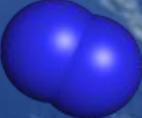
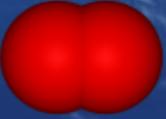
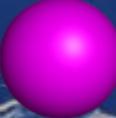
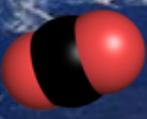


Climate and Terrestrial Biodiversity

Chapter 7

The Atmosphere

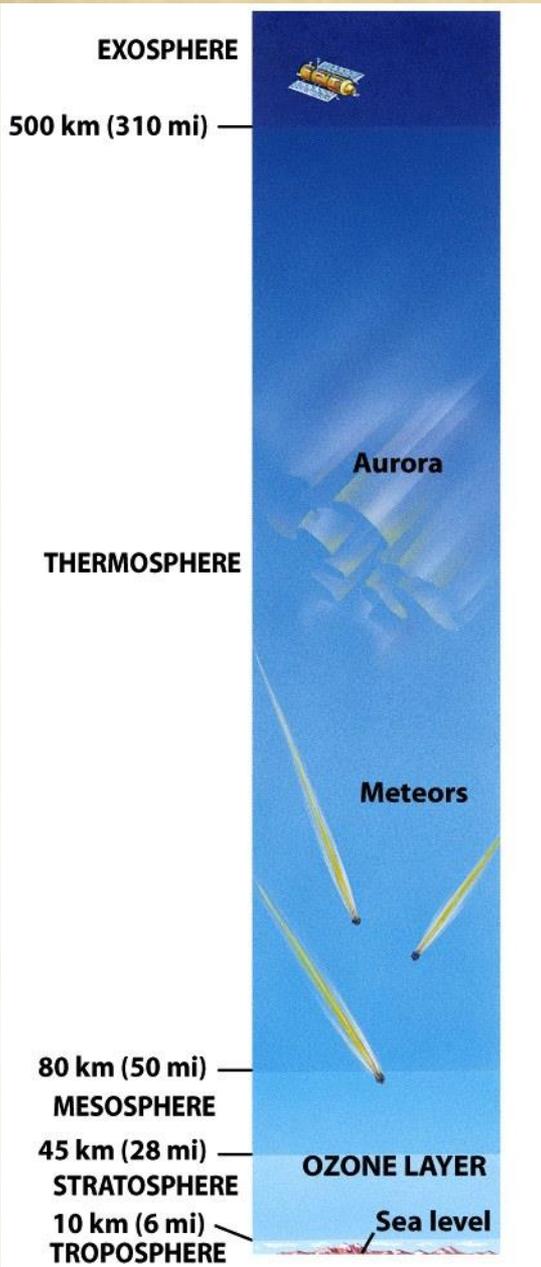
▶ Earth's atmosphere contains roughly:

78% nitrogen	
20.95% oxygen	
0.93% argon	
0.038% carbon dioxide	
Trace gases	
1% water vapor	

The mixture of gases known as air, protects life on Earth by:

- absorbing ultraviolet radiation
- reducing temperature extremes between day and night.

Atmospheric Layers

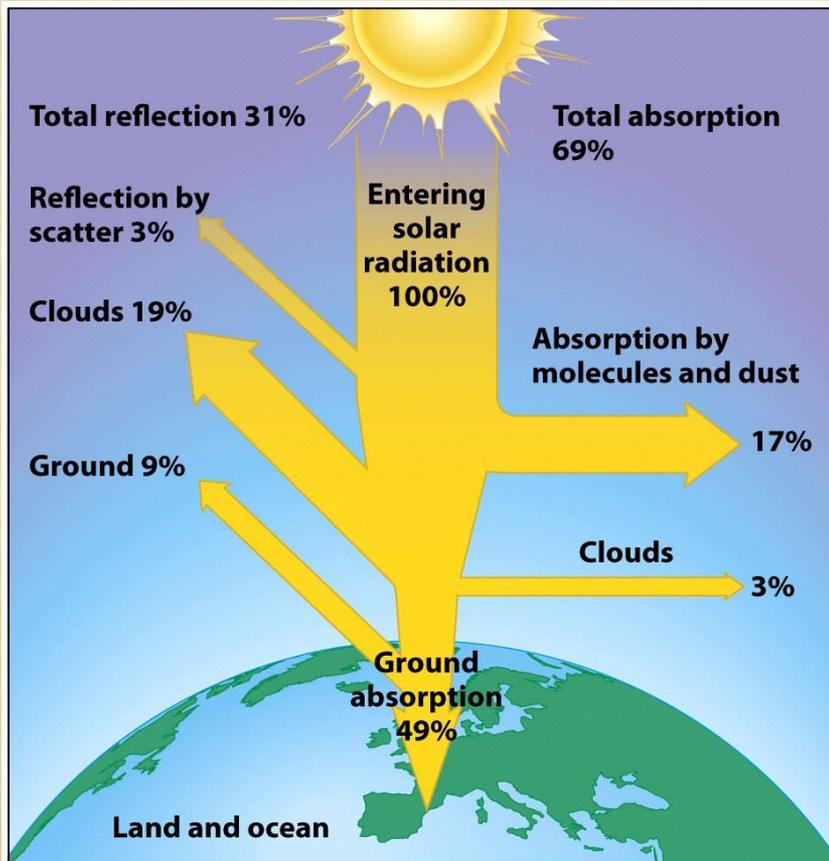


- ▶ **Exosphere (500km and up)**
 - ▶ Outermost layer
- ▶ **Thermosphere (80-500km)**
 - ▶ Gases in thin air absorb x-rays and short-wave UV radiation = very hot
 - ▶ Source of aurora borealis (northern lights)
- ▶ **Mesosphere (45-80km)**
 - ▶ Temperature decreases with altitude
- ▶ **Stratosphere (10-45km)**
 - ▶ Ozone layer absorbs UV rays
- ▶ **Troposphere (0-10km)**
 - ▶ Where weather occurs
 - ▶ Temperature decreases with altitude

REMEMBER: The Sexy Men Take Eggs

Solar Radiation

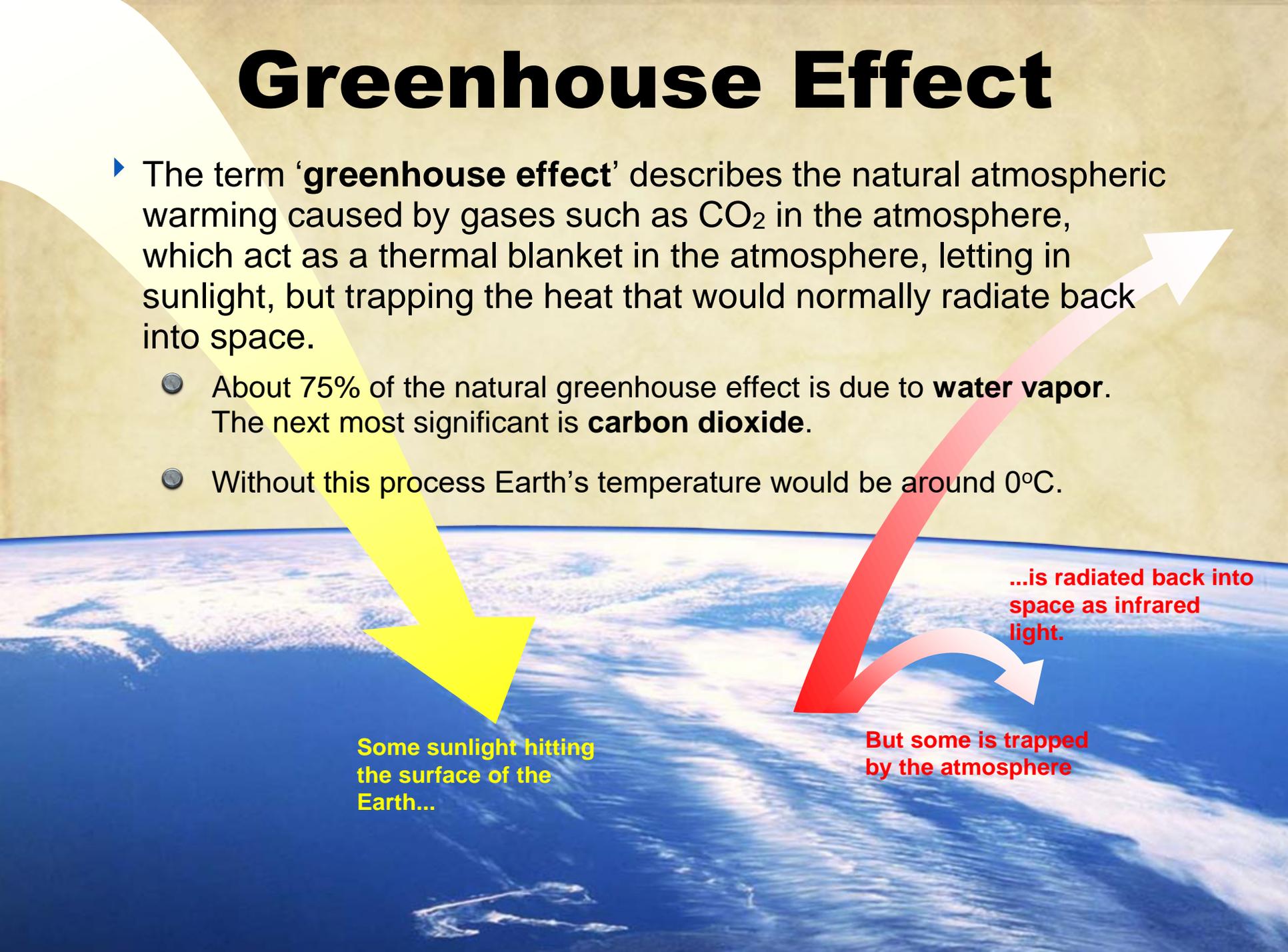
- Sun provides energy for life, powers biogeochemical cycles, and determines climate



- ▶ 69% of incoming solar radiation is absorbed by atmosphere and earth
 - ▶ Remainder is reflected
- ▶ Albedo
 - ▶ The reflectance of solar energy off earth's surface
 - ▶ Dark colors = low albedo
 - ▶ Forests, rocks and ocean
 - ▶ Light colors = high albedo
 - ▶ Ice caps

Greenhouse Effect

- ▶ The term '**greenhouse effect**' describes the natural atmospheric warming caused by gases such as CO₂ in the atmosphere, which act as a thermal blanket in the atmosphere, letting in sunlight, but trapping the heat that would normally radiate back into space.
 - About 75% of the natural greenhouse effect is due to **water vapor**. The next most significant is **carbon dioxide**.
 - Without this process Earth's temperature would be around 0°C.



Some sunlight hitting the surface of the Earth...

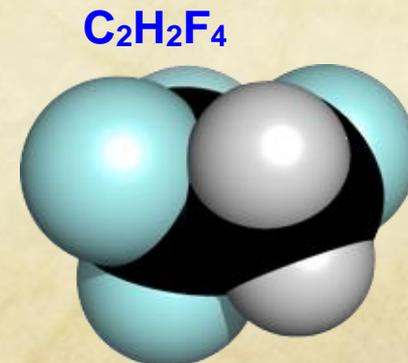
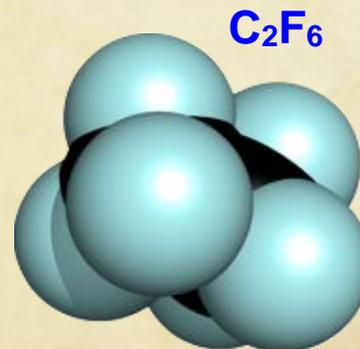
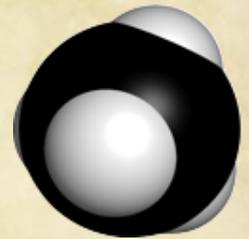
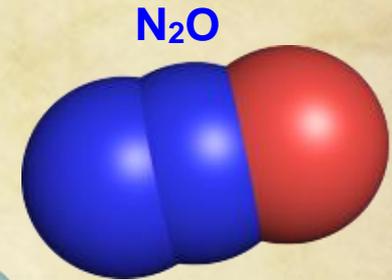
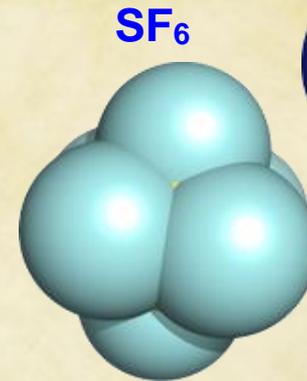
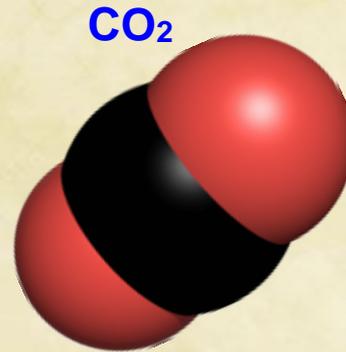
But some is trapped by the atmosphere

...is radiated back into space as infrared light.

