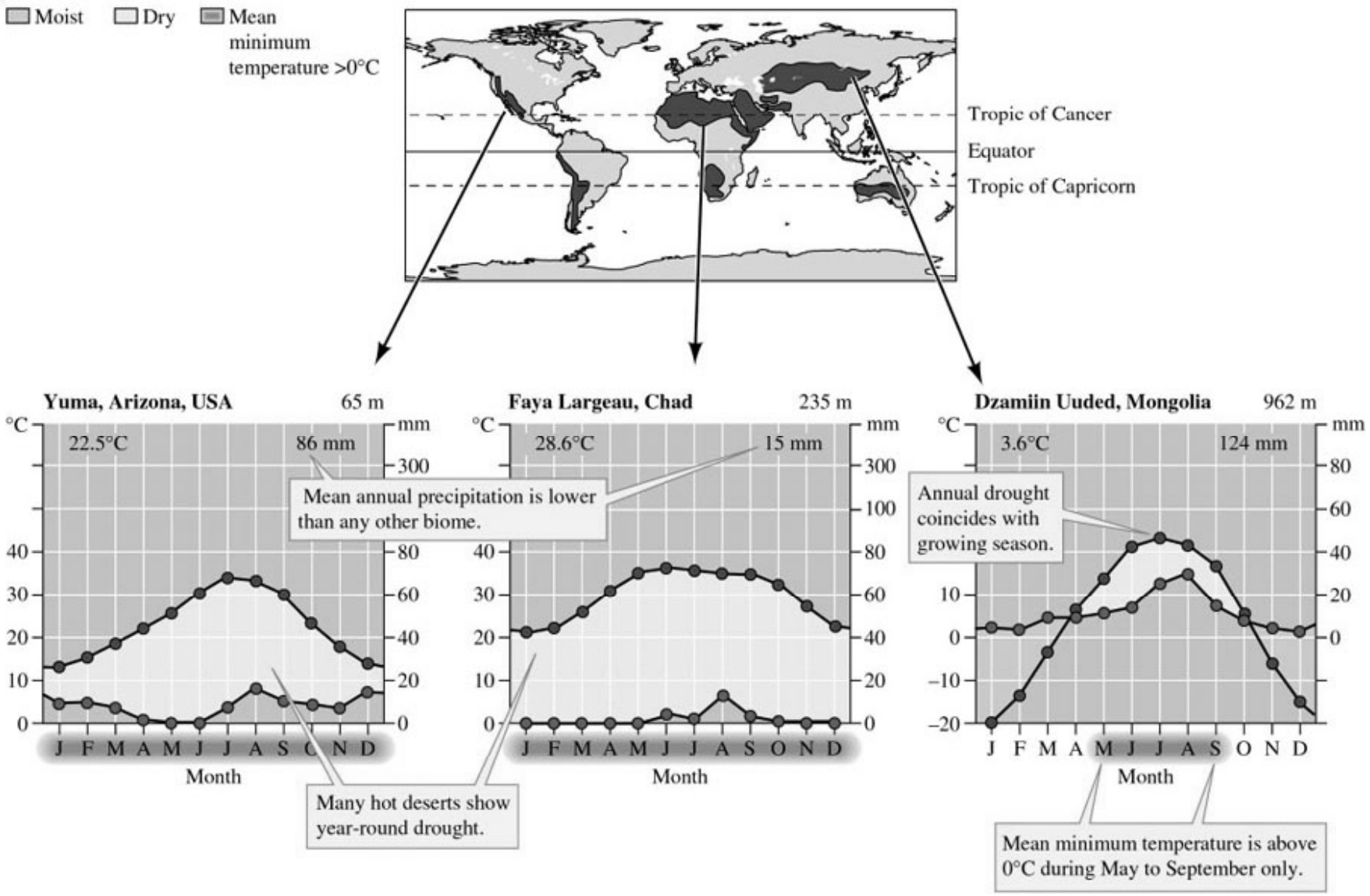
TROPICAL SAVANNA



DESERT

- Major bands at 30° N and 30° S latitude.
  - + Occupy about 20% of earth's land surface.
- Water loss usually exceeds precipitation.
- Soil usually extremely low in organic matter.
- Plant cover ranges from sparse to absent.
- Animal abundance low, but biodiversity may be high.
  - + Strong behavioral adaptations.
- Human intrusion increasing.

