CHAPTER 7

Climate and Biodiversity

Weather & Climate

Weather

- Short term atmospheric conditions-hours to days
- Temperature, pressure, moisture content, precipitation, cloud cover, wind speed and direction all influence weather.
- Most weather due to interactions between leading edges of moving masses of warm and cold air.

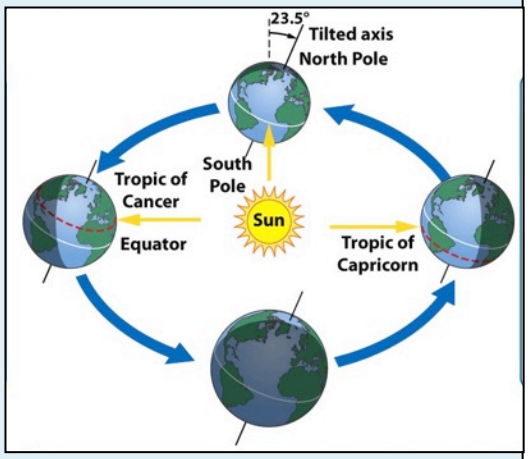
Climate

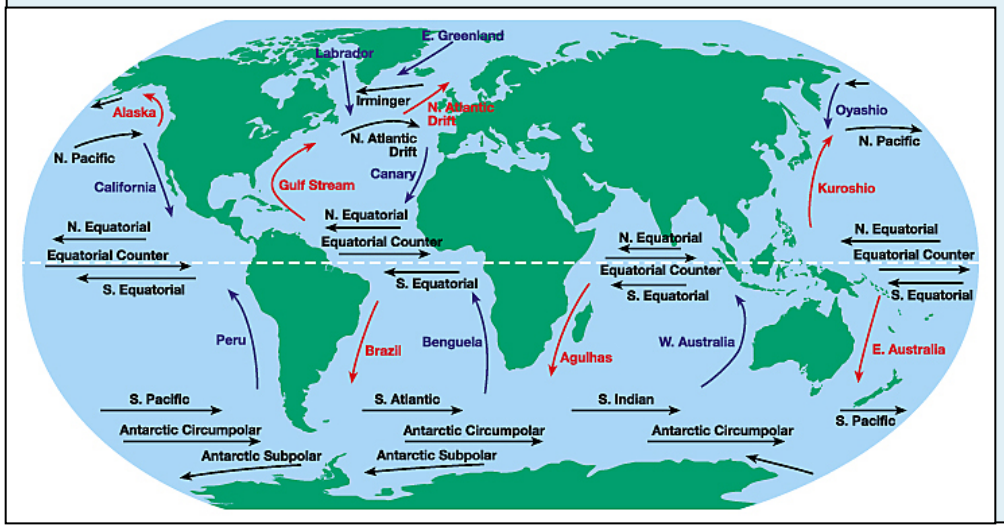
- A region's general pattern of long-term atmospheric conditions
- Regional differences in temperature and precipitation are main factors in determining climate and thus which organisms can survive in each region.
- Latitude and altitude also play a role.

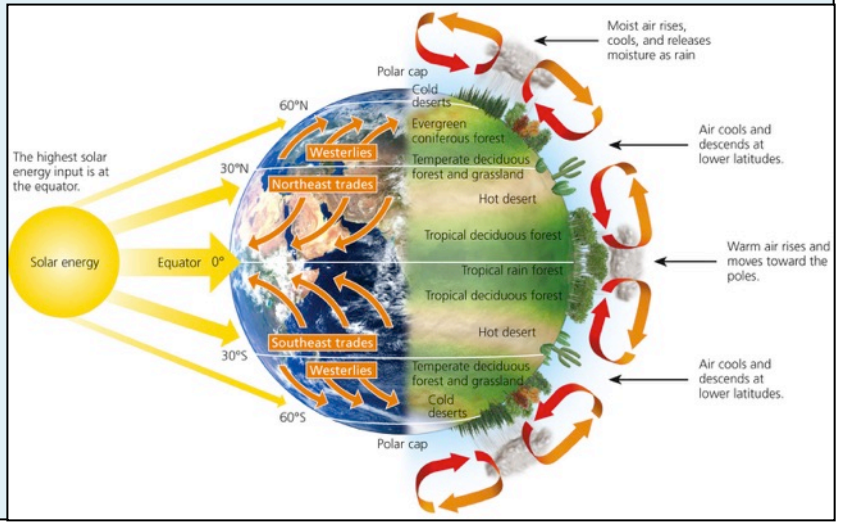
Factors that Influence Earth's Climate

Climate varies in different parts of the Earth because of:

1) Uneven heating of Earth by sun
2) Atmospheric convection currents
3) Rotation of Earth
4) Earth's orbit around the sun on a tilted axis
5) Ocean currents





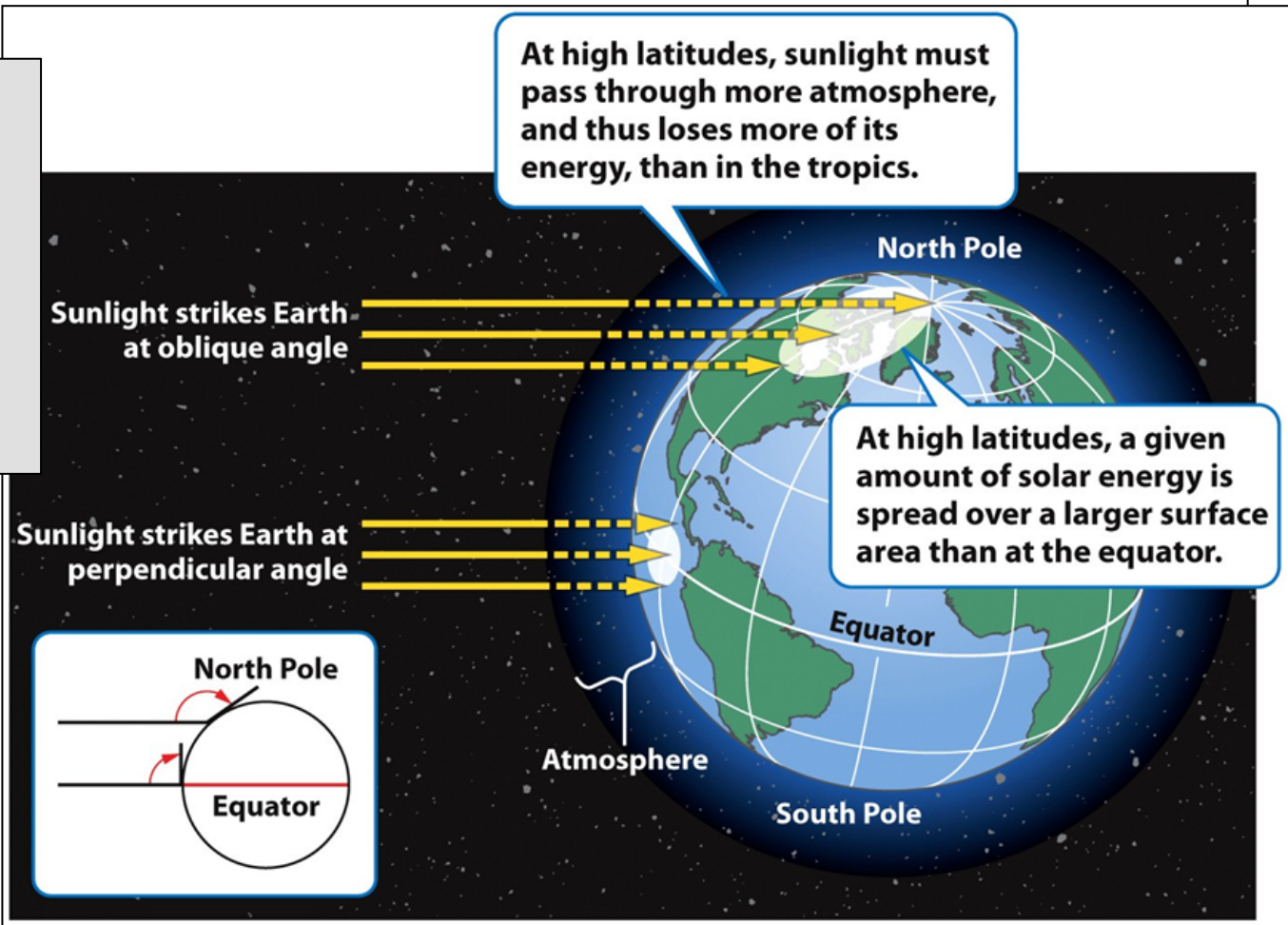


Climate- Uneven Heating of the Earth by the Sun

Uneven heating of earth's surface by the *variation in angle* at which the *suns rays strike Earth*. **Air is heated more at the equator**, where sun strikes <u>directly</u> than at the *poles where sun strikes at angle and spreads over a greater surface area.*

This explains the existence of Earth's major climate regions:

- Tropical
- Polar
- Temperate



Different Climates Support Different Life Forms

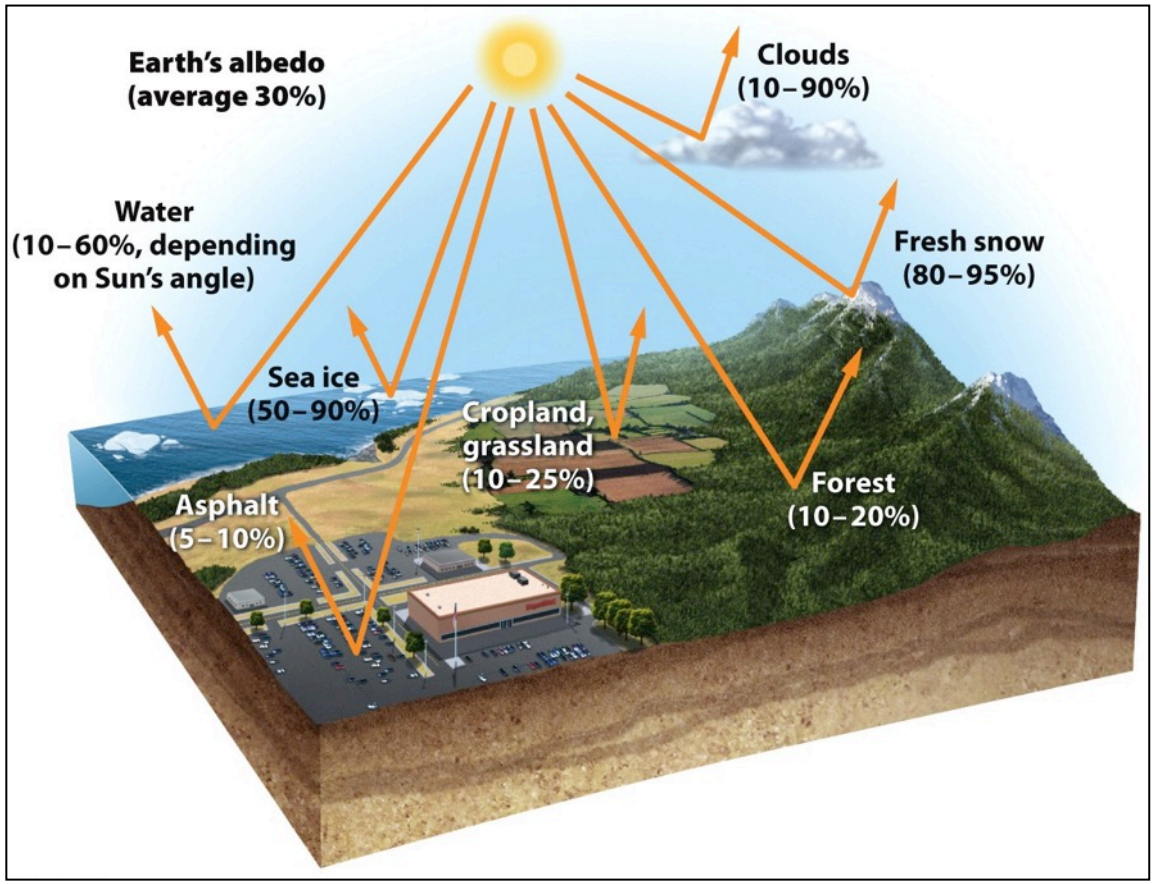
Tropical: equator, intense sunlight →

Polar: poles, little sunlight →

Temperate: between tropical & polar →

Albedo Influences Earth's Surface Temperatures

Albedo: *the percent of incoming solar radiation that is reflected or absorbed.* Higher the albedo of a surface, the more solar energy it reflects and the less it absorbs. ***White surface high albedo; Dark surface low albedo***



Global average albedo 30%; 10-20%tropics with dense green foliage and 80-95% in snow covered polar regions

Climate- Atmospheric Convection Currents

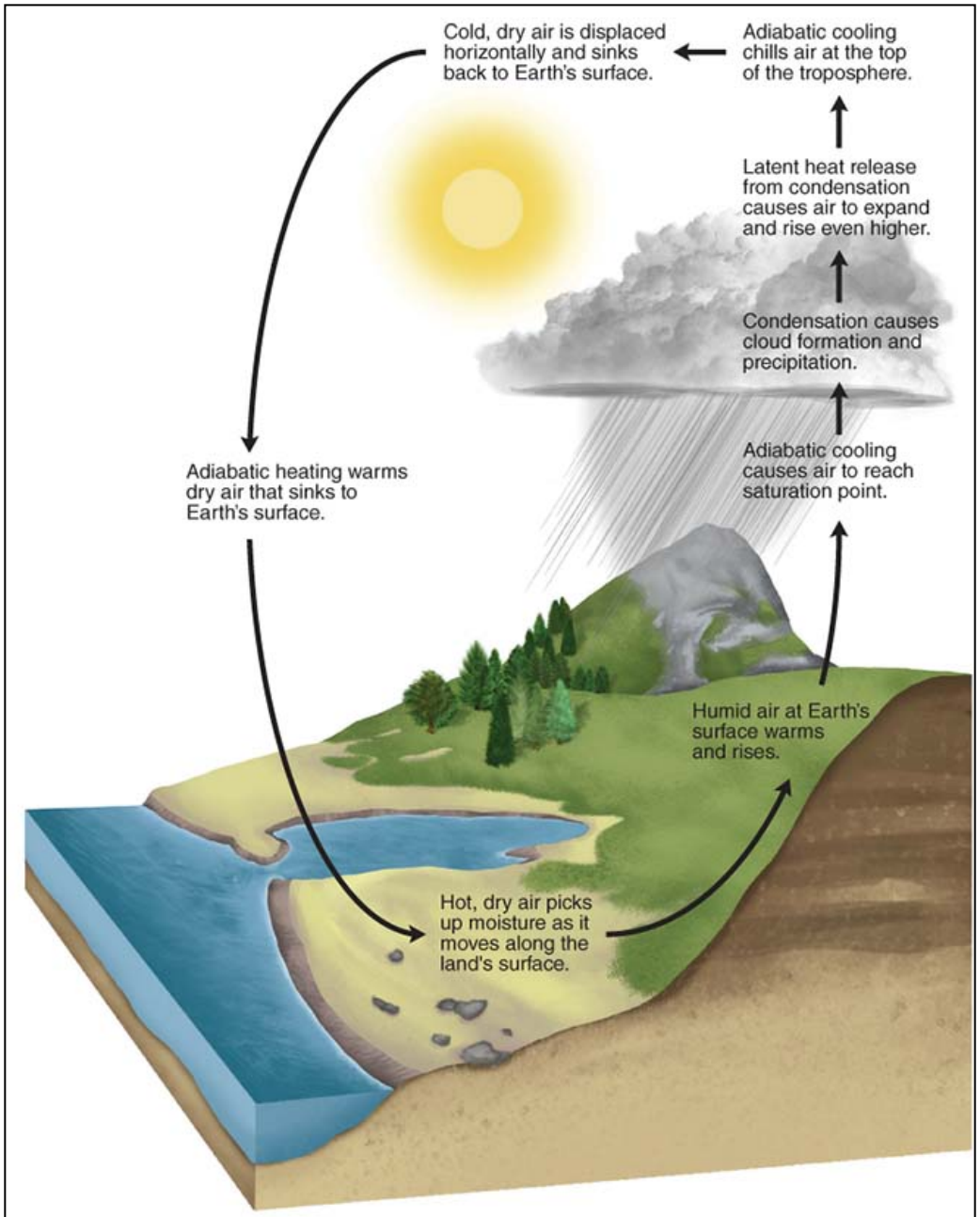
Properties of Air

Density: cold/more dense sinks; warm/less dense rises

Water Vapor Capacity: warm air has a higher capacity for water vapor than cold air

Adiabatic Cooling: air rises, pressure decreases, expands in volume and lowers temp of the air.

Adiabatic Heating: air sinks, pressure increases, volume decreases and air temp rises



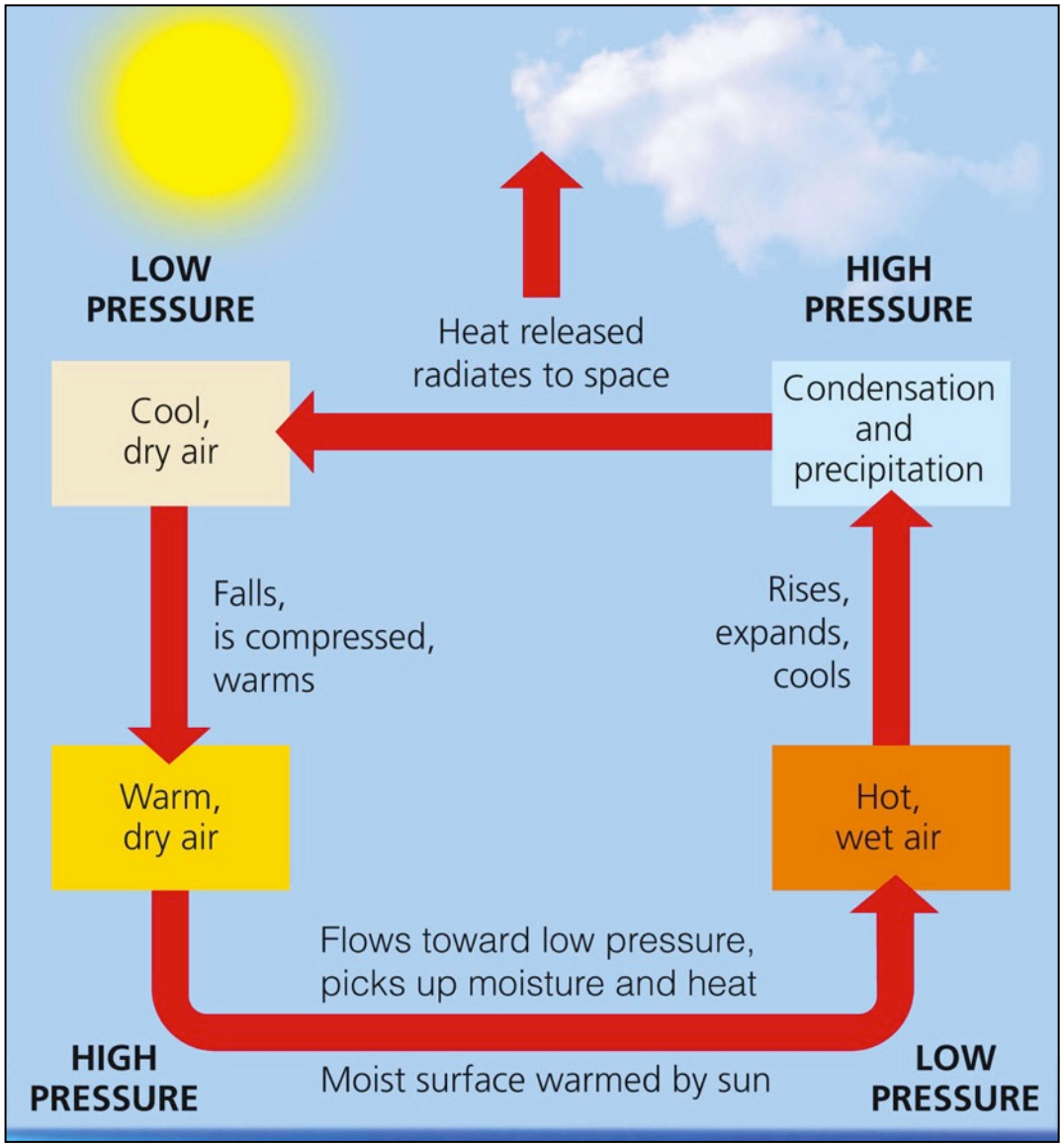
Climate- Atmospheric Convection Currents

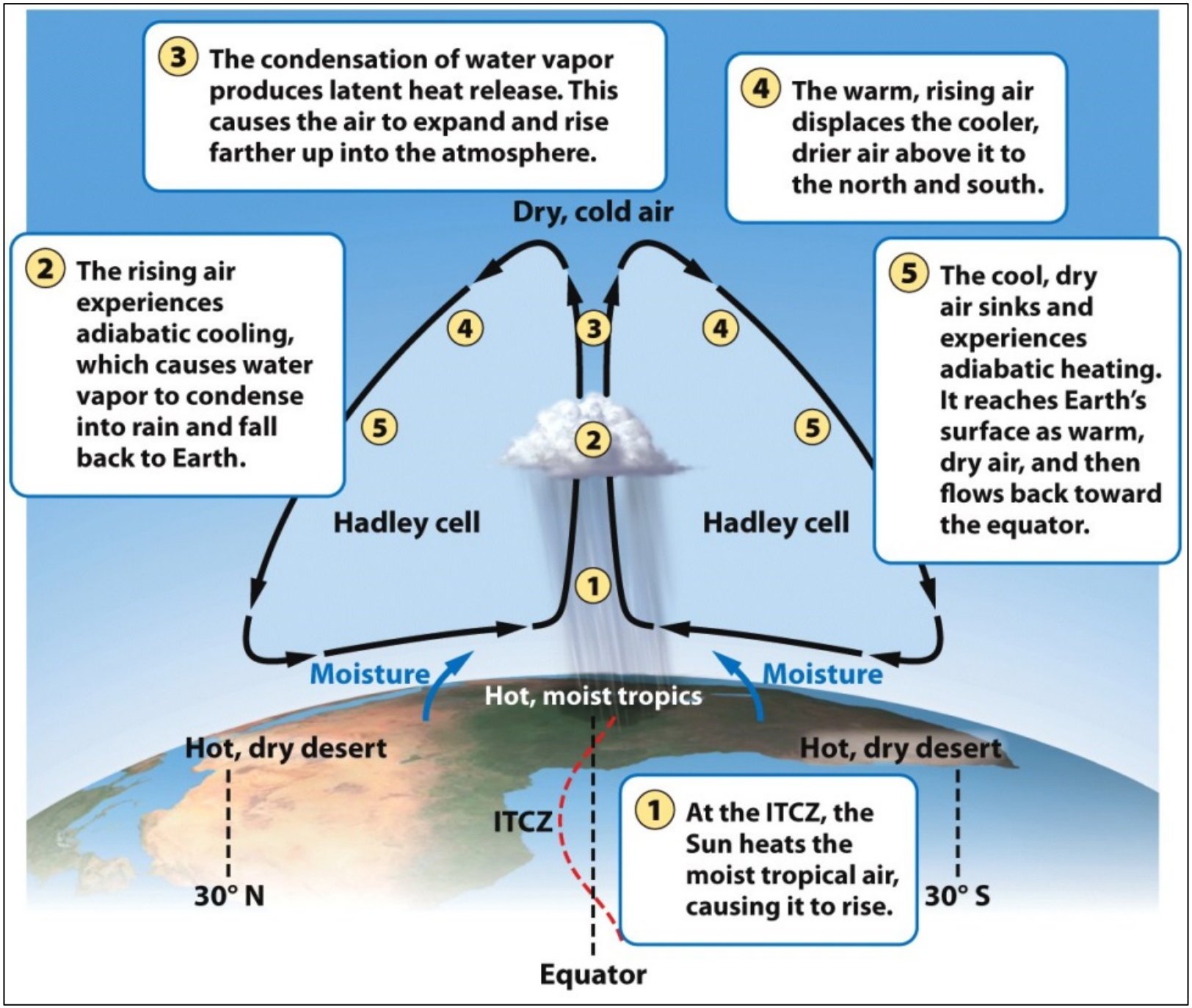
Properties of Air

Sun's energy **evaporates** water and forms vapor/ **water vapor condenses** to a liquid & heat are produced. This is **latent heat**

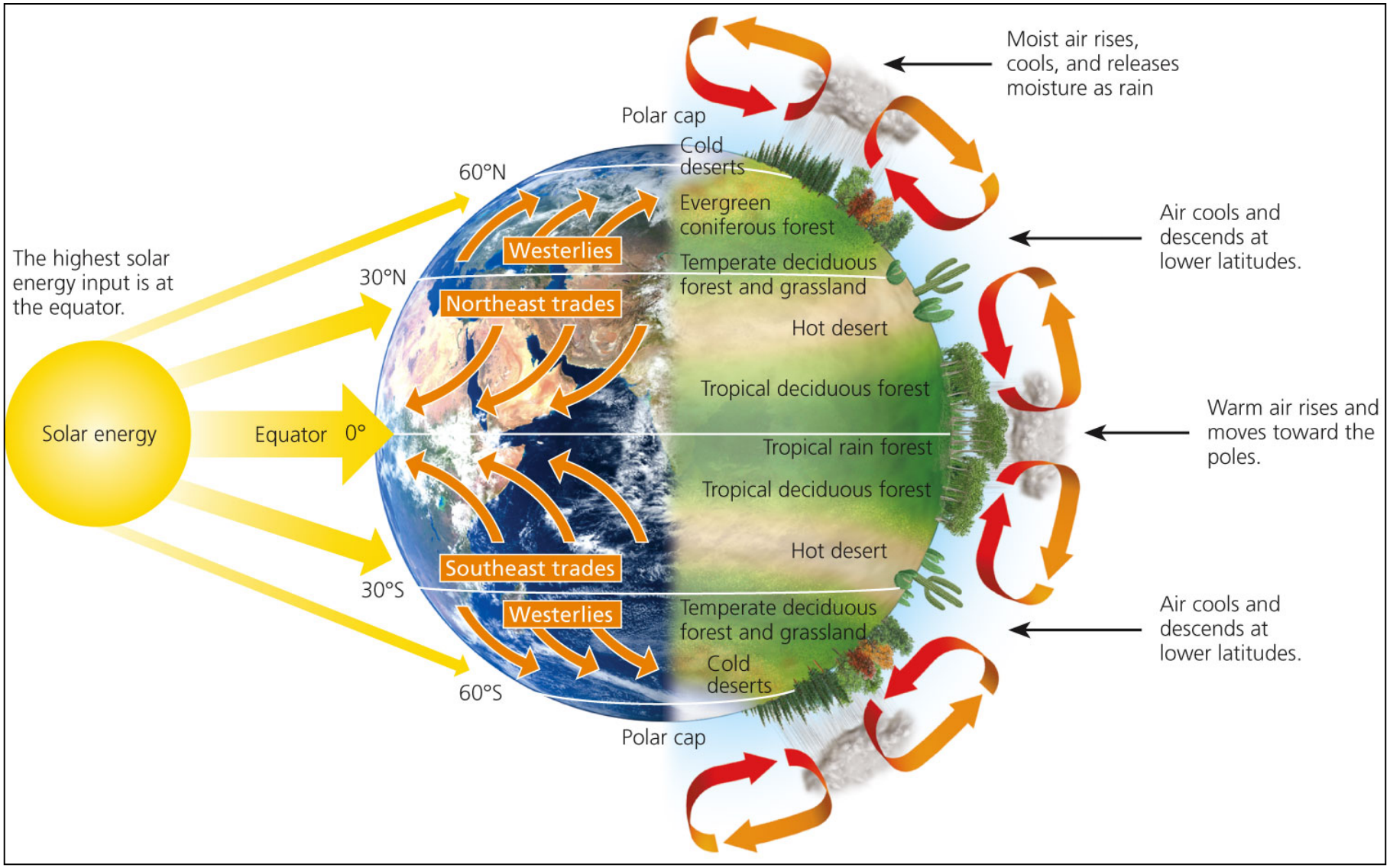
Low Pressure: less dense, warm moist air rises allowing surface flows to move to the center of the low where air is rising.