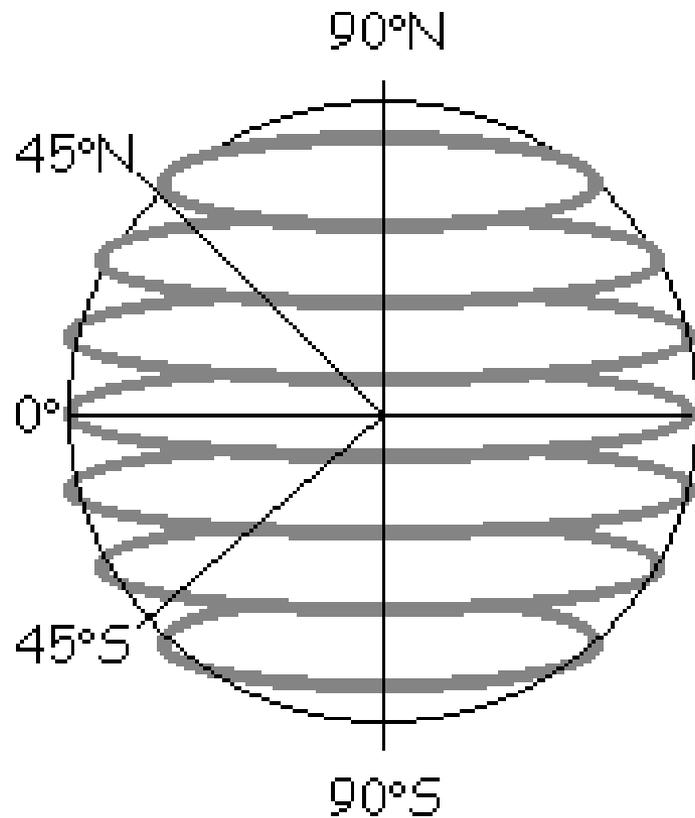
Greenhouse Gases

- ▶ Recently six gases or groups of gases have been named by the **Environmental Protection Agency (EPA)** in the USA as major contributors to the greenhouse effect.
- ▶ These gases are:

Carbon dioxide	CO ₂
Methane	CH ₄
Nitrous oxide	N ₂ O
Hydrofluorocarbons	HFCs
Perfluorocarbons	PFCs
Sulfur hexafluoride	SF ₆

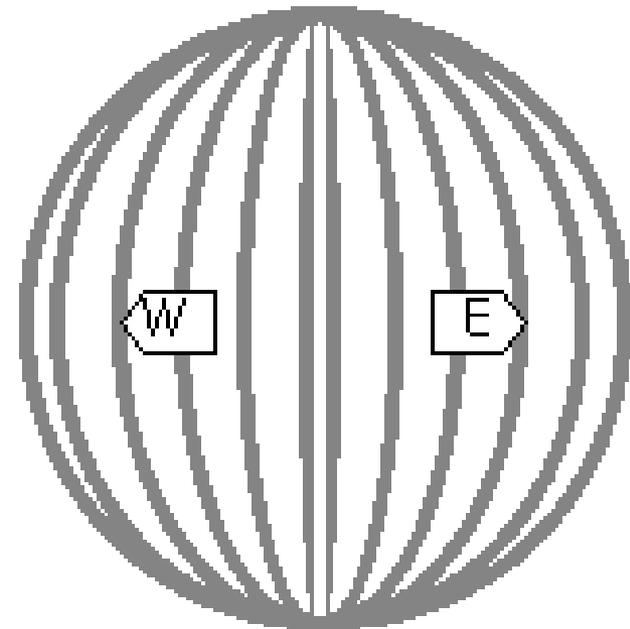


Latitude (North/South)



Latitude varies from 0° at the equator to 90° North and South at the poles

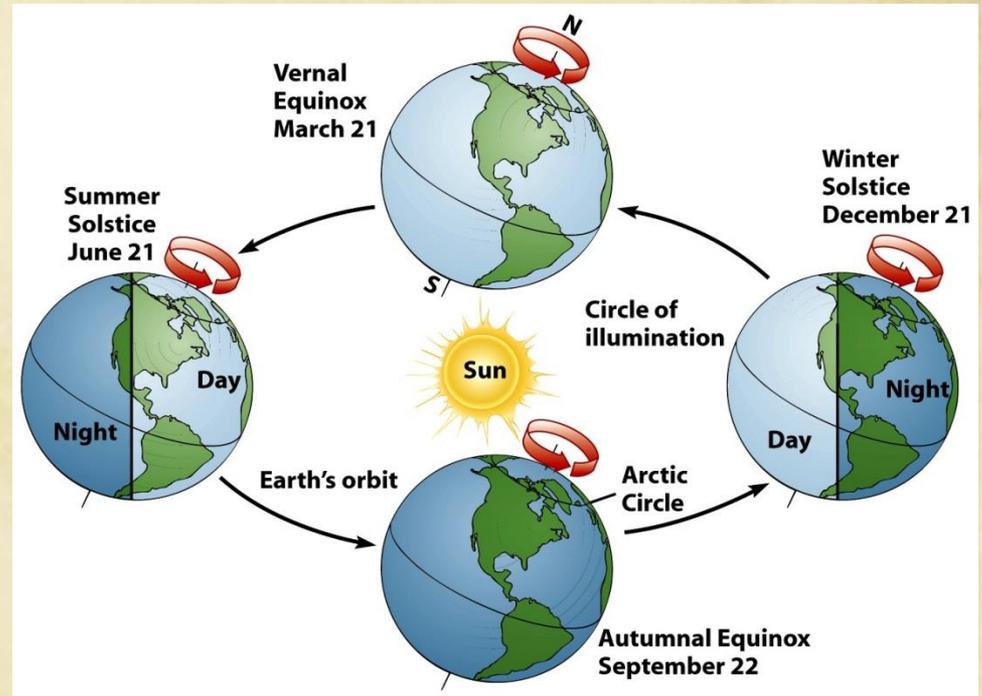
Longitude (West/East)



Longitude varies from 0° at Greenwich to 180° East and West

Temperature Changes with Season

- ▶ Seasons determined by earth's tilt (23.5°)
- ▶ Causes each hemisphere to tilt toward the sun for half the year



- Northern Hemisphere tilts towards the sun from March 21-September 22 (warm season)
- Opposite in southern hemisphere

Animation: Seasonal variation



Temperature Changes with Latitude

Solar energy does not hit earth uniformly, Due to earth's spherical shape and tilt

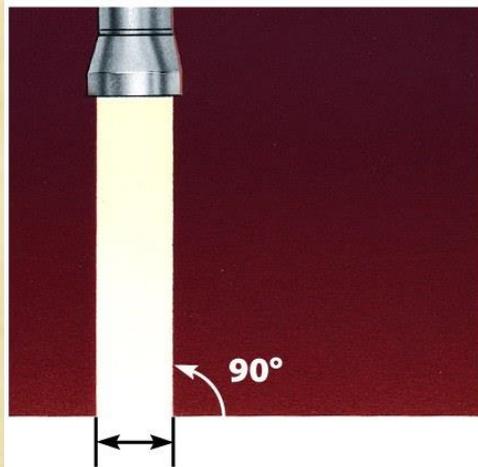
Equator (a)

High concentration
Little Reflection
High Temperature

From (a) to (c)
In diagram below

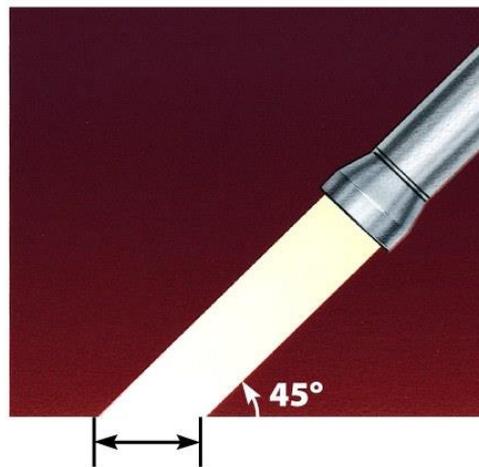
Closer to Poles (c)

Low concentration
Higher Reflection
Low Temperature



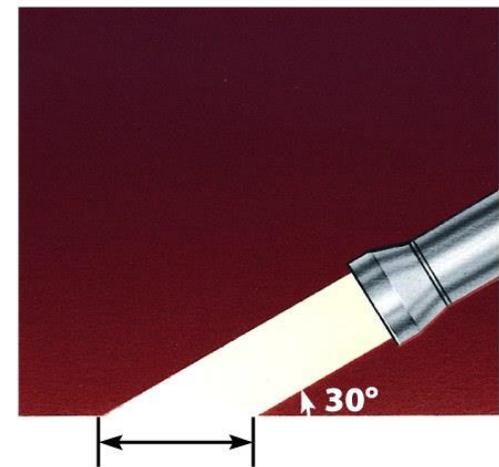
1 unit of surface area

(a) One unit of light is concentrated over one unit of surface area.



1.4 units of surface area

(b) One unit of light is dispersed over 1.4 units of surface area.



2 units of surface area

(c) One unit of light is dispersed over 2 units of surface area.

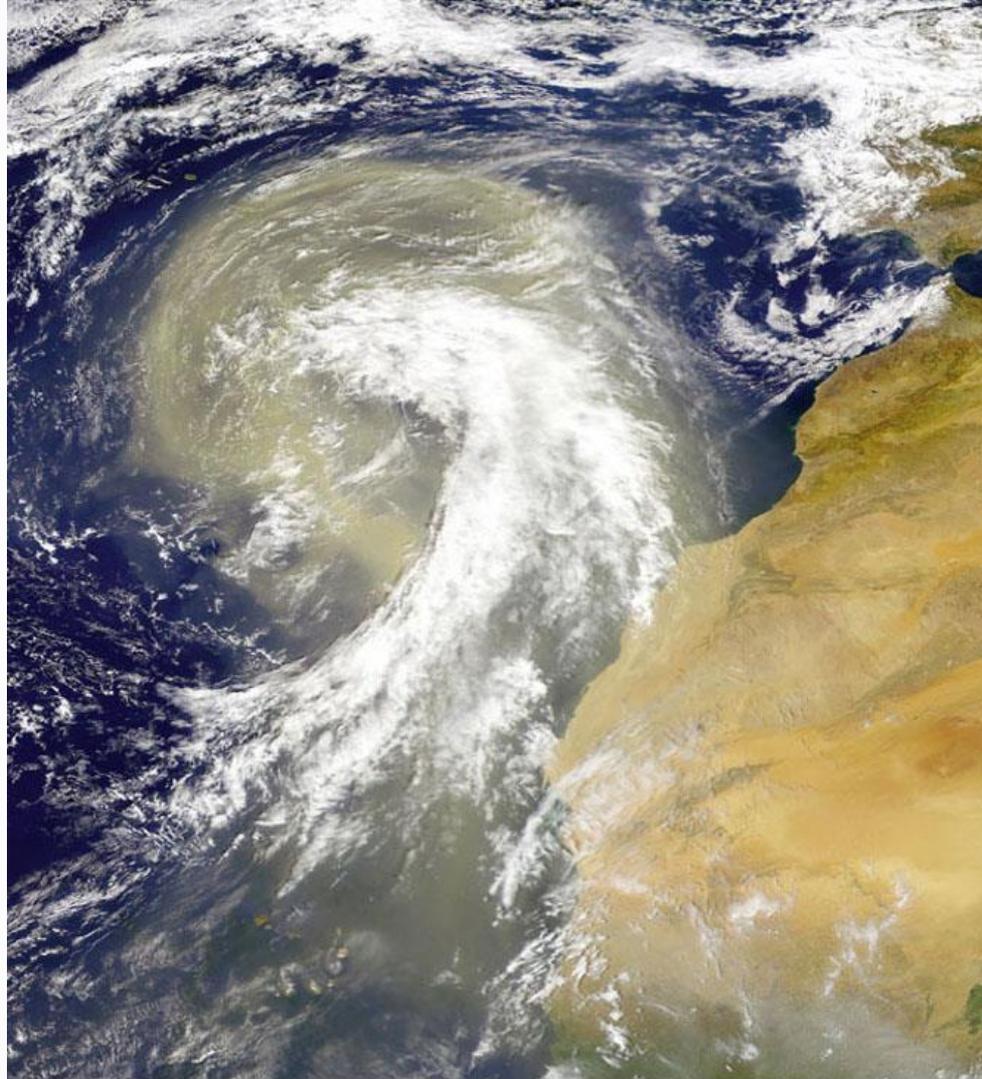
Core Case Study: Connections between Wind, Climate, and Biomes

- Wind
 - Indirect form of solar energy
 - Circulates
 - Heat
 - Moisture
 - Plant nutrients
 - Soil particles
 - Long-lived air pollutants
-

The Earth Has Many Different Climates (1)

- **Weather = local short-term atmospheric conditions (e.g., temp., humidity, wind...)**
 - **Climate = regional, long-term(decades to centuries) patterns of weather/atmospheric conditions**
 - Air circulation in lower atmosphere due to
 - Uneven heating of the earth's surface by the sun
 - Rotation of the earth on its axis
 - Properties of air, water, and land
-