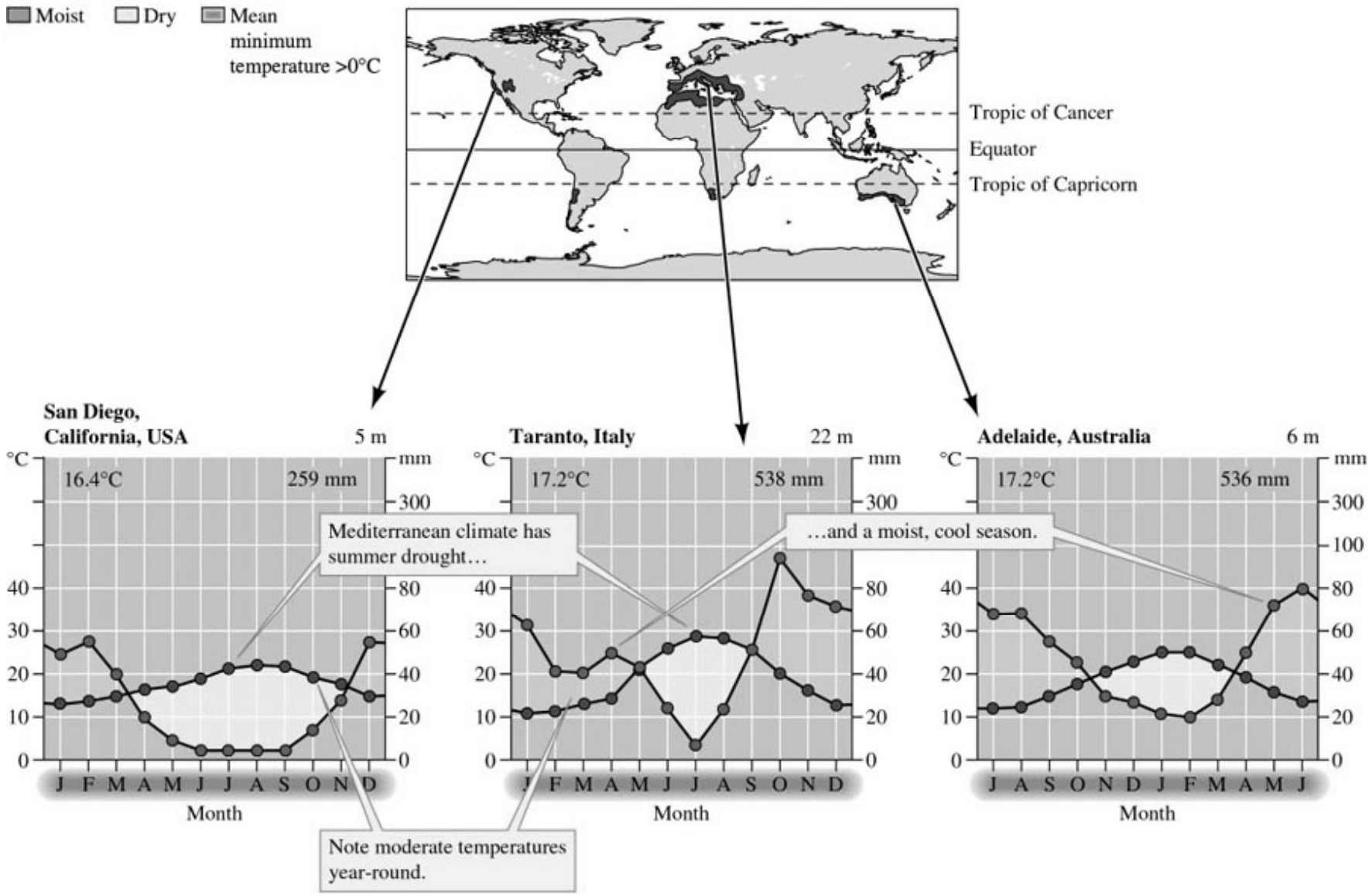
DESERT


Moist
Dry
Mean minimum temperature >0°C
Tropic of Cancer
Equator
Tropic of Capricorn
Yuma, Arizona, USA
65 m
22.5°C
86 mm
Mean annual precipitation is lower than any other biome.
Faya Largeau, Chad
235 m
28.6°C
15 mm
Dzamiin Uuded, Mongolia
962 m
3.6°C
124 mm
Annual drought coincides with growing season.
°C
mm
J F M A M J J A S O N D
Month
Many hot deserts show year-round drought.
Mean minimum temperature is above 0°C during May to September only.

MEDITERRANEAN WOODLAND AND SHRUBLAND

- Occur in all continents except Antarctica.
- Climate cool and moist in fall, winter, and spring, but can be hot and dry in summer.
- Fragile soils with moderate fertility.
- Trees and shrubs typically evergreen.
- Fire-resistant plants due to fire regime.
- Long history of human intrusion.
  - Cleared for agriculture.

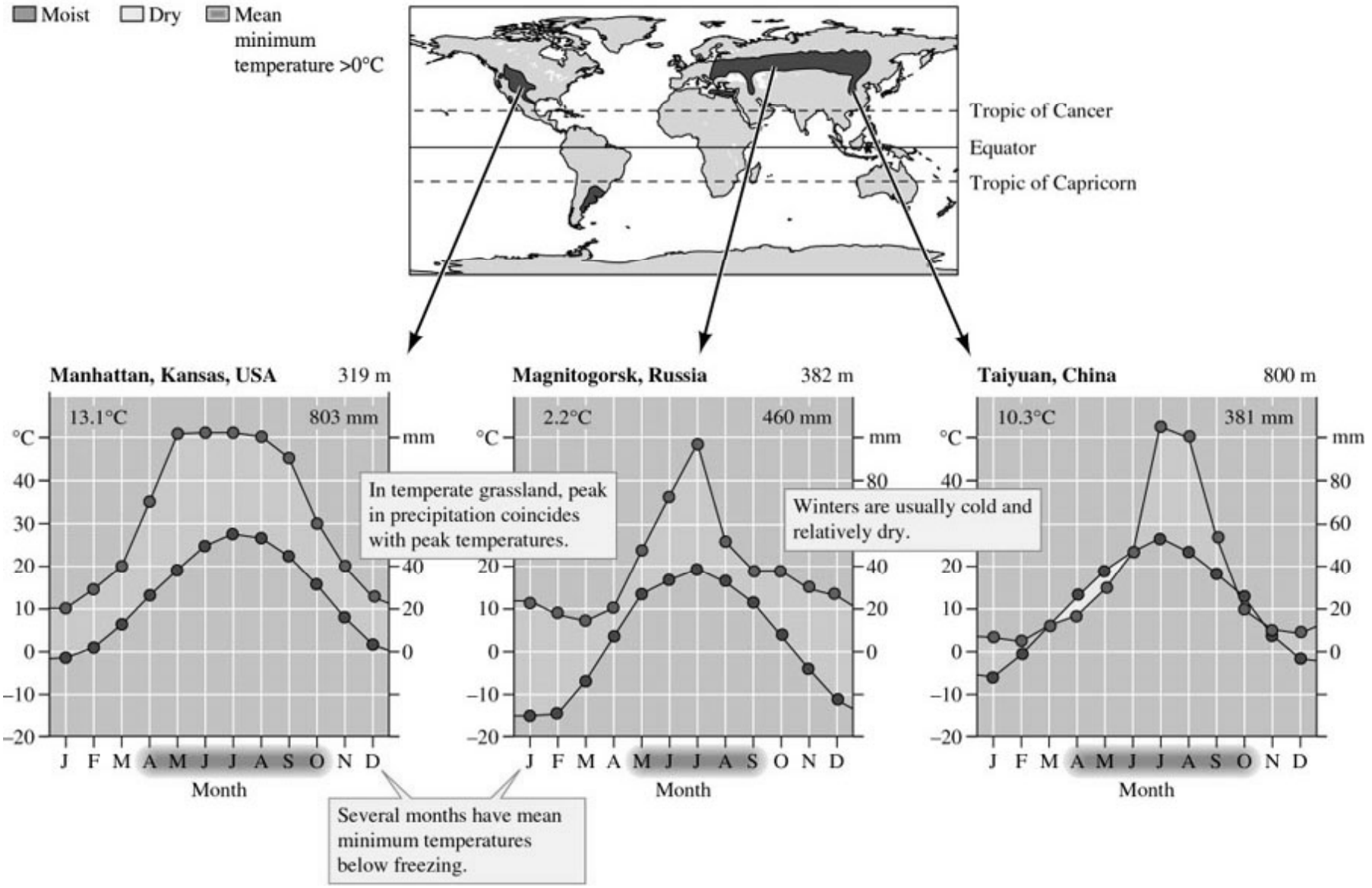
MEDITERRANEAN WOODLAND AND



TEMPERATE GRASSLAND

- Extremely widespread distribution.
- Annual rainfall 300 - 1,000 mm.
- Experience periodic droughts.
- Soils tend extremely nutrient rich and deep.
- Thoroughly dominated by herbaceous vegetation.
- Large roaming ungulates.
  - Bison vs. cattle