High Pressure: more dense, cold dry air sinks and spreads outward as it strikes the ground creating surface flows (wind) that move outward from the center of the high.

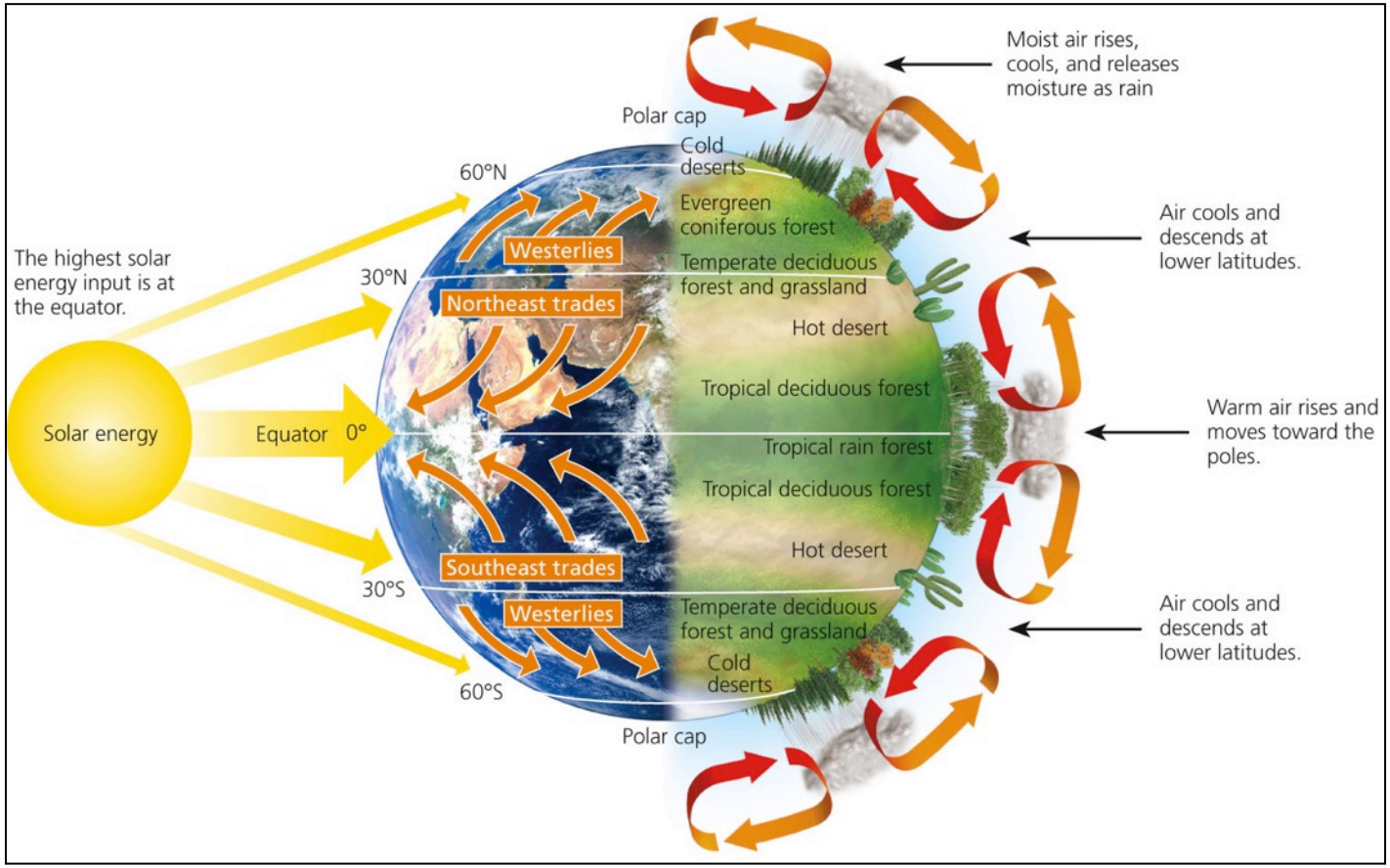



3 The condensation of water vapor produces latent heat release. This causes the air to expand and rise farther up into the atmosphere.
4 The warm, rising air displaces the cooler, drier air above it to the north and south.
Dry, cold air
2 The rising air experiences adiabatic cooling, which causes water vapor to condense into rain and fall back to Earth.
5 The cool, dry air sinks and experiences adiabatic heating. It reaches Earth's surface as warm, dry air, and then flows back toward the equator.
4
3
4
5
2
5
Hadley cell
Hadley cell
1
Moisture
Moisture
Hot, moist tropics
Hot, dry desert
Hot, dry desert
ITCZ
1 At the ITCZ, the Sun heats the moist tropical air, causing it to rise.
30° N
30° S
Equator

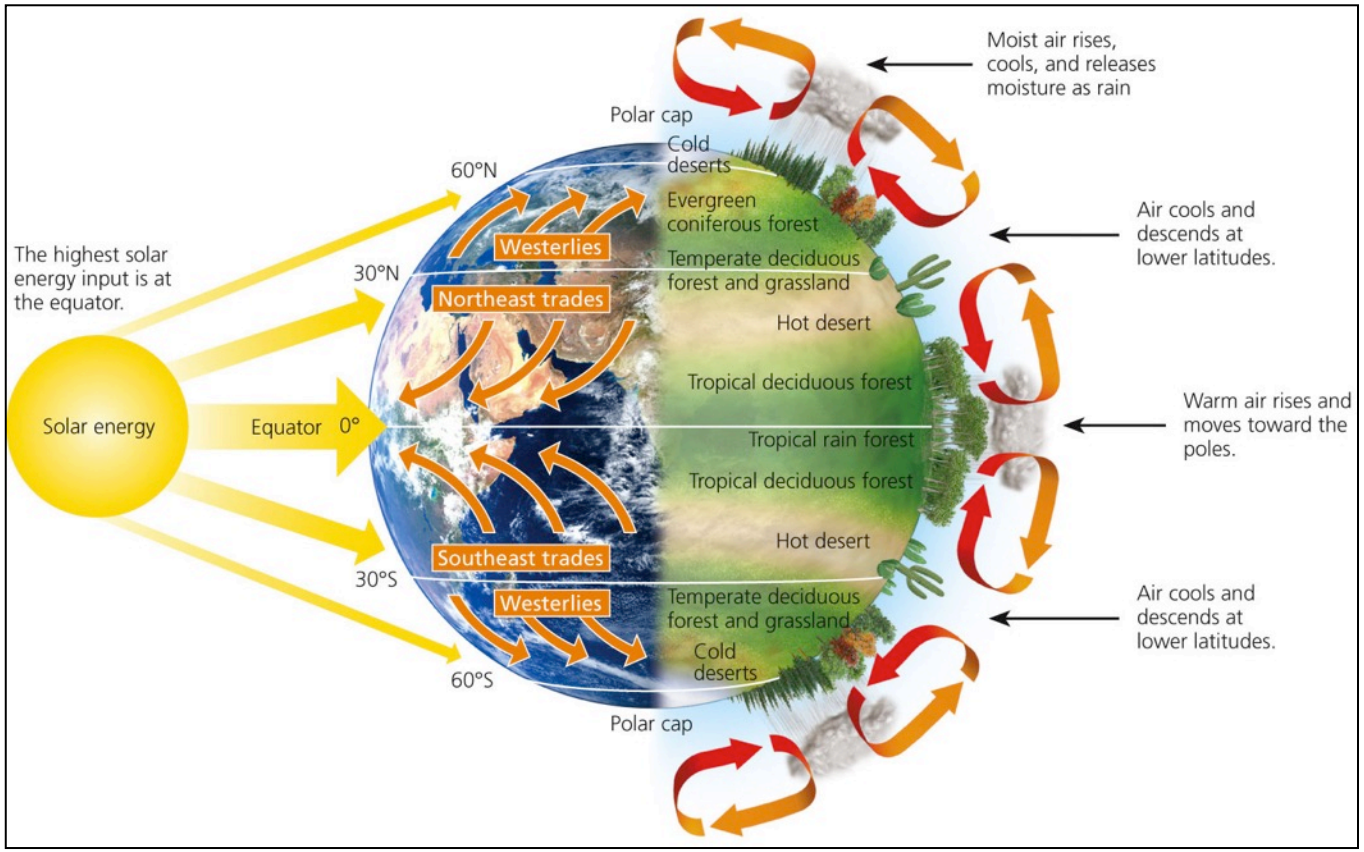
Formation of Convection Currents: global patterns of air movement initiated by unequal heating of Earth.

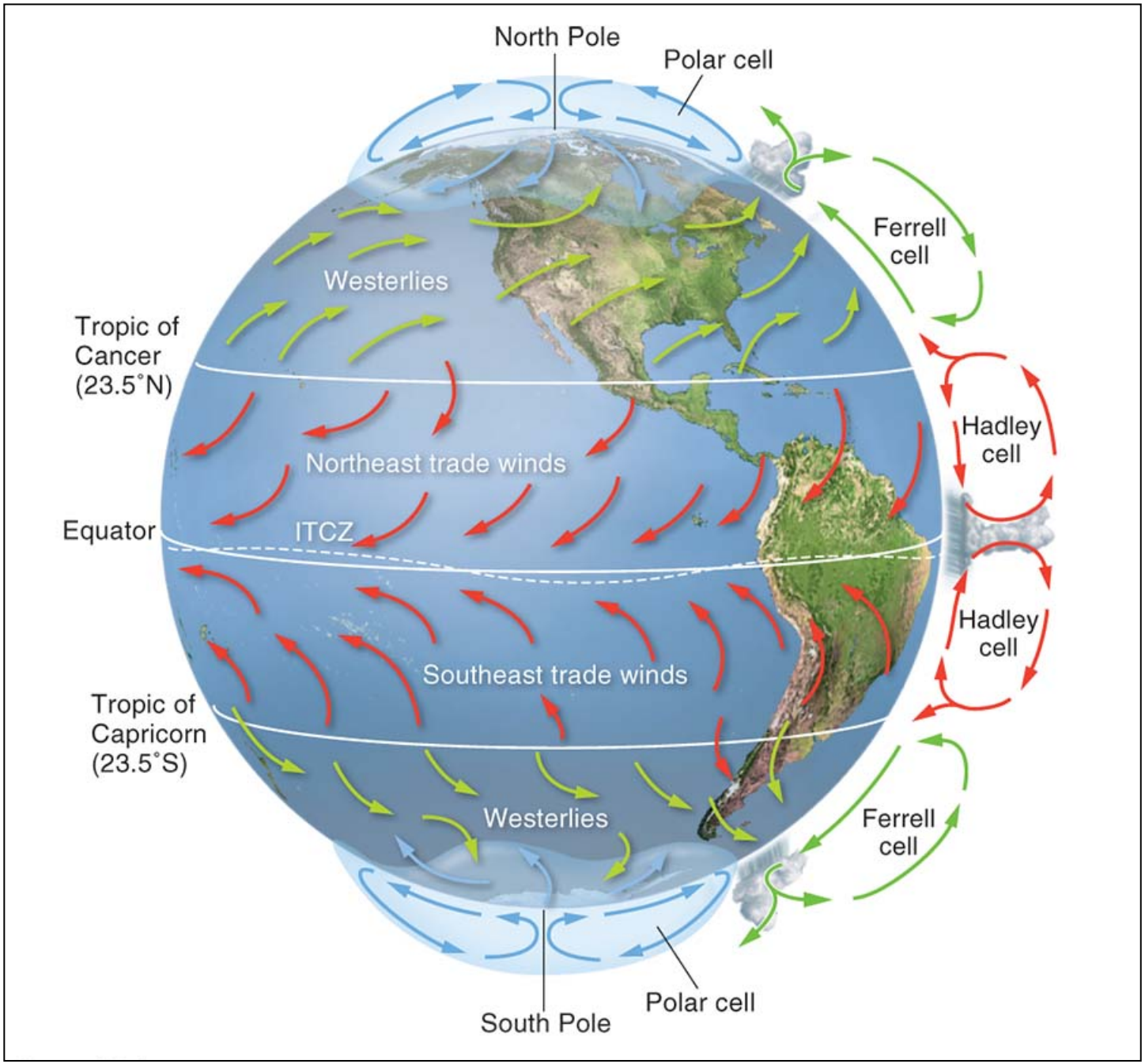


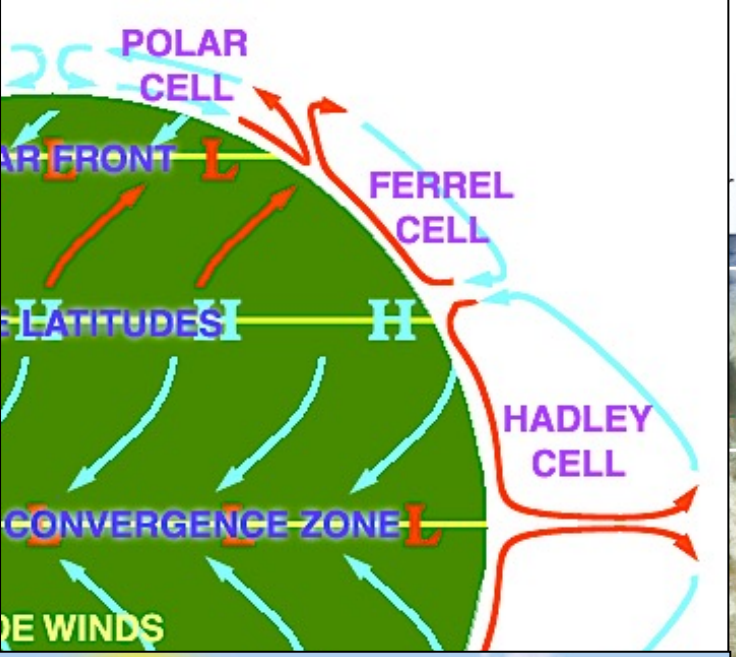
- Warm humid air in tropics rises, *lower pressure* and adiabatic cooling, reaches saturation point which leads to condensation, cloud formation and precipitation.
- Cold, dry air is displaced horizontally N and S of equator where it eventually sinks at 30^{o} N and S, creating an area of high pressure. When it reaches Earth's surface it is hot and dry-desert.

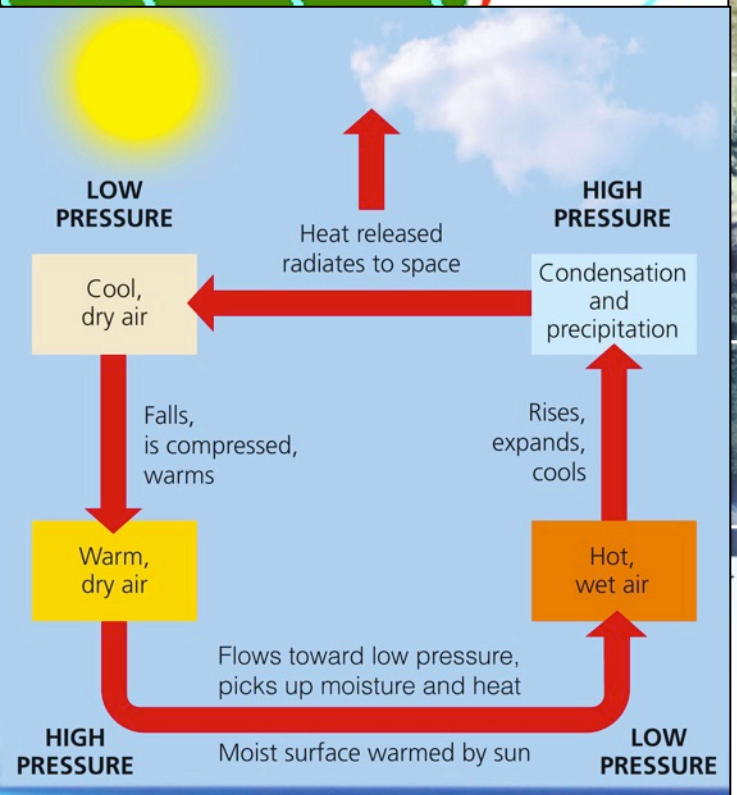


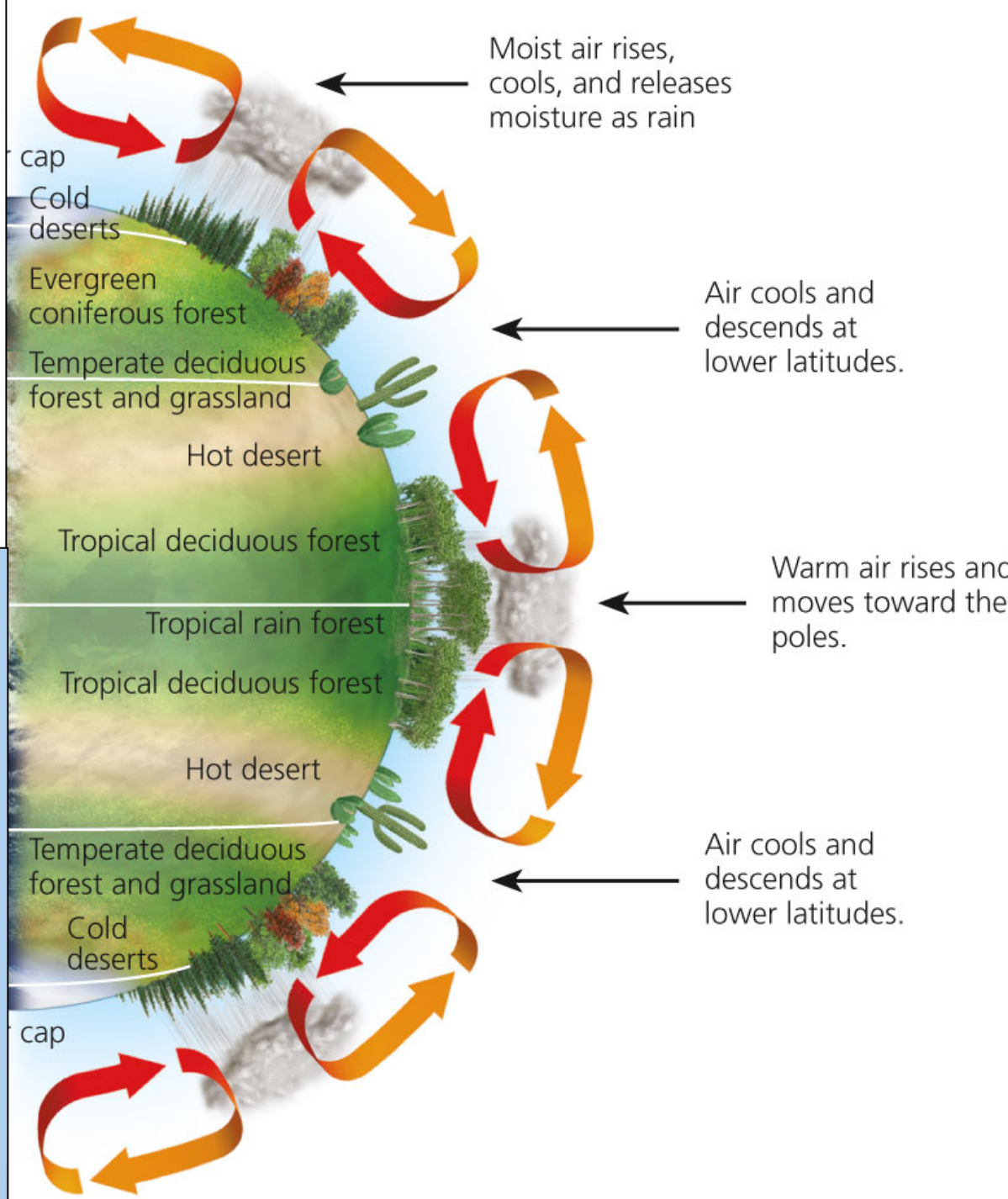
- Hadley Cells: Convection Currents that cycle between equator and 30^{o} N and S.
- Ferrell cells at mid-latitudes 30^{o} – 60^{o} N and S
- Polar cells form at 60^{o} N and S.
- Air circulation driven by alternating convection cells.




North Pole
Polar cell
Ferrell cell
Westerlies
Tropic of Cancer (23.5°N)
Hadley cell
Northeast trade winds
Equator
ITCZ
Hadley cell
Southeast trade winds
Tropic of Capricorn (23.5°S)
Westerlies
Ferrell cell
Polar cell
South Pole

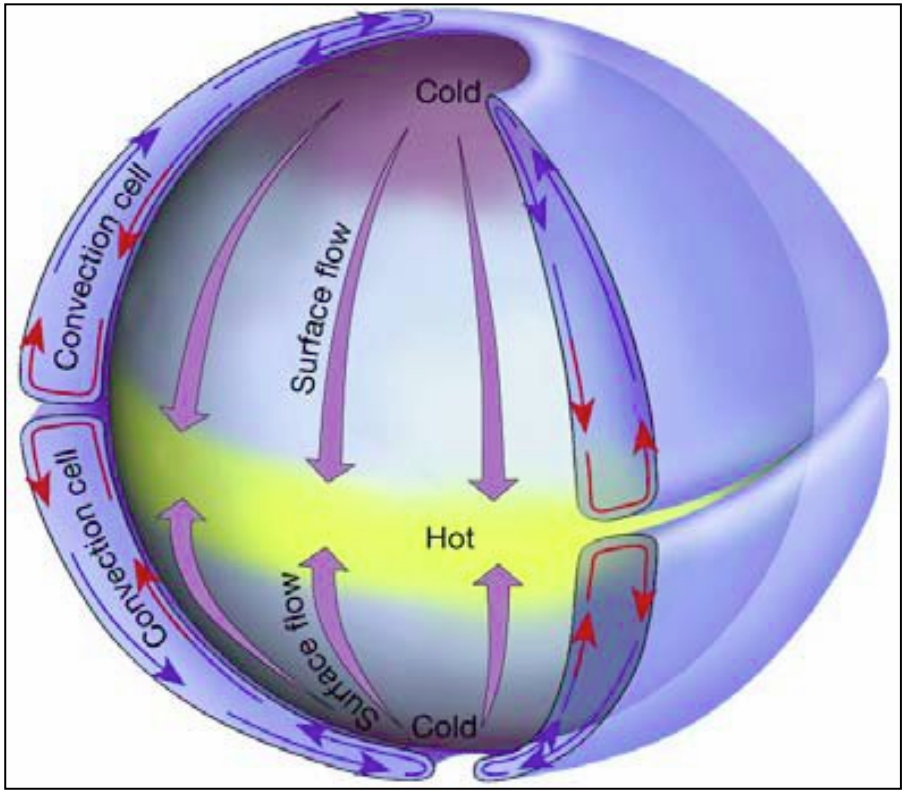

POLAR
CELL
FERREL
CELL
HADLEY
CELL
L
H
L
H
L
L

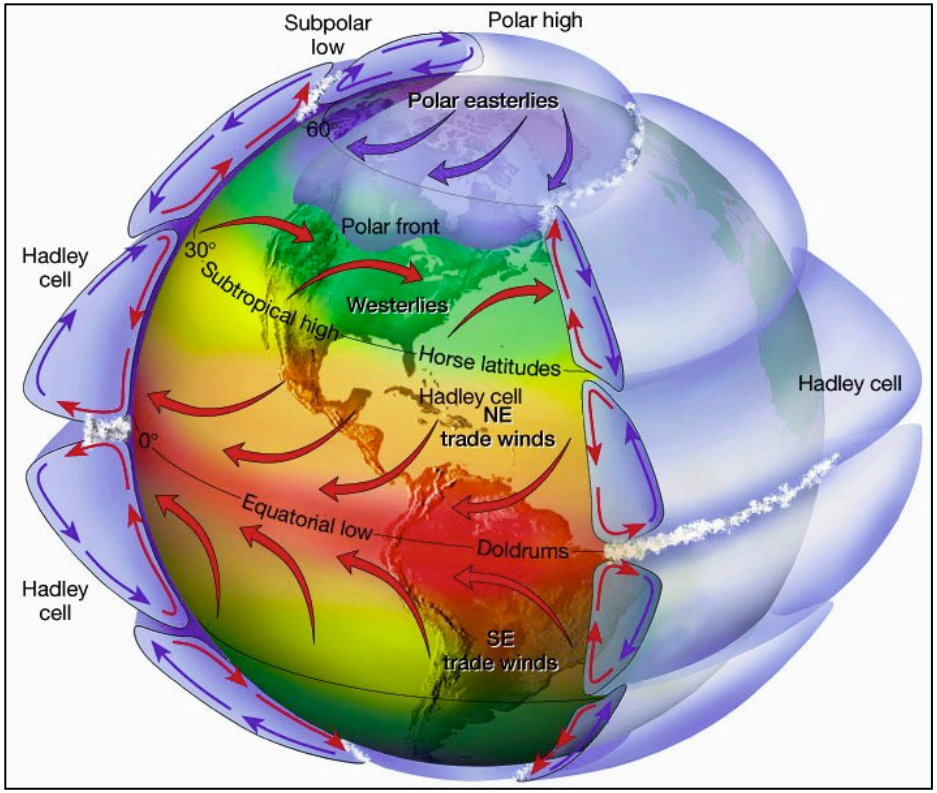

LOW
PRESSURE
HIGH
PRESSURE
Heat released
radiates to space
Cool,
dry air
Condensation
and
precipitation
Falls,
is compressed,
warms
Rises,
expands,
cools
Warm,
dry air
Hot,
wet air
Flows toward low pressure,
picks up moisture and heat
HIGH
PRESSURE
Moist surface warmed by sun
LOW
PRESSURE


Moist air rises,
cools, and releases
moisture as rain
cap
Cold
deserts
Evergreen
coniferous forest
Temperate deciduous
forest and grassland
Hot desert
Tropical deciduous forest
Tropical rain forest
Tropical deciduous forest
Hot desert
Temperate deciduous
forest and grassland
Cold
deserts
cap
Air cools and
descends at
lower latitudes.
Warm air rises and
moves toward the
poles.
Air cools and
descends at
lower latitudes.