Dust Blown from West Africa to the Amazonian Rain Forests

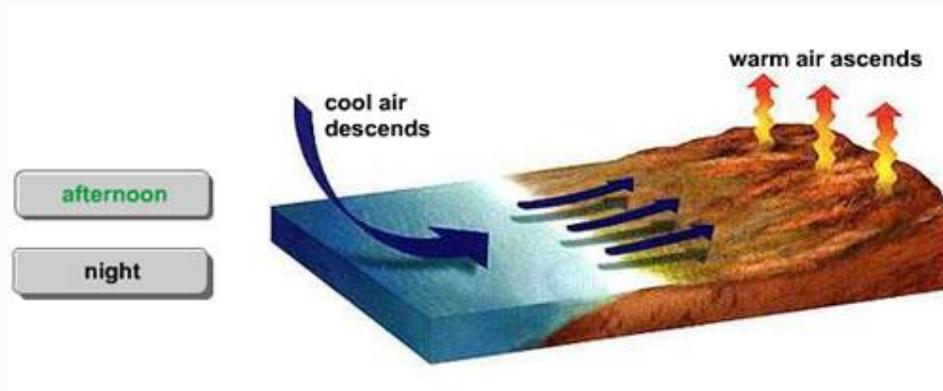


© Brooks/Cole, Cengage Learning

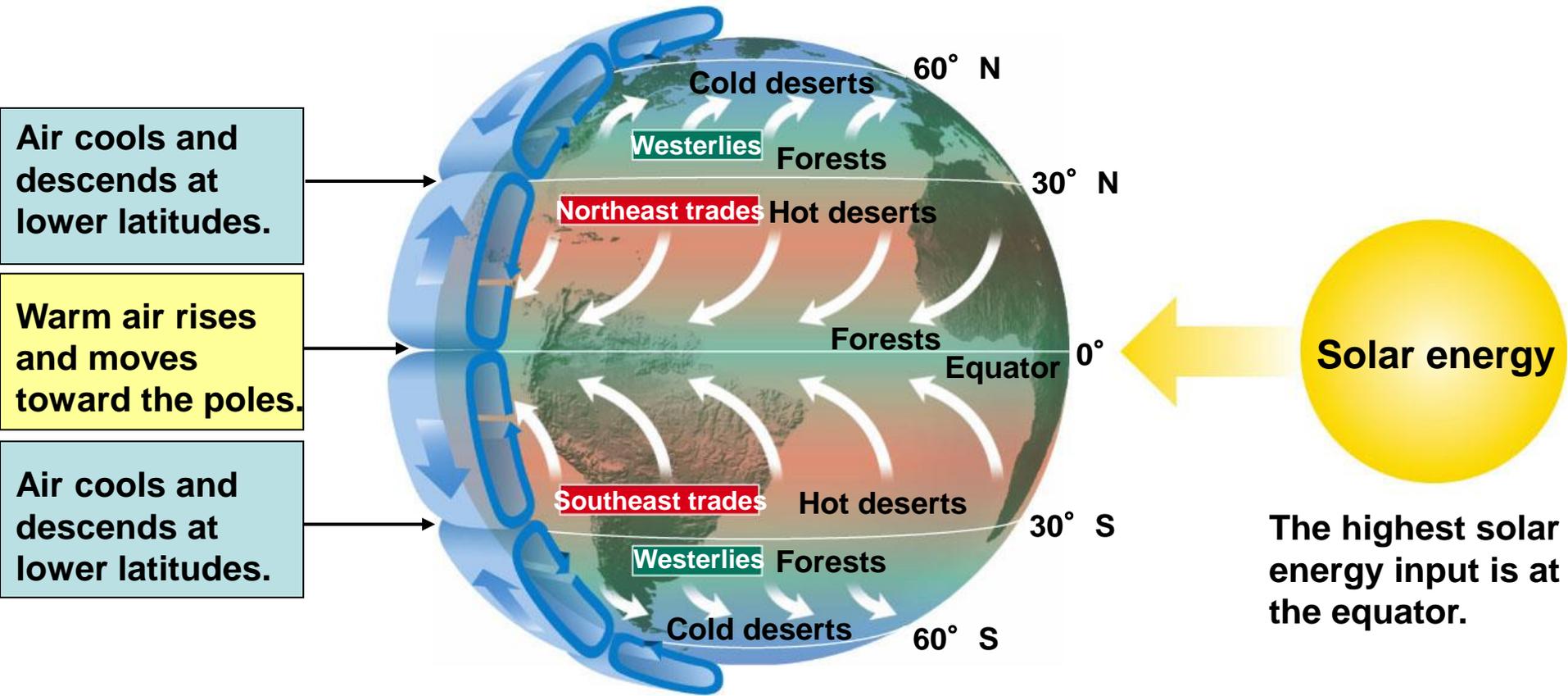
7-1 What Factors Influence Climate?

- **Concept 7-1** *An area's **climate** is determined mostly by **solar radiation**, the **earth's rotation**, global patterns of air and water movement, gases in the atmosphere, and the earth's surface features.*
-

Animation: Coastal breezes



Global Air Circulation



© Brooks/Cole, Cengage Learning

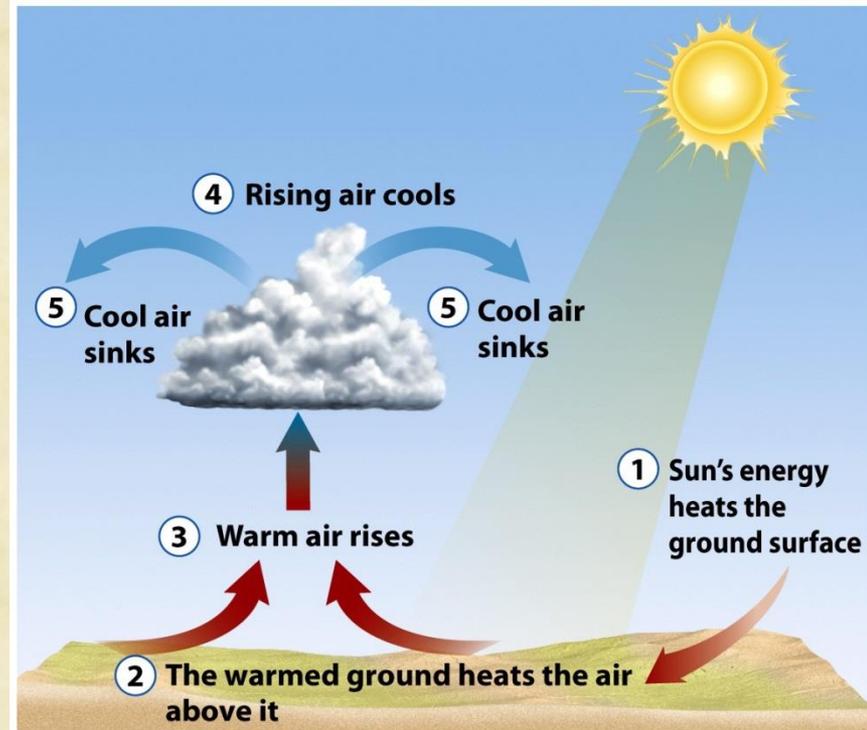
Atmospheric Circulation

- ▶ Near Equator
 - ▶ Warm air rises, cools and splits to flow towards the poles
 - ▶ $\sim 30^{\circ}\text{N}\&\text{S}$ sinks back to surface
 - ▶ Air moves along surface back towards equator

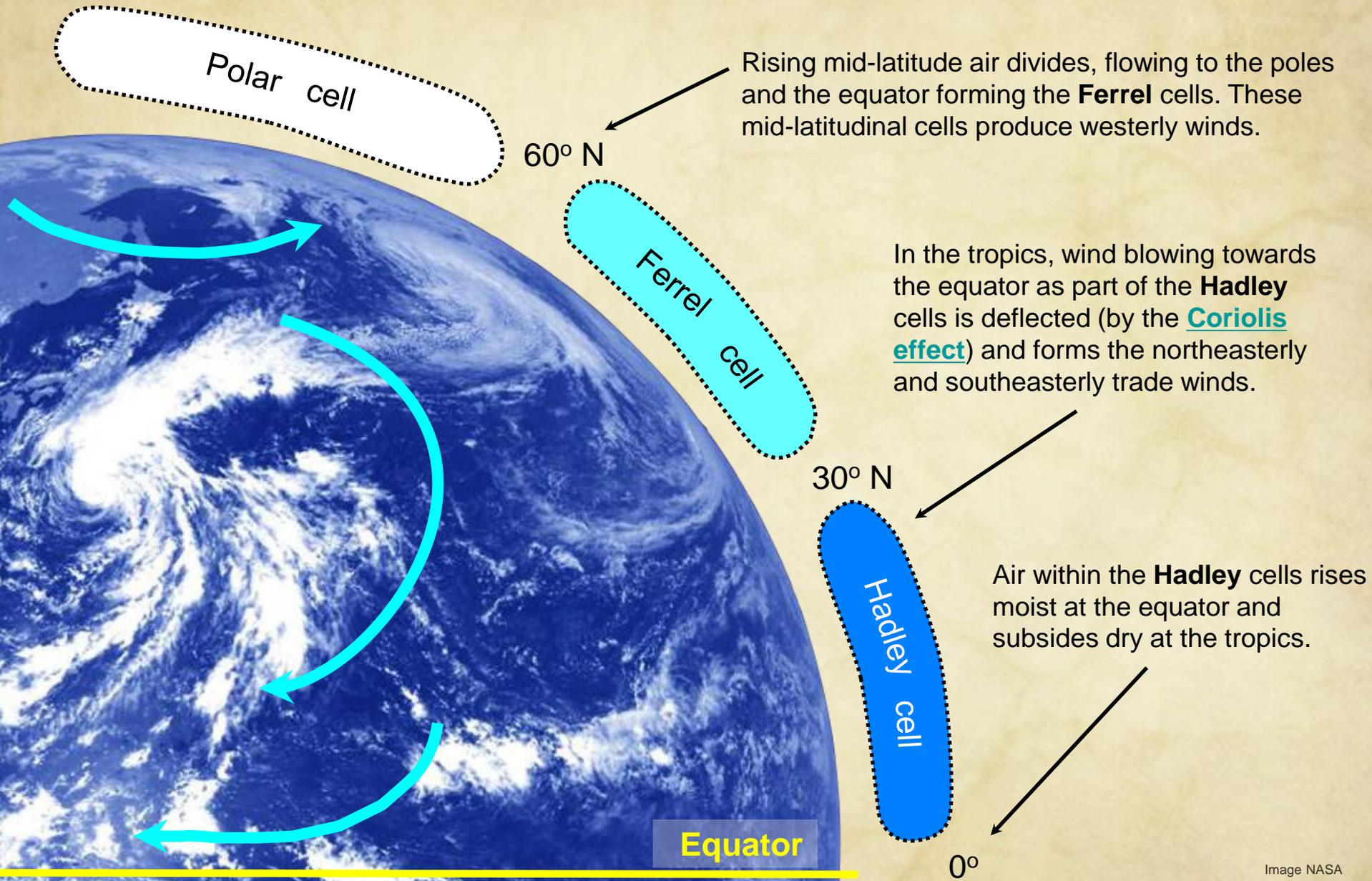
Atmospheric Circulation explained (2:25)

<http://youtu.be/Ye45DGkqUkE>

- ▶ This occurs at higher latitudes as well
 - ▶ Moves heat from equator to the poles

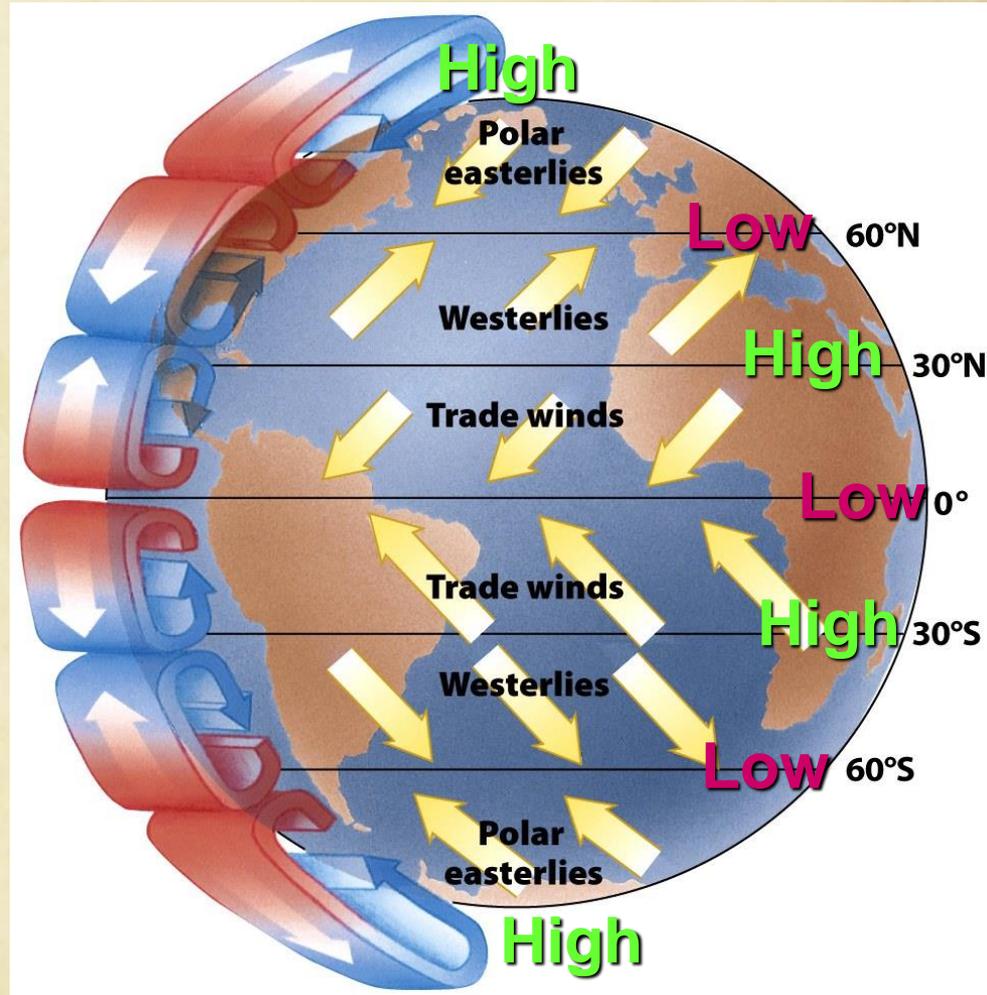


Air Cells



Surface Winds

- ▶ Large winds due in part to pressures caused by global circulation of air
 - ▶ Left side of diagram
- ▶ Winds blow from high to low pressure
 - ▶ Right side of diagram



Coriolis Effect

- ▶ The deflection of moving air is called the Coriolis effect
- ▶ It is responsible for the direction of movement of large-scale **weather systems** in both hemispheres.

- ▶ Air flows from high pressure to low pressure.
 - In the northern hemisphere, **cyclonic** (low pressure) systems rotate **counterclockwise**.
 - In the southern hemisphere, cyclonic systems spiral in a **clockwise** direction.