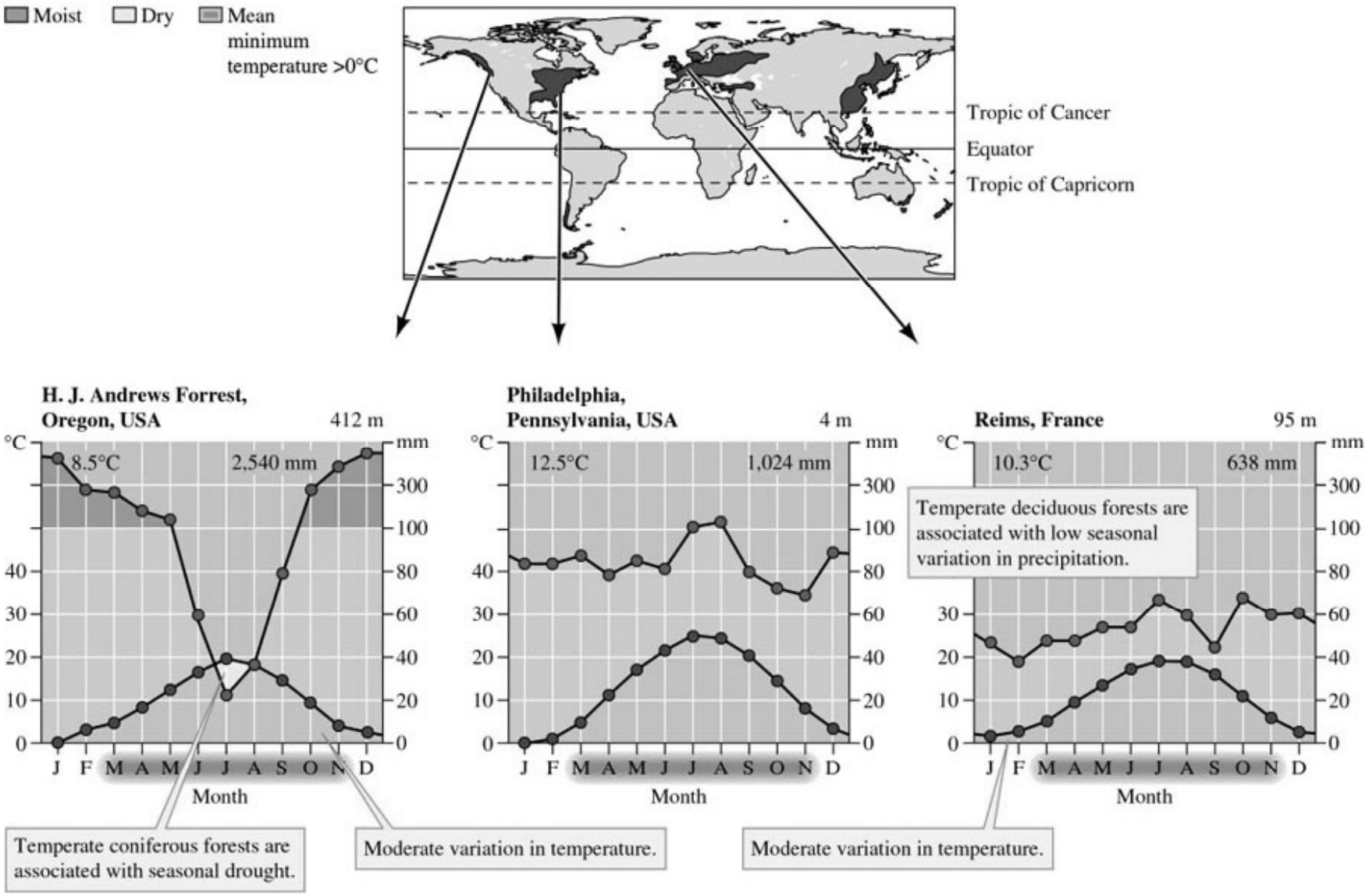
TEMPERATE GRASSLAND



TEMPERATE FOREST (OLD GROWTH)

- Majority lie between 40^{o} and 50^{o} latitude.
- Rainfall averages 650 - 3,000 mm.
- Fertile soils
  - Long growing seasons dominated by deciduous plants.
  - Short growing seasons dominated by conifers.
- Biomass production can be very high.
- Many major human population centers.

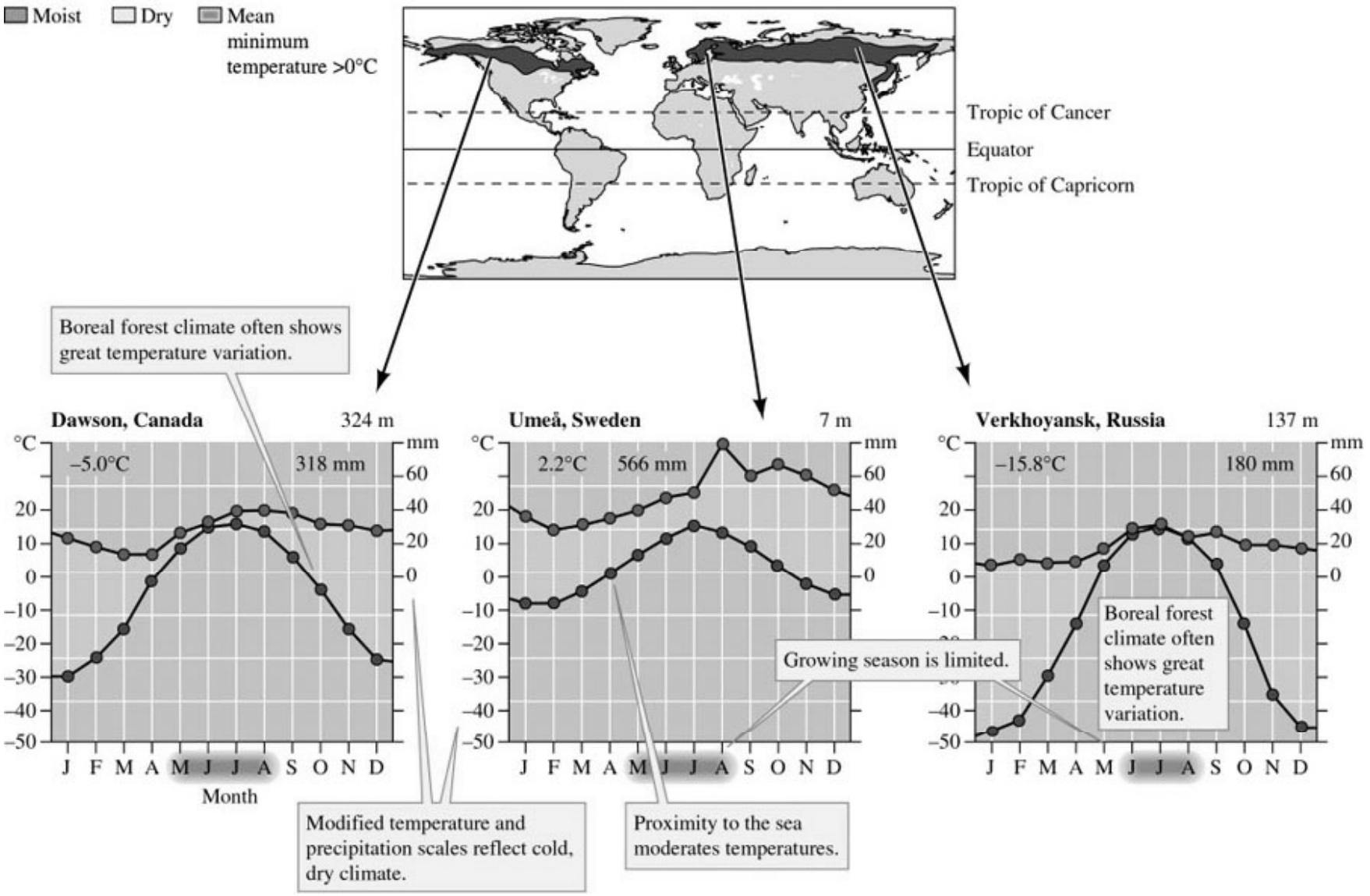
TEMPERATE FOREST (OLD GROWTH)



BOREAL FOREST (TAIGA)

- Confined to Northern Hemisphere.
  - Covers 11% of earth's land area.
- Thin, acidic soils low in fertility.
- Generally dominated by evergreen conifers.
- Relatively high animal density.
- Historically, low levels of human intrusion.