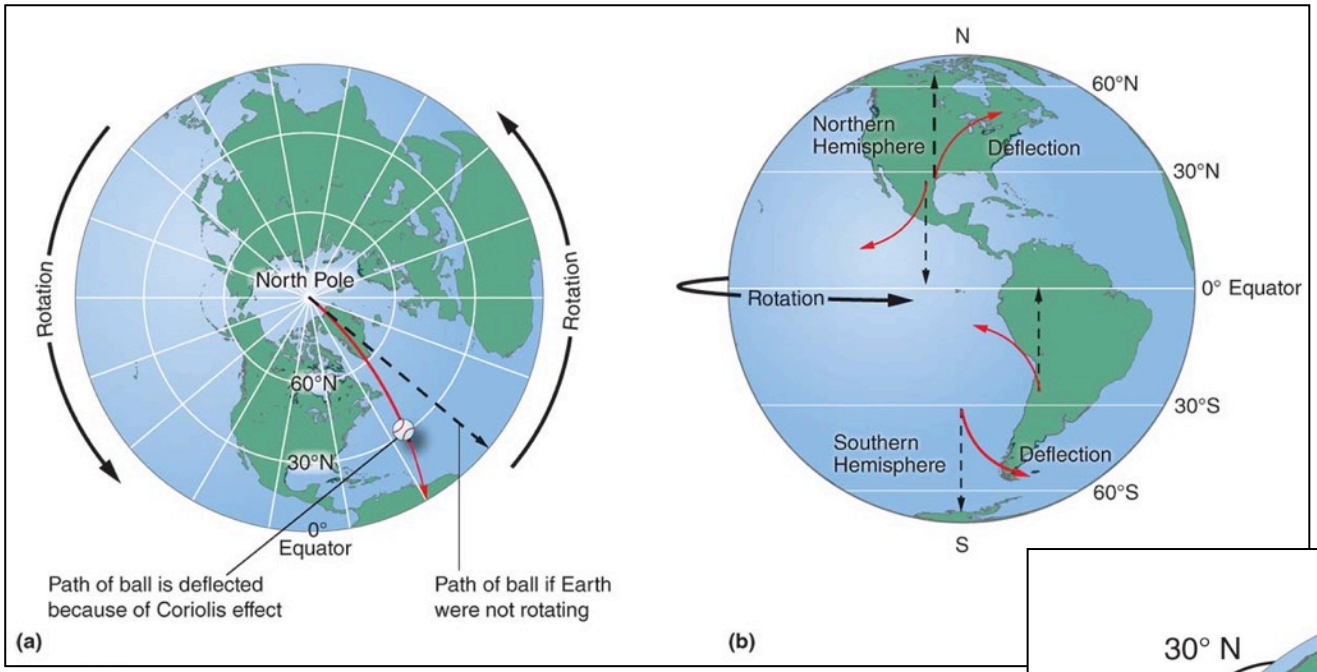
Climate- Earth's Rotation: The Coriolis Effect

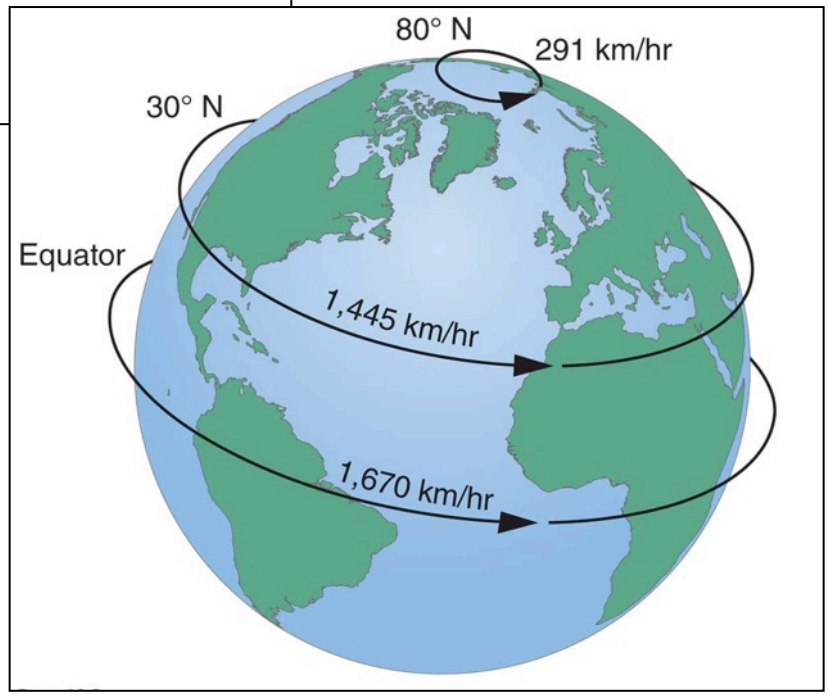
Earth moves faster at equator because of difference in circumference causing deflection of objects that are moving directly N or S. As a result prevailing winds are produced by a combination of atmospheric convection currents and the Coriolis effect.



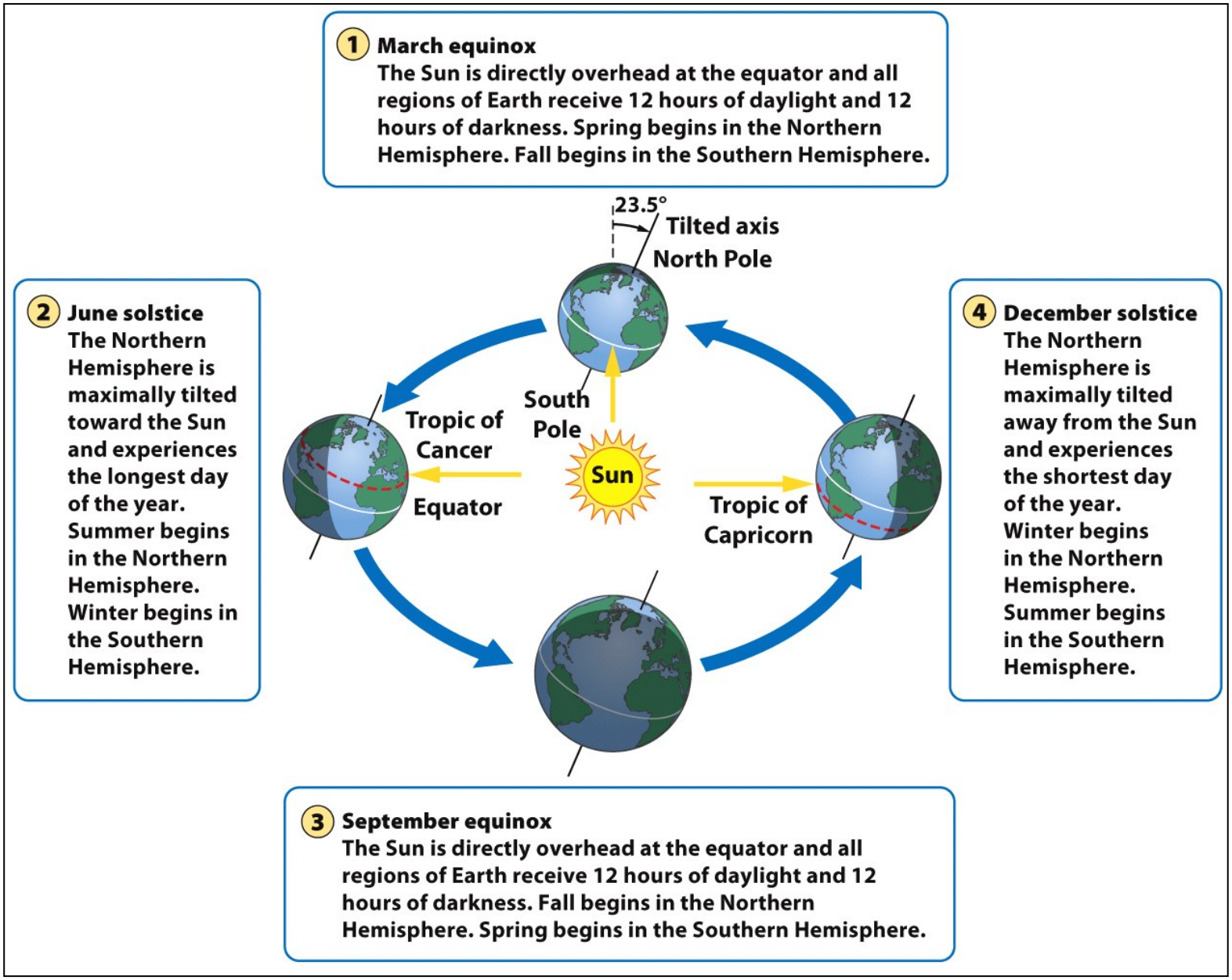


Climate- Earth's Rotation: The Coriolis Effect





Climate- Earth's Tilt: The Reason For The Seasons

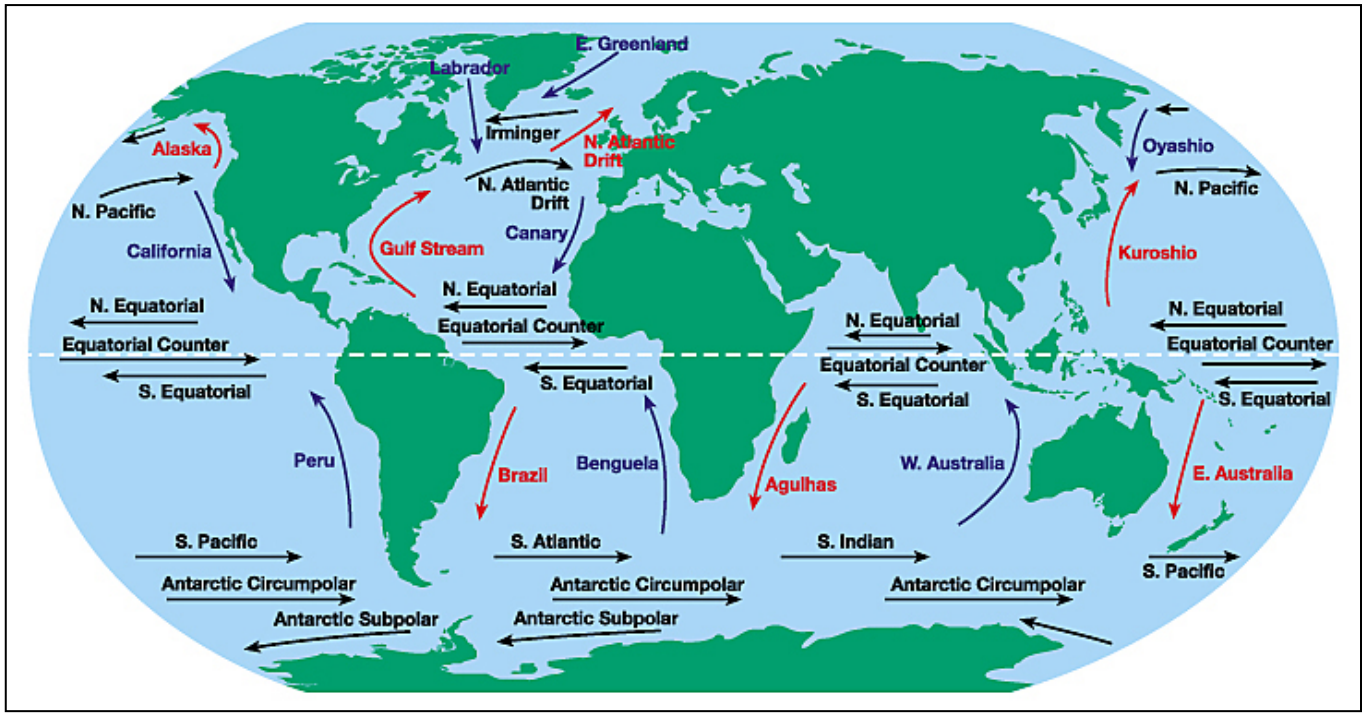


Climate- Ocean Currents

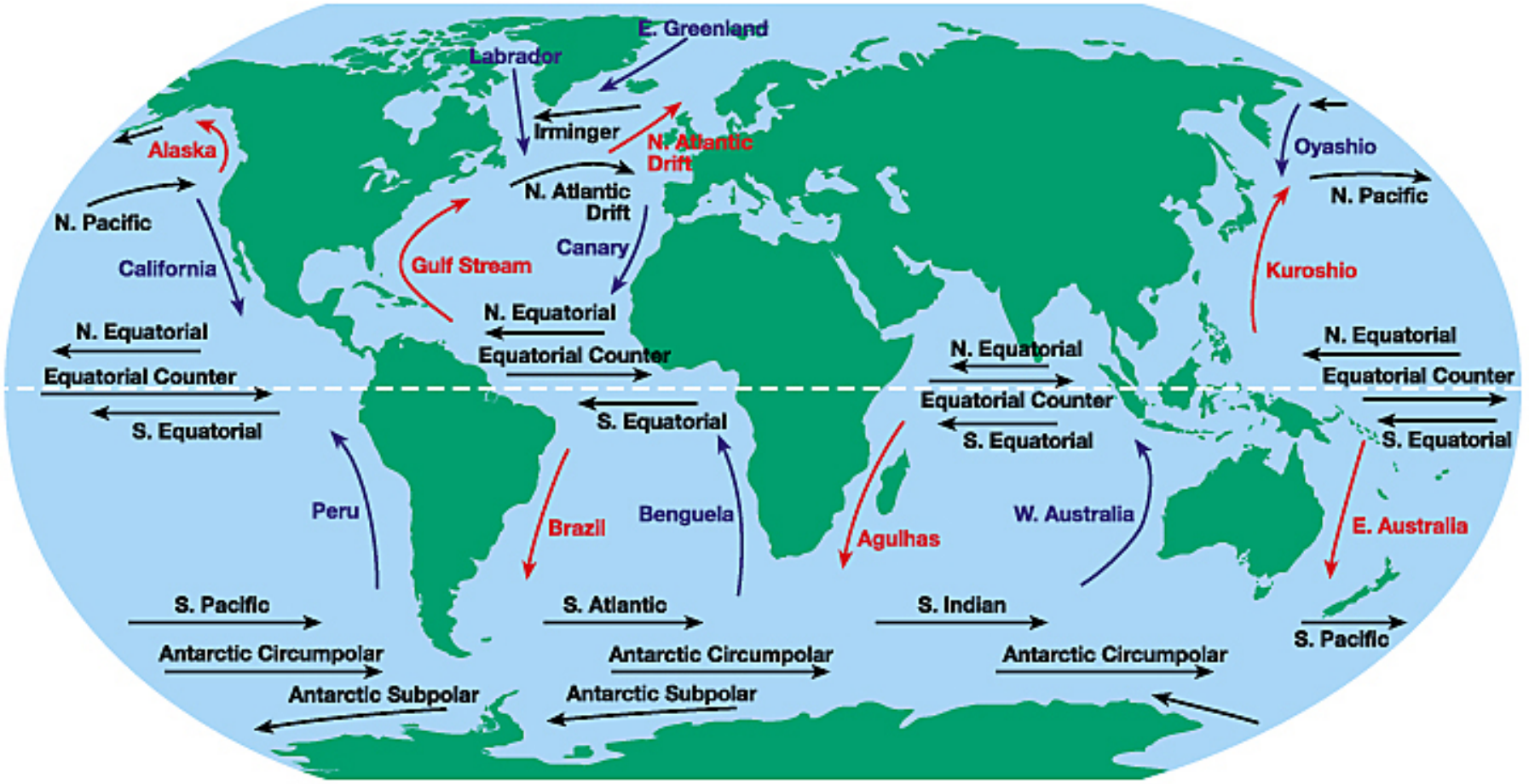
Ocean currents: the flow of water across the surface of the ocean. Driven by a combination of ***prevailing winds***, temperature, gravity, the Coriolis effect and the location of continents.

Gyres: large-scale patterns of water circulation; combinations of ocean currents.

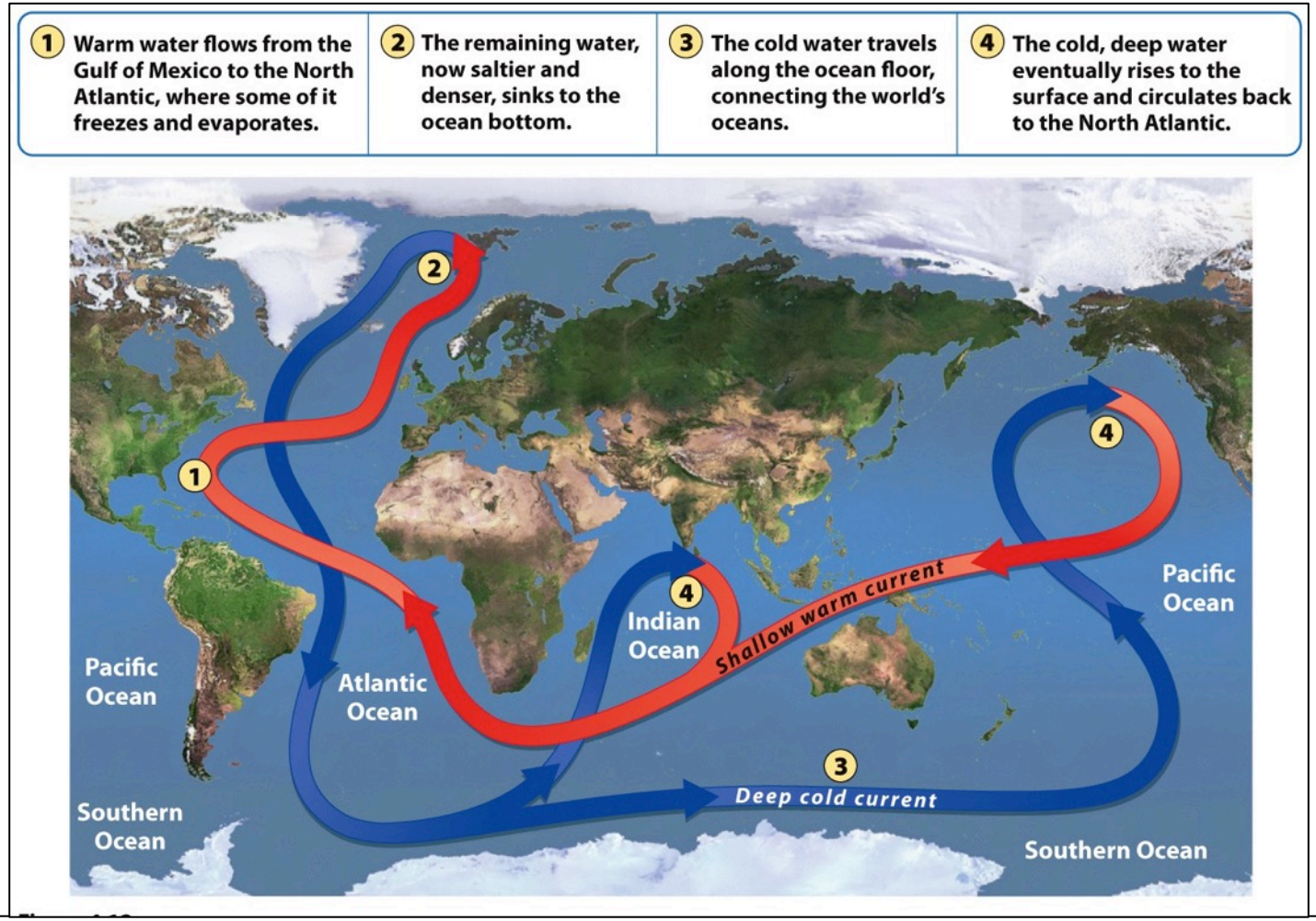
Ocean currents are a major factor in the global distribution of heat and ultimately, climate.



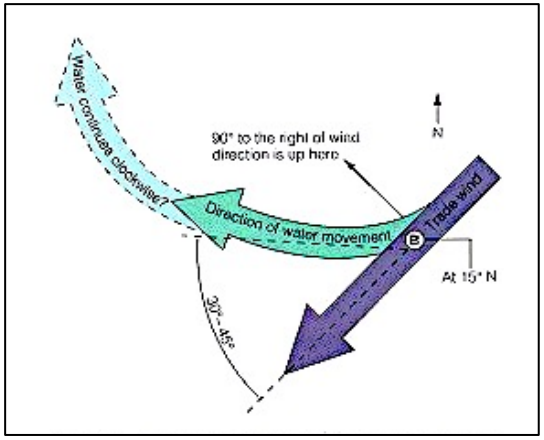
Climate- Ocean Currents

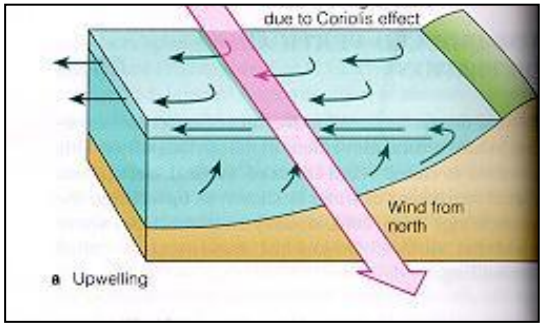


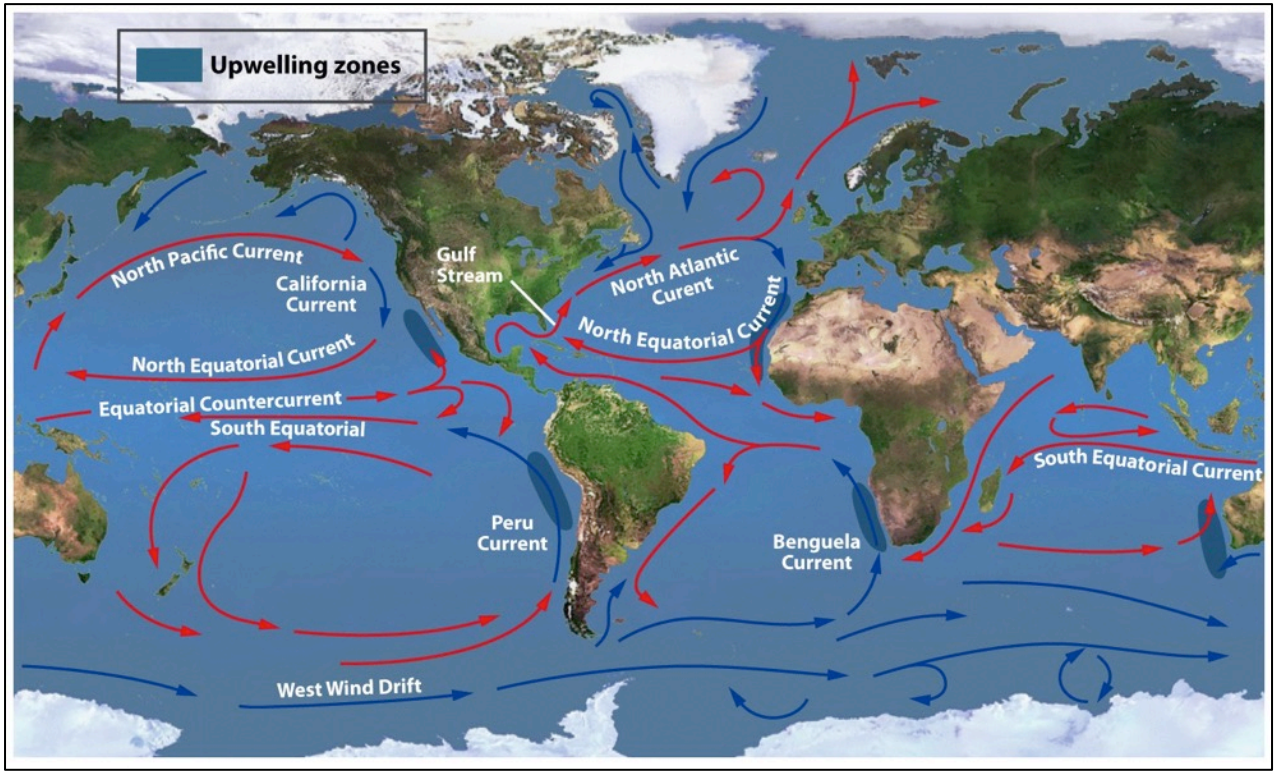
Thermohaline circulation: the global circulation of ocean water initiated by density differences due to variations in temperature and salinity (salt concentrations). Cold salty water at high latitudes (near the poles) sinks and warm water near equator rises driving a global conveyor belt or deep ocean current that mixes all ocean waters.