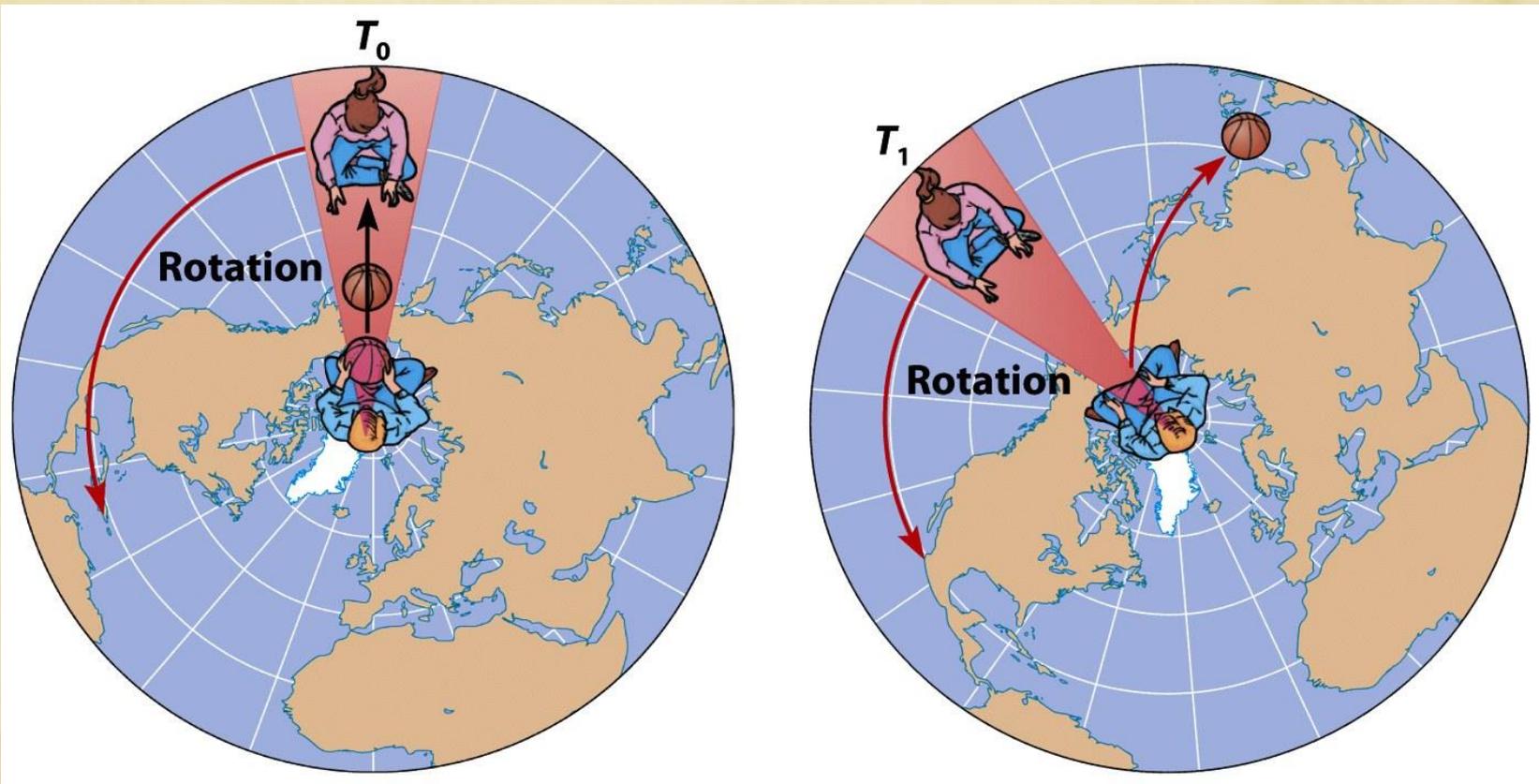
Hurricane, Northern hemisphere



Cyclone, Southern hemisphere

Coriolis Effect

Visualize it as a Merry-Go-Round

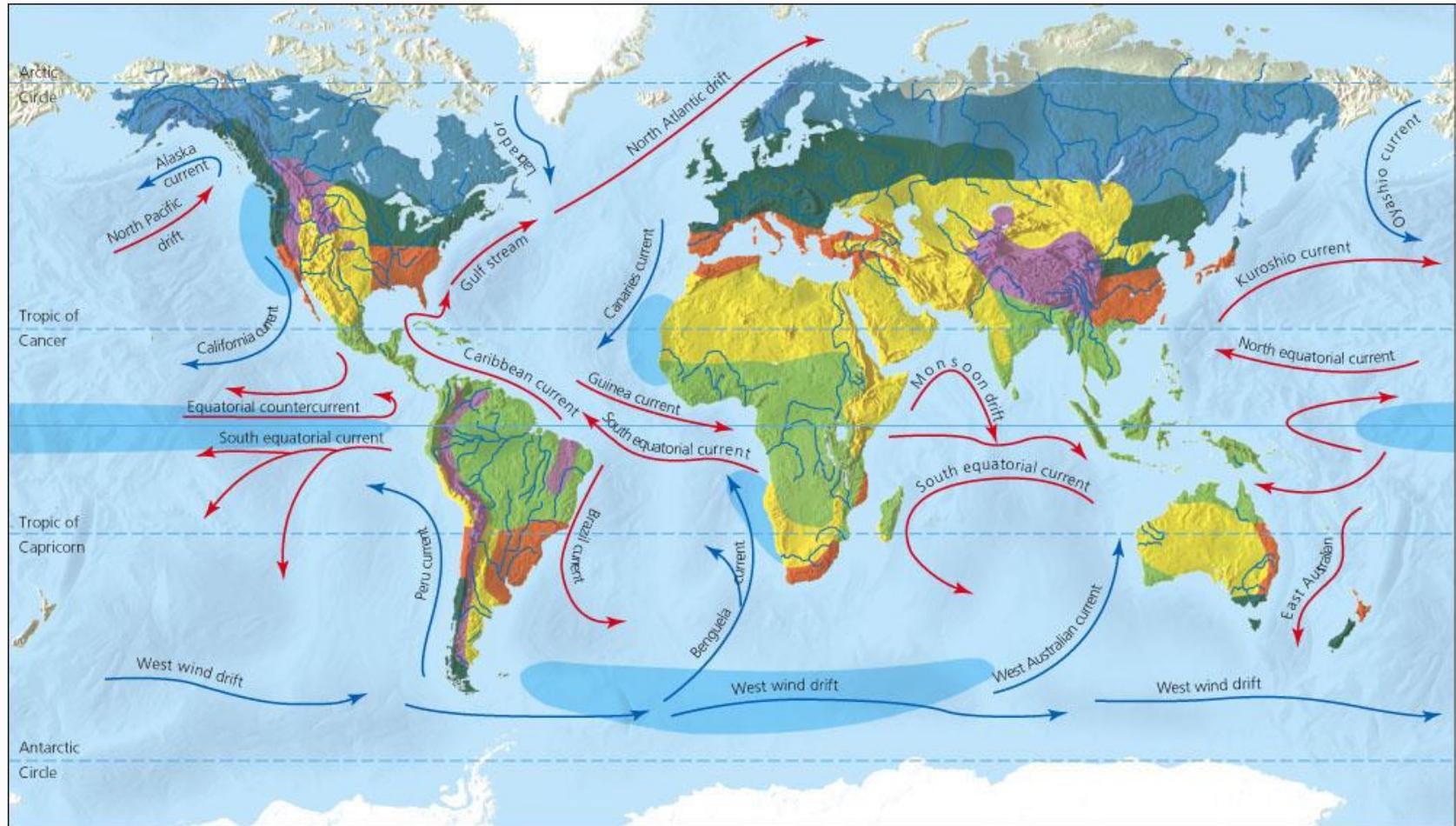


The Earth Has Many Different Climates (2)

- **Ocean Currents & Atmosphere Relationship...**
 - Prevailing winds
 - Earth's rotation
 - Redistribution of heat from the sun

 - Link between air circulation, ocean currents, and biomes (Fig. 7-2)
-

Natural Capital: Generalized Map of the Earth's Current Climate Zones



- | | | | | | |
|----------------|------------------|----------------|-----------------------|--------------------|-------|
| Polar (ice) | Subarctic (snow) | Cool temperate | Highland | Warm ocean current | River |
| Warm temperate | Dry | Tropical | Major upwelling zones | Cold ocean current | |

Ocean Currents

- ▶ The deep-water ocean currents (the **thermohaline** circulation) is driven by the cooling and sinking of water masses in polar and subpolar regions.
- ▶ Cold water circulates through the Atlantic, penetrating the Indian and Pacific oceans, before returning as warm upper ocean currents to the South Atlantic.

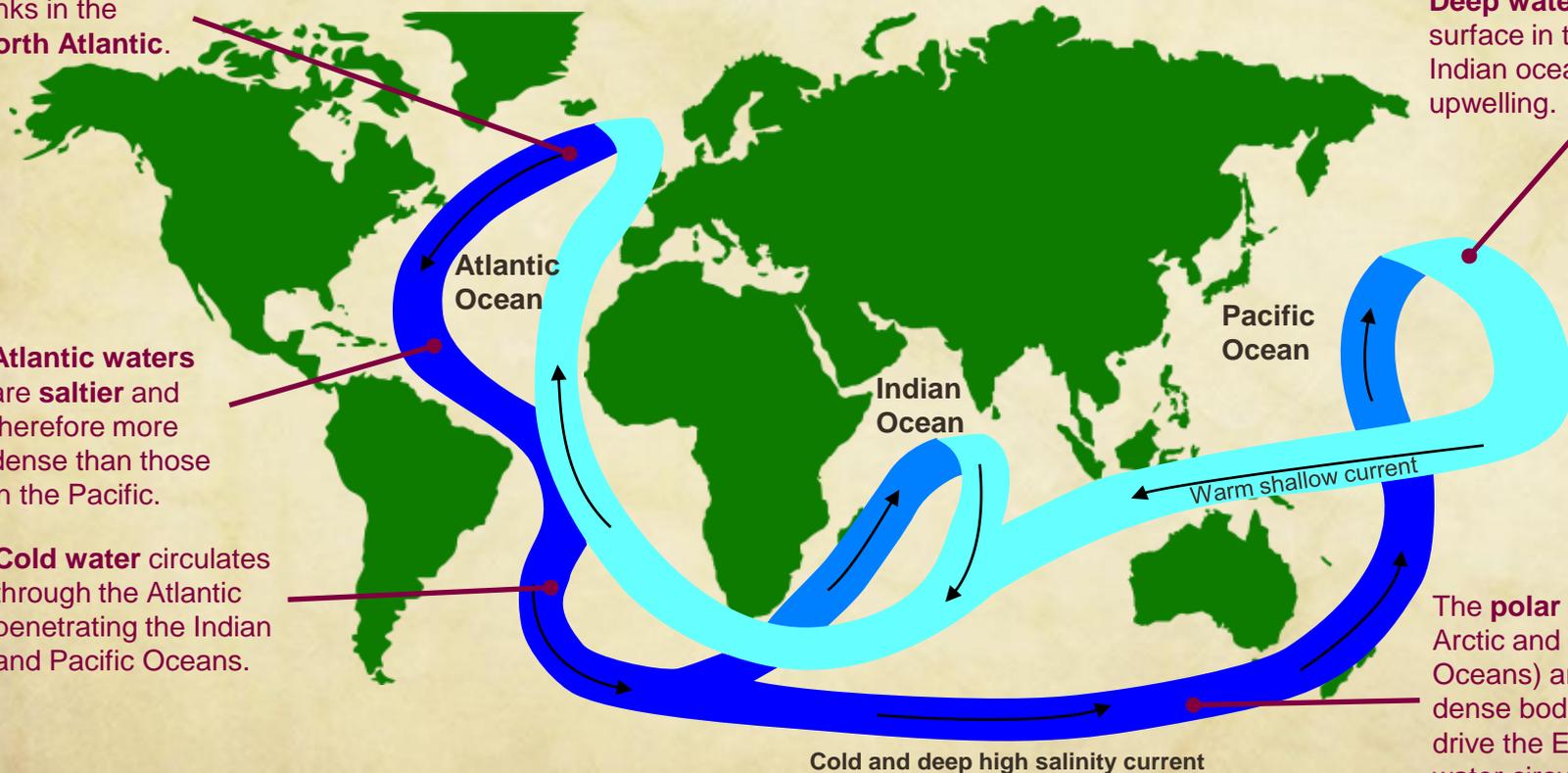
High salinity water cools and sinks in the **North Atlantic**.

Deep water returns to the surface in the Pacific and Indian oceans through **upwelling**.

Atlantic waters are **saltier** and therefore more dense than those in the Pacific.

Cold water circulates through the Atlantic penetrating the Indian and Pacific Oceans.