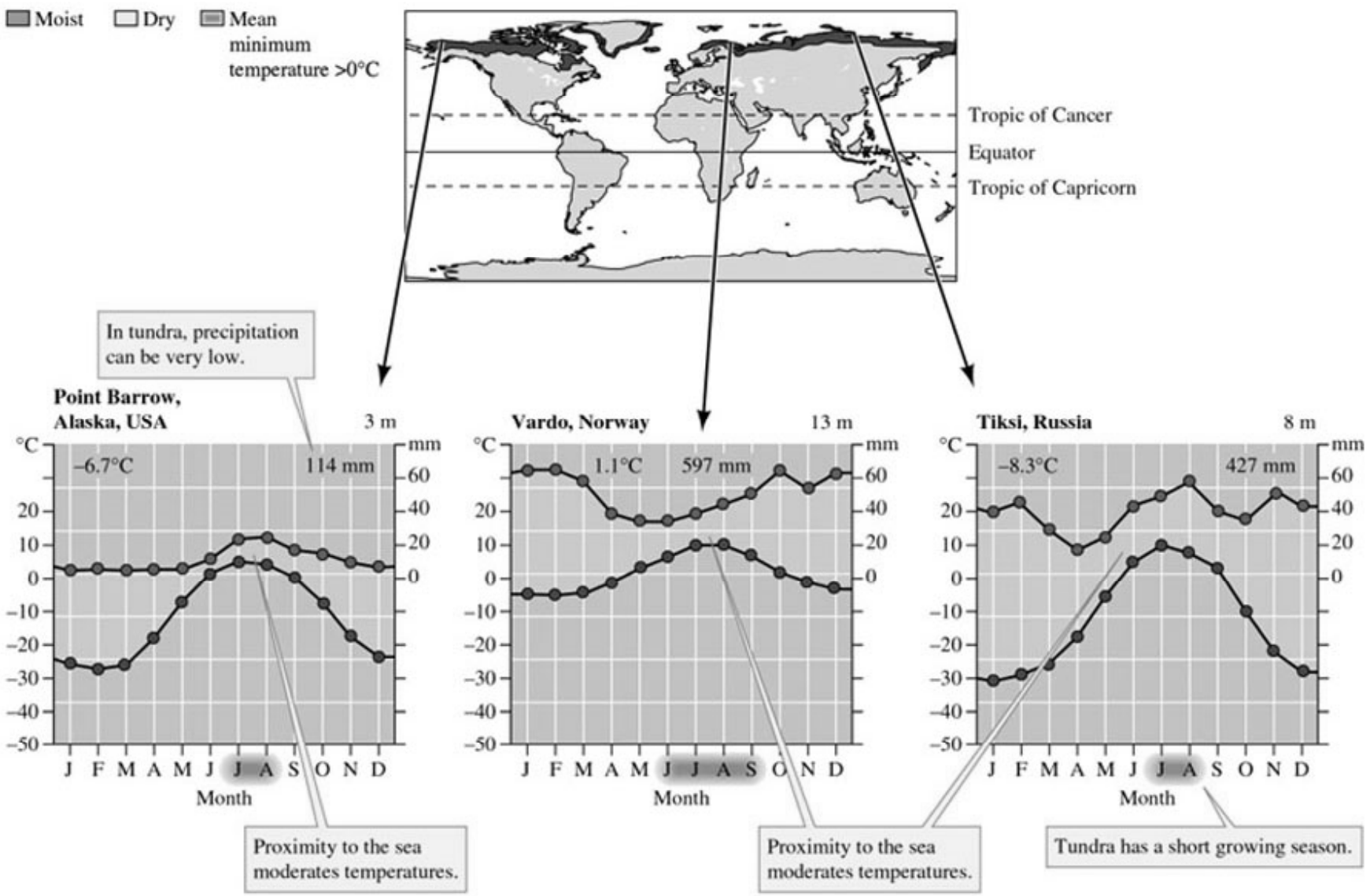
BOREAL FOREST (TAIGA)



TUNDRA

- Covers most of lands north of Arctic Circle.
  - Climate typically cool and dry with short summers.
    - 200 - 600 mm precipitation.
- Low decomposition rates.
- Supports substantial numbers of native mammals.
- Human intrusion historically low, but increasing as resources become scarce.

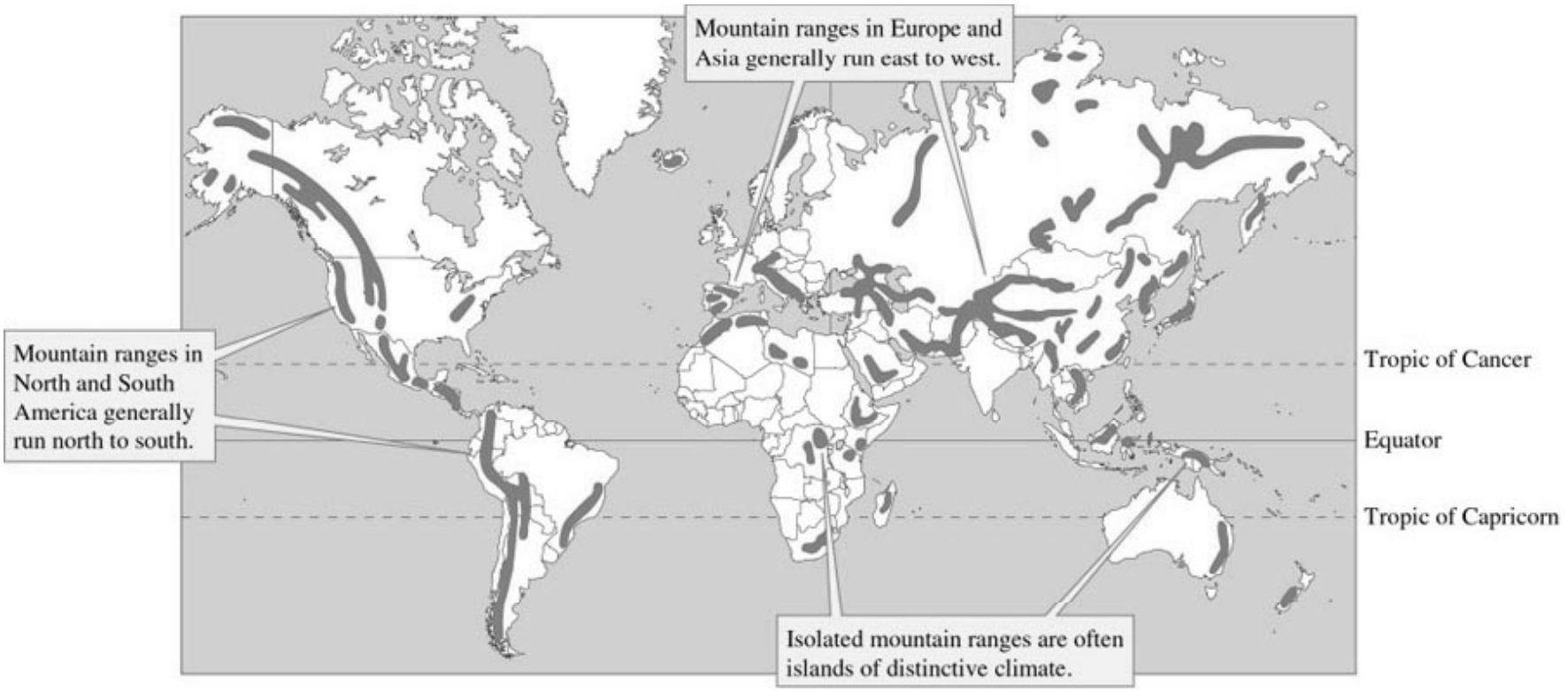
TUNDRA


Moist
Dry
Mean minimum temperature >0°C
Tropic of Cancer
Equator
Tropic of Capricorn
In tundra, precipitation can be very low.
Point Barrow, Alaska, USA
3 m
–6.7°C
114 mm
Vardo, Norway
13 m
1.1°C
597 mm
Tiksi, Russia
8 m
–8.3°C
427 mm
°C
mm
J F M A M J J A S O N D
Month
Proximity to the sea moderates temperatures.
Proximity to the sea moderates temperatures.
Tundra has a short growing season.