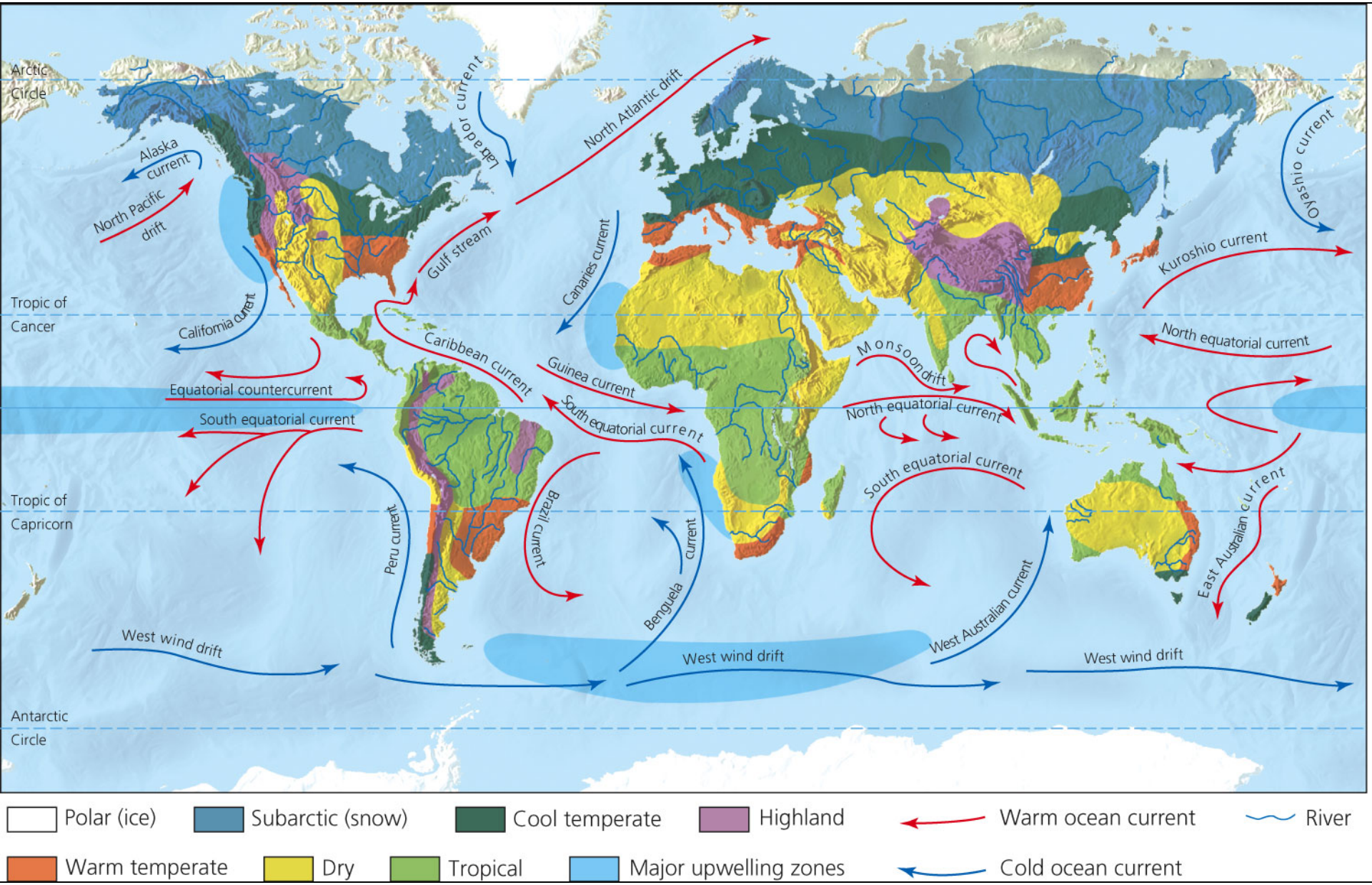
Upwelling: In certain geographic regions, prevailing winds, along with ocean currents, push surface water away from the shore, which is then replaced by waters from below. This brings cold, nutrient rich waters to the surface. This upward movement of water towards the surface distributes nutrients and thus determines coastal areas of productivity.







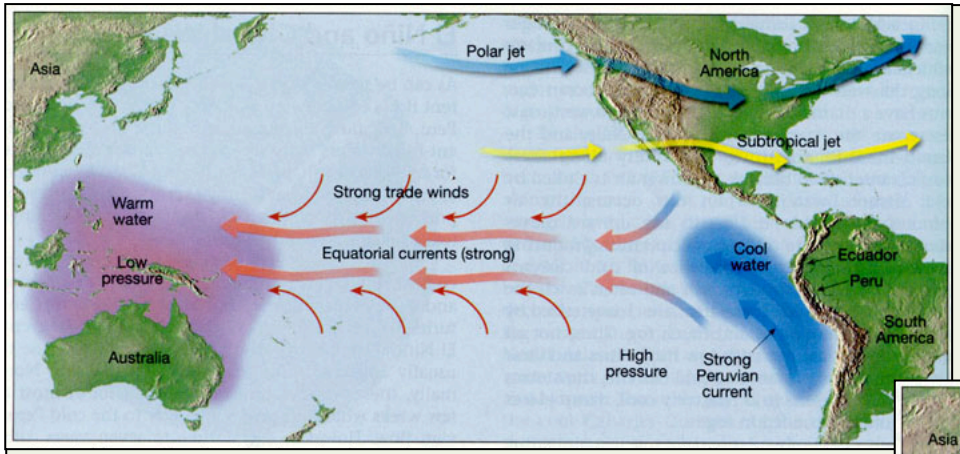
A Complex Interplay of Factors Influence Earth's Climate



Climate- El Niño -Southern Oscillation (ENSO)

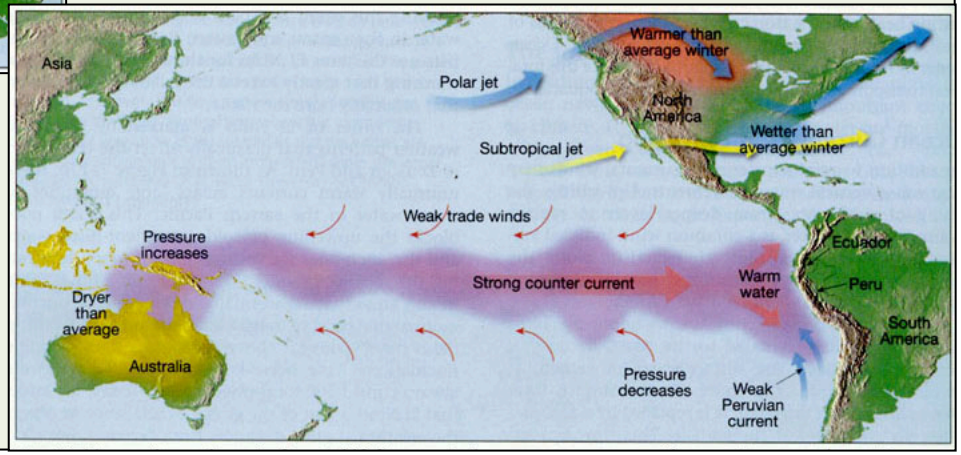
Occurring every 3-7 years, this interaction between the ocean and the atmosphere results from weakened or reversed trade winds.

The normally cold waters off western coast of S. America warm and suppress the upwelling of nutrient rich water, resulting in decreased productivity and decline in fish populations.



← Normal Conditions

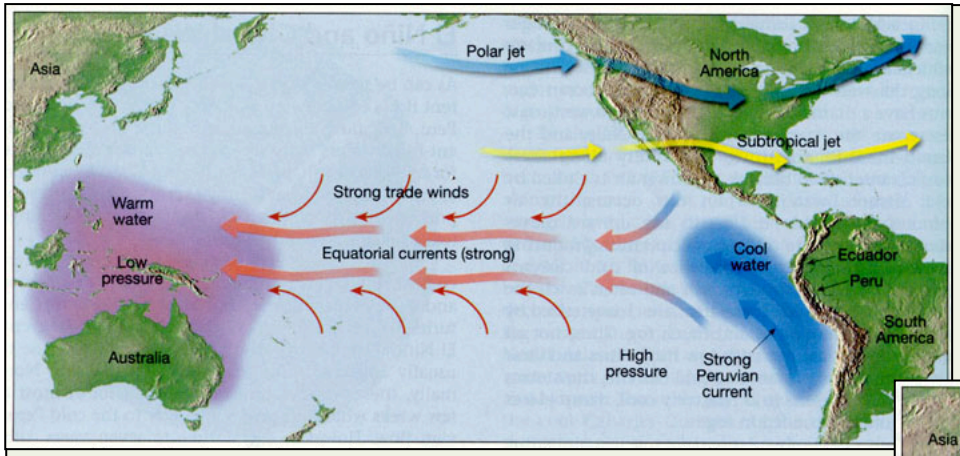
El Niño Conditions →



Climate- El Niño -Southern Oscillation (ENSO)

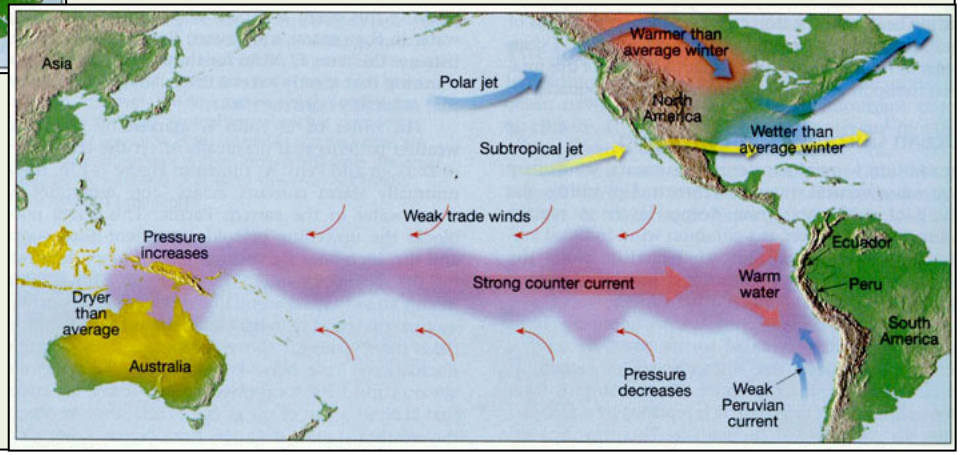
The area of humid, rising air and abundant rainfall, normally in the western Pacific, shifts eastward, to the central, and eastern Pacific.

This shift causes torrential rains and flooding in the normally arid areas along the west coast of South America.

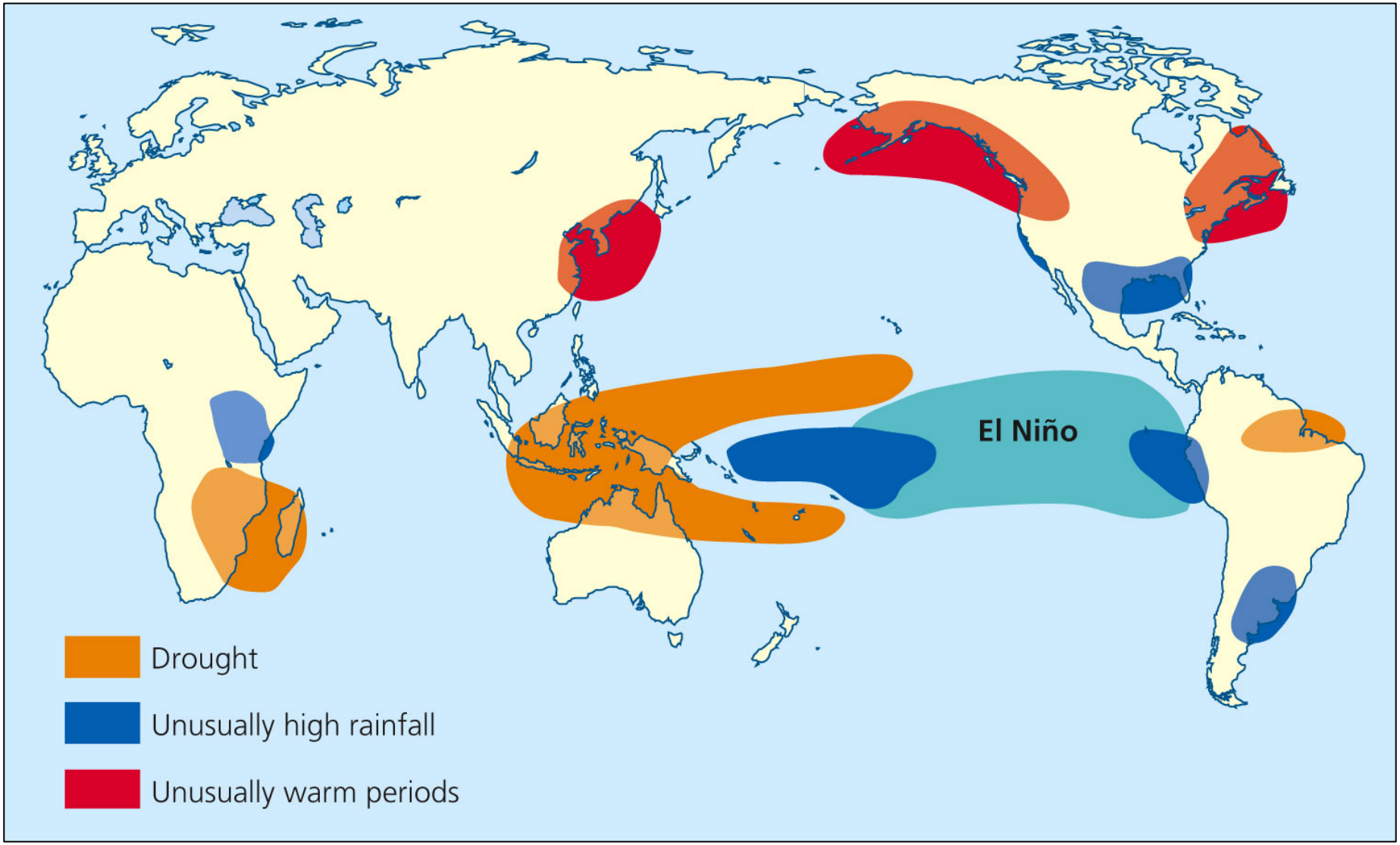


← Normal Conditions

El Niño Conditions →



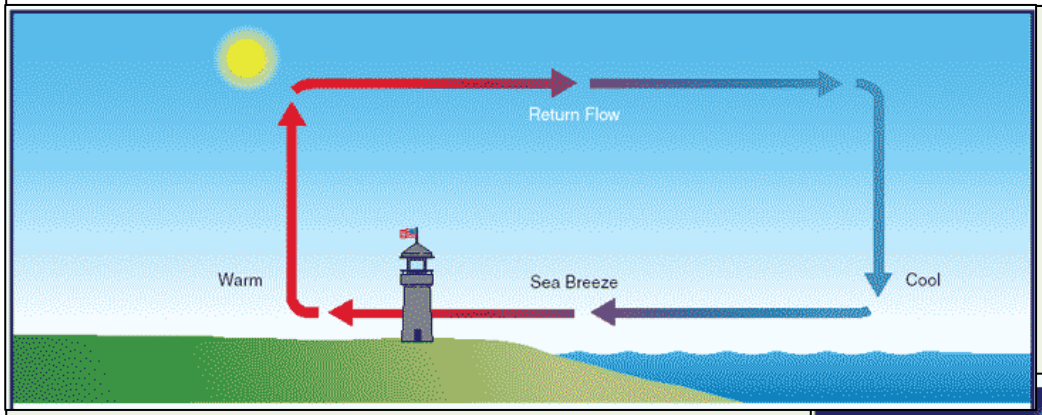
Climate- El Niño -Southern Oscillation (ENSO)



Climate- Land and Sea Breezes

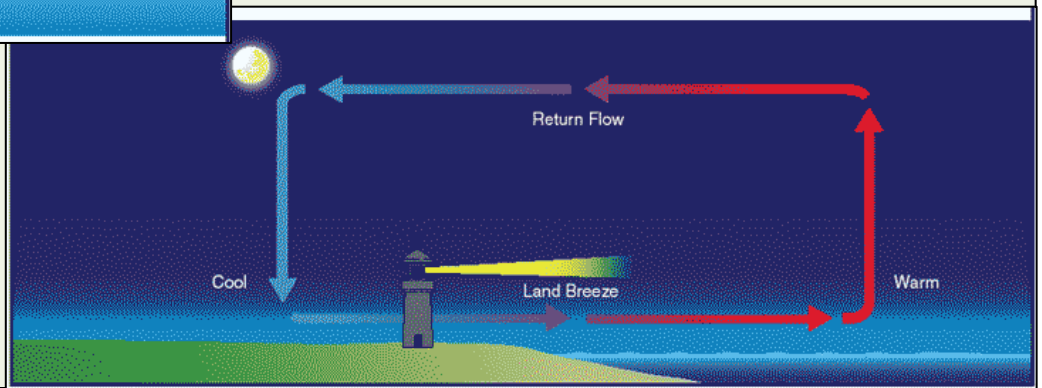
Water has a greater ***heat capacity*** than land, which means it gains and loses heat at a much slower rate than land. In other words, water stays in the same temperature range day to night and season to season, while land temperature fluctuates often.

Heat is *absorbed* and *released* more slowly by water than by land to create land and sea breezes that moderate climate by oceans and large bodies of water.



← Sea Breezes
from water to land

Land Breezes →
blow from the land to the water

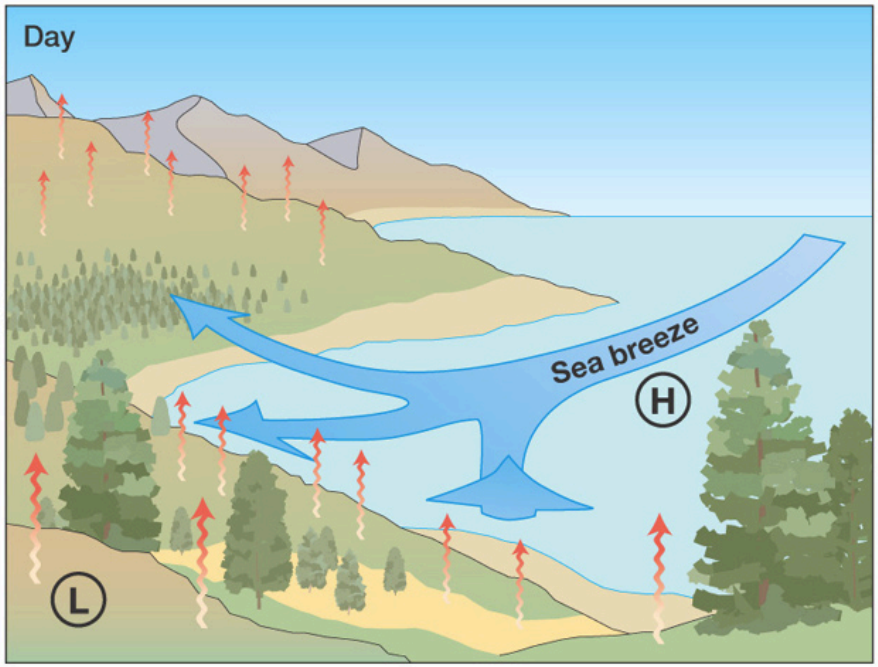


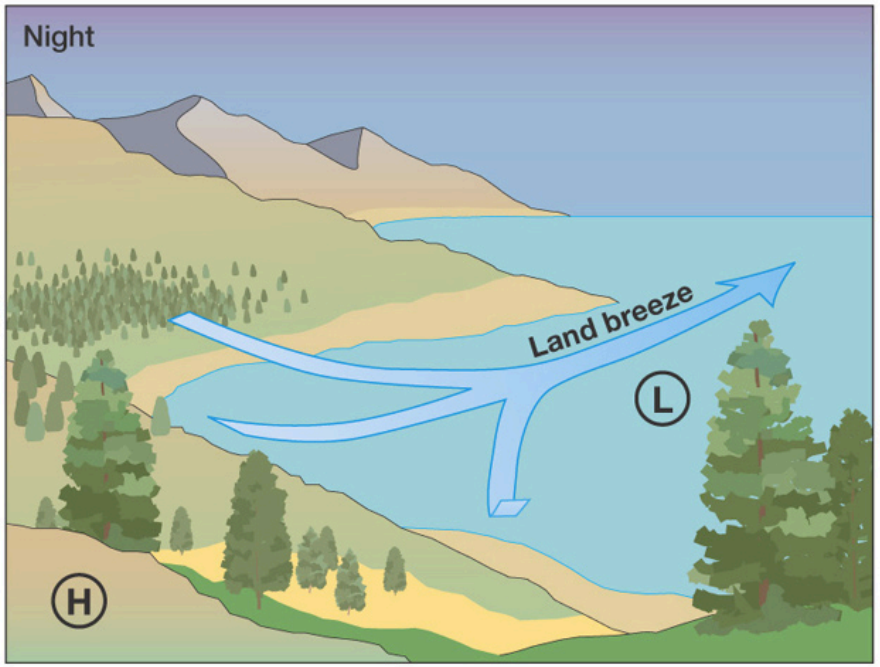
Climate- Land and Sea Breezes

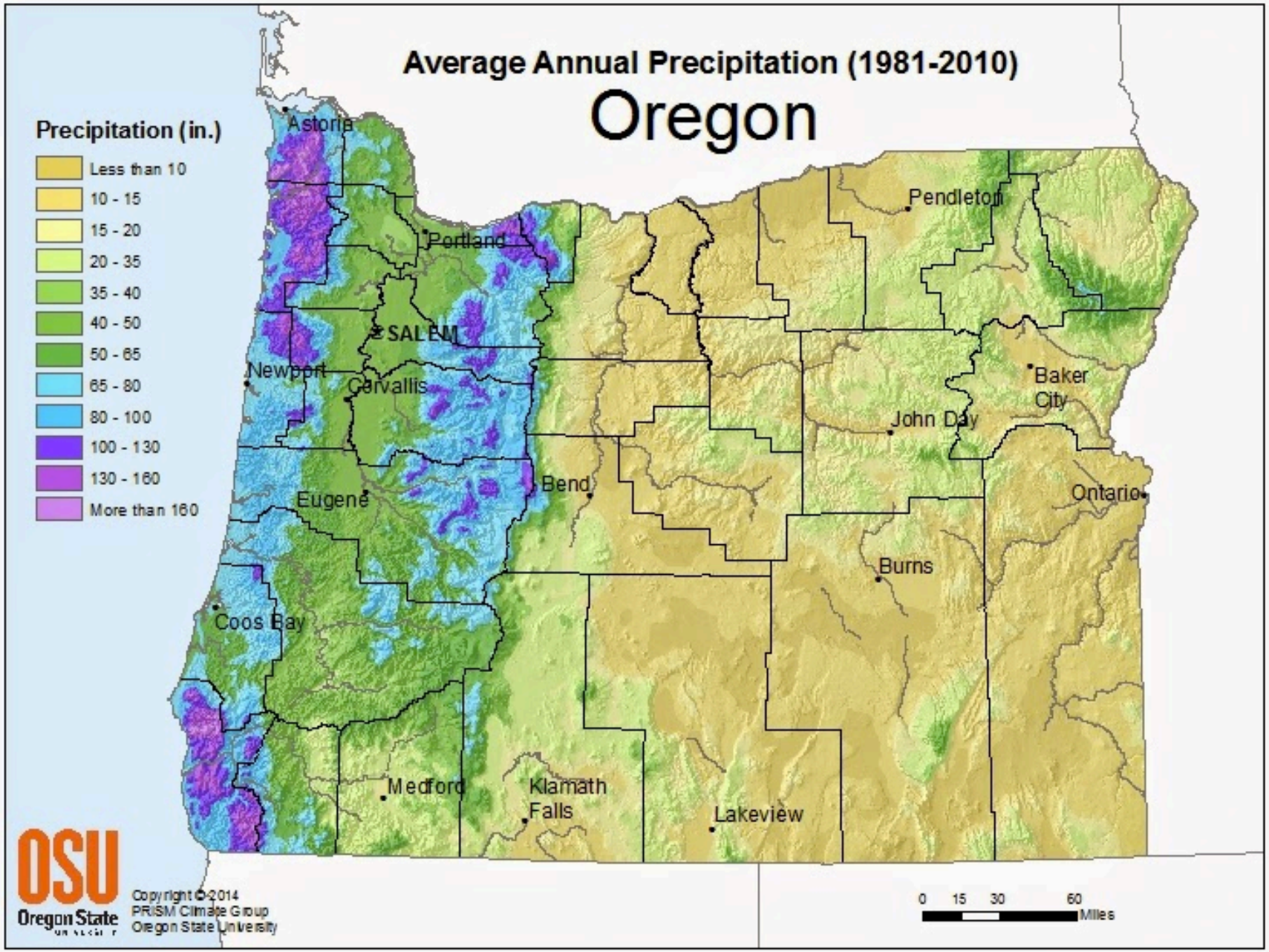
Land breezes blow from the land to the water.

Sea breezes from water to land.

During the day the sand will heat faster than the water, creating an updraft of rising air that then allows surface flows (wind) to flow inland from the ocean. At night the sand will cool faster than the water, thus reversing the flow & wind will blow from land to water.