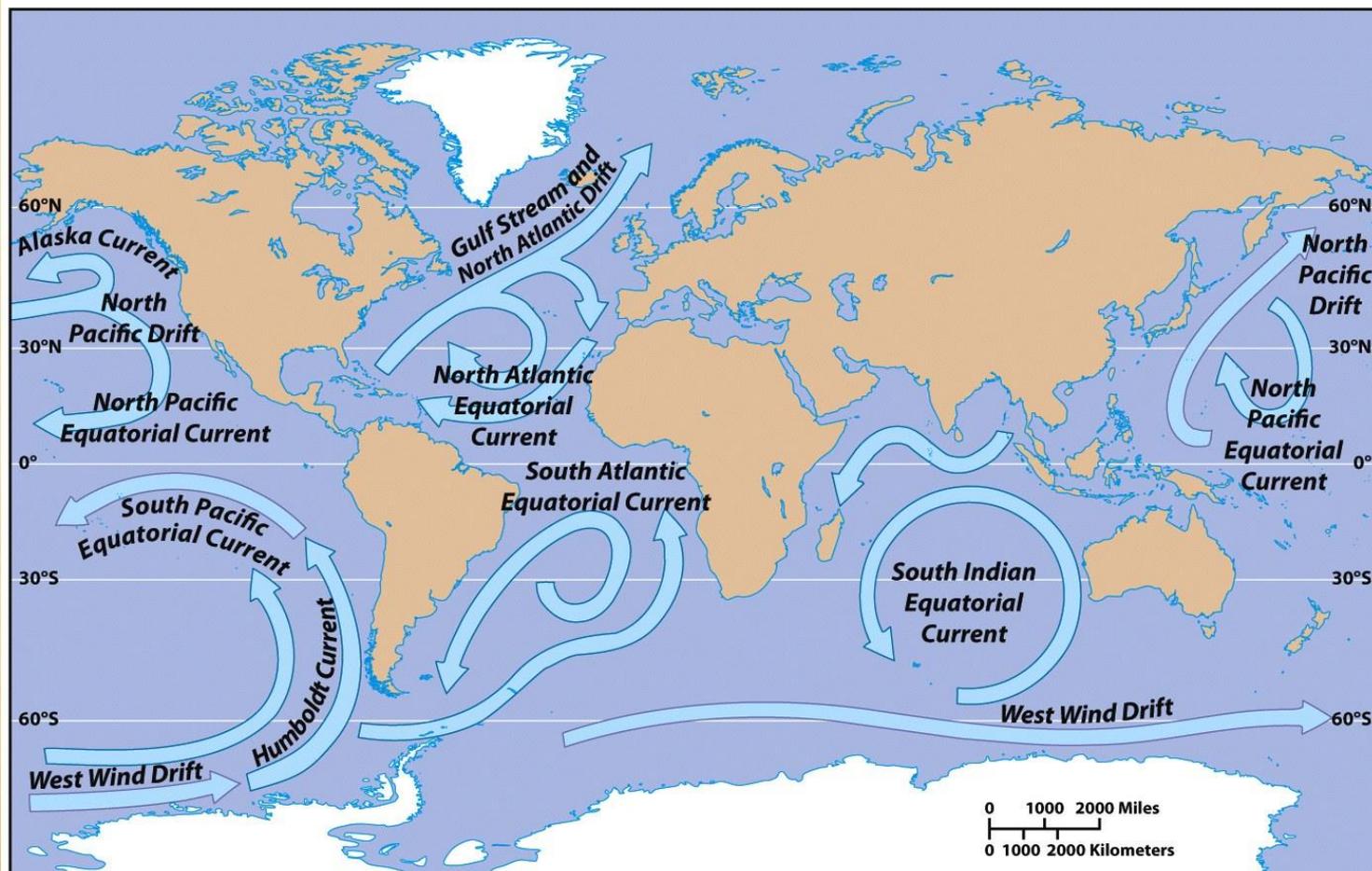
The **polar oceans** (the Arctic and Southern Oceans) are sources of cold dense bodies of water that drive the Earth's deep water circulation.



Cold and deep high salinity current

Warm shallow current

If you notice here in the northern hemisphere although large scale weather patterns spin counterclockwise, Large ocean Gyres and large ocean currents flow clockwise.



Gyres

- ▶ The movement of surface waters tends to form ocean-wide vortices.
- ▶ At the center of these vortices, water currents are almost nonexistent and water tends to be stagnant.
- ▶ The **Sargasso Sea** is a well known example.



Great Pacific Garbage Patch

- ▶ As with all vortices, debris is swept towards the middle of the water currents.
- ▶ The **Great Pacific Garbage Patch** is an accumulation of plastic and other debris in the middle of the **North Pacific Gyre**.
<http://youtu.be/iVESX5HCq-s> (1:35)



Midway Island lies near the center of the GPGP. Every tide brings in vast amounts of debris, from parts of old fishing nets to plastic bags and bottles. It is a poignant example of how even the most isolated places of Earth are affected by human activities.



Nearly two million Laysan albatrosses live on Midway. It is estimated all of them contain some quantity of plastic. This juvenile died after swallowing at least three bottle caps, some fishing line and a felt tip pen.

The World Ocean: A Global Temperature Regulator

- ▶ The world ocean absorbs and stores energy from sunlight which regulates temperatures in Earth's atmosphere.
- ▶ The ocean absorbs and releases heat slower than land, so the temperature of the atmosphere changes slowly.
- ▶ If the ocean did not regulate atmospheric and surface temperatures, temperatures would be too extreme for life to exist on Earth.

A Global Temperature Regulator

- ▶ Local temperatures in different areas of the planet are also regulated by the world ocean.
- ▶ Currents circulate warm water causing land areas they flow past to have warmer climates.
- ▶ Why doesn't it snow much in London if they are on a **latitude** further north than Maine?!

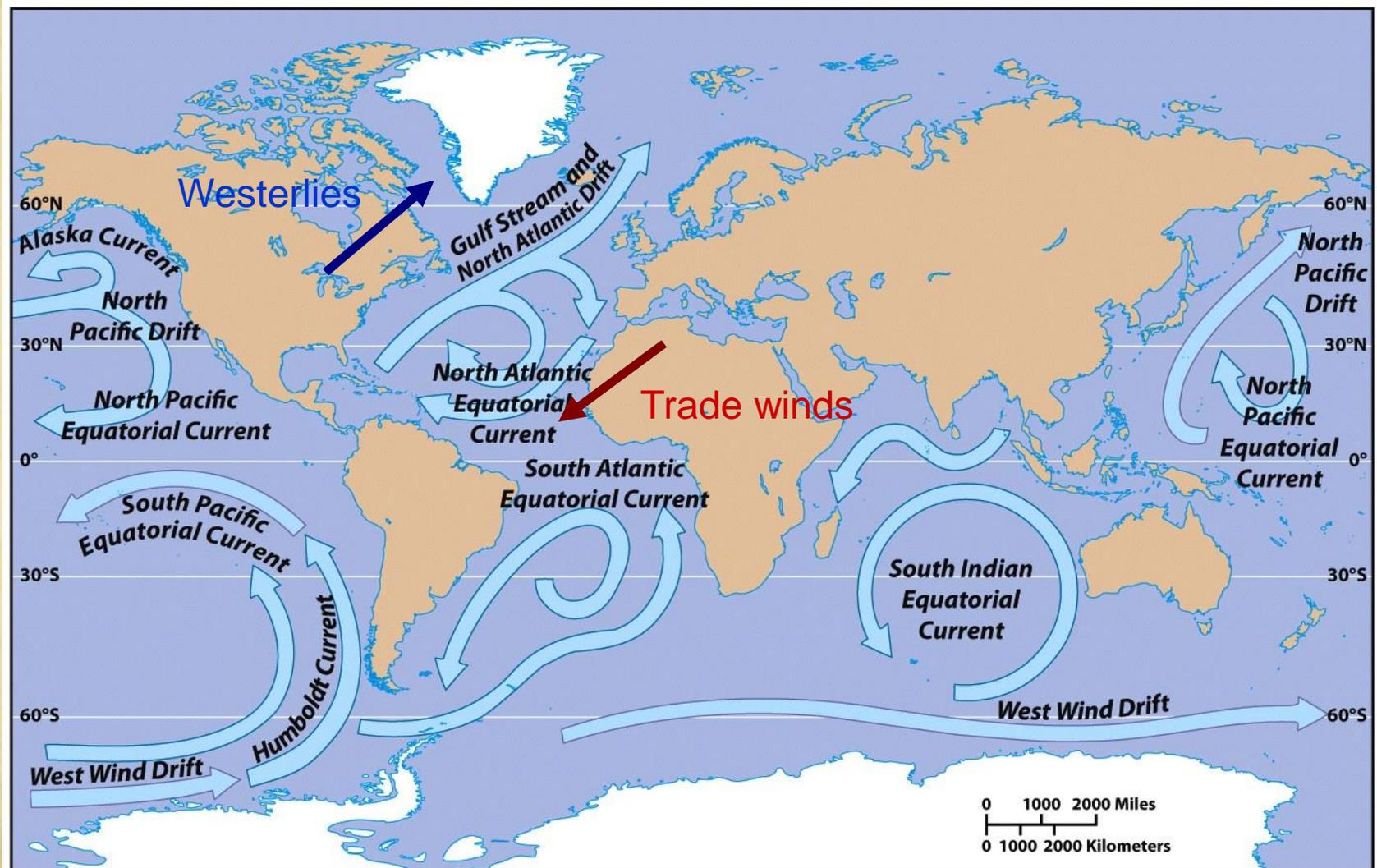


Global Ocean Circulation

Thermohaline circulation explained (1:46)

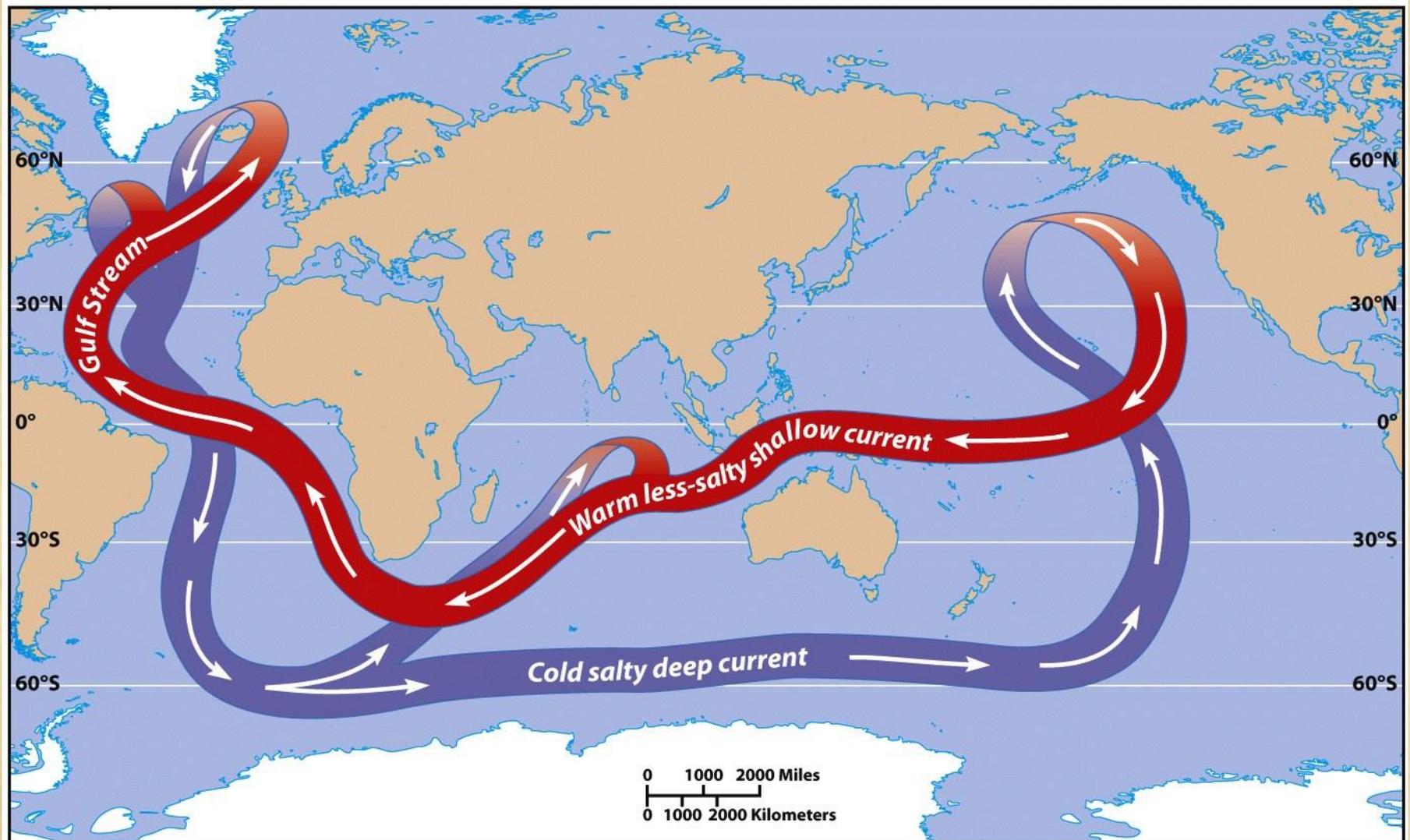
(thermo= temperature) (haline = salty)

<http://youtu.be/tjHS47ZxJNU>



Vertical Mixing of Ocean

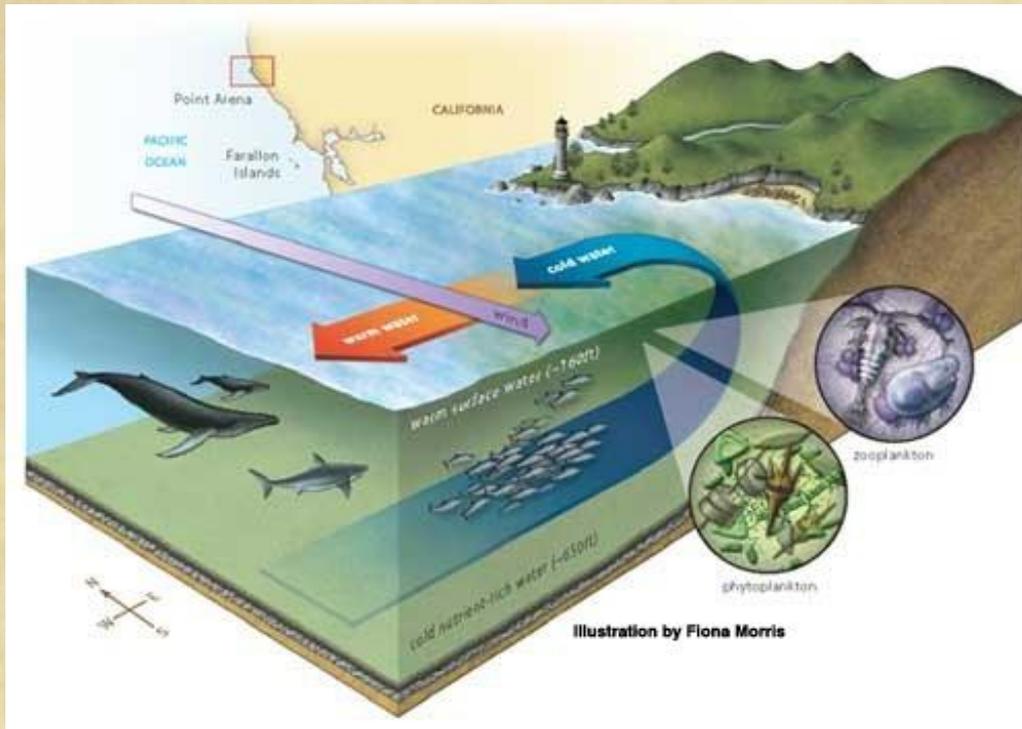
The Gulf Stream & climate change (5:05): <http://youtu.be/UuGrBhK2c7U>