MOUNTAINS: ISLANDS IN THE SKY

- Built by geological processes and thus concentrated in belts of geological activity.
- Climate changes with elevation and latitude.
- Soils are generally well-drained and thin.
- Flora and fauna change with elevation.
- Historically used as a source of raw materials for human settlements.

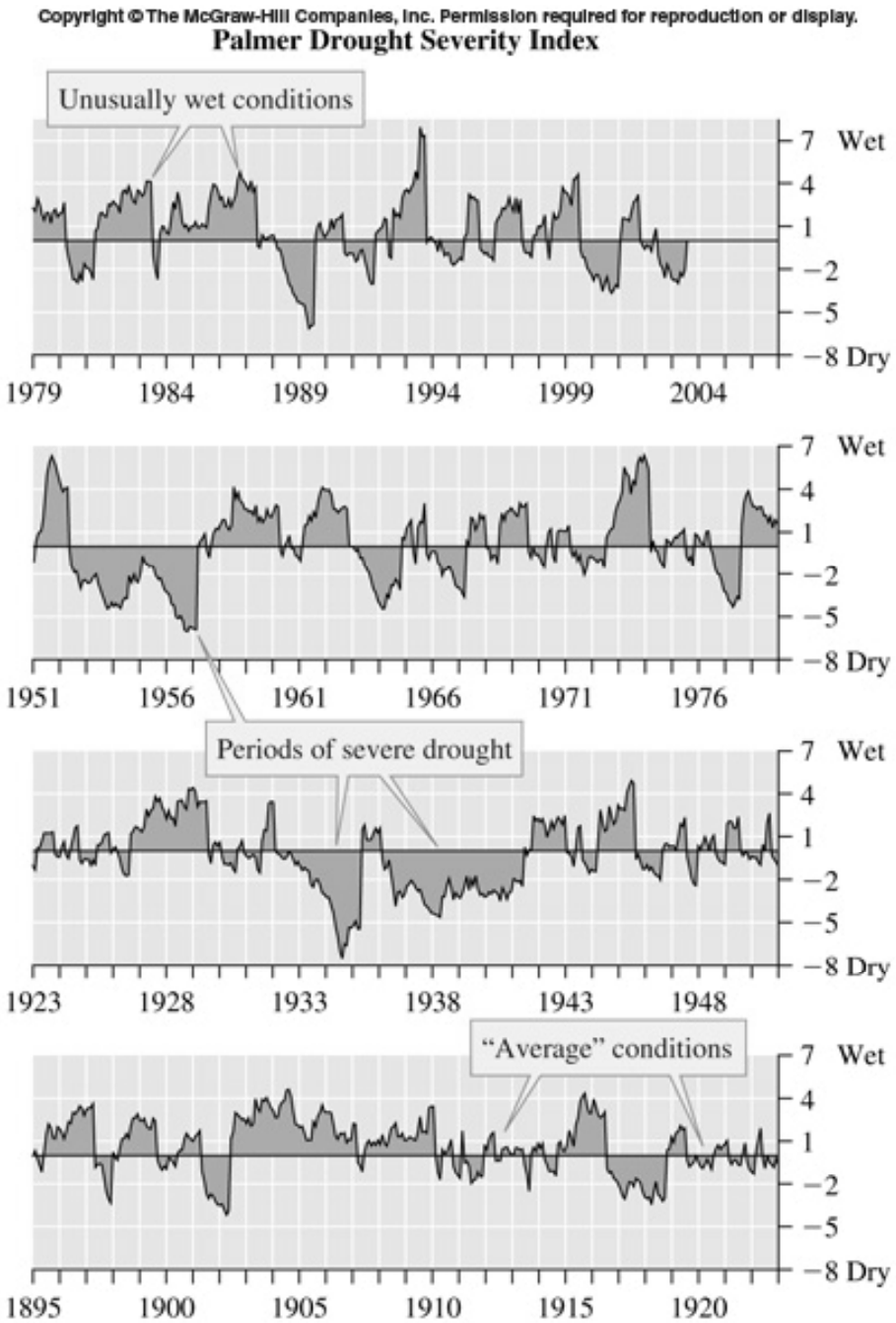
MOUNTAINS: ISLANDS IN THE SKY



Palmer Drought Severity Index

Manhattan, Kansas

Go K-State!!