Average Annual Precipitation (1981-2010)
Oregon
Precipitation (in.)
Less than 10
10 - 15
15 - 20
20 - 35
35 - 40
40 - 50
50 - 65
65 - 80
80 - 100
100 - 130
130 - 160
More than 160
Astoria
Portland
SALEM
Newport
Corvallis
Eugene
Bend
Pendleton
Baker City
John Day
Ontario
Burns
Coos Bay
Medford
Klamath Falls
Lakeview
OSU
Oregon State University
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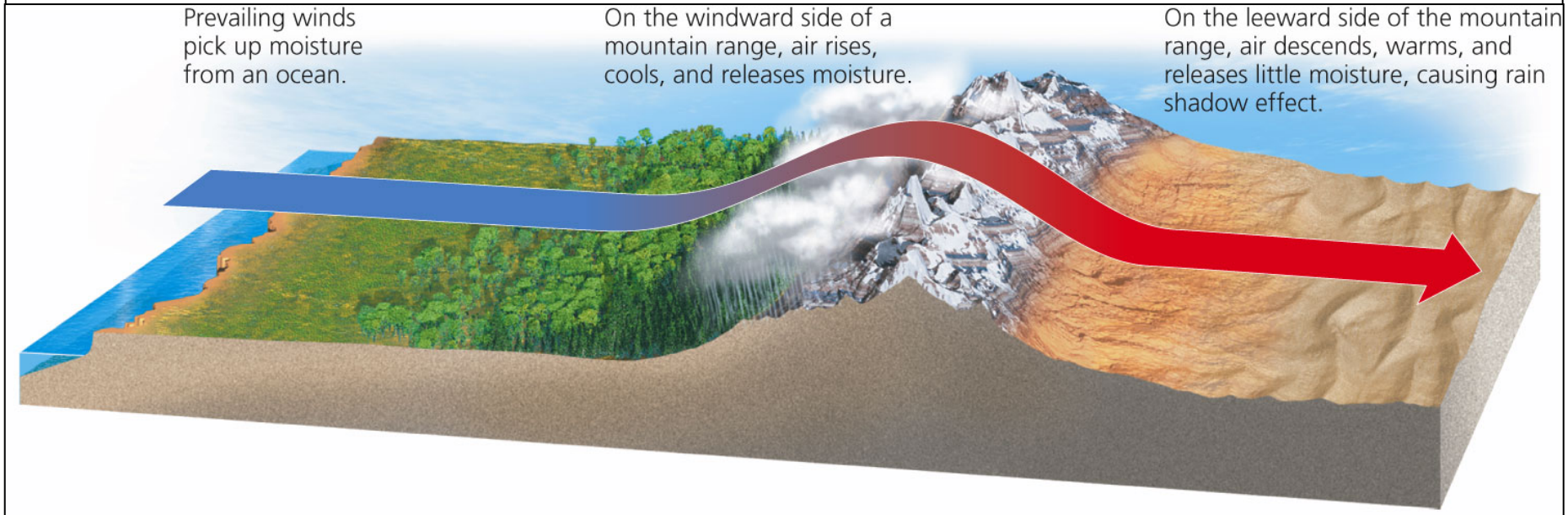
PRISM Climate Group
Oregon State University
0 15 30 60
Miles

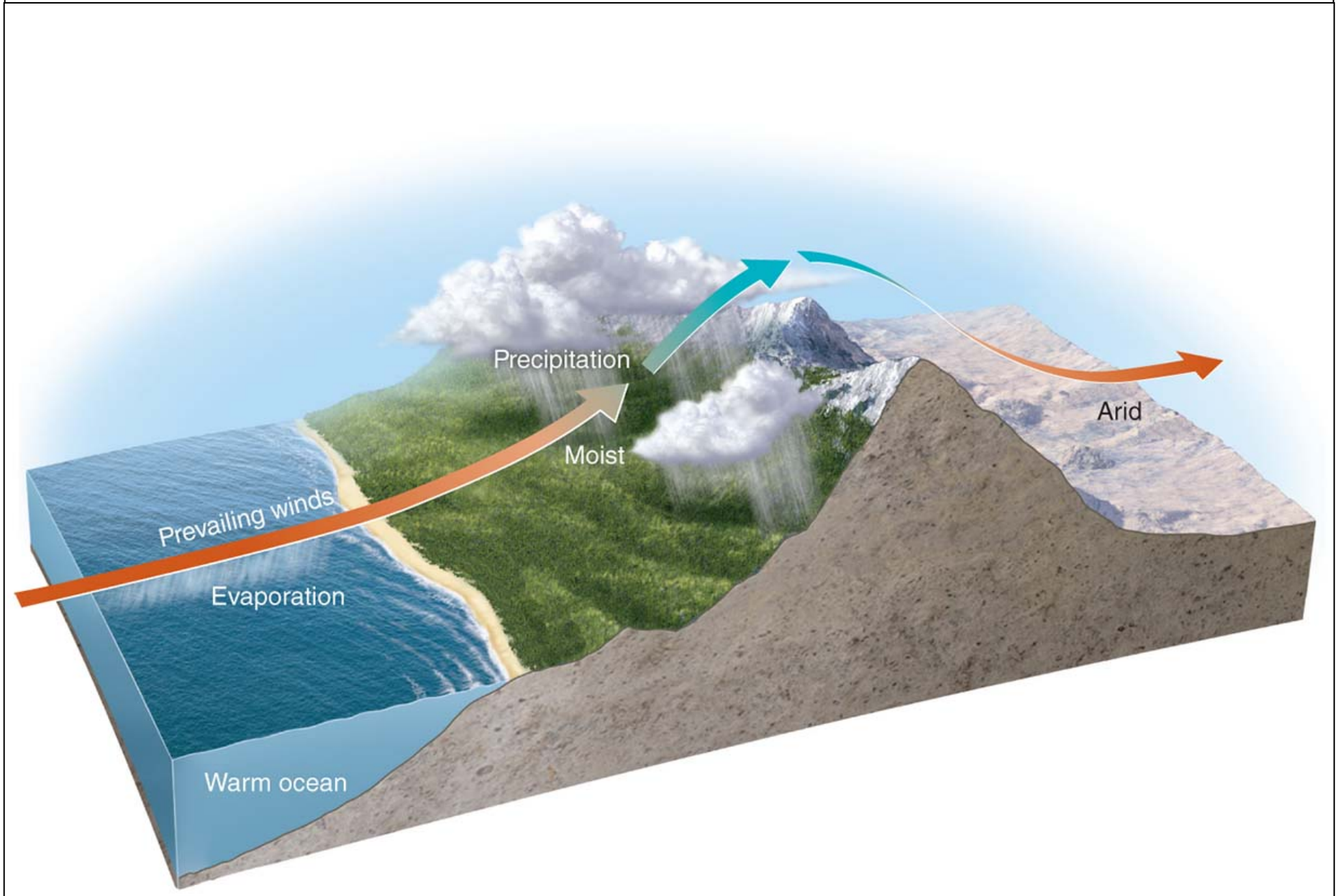
Climate- Rainshadow Effect

Rainshadow Effect: when moist air blowing inland reaches mountains it cools and expands as it rises, dumping moisture on windward side as rain or snow (also known as orographic lifting). Consequently leaving the leeward side with a dry air mass that draws moisture out of plants and soil. Often forms desert (e.g. death valley, leeward side of Cascades, Gobi desert).

- Most precipitation falls on the windward side (green side) of mountain ranges; resulting in forest and areas of high productivity
- Deserts leeward (dry side)

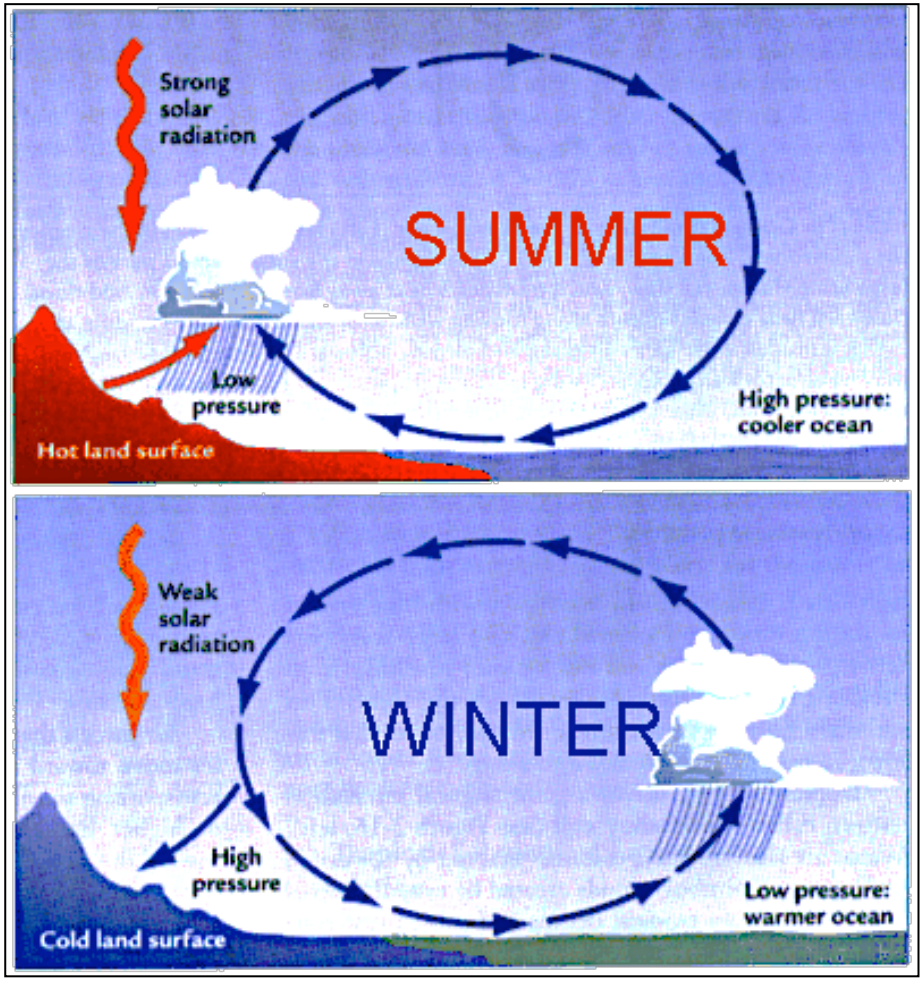


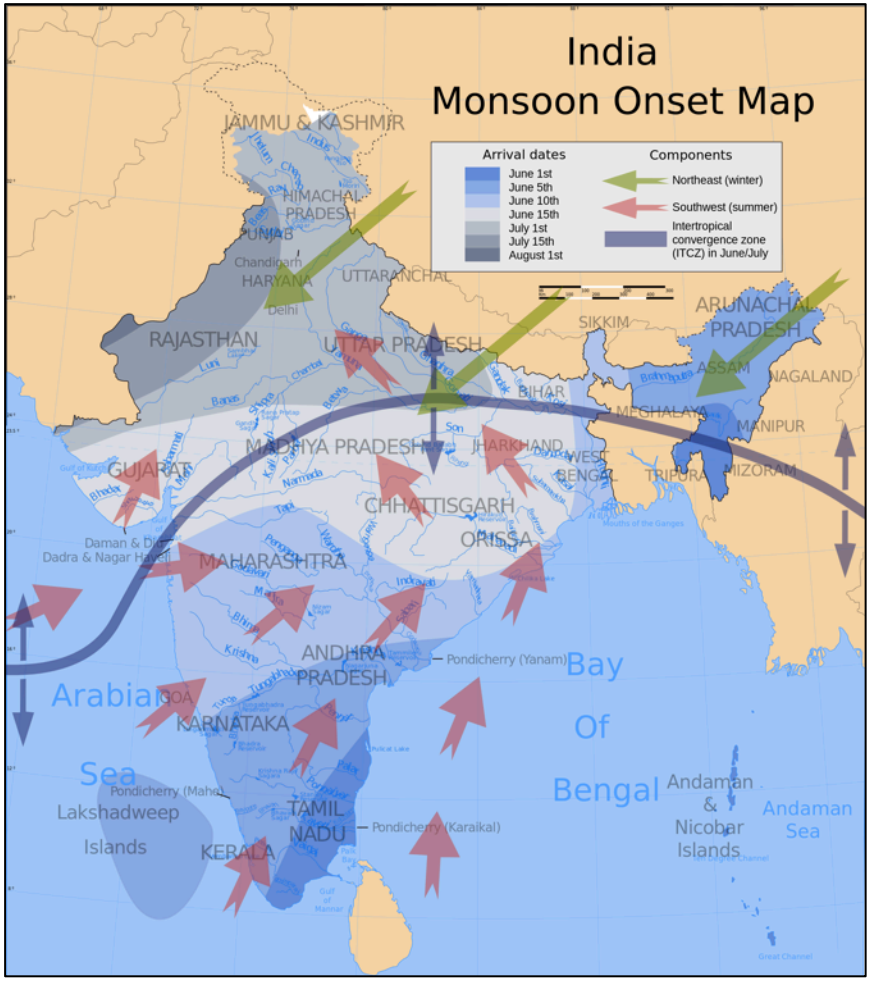
Climate- Rainshadow Effect



Climate- Rainshadow Effect- Himalayan Mountains

Climate- Monsoons





Climate- Monsoons

Asian monsoons

Monsoon is used to describe seasonal reversals of wind direction, caused by temperature differences between the land and sea. The most well-known of these, where the term is most often applied, is the Asian Monsoon.

SPRING/SUMMER

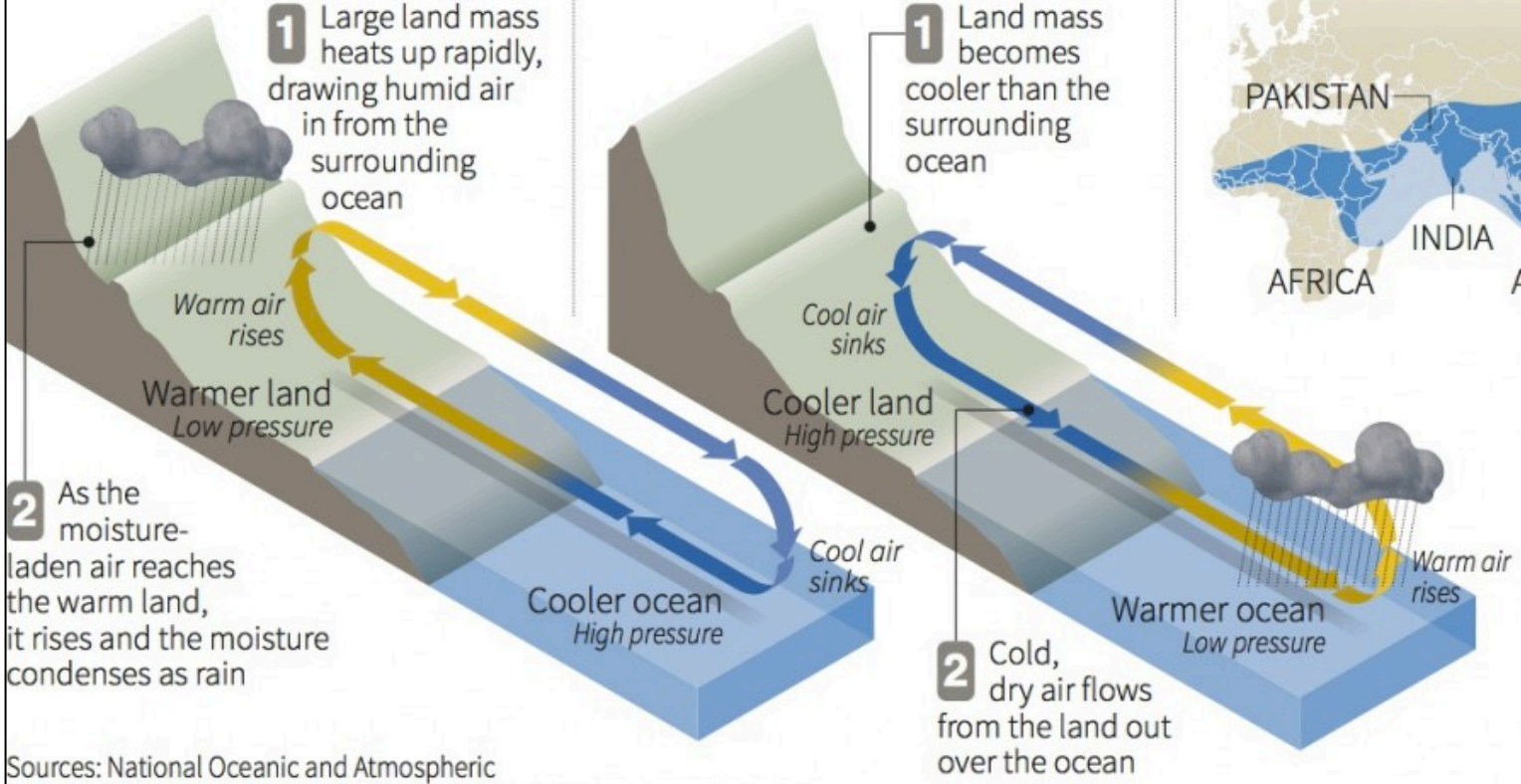
- Southwest monsoon
- When*: May through September

WINTER

- Northeast or retreating monsoon
- When*: October through January

MONSOONAL REGION

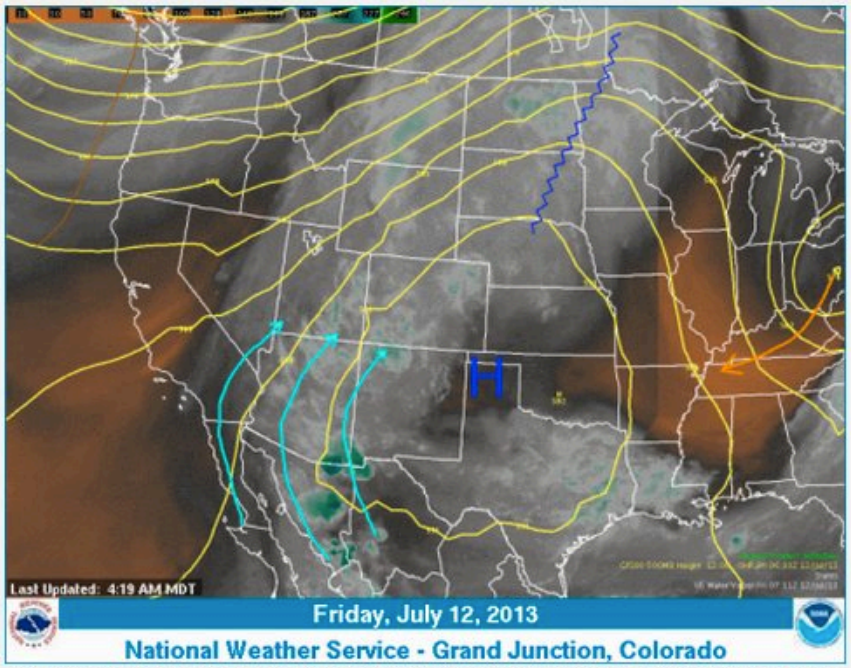
Asian monsoons are made up of the Indian and East Asian subsystems



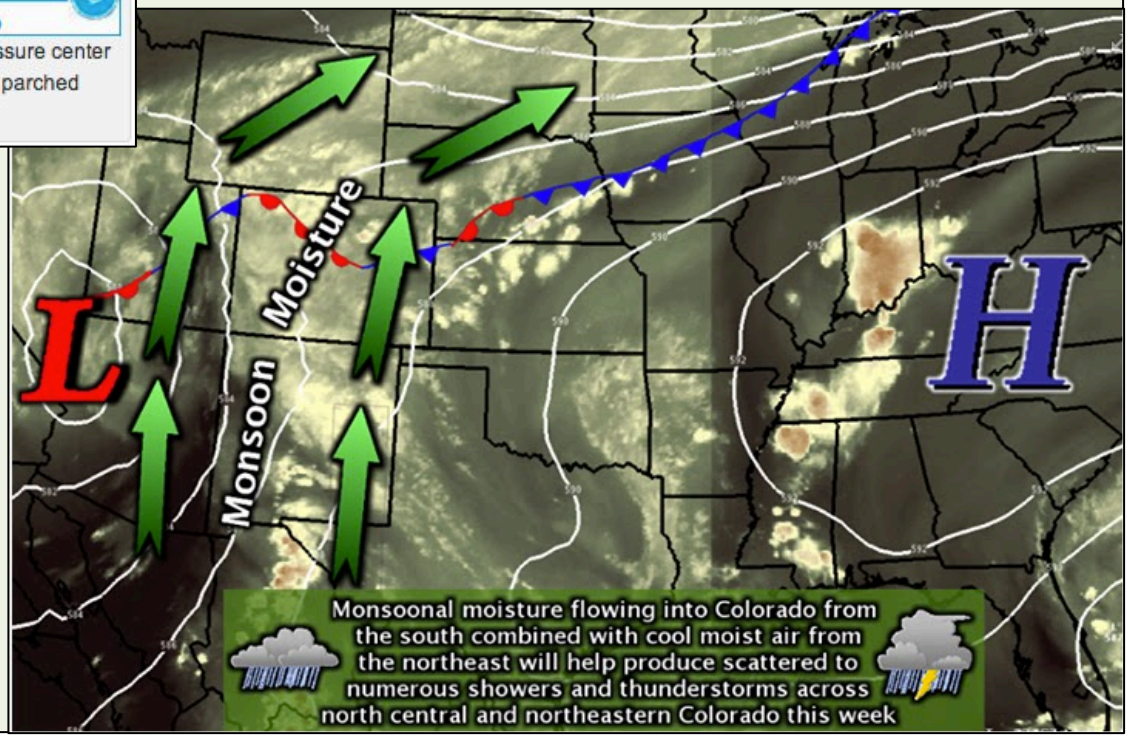
Sources: National Oceanic and Atmospheric Administration (NOAA); National Geographic; Quaternary Science Review

Climate- Monsoons

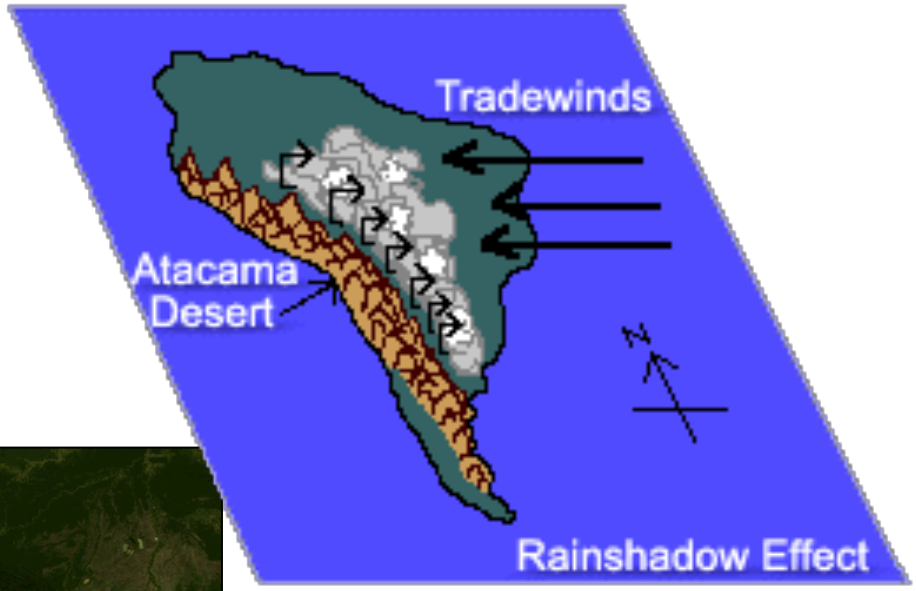
North American Monsoons: a Counter-clockwise rotating low pressure system develops over the Gulf of Mexico and directs warm, moist air to the great plains and the Rocky Mountains.

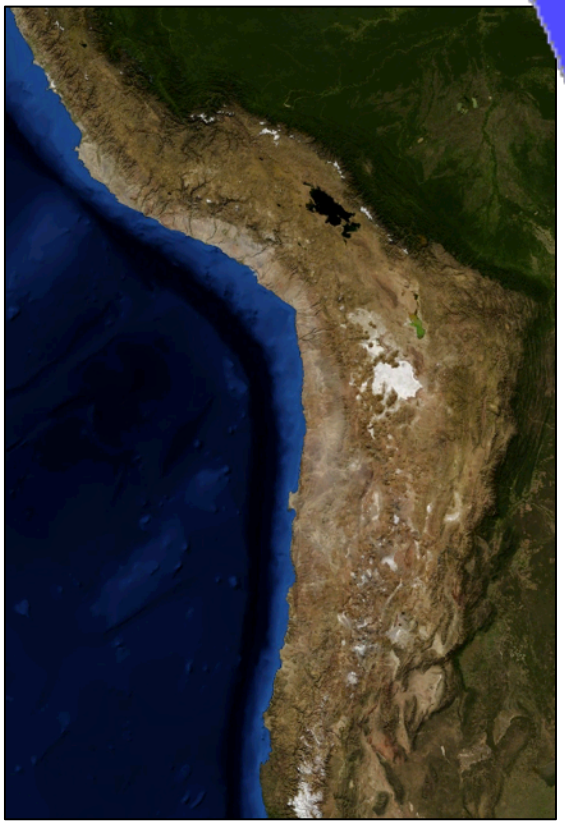


A classic monsoonal flow of moisture, moving clockwise around a high pressure center over the Texas panhandle, is delivering plentiful moisture to parts of the parched Southwest.



Climate- Rainshadow Effect- Atacama Desert, Chile



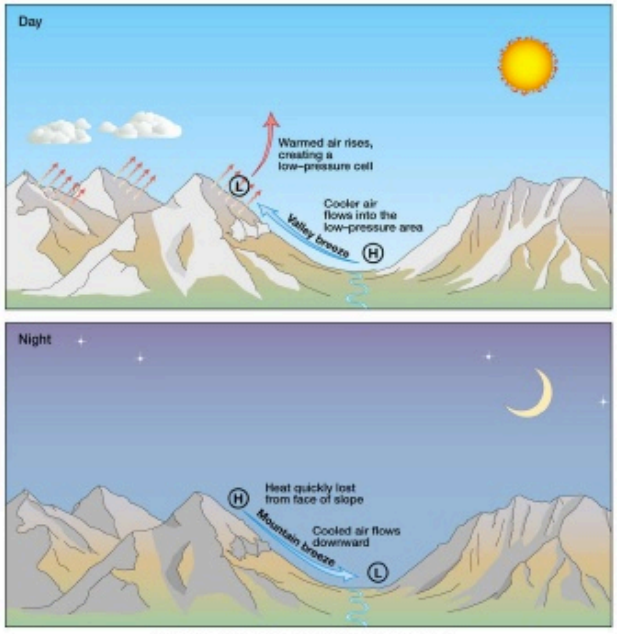


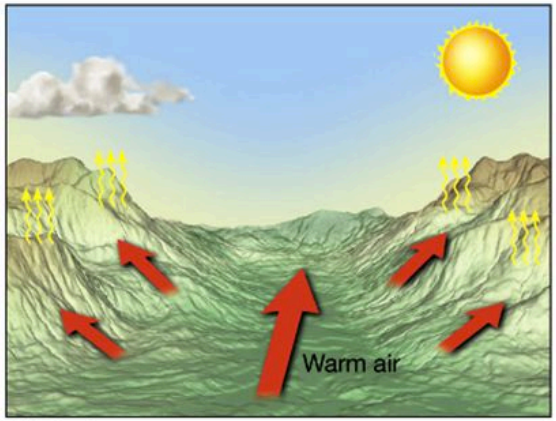
Climate- Mountain & Valley Breezes

Mountain & valley breezes are similar to land and sea breezes in their diurnal cycle (twice a day). Thus, they are often known as the diurnal shift.

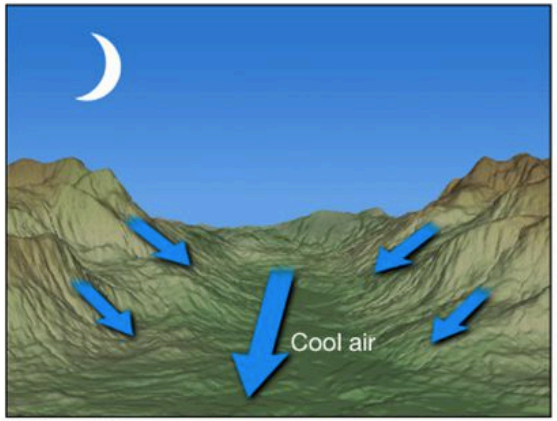
Valley breezes occur during the day because air along mountain slopes is heated and rises up through the valley.

At night as air cools, due to rapid radiational heat loss, reversing the process sending a flow of colder denser air down the valley producing a mountain breeze.





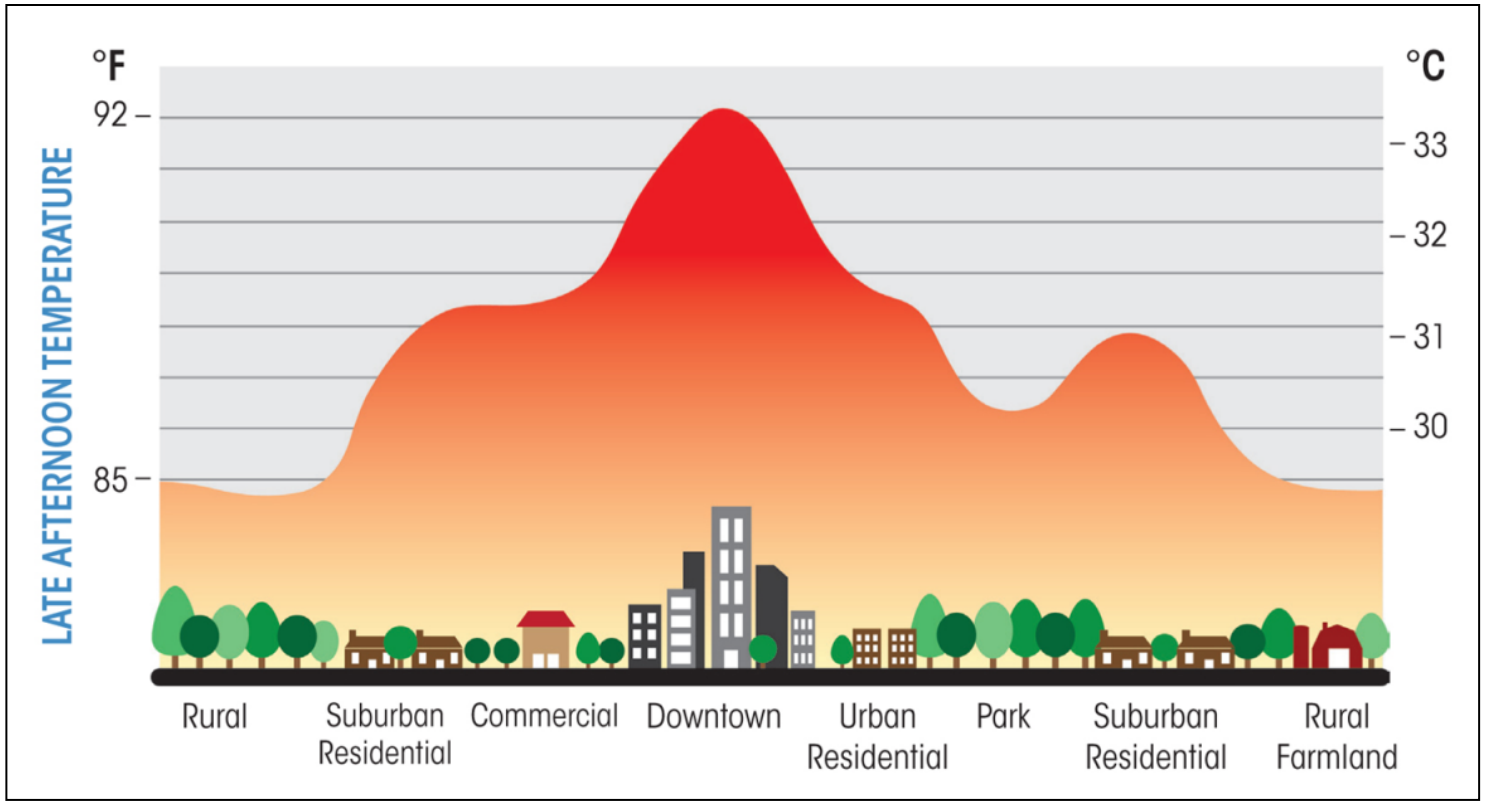
(a) Valley breeze



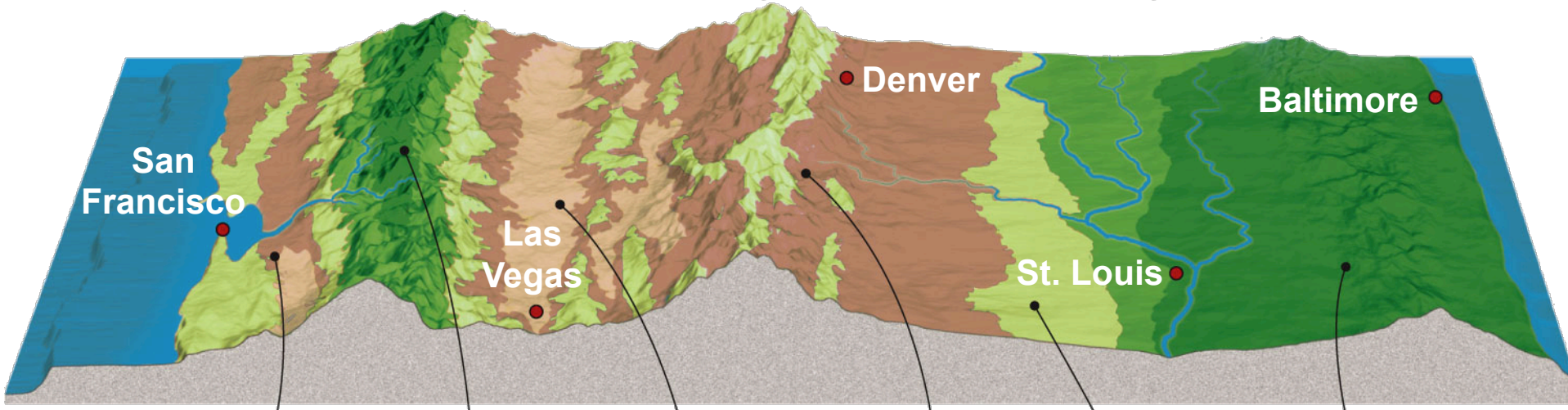
(b) Mountain breeze

Urban Heat Island (UHI)

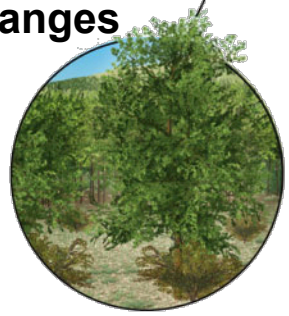
Metropolitan areas are significantly warmer than surrounding rural areas. Cities create microclimates because concrete and asphalt absorb and hold heat; plus buildings block wind flow; motor vehicles and the climate control systems of buildings release large quantities of heat and pollutants



Biomes- Ecosystem Diversity

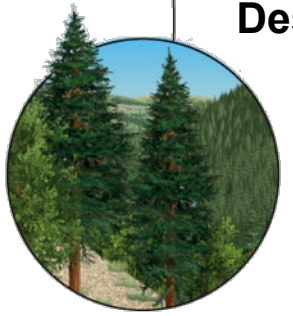


Coastal mountain ranges



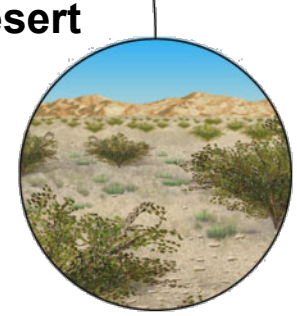
Coastal chaparral & scrub

Sierra Nevada



Coniferous forest

Great American Desert

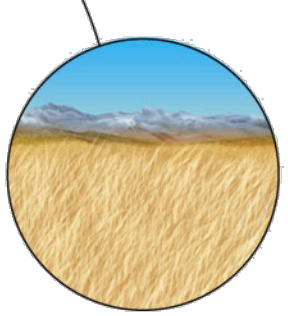


Desert

Rocky Mountains

Coniferous forest

Great Plains



Prairie grassland

Mississippi River Valley

Appalachian Mountains

Deciduous forest

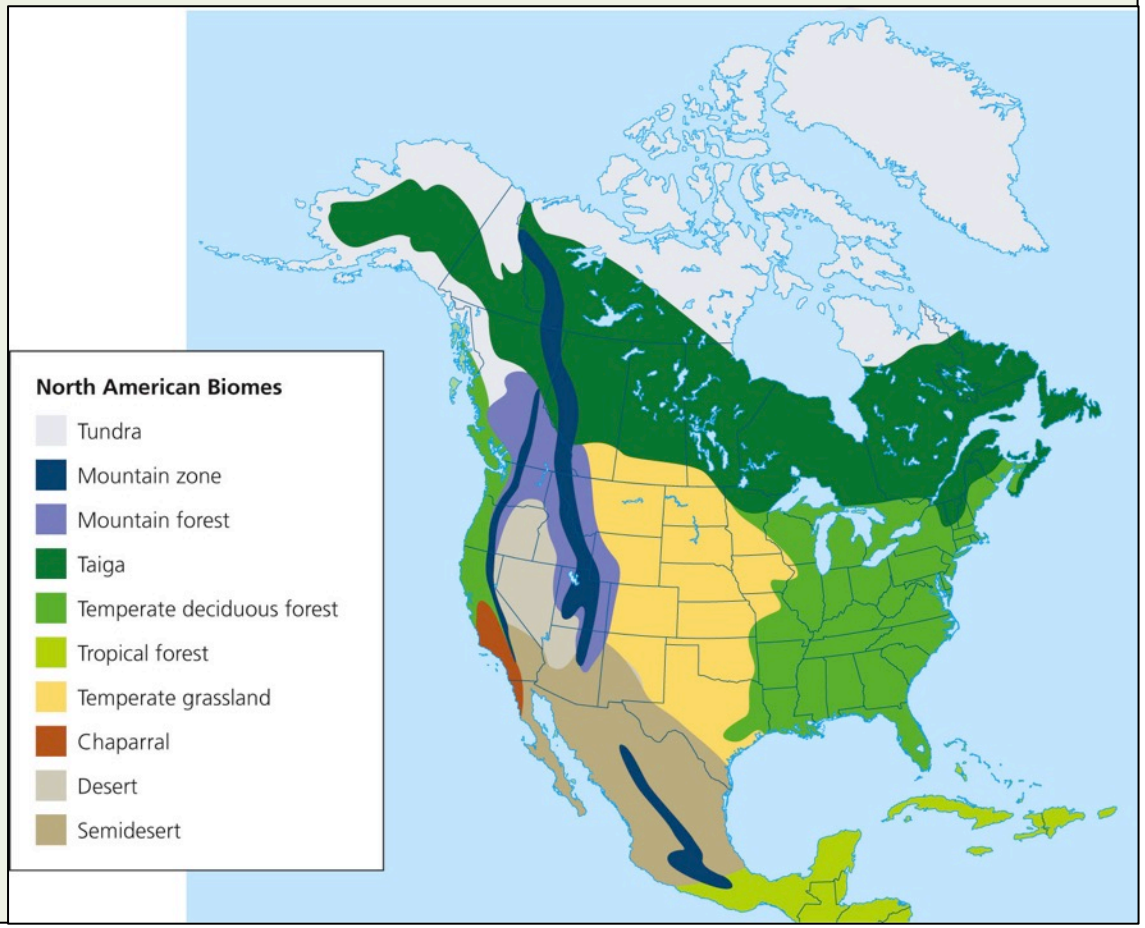
Biomes are large regions characterized by specific climates and communities of species that are specifically adapted to the biotic and abiotic components of their ecosystems.
This variety of ecosystems is a major component of biodiversity.
Each of these ecosystems (biomes) is a storehouse of genetic and species diversity.

Abiotic Factors Determine Climate Zones: Biomes

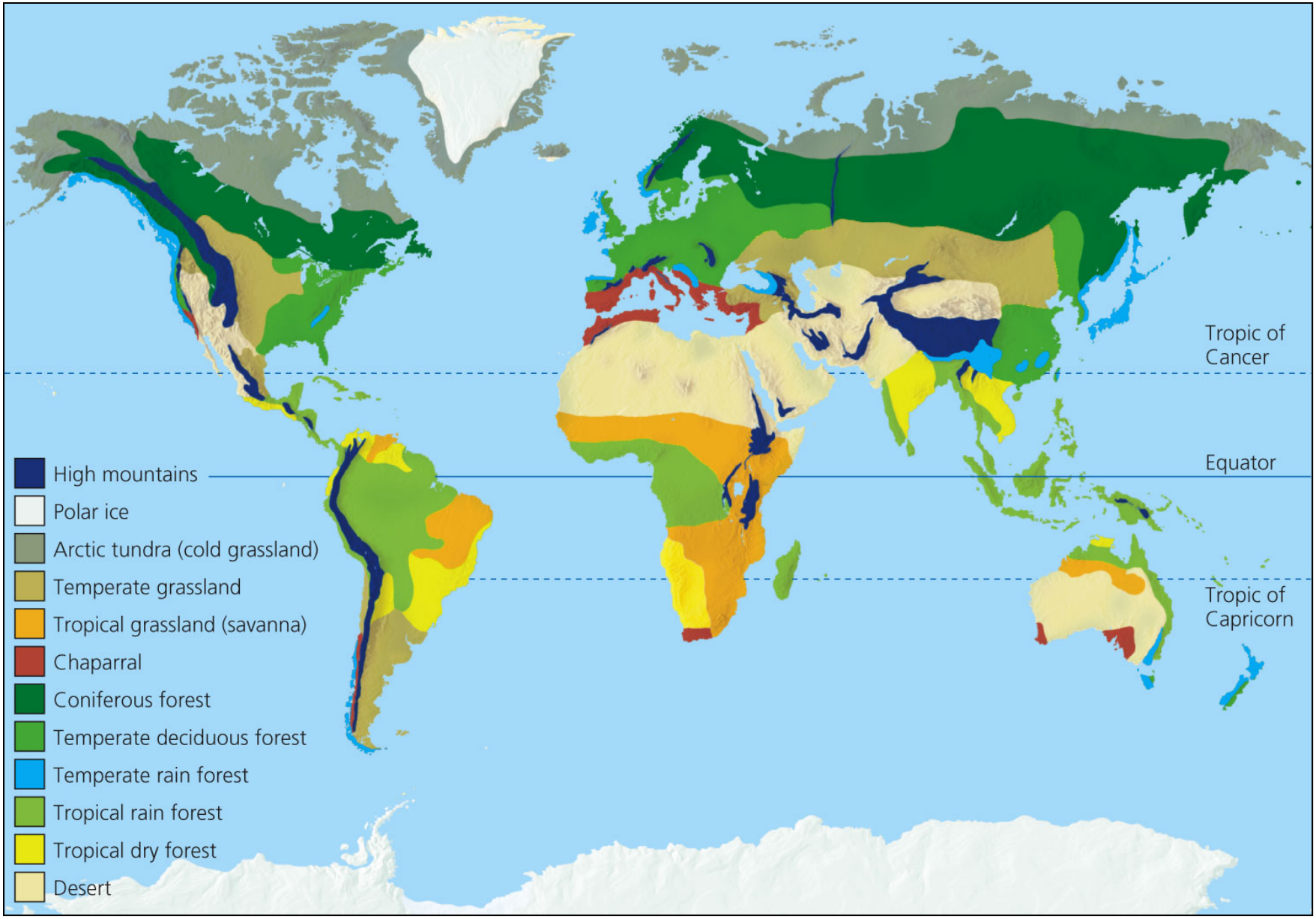
Major **biomes**: large land regions with certain types of climate and dominant plant life

- Not uniform
- Mosaic of patches

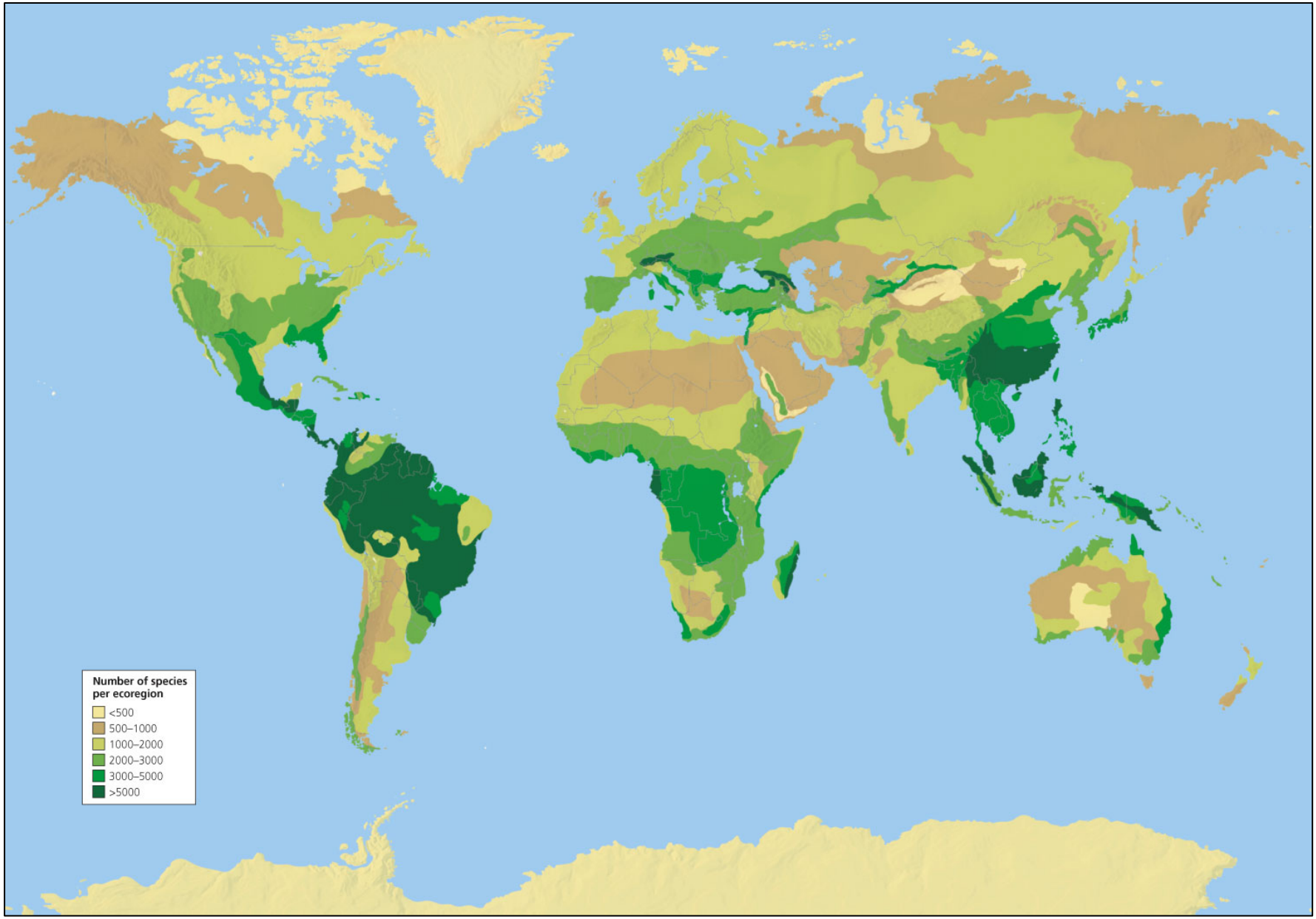
- Latitude and elevation
- Annual precipitation
- Temperature



The Earth's Major Biomes



Global Plant Biodiversity

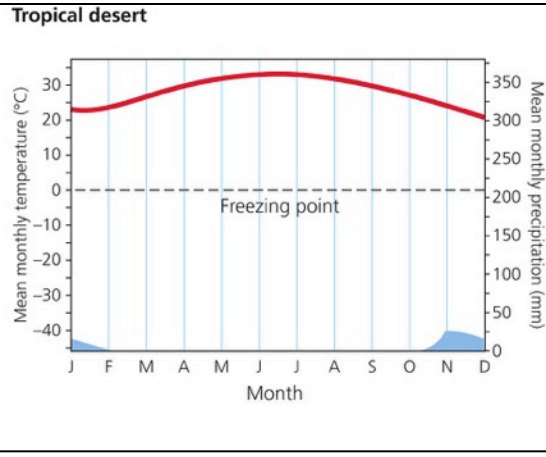


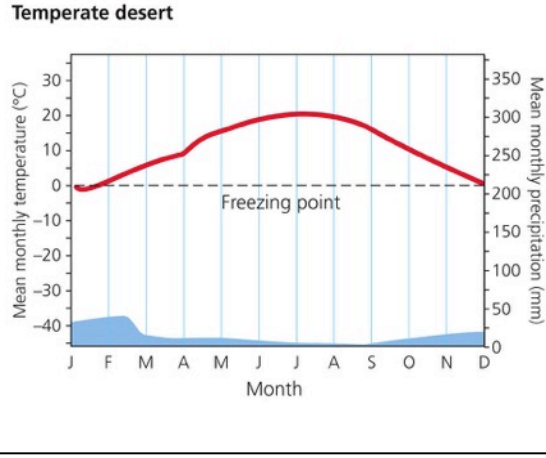
3-Types of Deserts

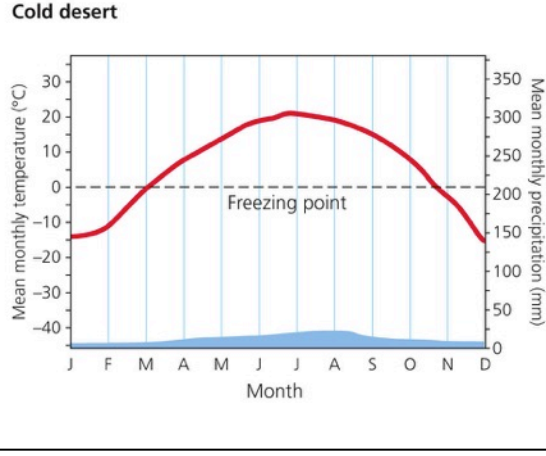
1. **Tropical deserts**
2. **Temperate deserts**
3. **Cold deserts**

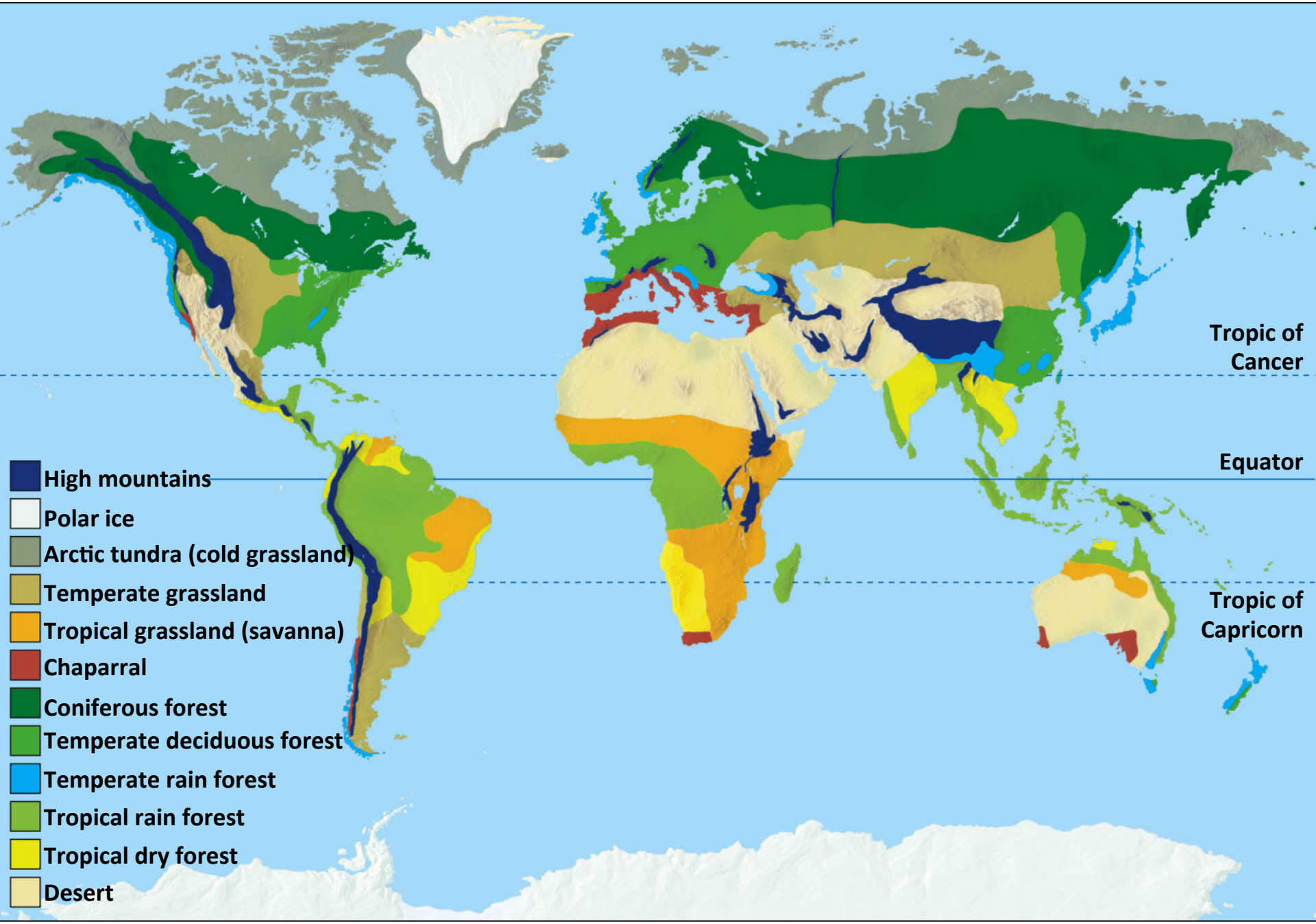
Fragile ecosystem

- Slow plant growth
- Low species diversity
- Slow nutrient recycling
- Lack of water