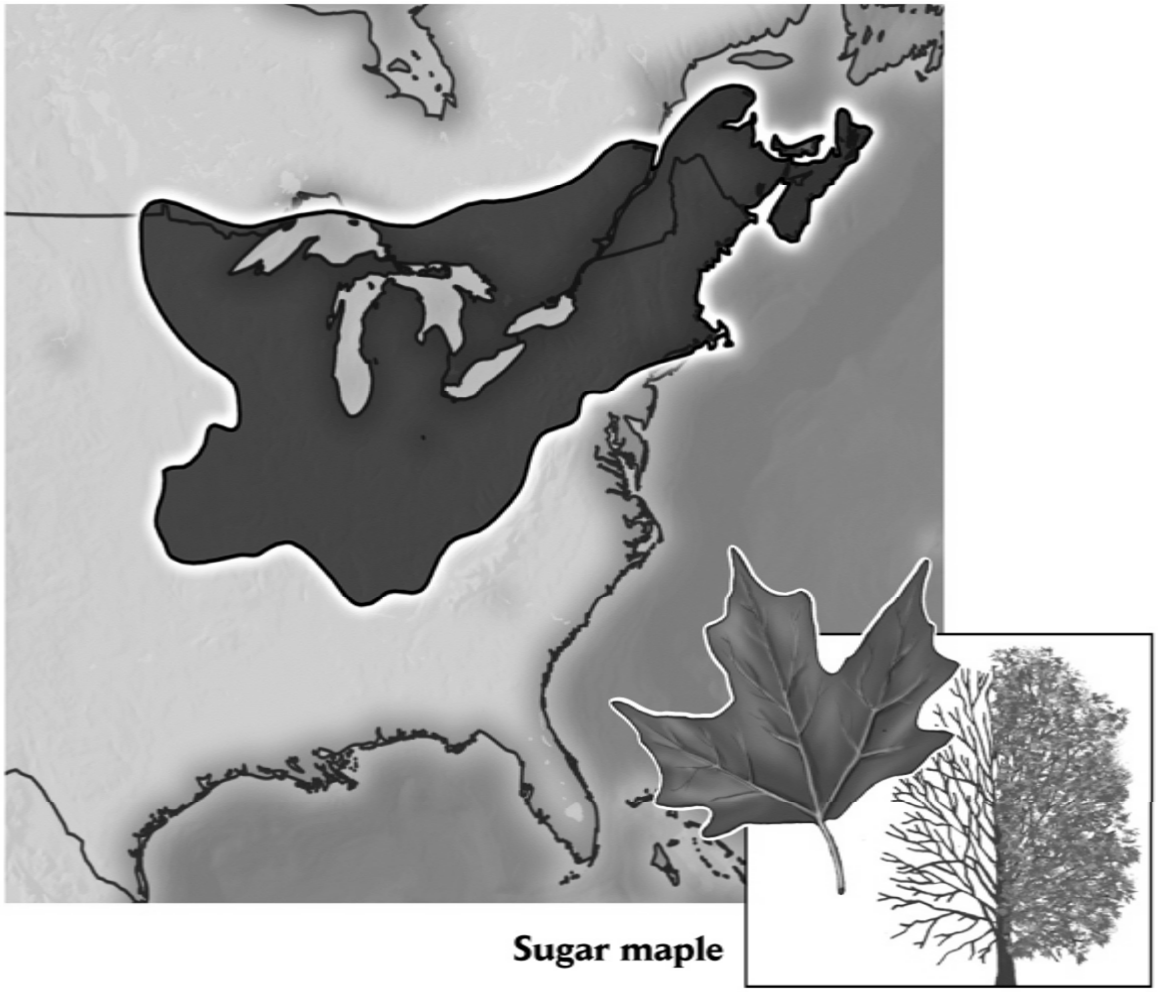
***PROXIMATE/FUNCTIONAL APPROACH…

- What is the major factor determining biomes?

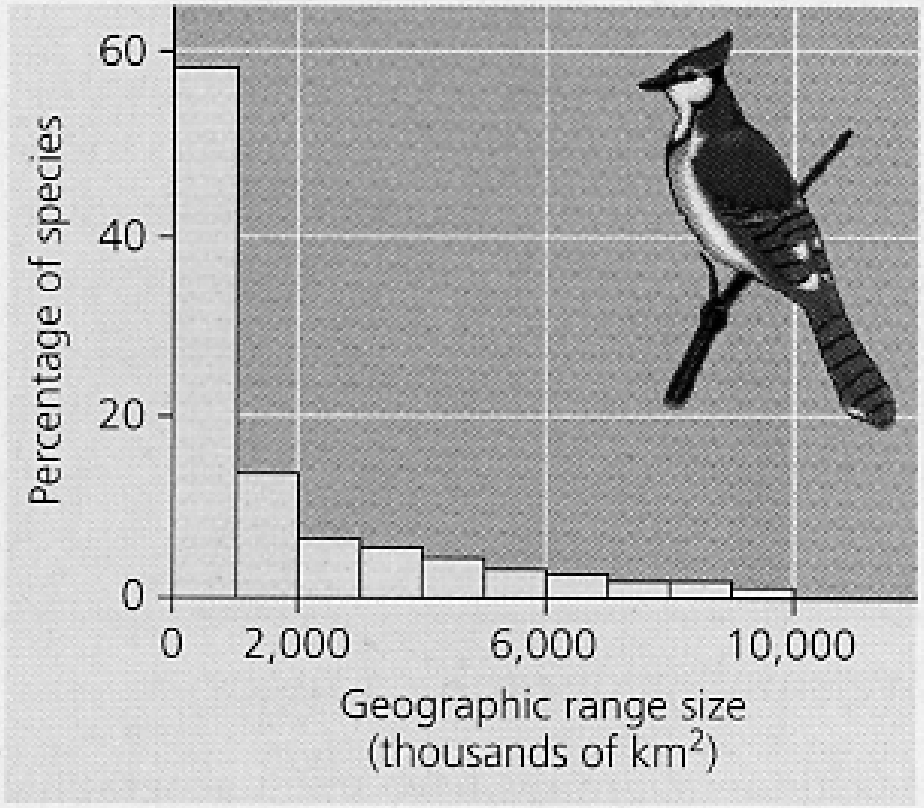
- In one sentence:
  Why isn't there a single biome for the earth?

CLIMATE IS THE MAJOR DETERMINANT OF PLANT DISTRIBUTIONS.

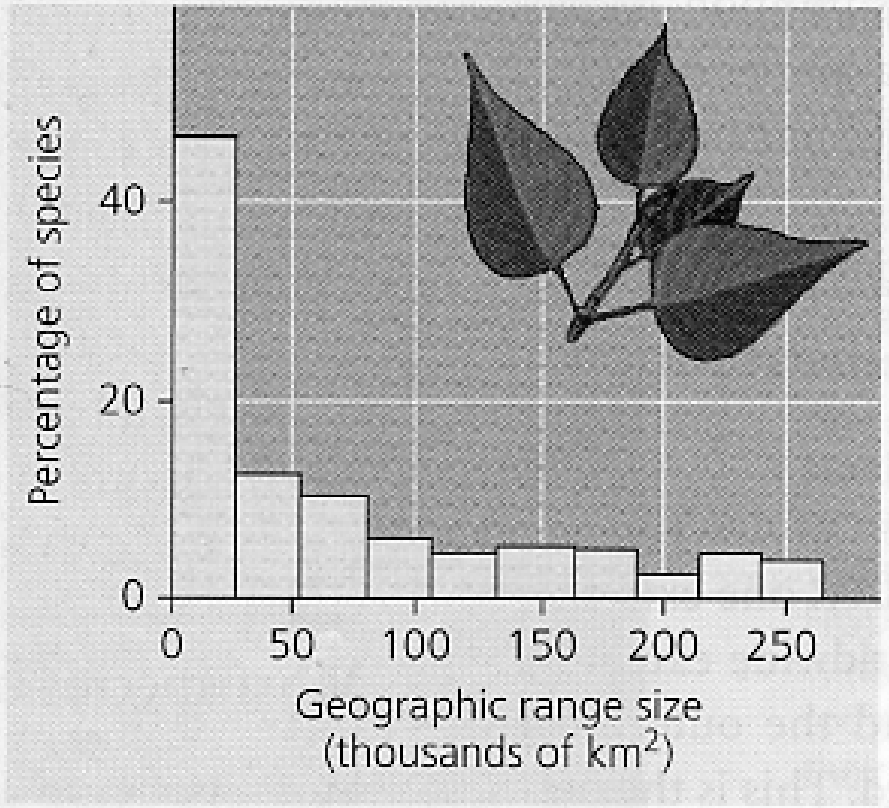
SECONDARY FACTORS ARE SOIL, FIRE, GRAZING, TOPOGRAPHY.