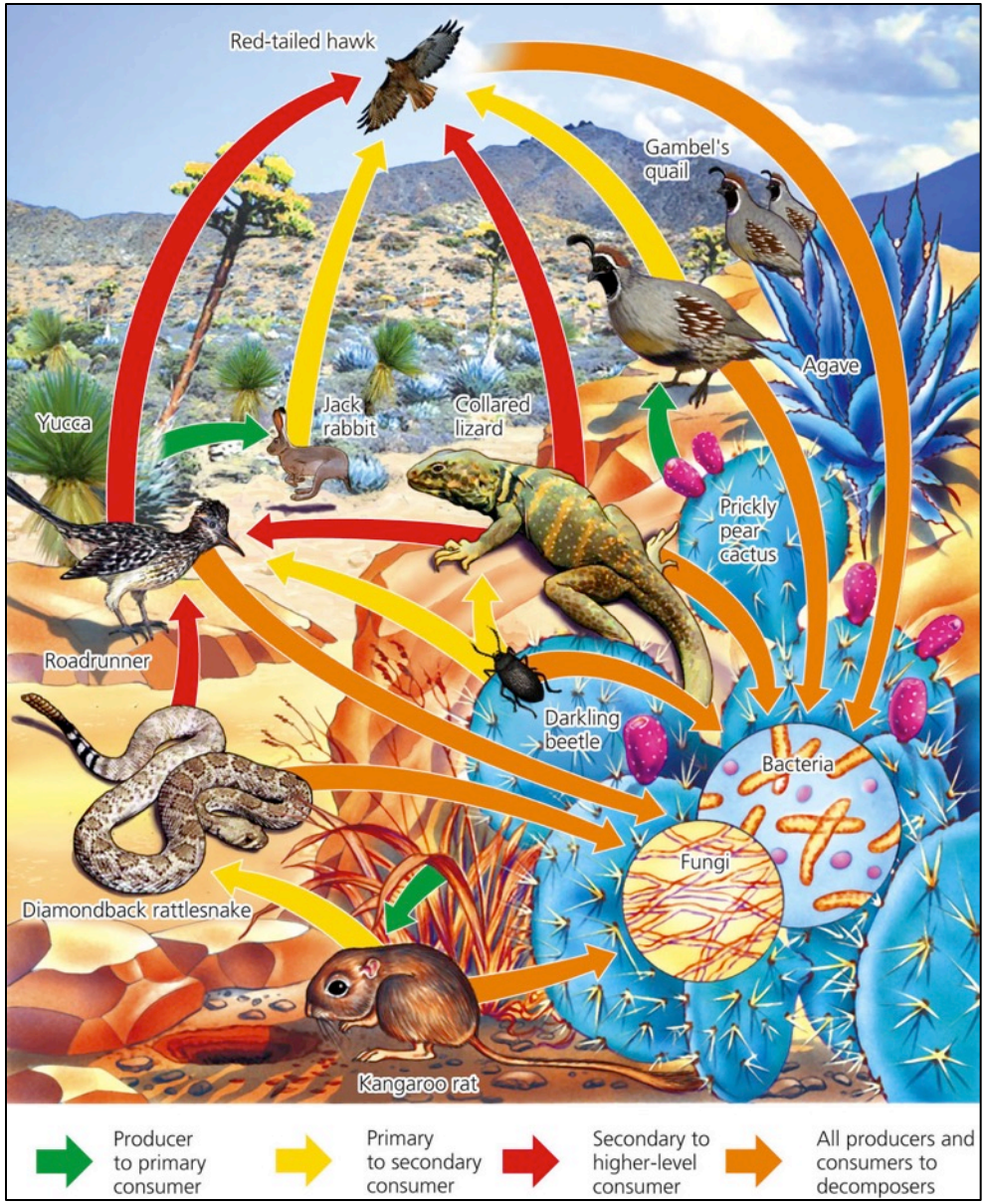







Tropic of Cancer
Equator
Tropic of Capricorn
High mountains
Polar ice
Arctic tundra (cold grassland)
Temperate grassland
Tropical grassland (savanna)
Chaparral
Coniferous forest
Temperate deciduous forest
Temperate rain forest
Tropical rain forest
Tropical dry forest
Desert

Temperate Desert Ecosystem in North America



Staying Alive in the Desert

Beat the heat/every drop of water counts

- Plant adaptations
  - Succulents
  - Deep tap roots

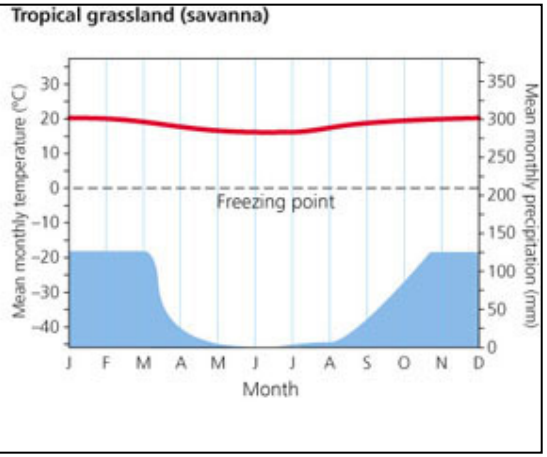
Animal strategies and adaptations

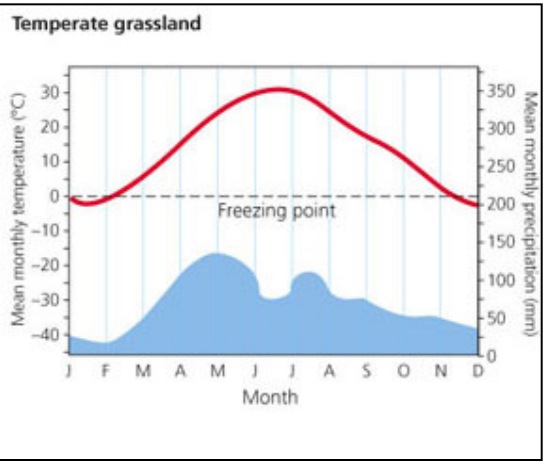
- Physiology and anatomy
- Behavior

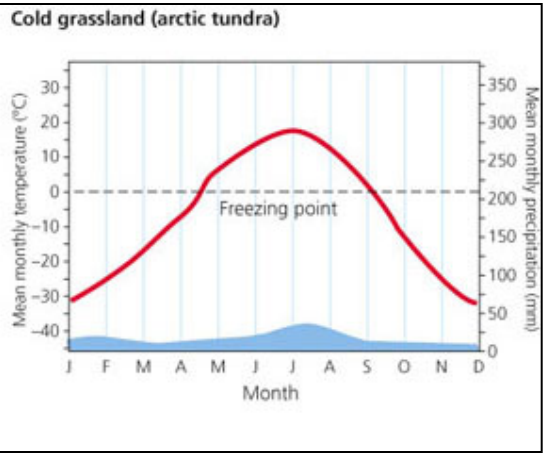
Wildflowers Bloom after Rain in Arizona

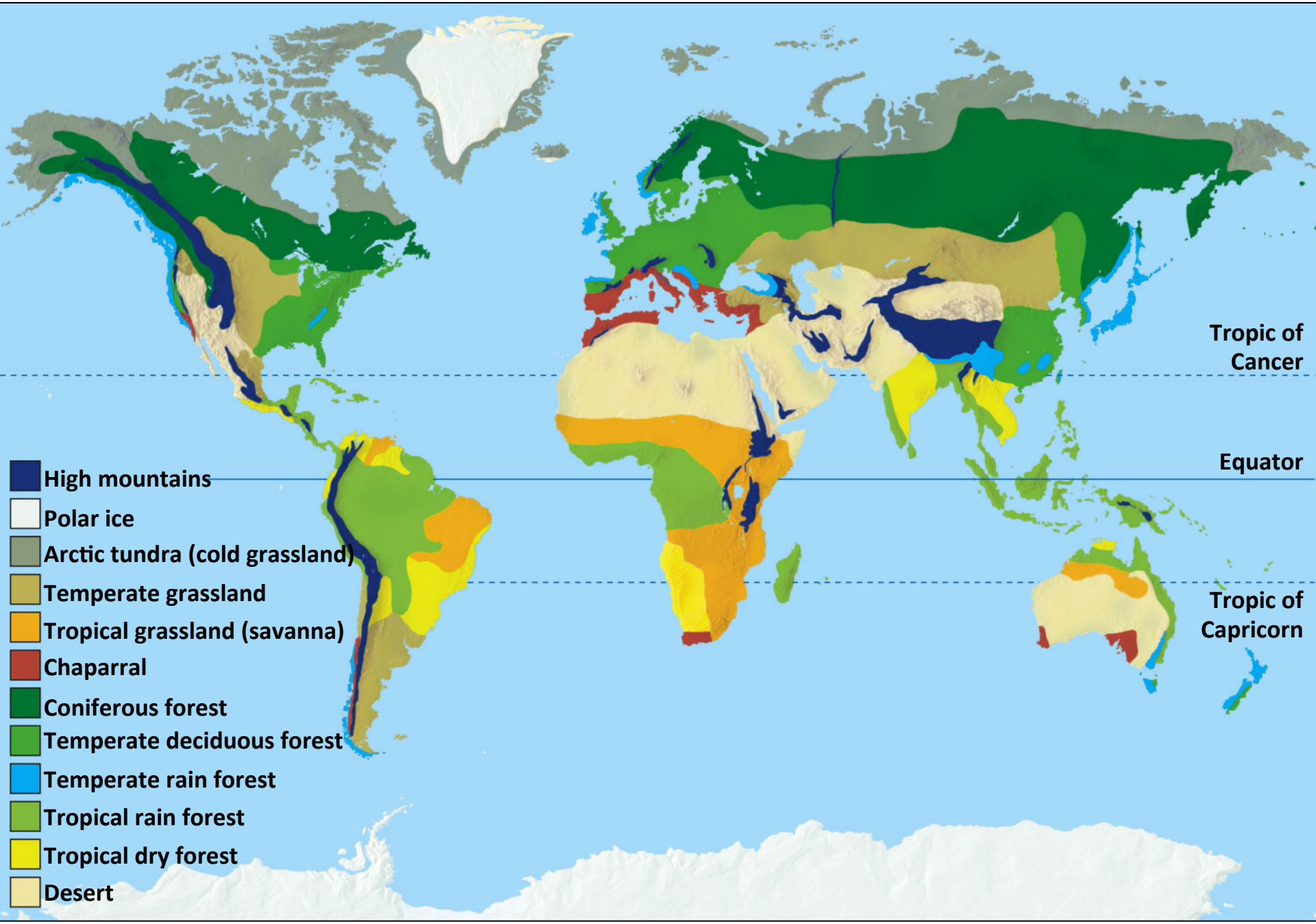
3-Types of Grasslands

1. Tropical
2. Temperate
3. Cold (arctic tundra)








Tropic of Cancer
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Tropical grassland (savanna)
Chaparral
Coniferous forest
Temperate deciduous forest
Temperate rain forest
Tropical rain forest
Tropical dry forest
Desert

3-Major Types of Grasslands

Tropical

- Savanna
  - Grazing animals
  - Browsing animals

Temperate

- Cold winters and hot and dry summers
- Tall-grass prairies & Short-grass prairies
- Often converted to farmland

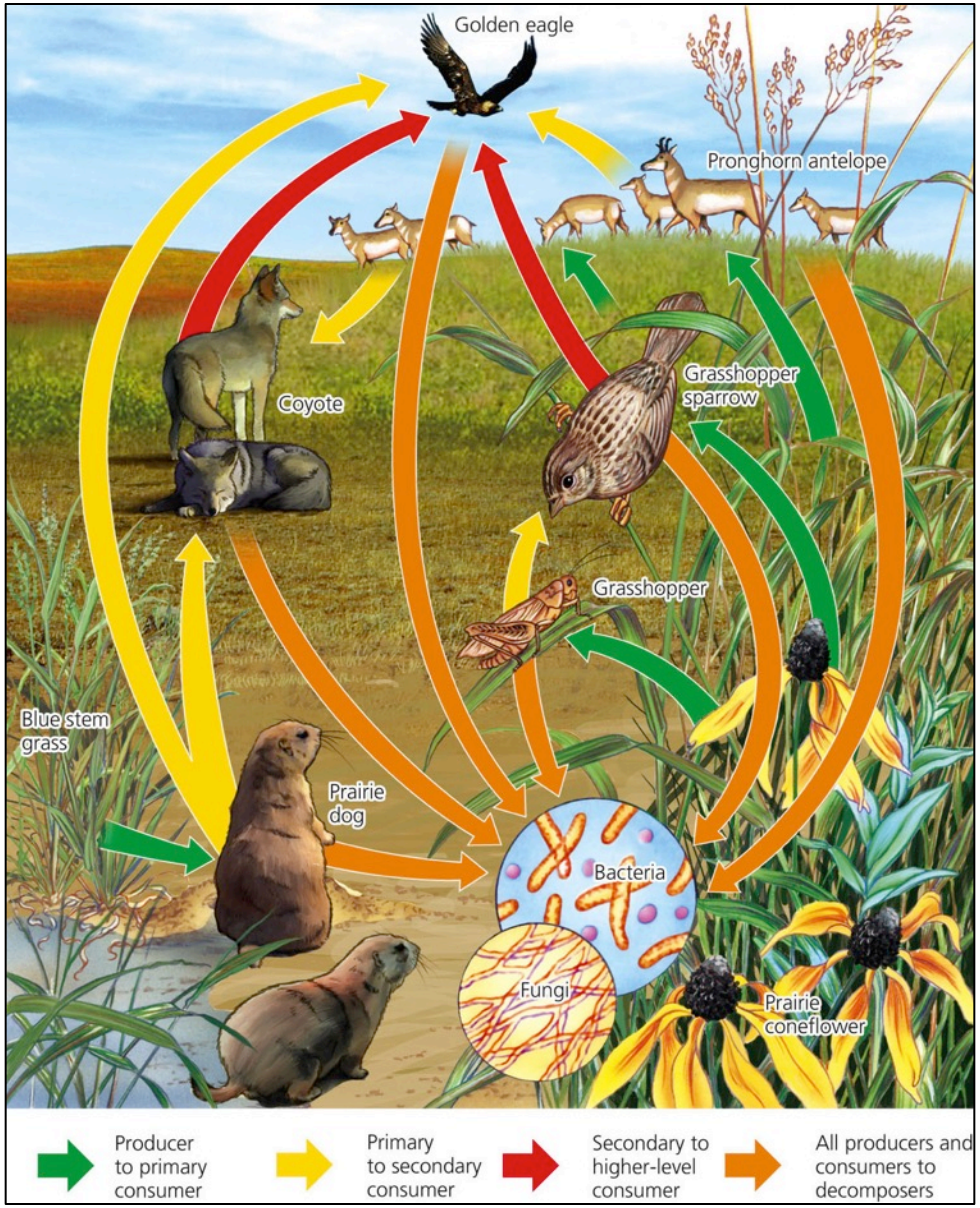
Arctic tundra: fragile biome

-Plants close to ground to conserve heat & most growth in short summer

- Animals have thick fur
  - **Permafrost**
    - Underground soil that stays frozen

✧ **Alpine tundra**: above tree line in mountains

Temperate Tall-Grass Prairie Ecosystem in North America

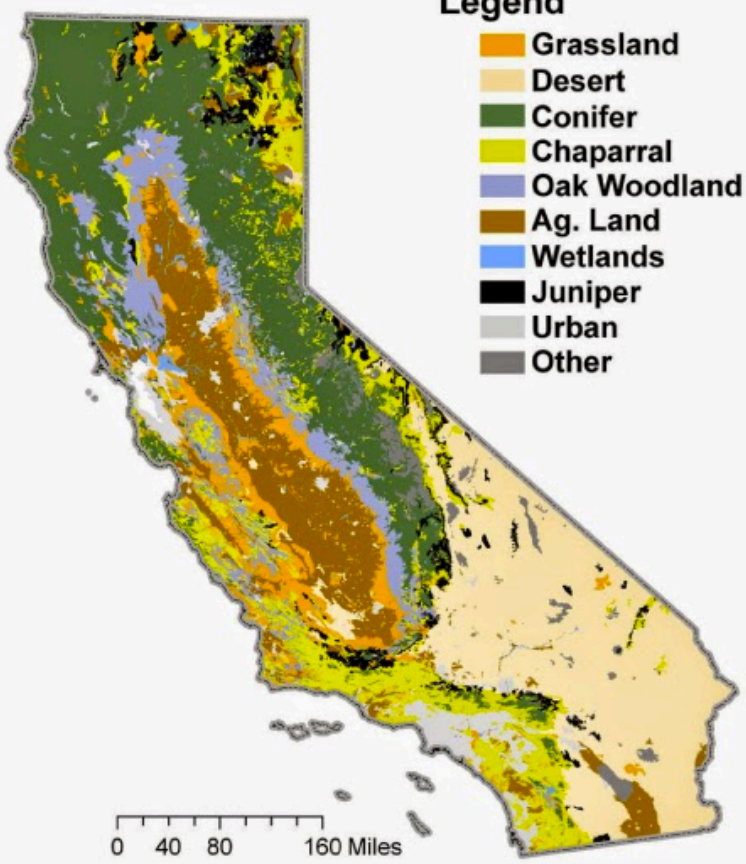


Monoculture Crop Replacing Biologically Diverse Temperate Grassland

Temperate Shrubland

Chaparral

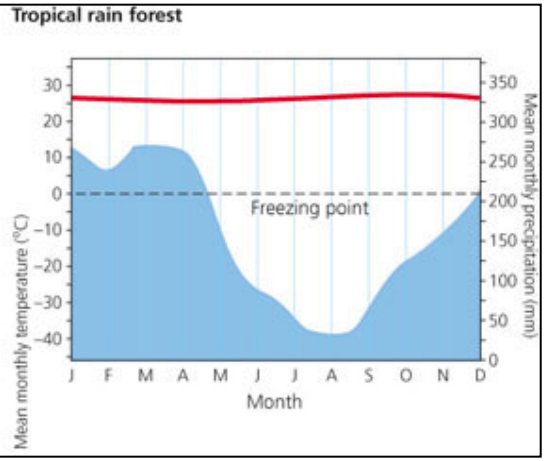
- Nice climate, risky place to live
- Near the sea: nice climate
- Prone to fires in the dry season

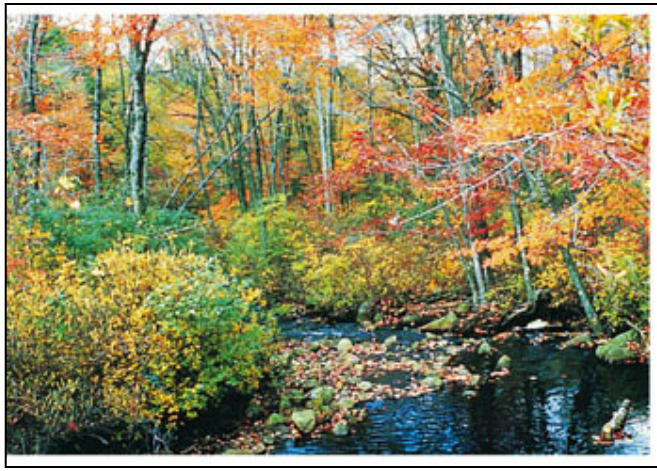


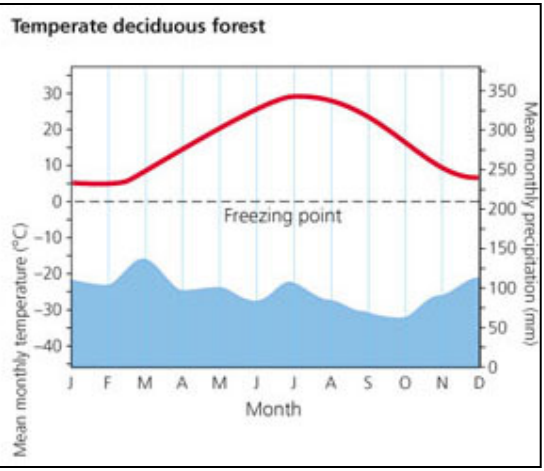
3-Types of Forests

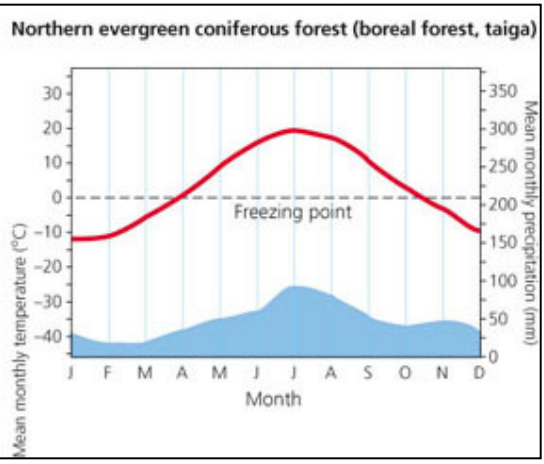
1. **Tropical**
2. **Temperate**
3. **Cold**

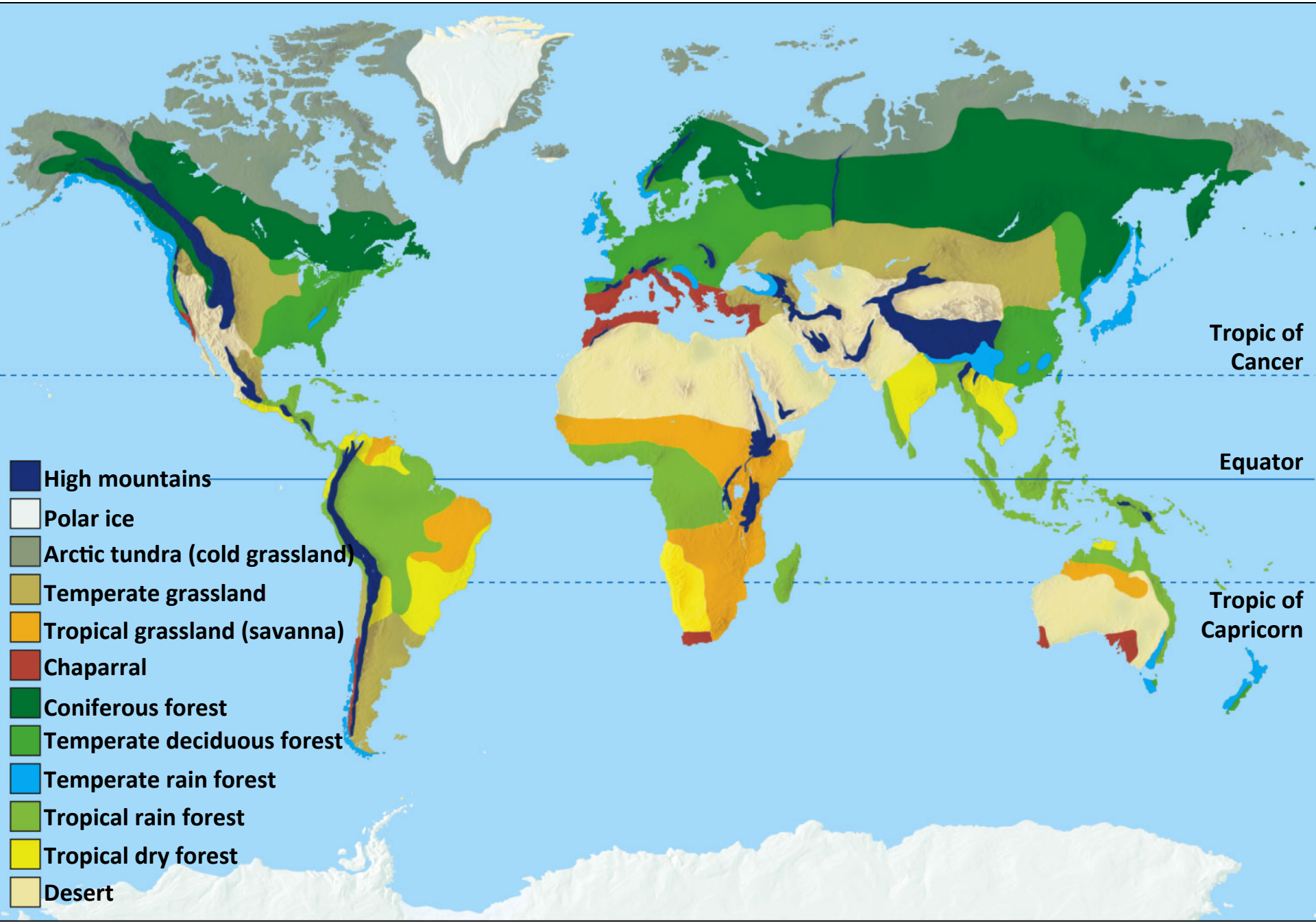
- Northern coniferous
- boreal forests
- subalpine forests







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High mountains
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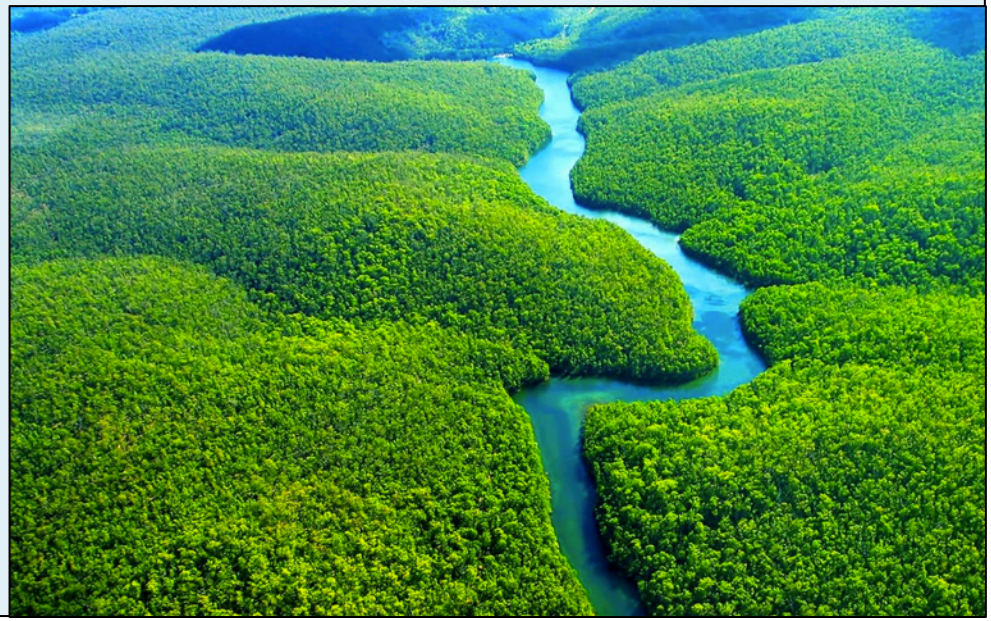
Tropical grassland (savanna)
Chaparral
Coniferous forest
Temperate deciduous forest
Temperate rain forest
Tropical rain forest
Tropical dry forest
Desert