MOST SPECIES HAVE LIMITED TOLERANCE; HENCE SMALL RANGES AND BIOMES



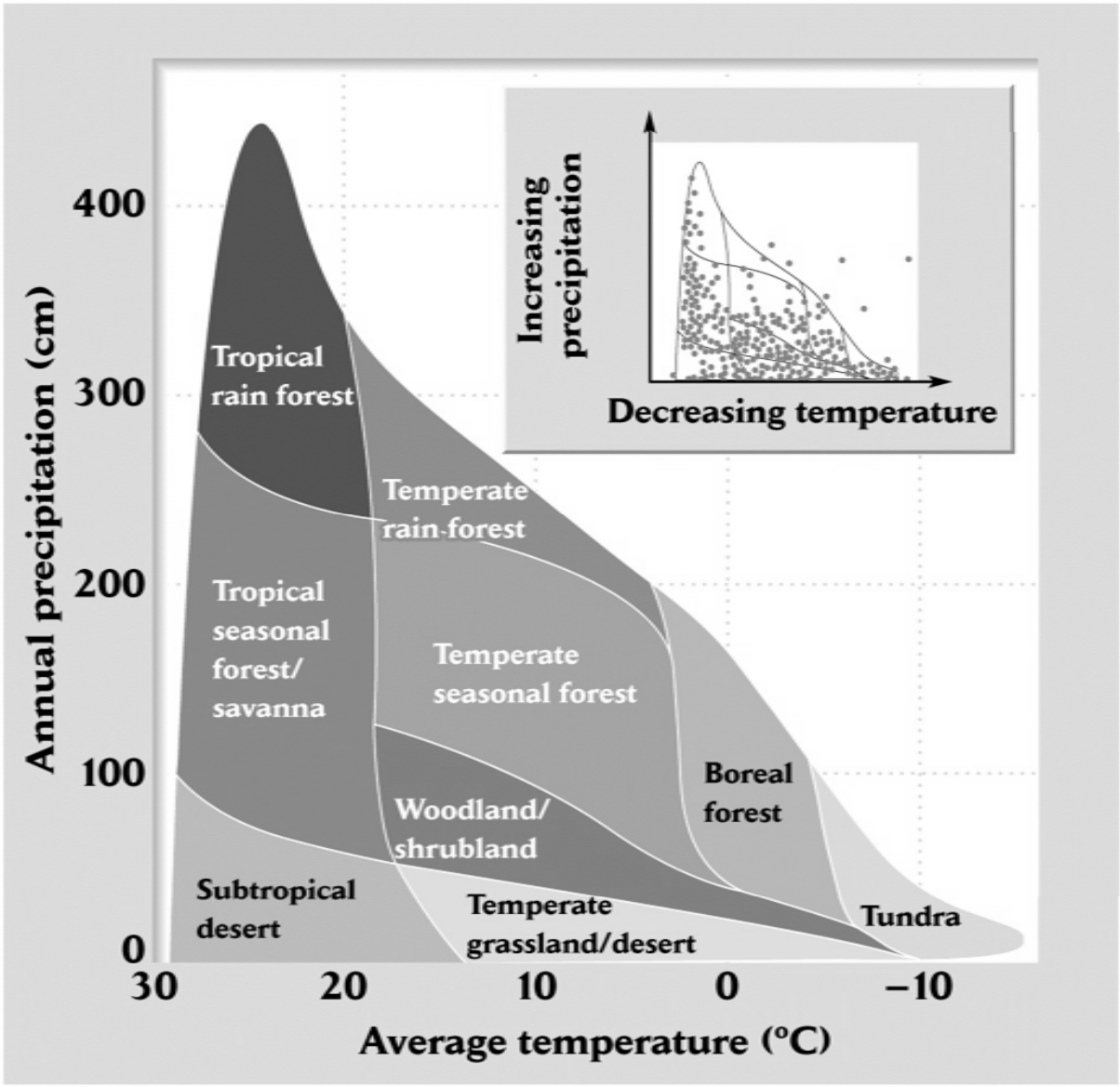
(a) North American birds



(b) British vascular plants

***In one sentence: Compare the ranges of birds/plants.

WHITTAKER'S SCHEME: BIOMES DELINEATED BY AVERAGE TEMPERATURE AND PRECIPITATION.



OBSERVATION:
PLANT GROWTH FORM IS SIMILAR IN WIDELY SEPARATED AREAS. ***SPECULATE WHY?

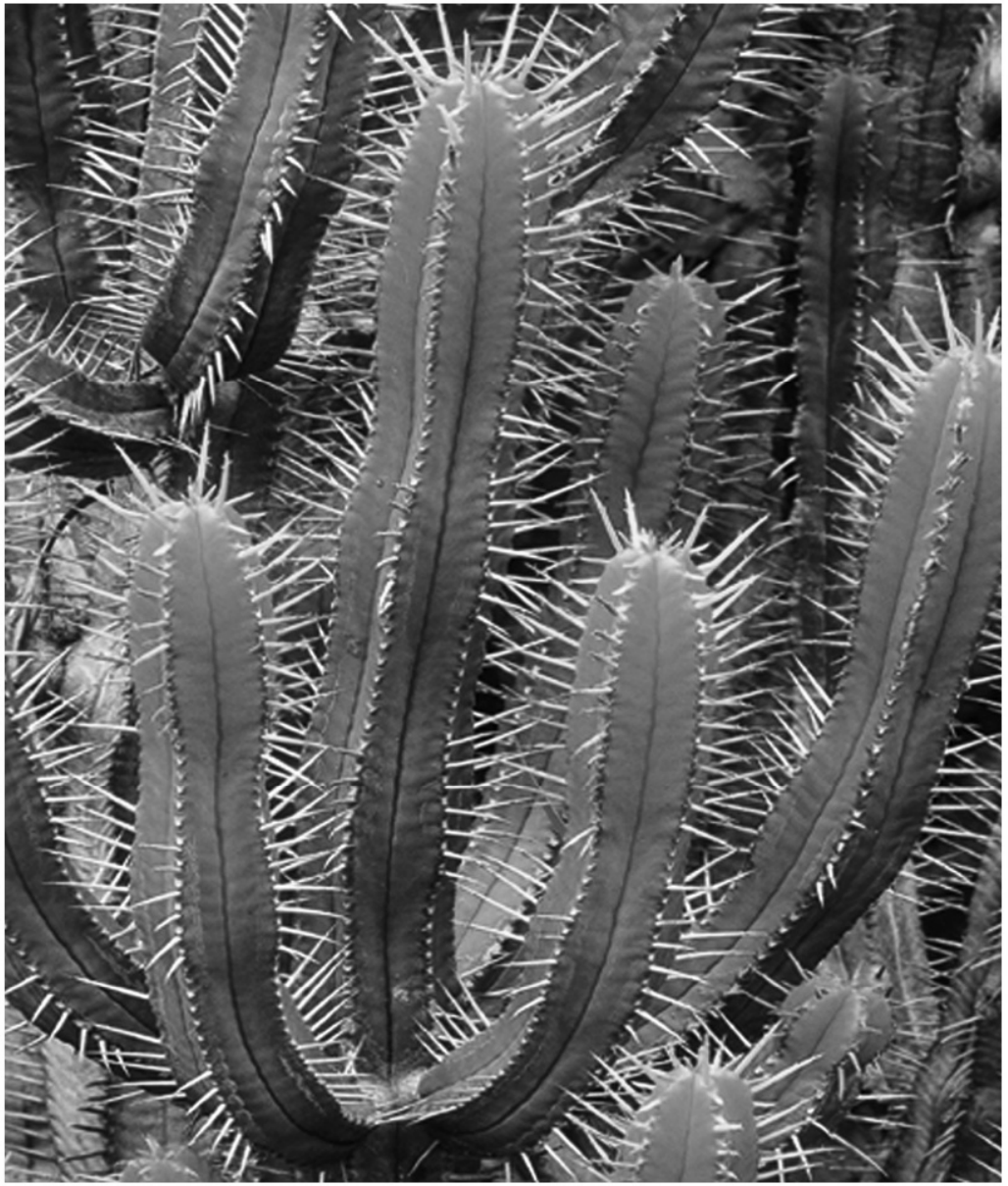
Mexico

Kenya

***HYPOTHESIS:

IF FORM AND FUNCTION MATCH THE ENVIRONMENT,

THEN...?

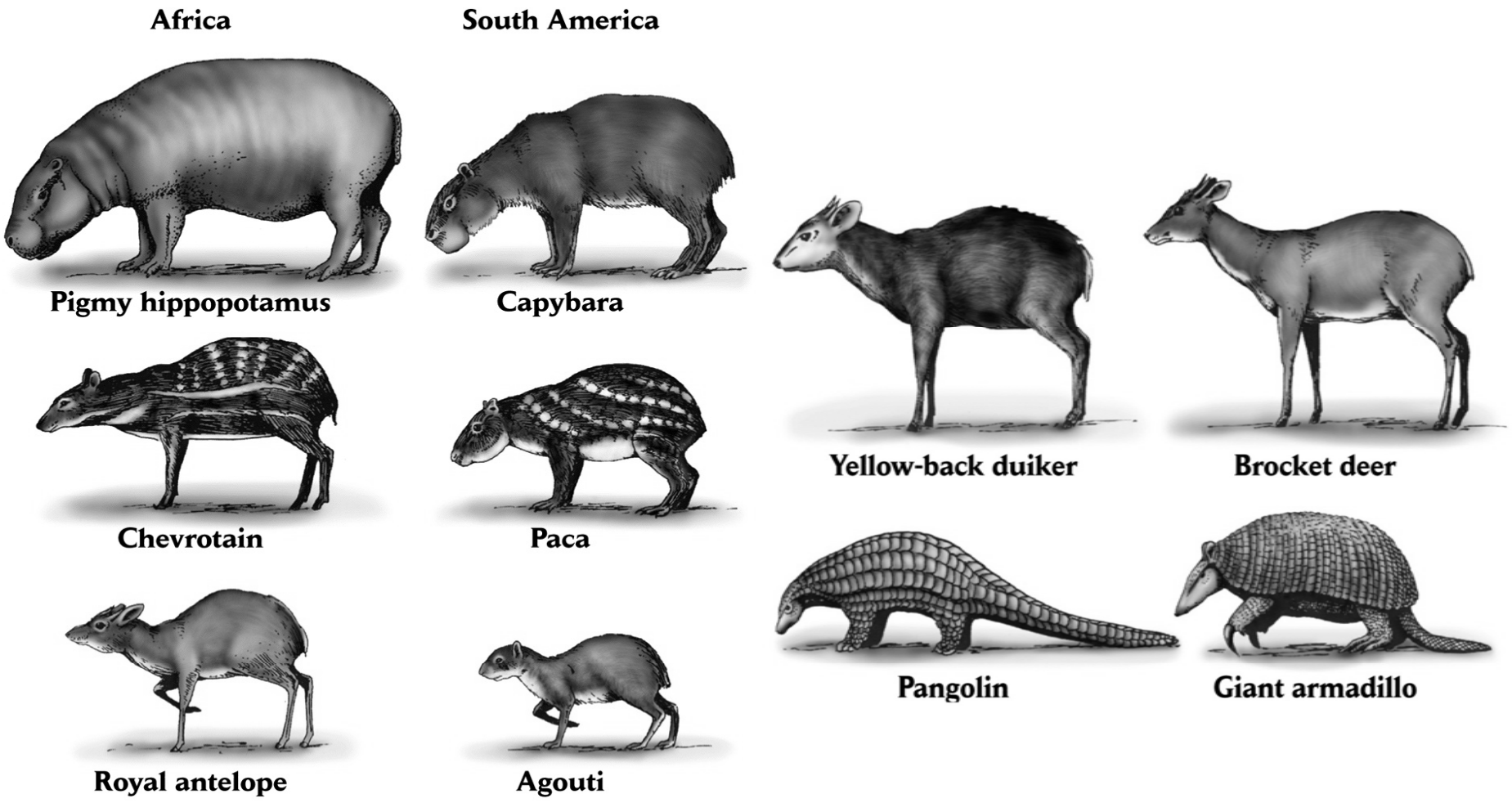


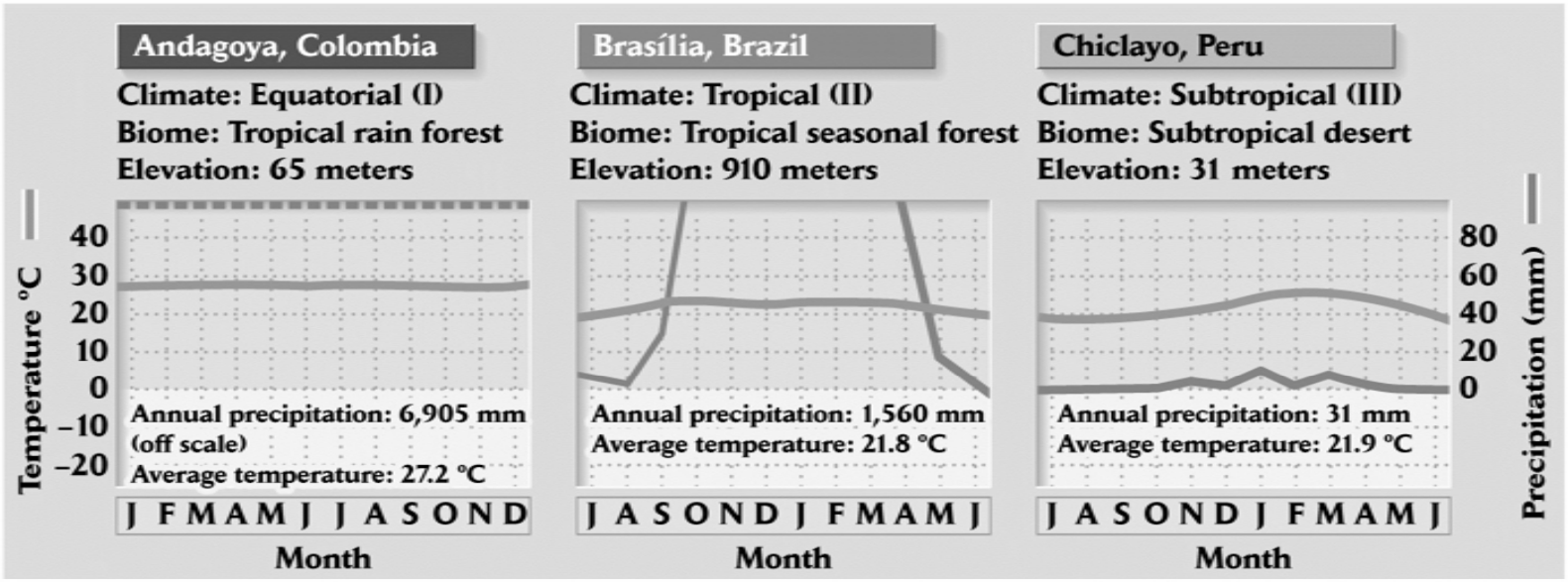
PREDICTION: THEN UNRELATED ORGANISMS IN SIMILAR ENVIRONMENTS WILL EVOLVE SIMILAR FORM AND FUNCTION = *CONVERGENT EVOLUTION*

Mexico

Kenya

UNRELATED AFRICAN AND SOUTH AMERICAN RAINFOREST MAMMALS SHOW STRIKING CONVERGENCE.





EXAMPLE OF EXAM QUESTION…

A. Which biome would occur in each climate?

B. What is the limiting climatic factor(s) for each biome?

C. ~~Where is each biome located in the Western (New~~ World) and Eastern (Old World) hemisphere? Put letters on map.

***WHAT IS THE CLUE THAT THIS IS A DESERT?