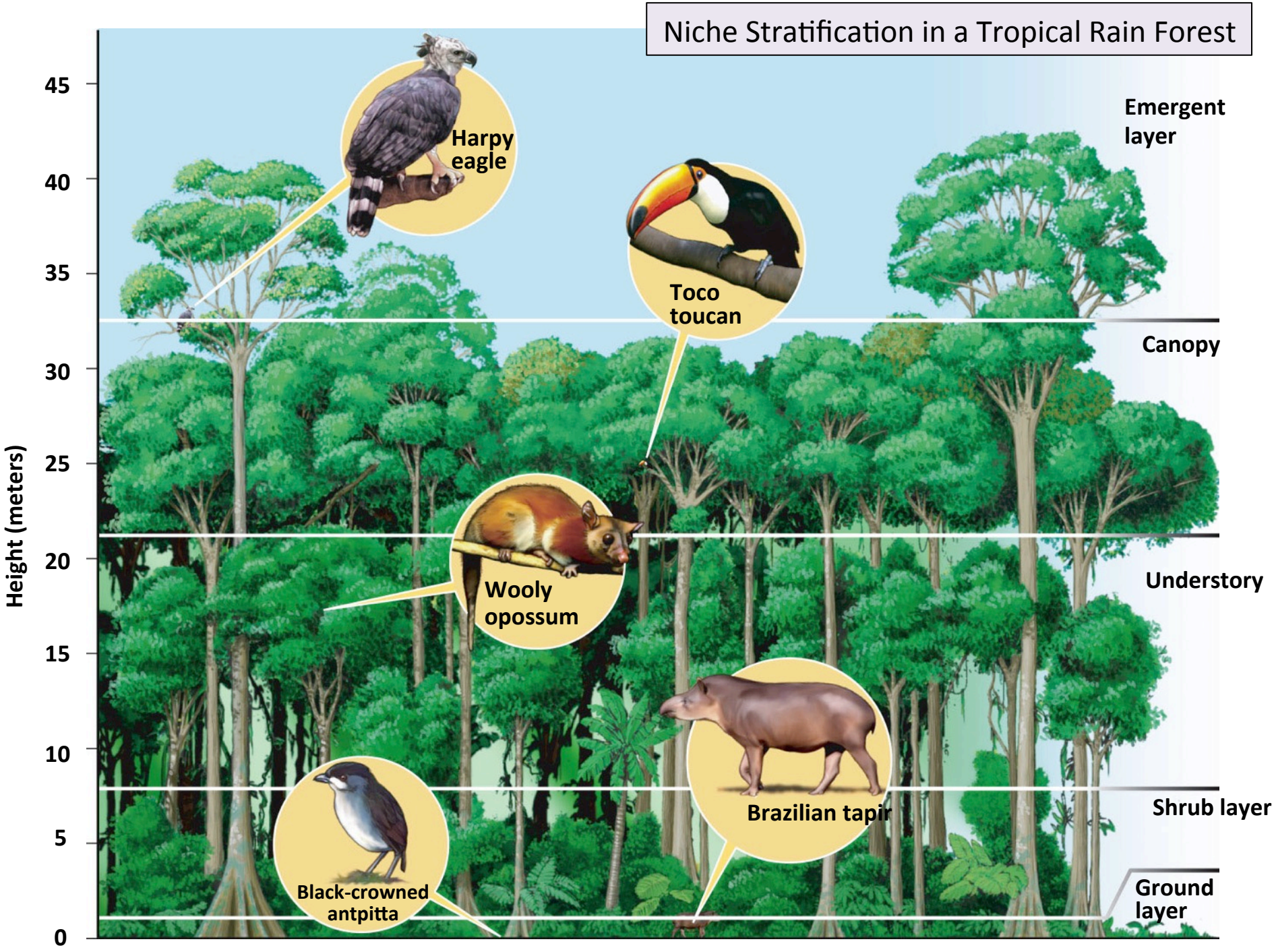
3-Major Types of Forests

Tropical rain forests

- Temperature and moisture
- Stratification of specialized plant and animal niches
- Little wind
- Rapid recycling of scarce soil nutrients
- Impact of human activities: agriculture, forestry, mining, oil & gas



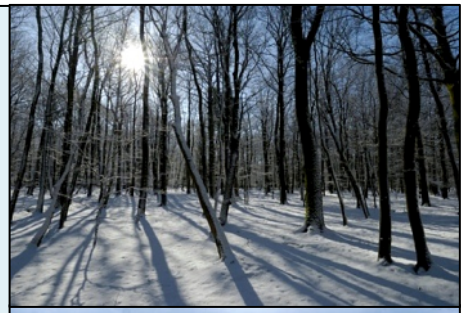
Tropical Rain Forest Ecosystem

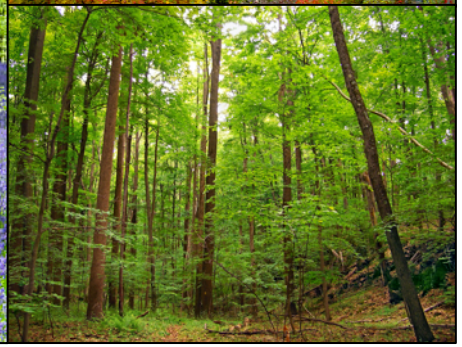

Niche Stratification in a Tropical Rain Forest
Height (meters)
45
40
35
30
25
20
15
10
5
0
Harpy eagle
Toco toucan
Wooly opossum
Brazilian tapir
Black-crowned antpitta
Emergent layer
Canopy
Understory
Shrub layer
Ground layer

3-Major Types of Forests

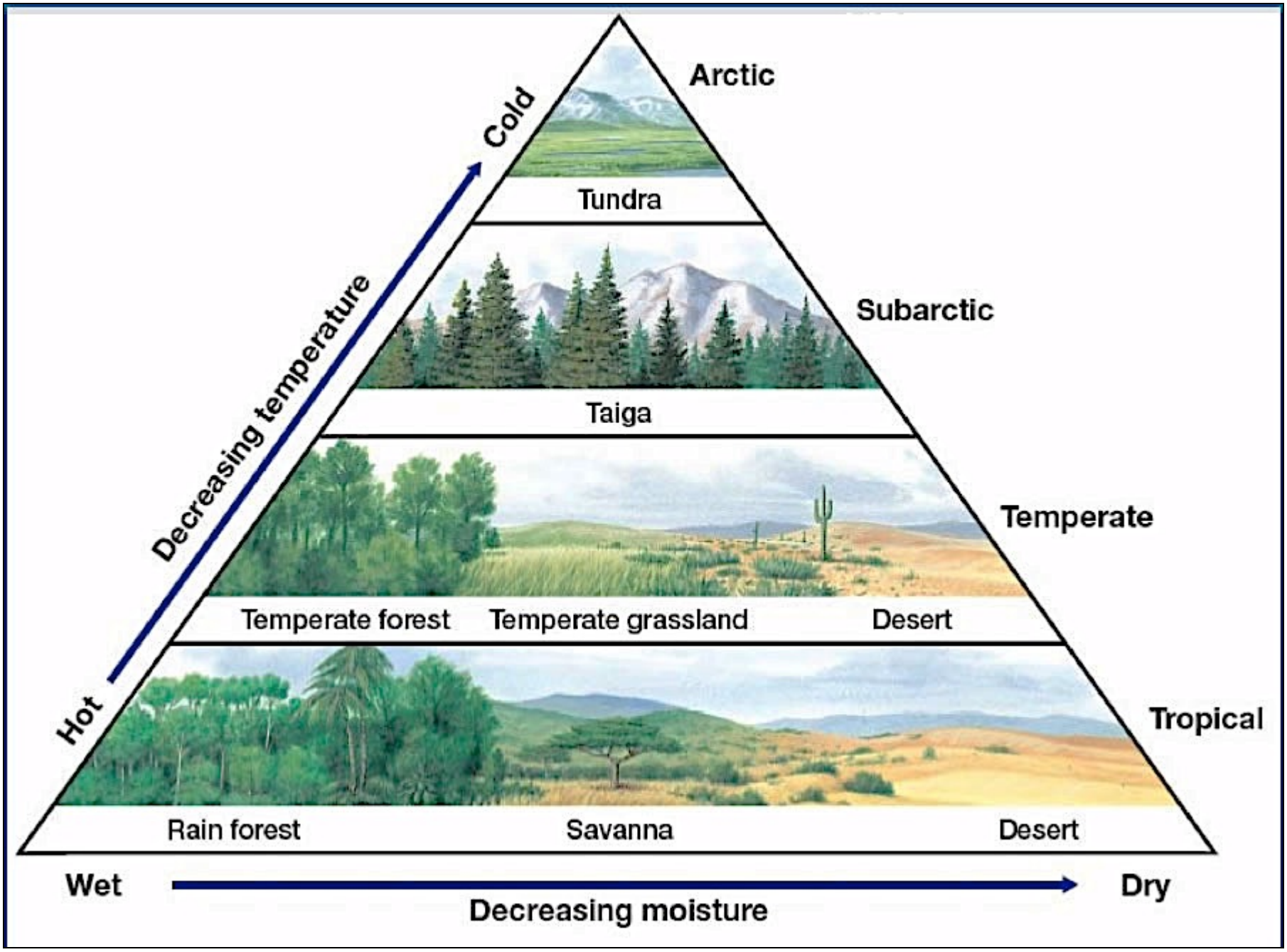
Temperate deciduous forests

- Temperature and moisture
- Broad-leaf trees
- Slow rate of decomposition: high biomass
- Impact of human activities

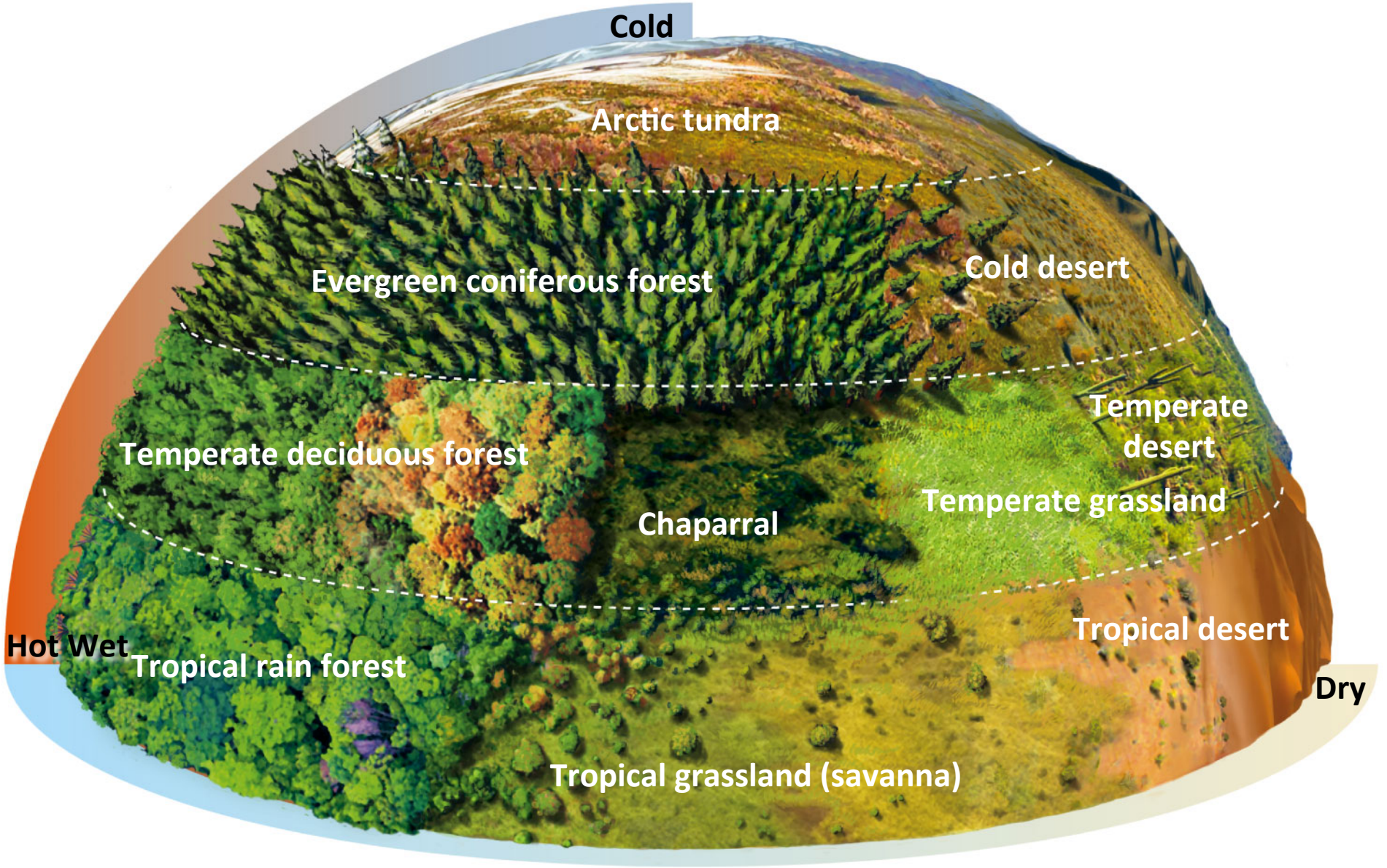




Temperate Deciduous Forest Ecosystem in North America


Arctic
Cold
Tundra
Subarctic
Taiga
Decreasing temperature
Temperate
Temperate forest
Temperate grassland
Desert
Hot
Tropical
Rain forest
Savanna
Desert
Wet
Dry
Decreasing moisture

Limiting Factors: Average Precipitation and Average Temperature

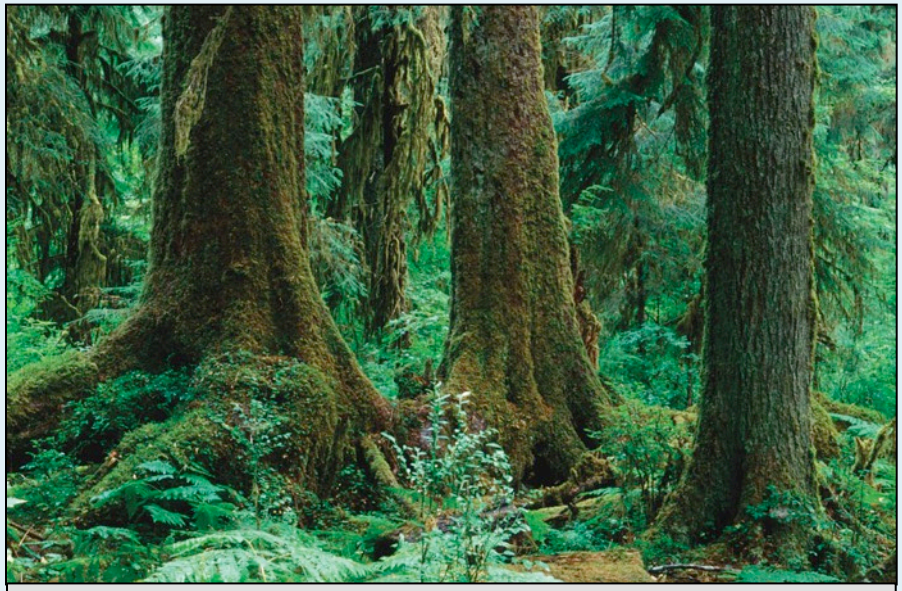


3-Major Types of Forests

- Evergreen coniferous forests: boreal and **taigas**
  - Temperature and moisture
  - Few species of cone: bearing trees
  - Slow decomposition: significance

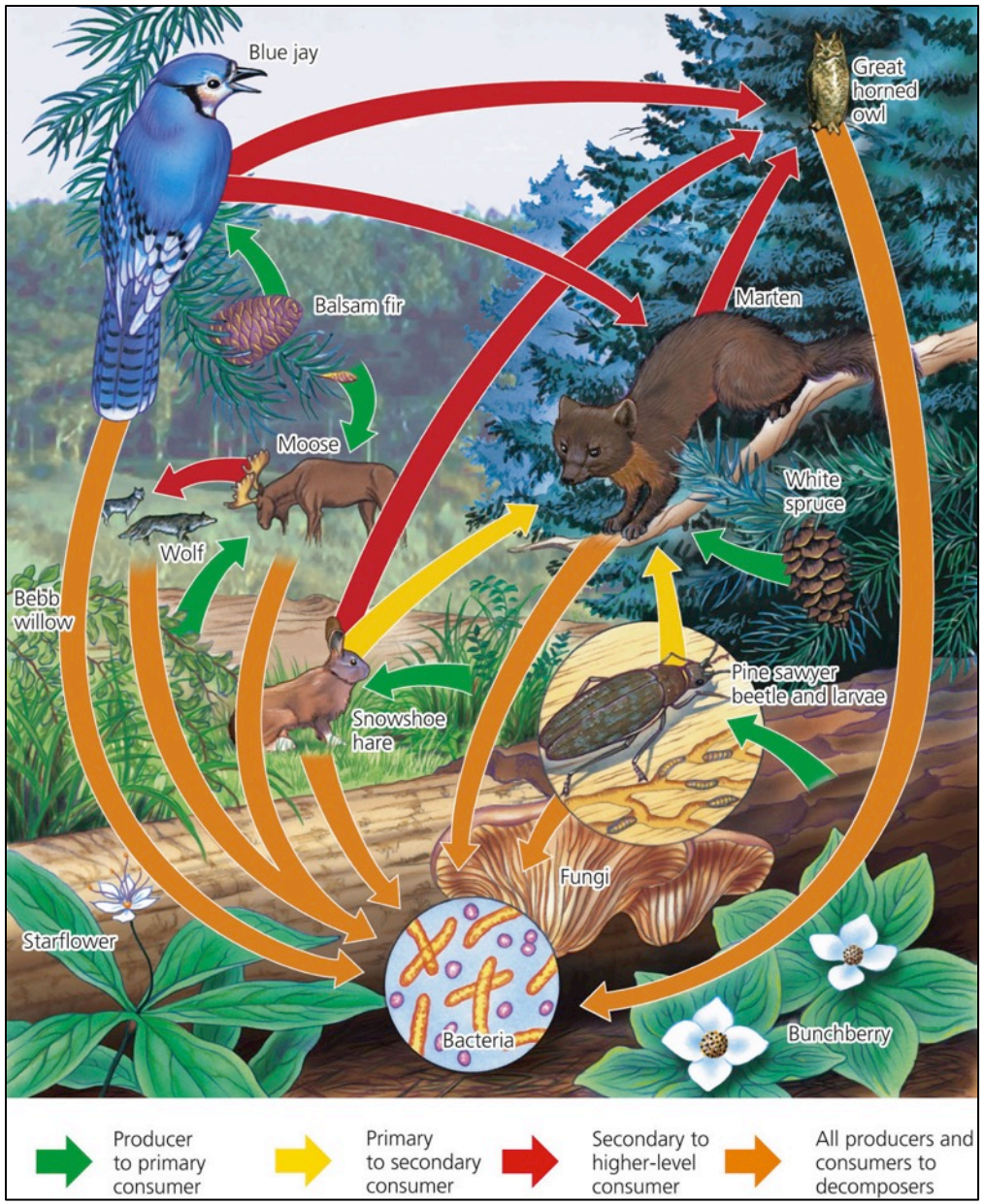
Canadian boreal forest →

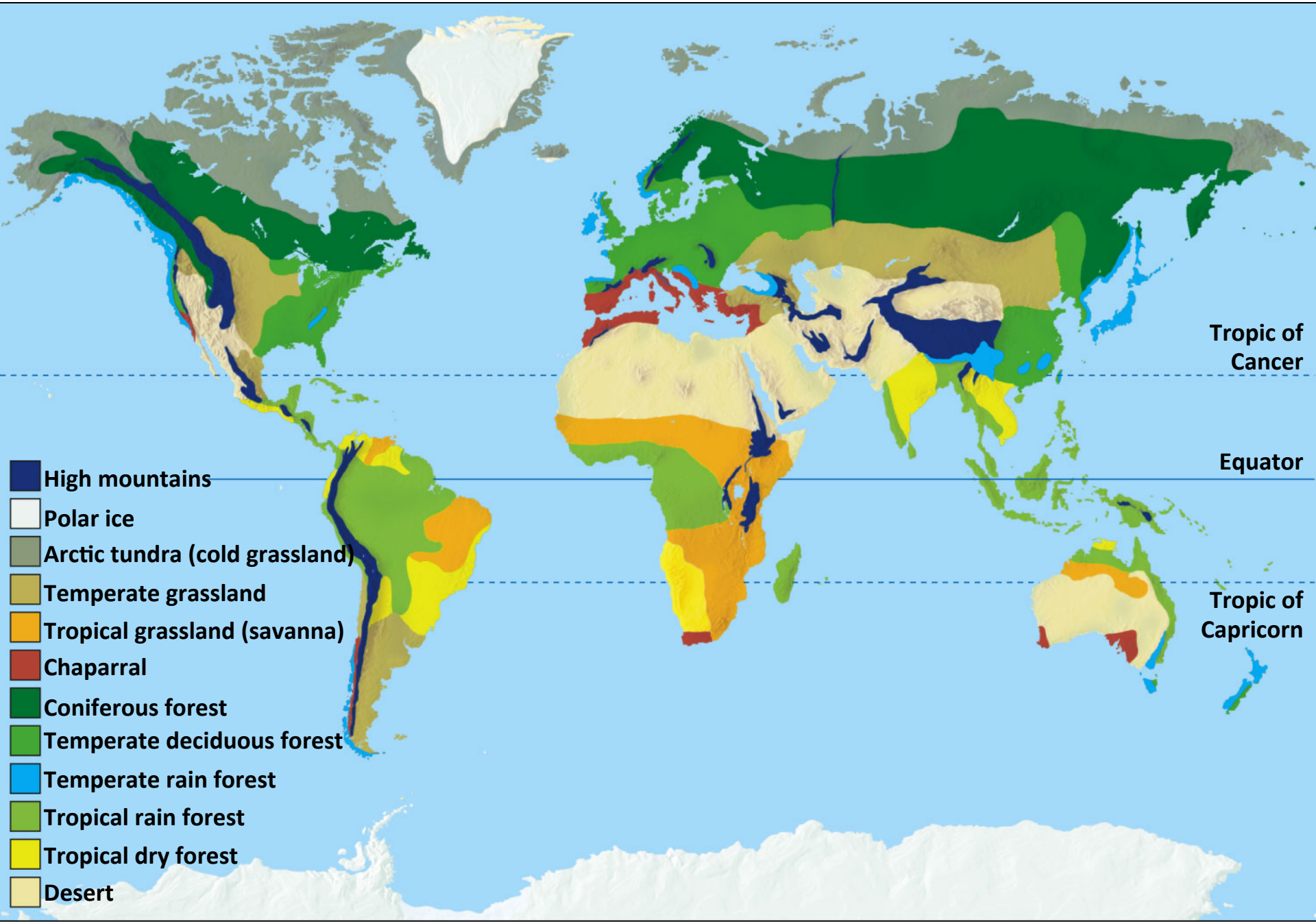
- Coastal coniferous forest & temperate rain forests



Temperate Rain Forest in Washington State

Evergreen Coniferous Forest Ecosystem in North America

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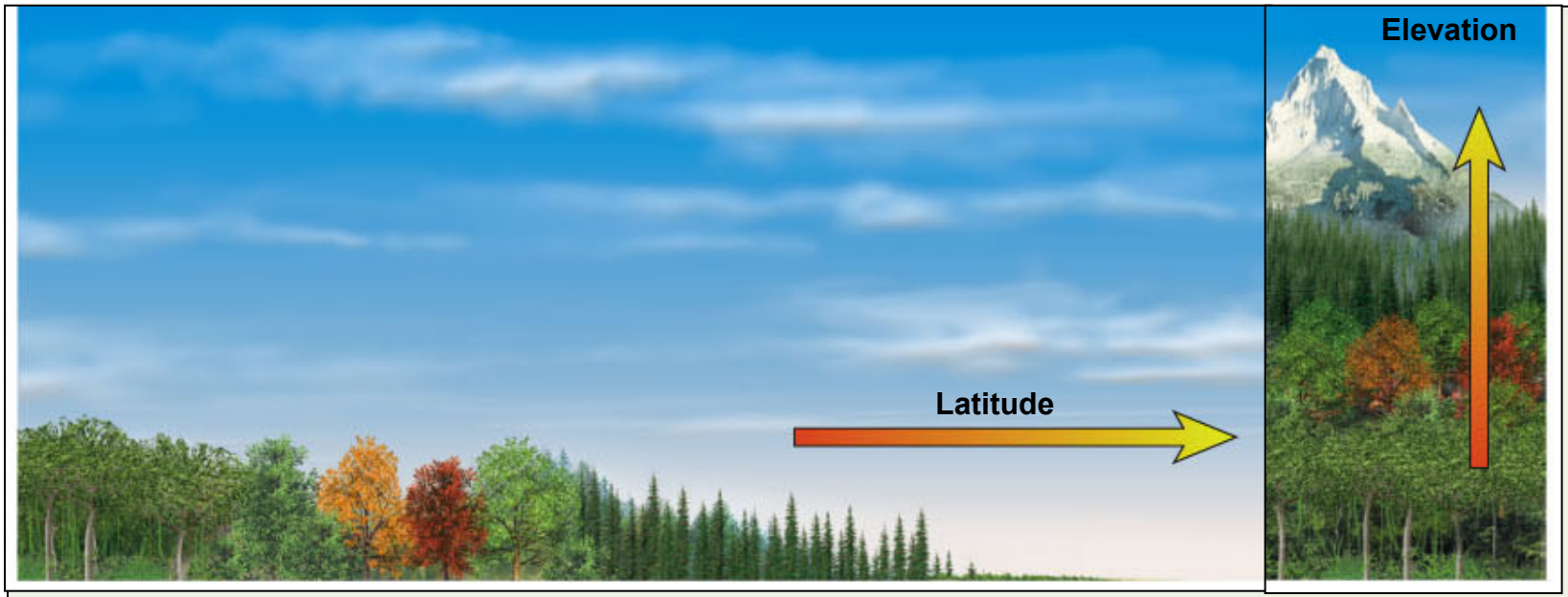
Tropical dry forest
Desert

Latitude & Elevation Gradients



The increase in species richness or biodiversity that occurs from the poles to the tropics, often referred to as the latitudinal diversity gradient (LDG), is one of the most widely recognized patterns in ecology. This pattern is also recognized as one increases in elevation.

Mountains Play Important Ecological Roles

- Majority of the world's forests
- Islands of biodiversity
- Habitats for endemic species
- Help regulate the earth's climate
- Major storehouses of water
  - Role in hydrologic cycle

Mount Rainier National Park in Washington State →

Natural Capital Degradation

Major Human Impacts on Terrestrial Ecosystems

Deserts

- Large desert cities
- Destruction of soil and underground habitat by off-road vehicles
- Soil salinization from irrigation
- Depletion of groundwater
- Land disturbance and pollution from mineral extraction

Grasslands

- Conversion to cropland
- Release of CO_2 to atmosphere from burning grassland
- Overgrazing by livestock
- Oil production and off-road vehicles in arctic tundra

Forests

- Clearing for agriculture, livestock grazing, timber, and urban development
- Conversion of diverse forests to tree plantations
- Damage from off-road vehicles
- Pollution of forest streams

Mountains

- Agriculture
- Timber and mineral extraction
- Hydroelectric dams and reservoirs
- Increasing tourism
- Air pollution blowing in from urban areas and power plants
- Soil damage from off-road vehicles
- Water supplies threatened by glacial melting