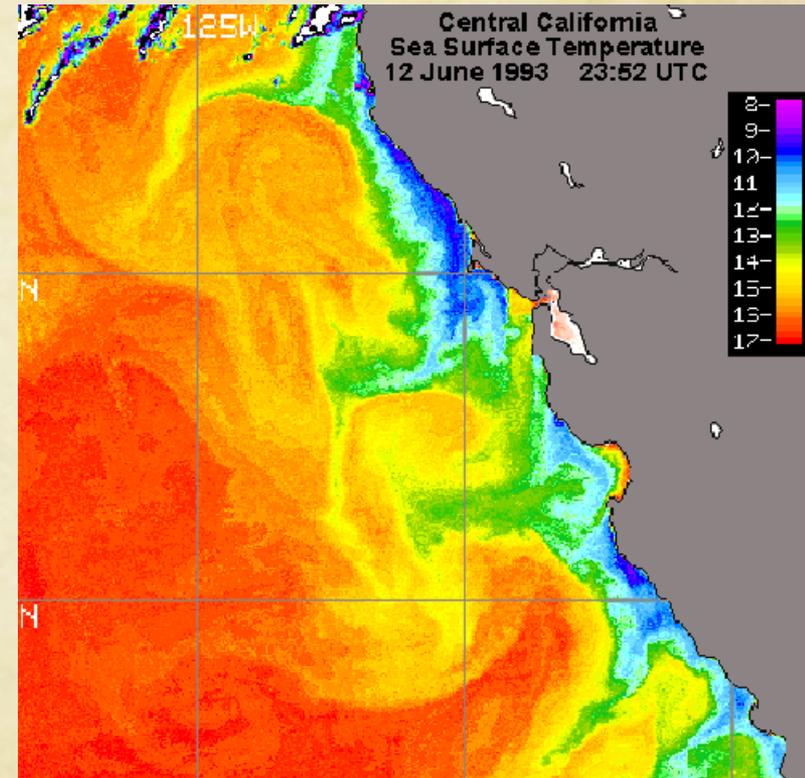
Ocean Interaction with Atmosphere

- ▶ El Niño-Southern Oscillation (ENSO)
 - ▶ Def: periodic large scale warming of surface waters of tropical (equatorial) eastern Pacific Ocean
- ▶ Alters ocean and atmospheric circulation patterns
- ▶ **Normal conditions-** westward blowing tradewinds keep warmest water in western Pacific
- ▶ **ENSO conditions-** trade winds weaken and warm water expands eastward to South America
 - ▶ Big effect on fishing industry off South America (no upwelling)

Upwelling helps explain El Nino



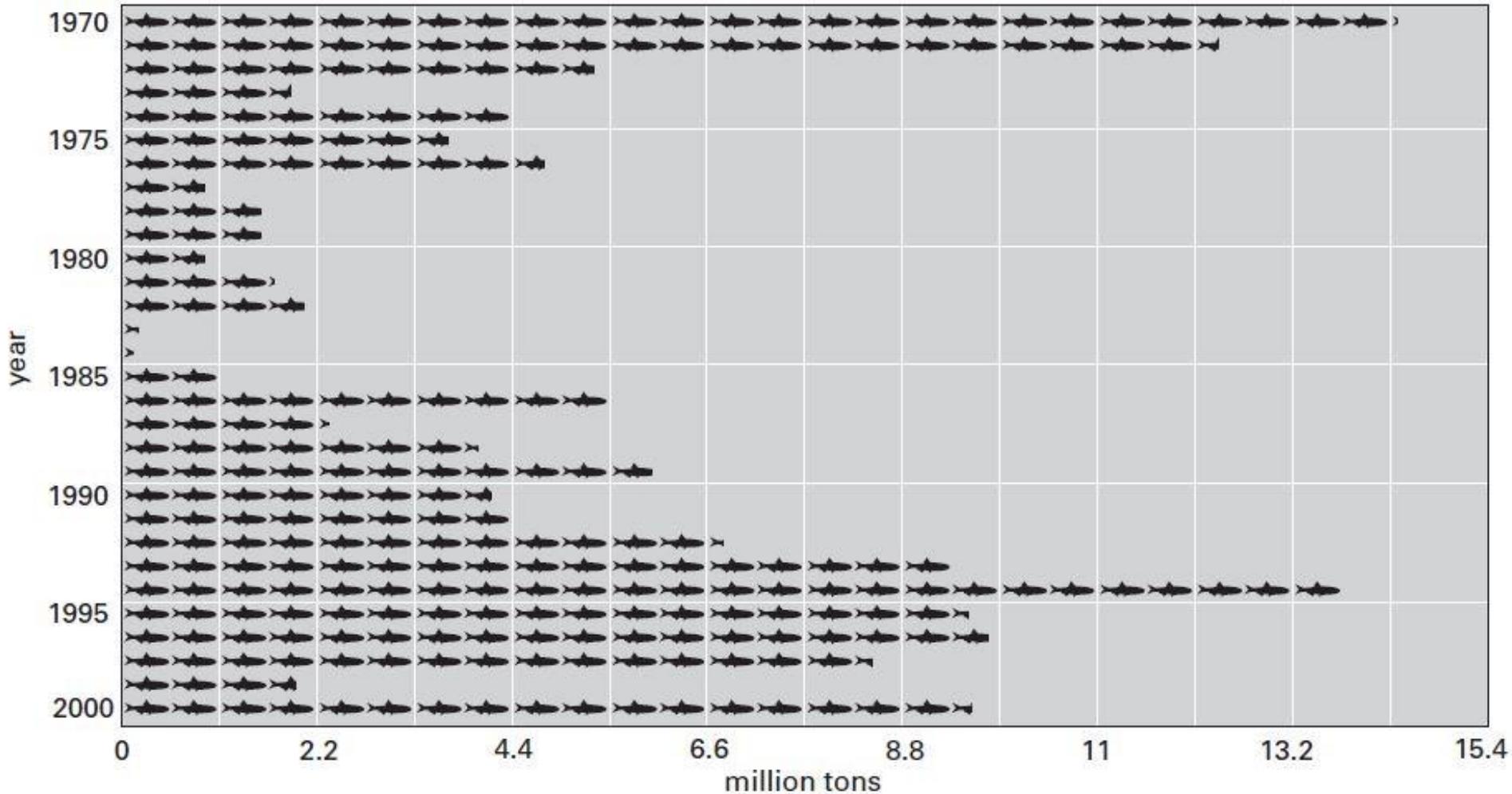
Winds blowing across the ocean surface push water away. Water then rises up from beneath the surface to replace the water that was pushed away.



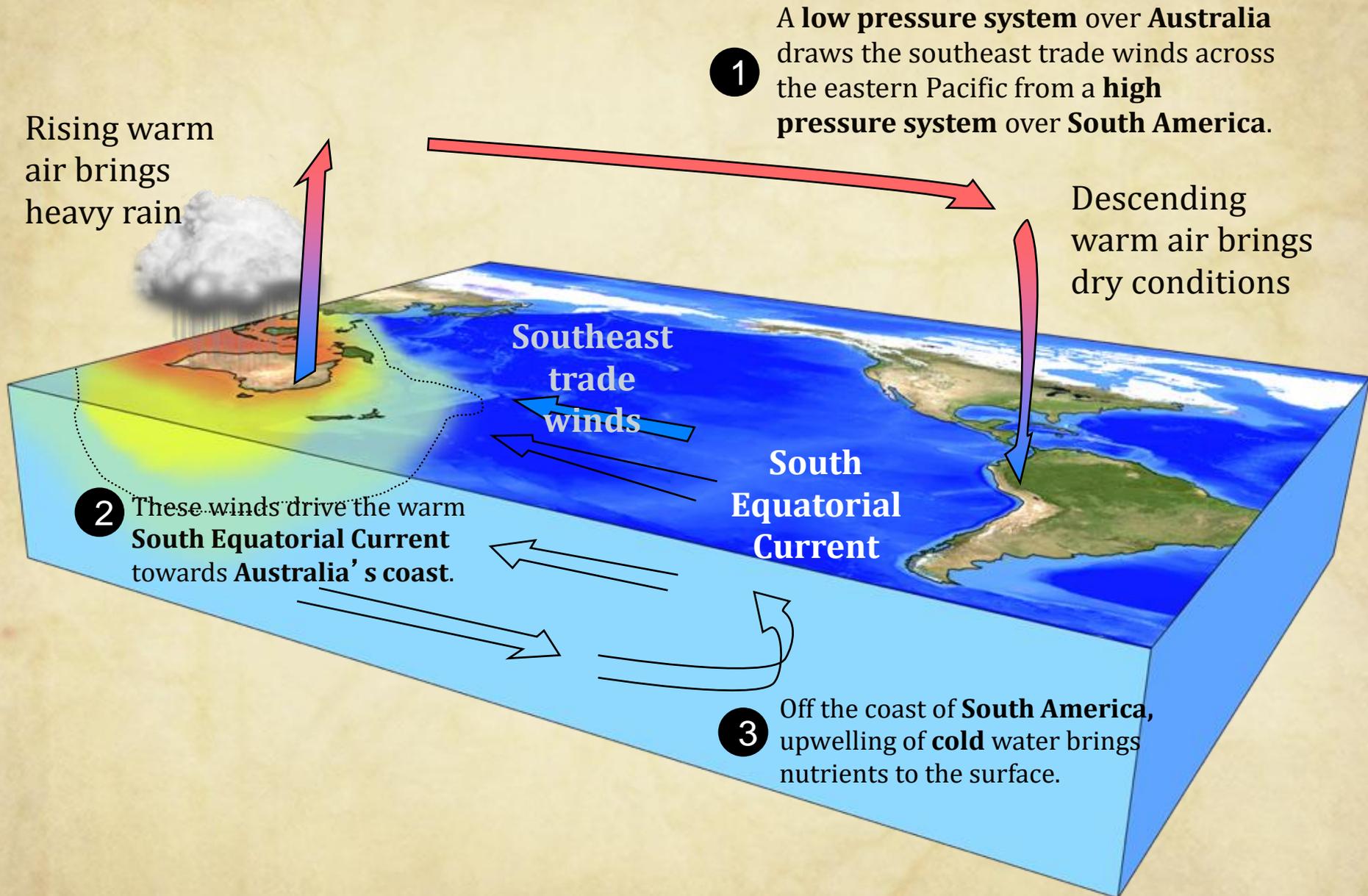
Anchovy catch off Peru 1970-2000

Anchoveta catches 1970-2000

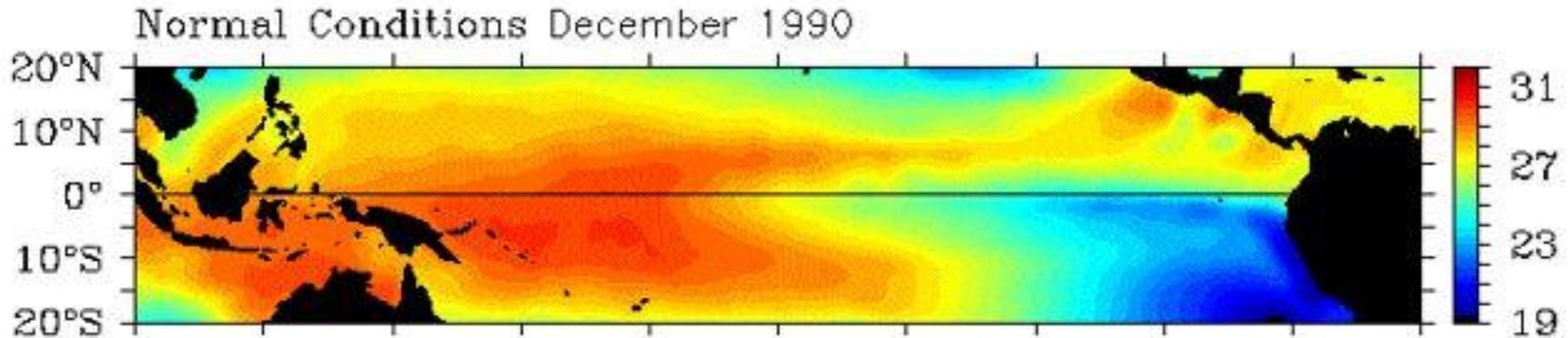
 = 0.5 million tons



Normal Conditions



Normal Conditions



Normal Conditions Simulation:

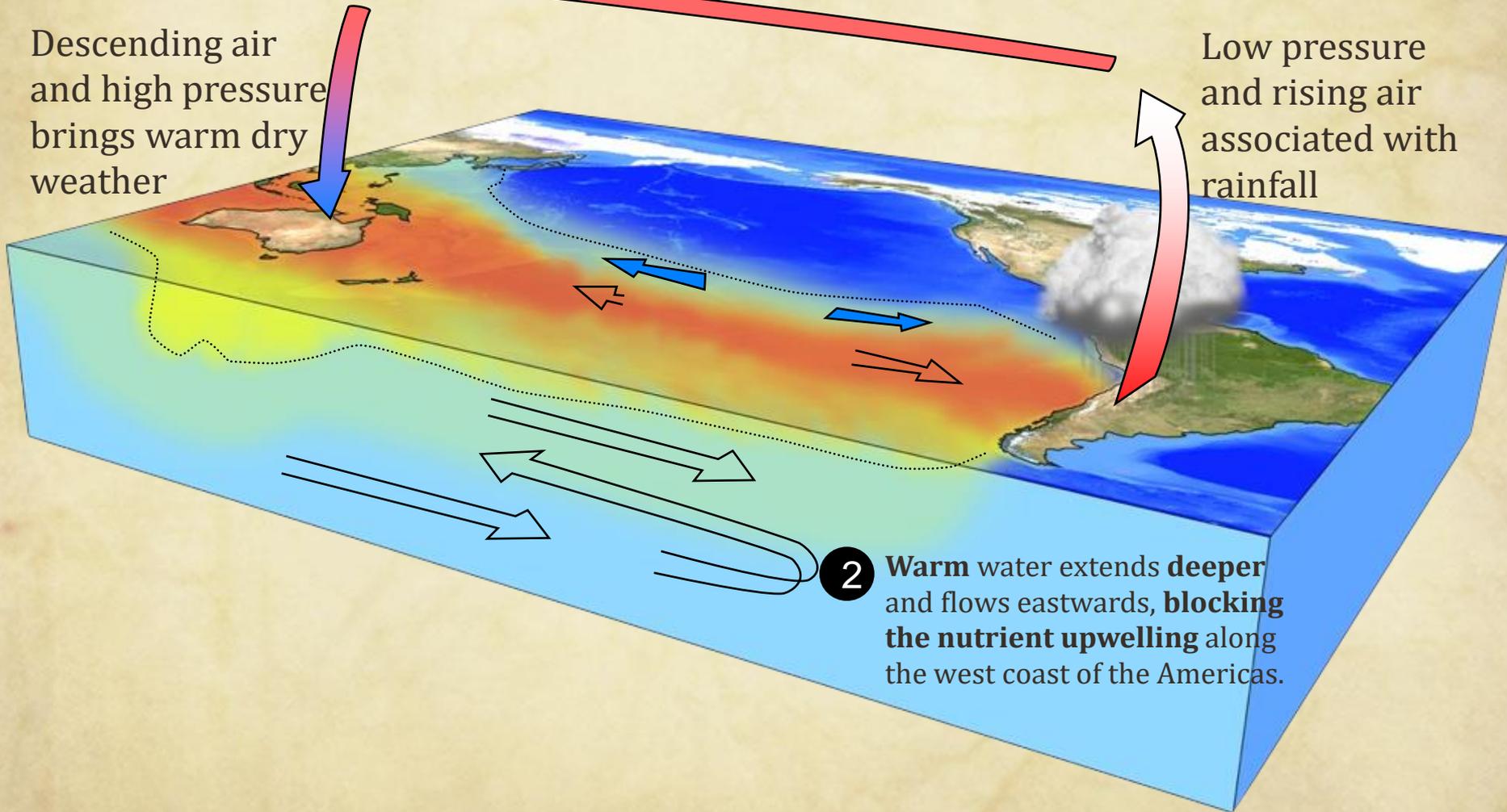
http://esminfo.prenhall.com/science/geoanimations/animations/26_NinoNina.html

During El-Niño

1

Pressure systems over Australia and South America are weakened or reversed.

Descending air and high pressure brings warm dry weather



3

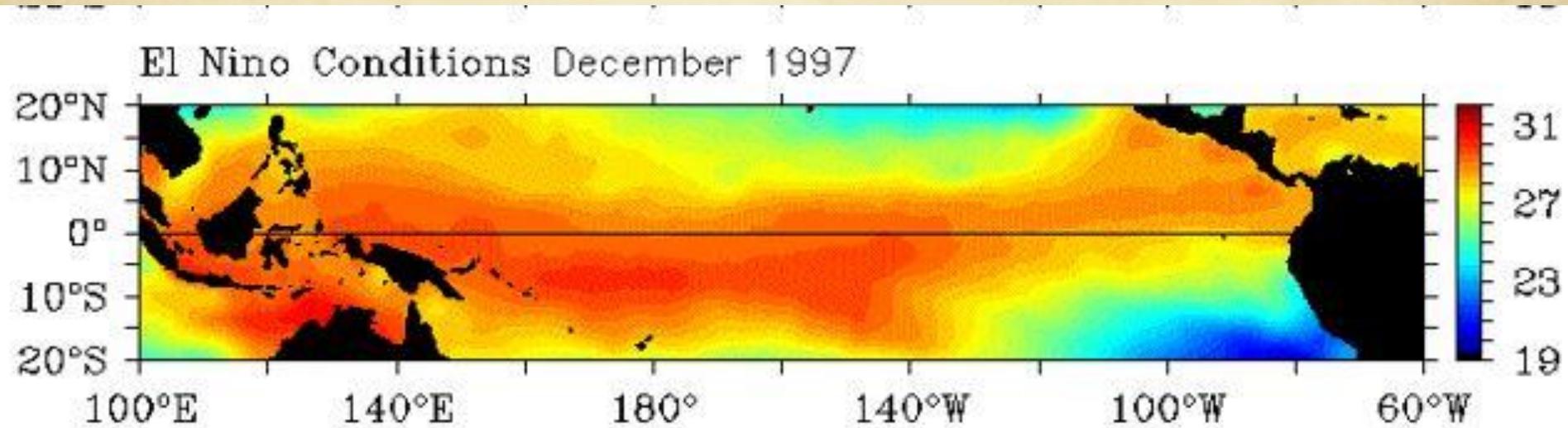
Heavy rain over Peru and Chile causes the deserts to bloom.

Low pressure and rising air associated with rainfall

2

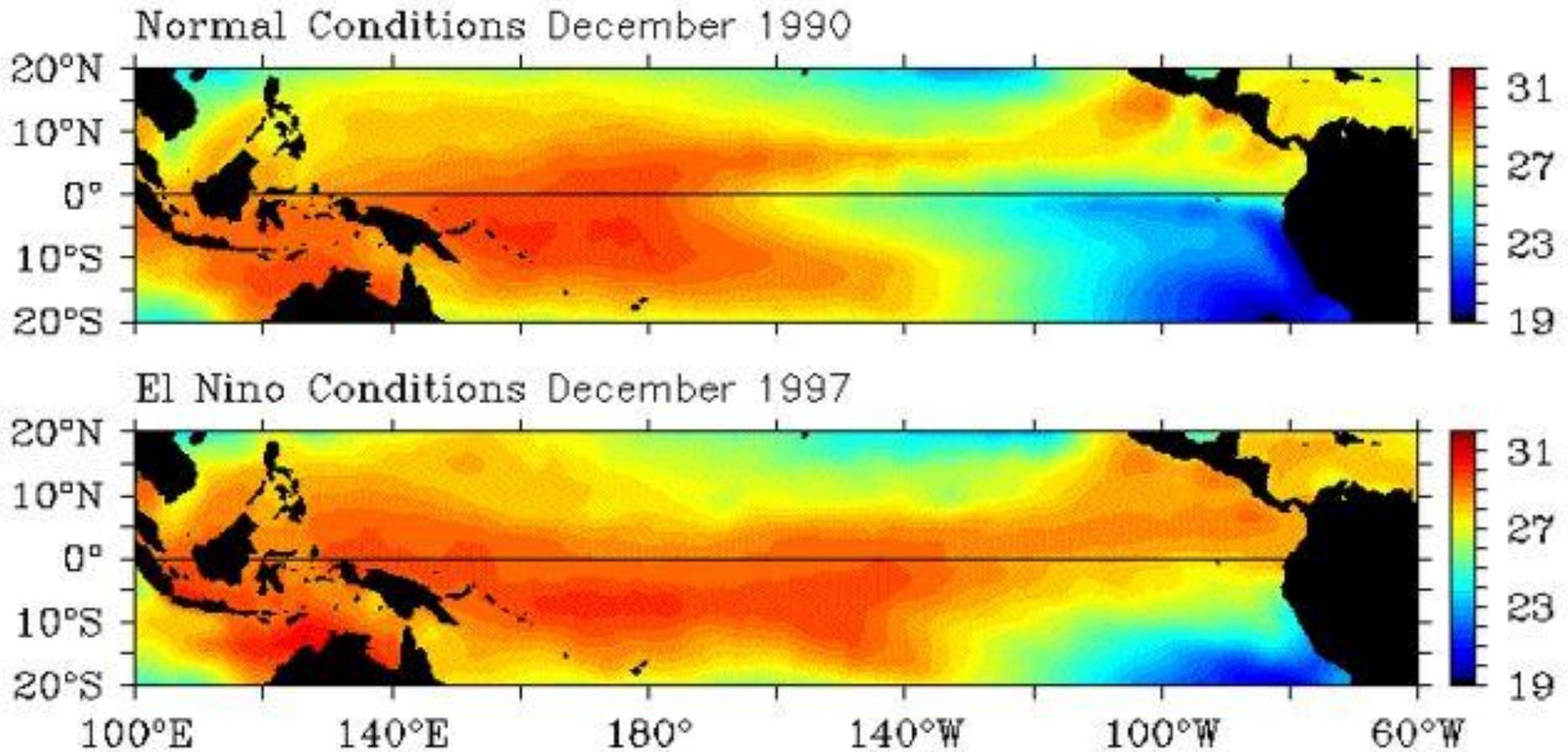
Warm water extends deeper and flows eastwards, blocking the nutrient upwelling along the west coast of the Americas.

El Nino Conditions



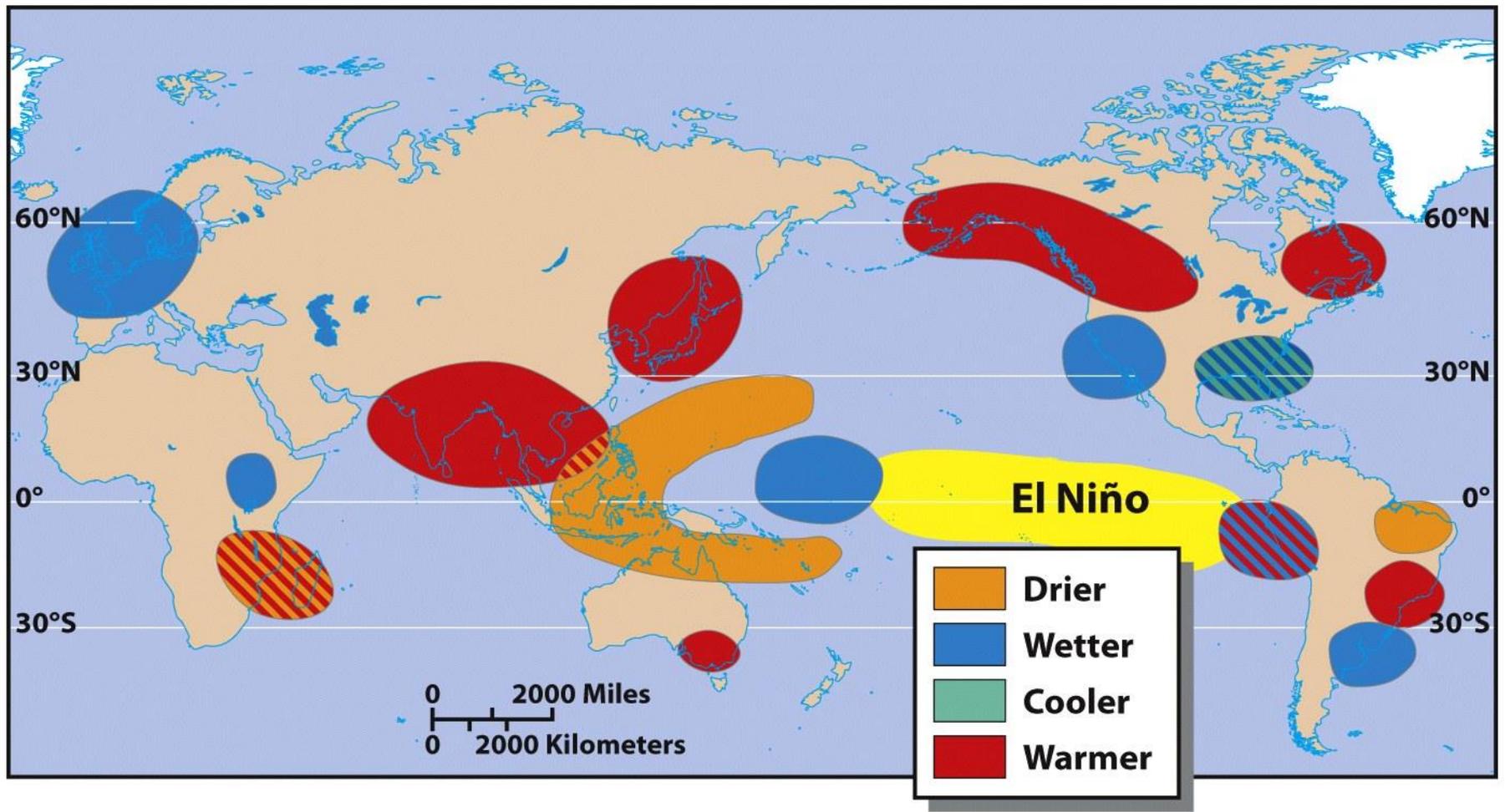
El Nino Simulation:

http://esminfo.prenhall.com/science/geoanimations/animations/26_NinoNina.html

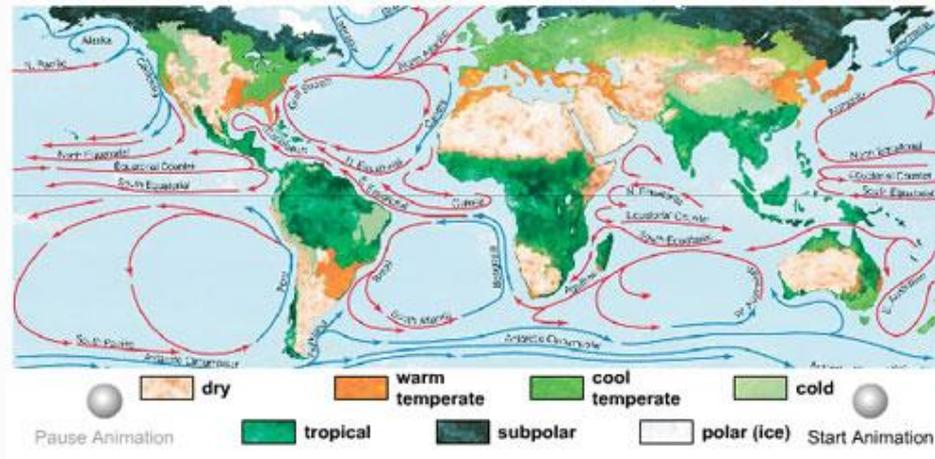


El Nino Explained “GRIST” style (2:56):
<http://youtu.be/faw3moP-XEg>

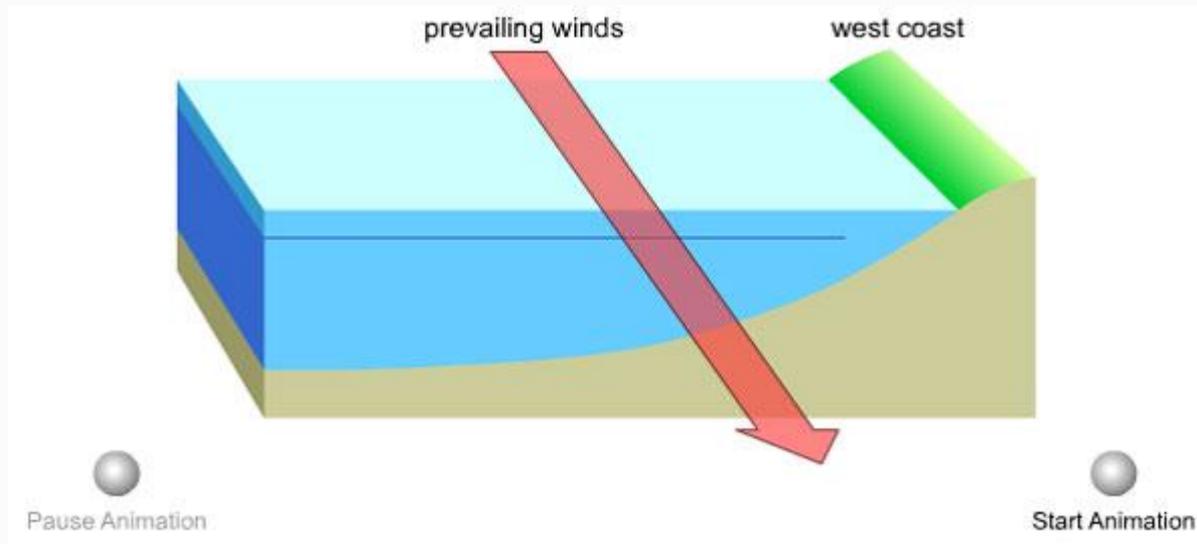
ENSO Climate Patterns



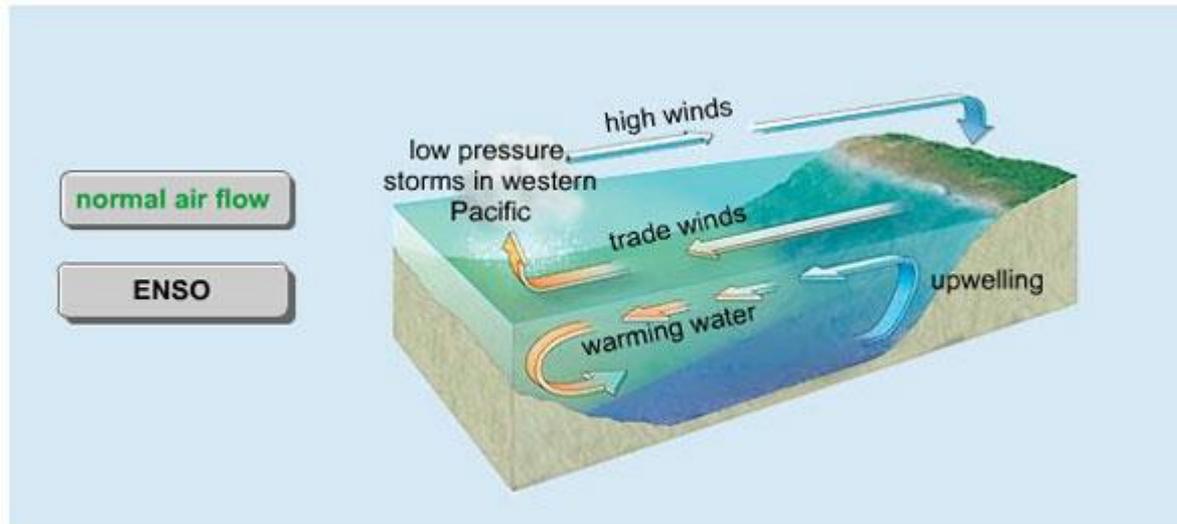
Active Figure: Climate and ocean currents map



Animation: Upwelling along western coasts



Animation: El Nino Southern Oscillation

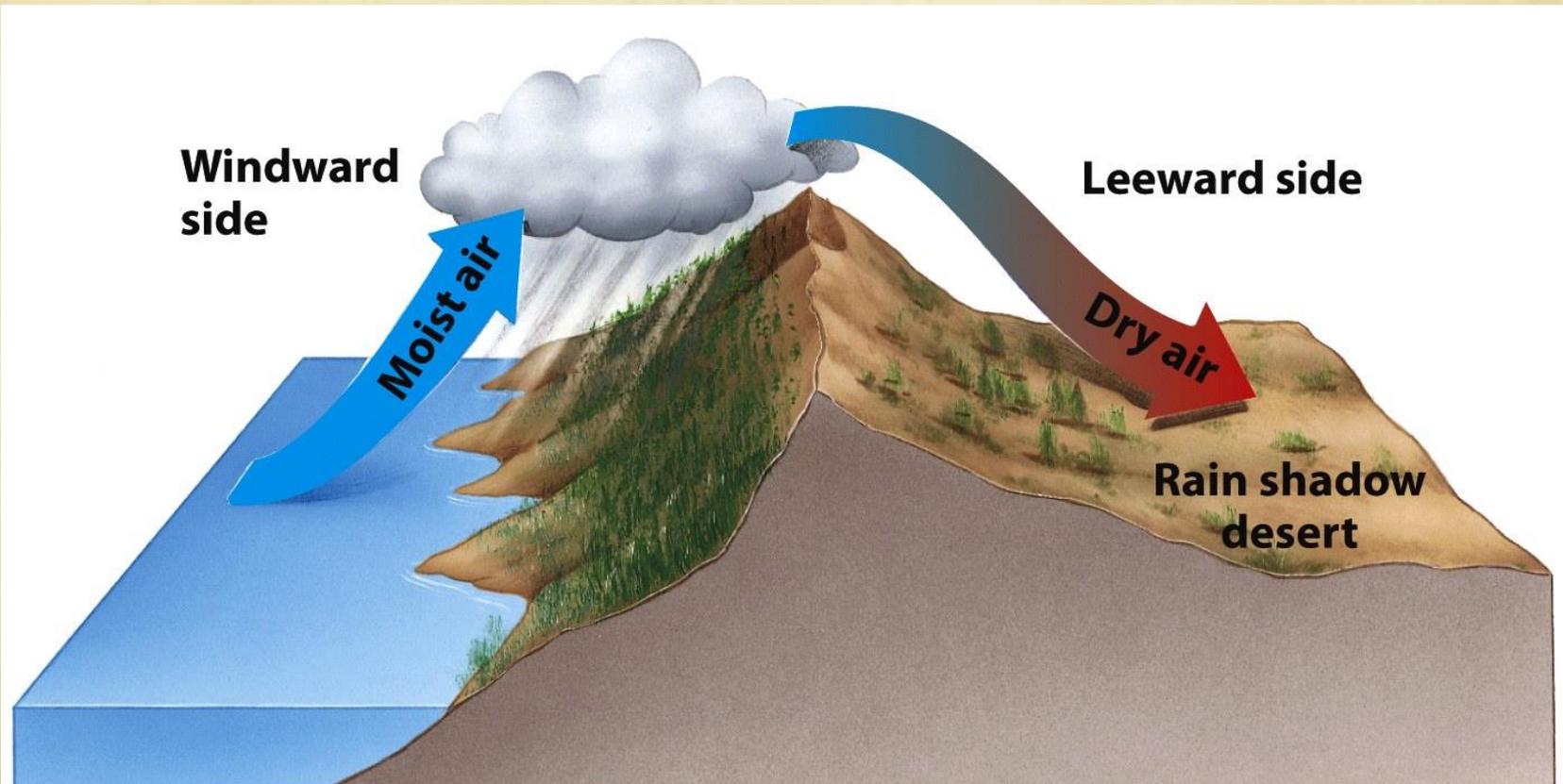


The Earth's Surface Features Affect Local Climates

- Heat absorption by land and water (thermal inertia)
 - Effect of
 - Mountains
 - **Rain shadow effect (Fig. 7-7)**
 - Cities
 - Microclimates
-

Rain Shadows

- ▶ Mountains force humid air to rise
- ▶ Air cools with altitude, clouds form and precipitation occurs (**windward side**)
- ▶ Dry air mass moves down opposite **leeward side** of mountain



7-2 How Does Climate Affect the Nature and Locations of Biomes?

- **Concept 7-2** *Differences in average annual precipitation and temperature lead to the formation of tropical, temperate, and cold deserts, grasslands, and forests, and largely determine their locations.*
-

Biomes

A large, relatively distinct terrestrial region with a similar climate soil, plants, and animals, regardless of where it occurs in the world

Location of each biome is primarily determined by:

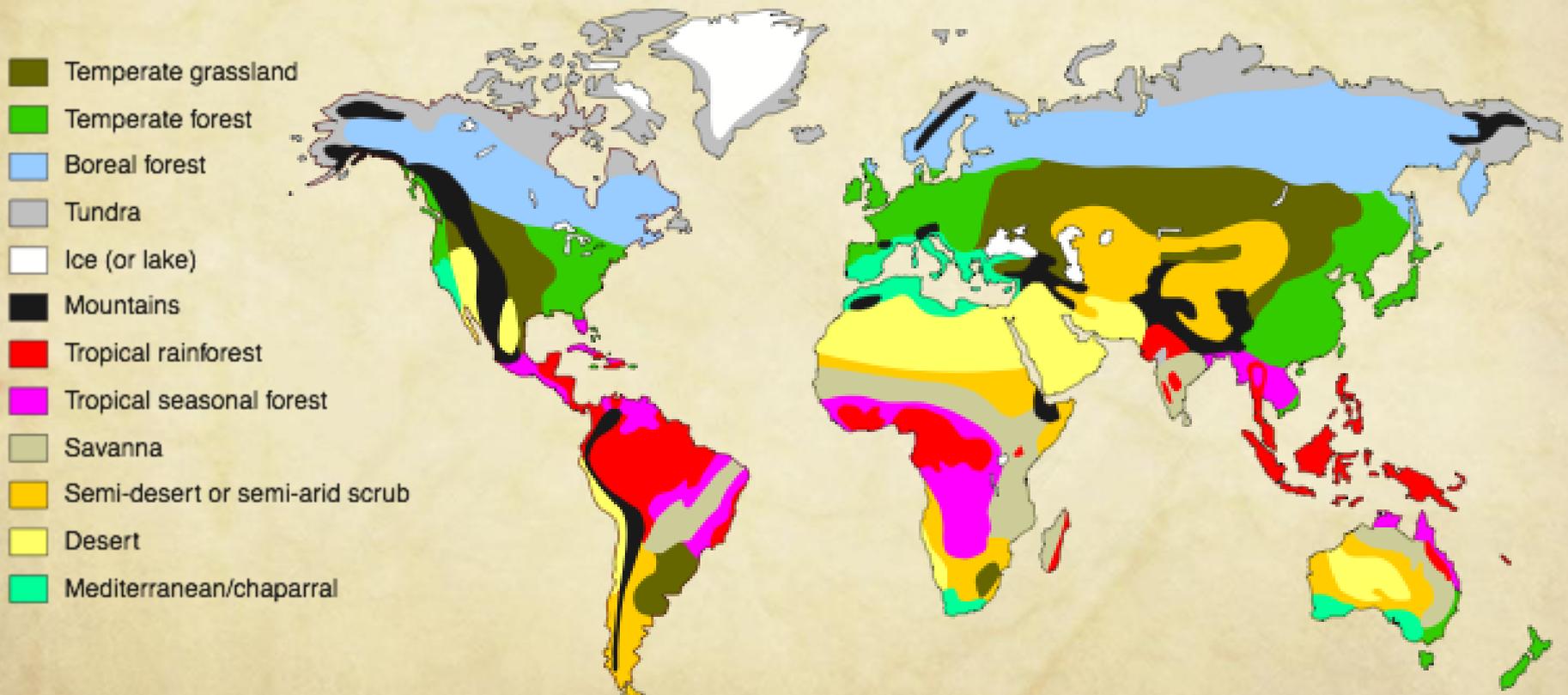
- ▶ Temperature (varies with both latitude and elevation)
- ▶ Precipitation

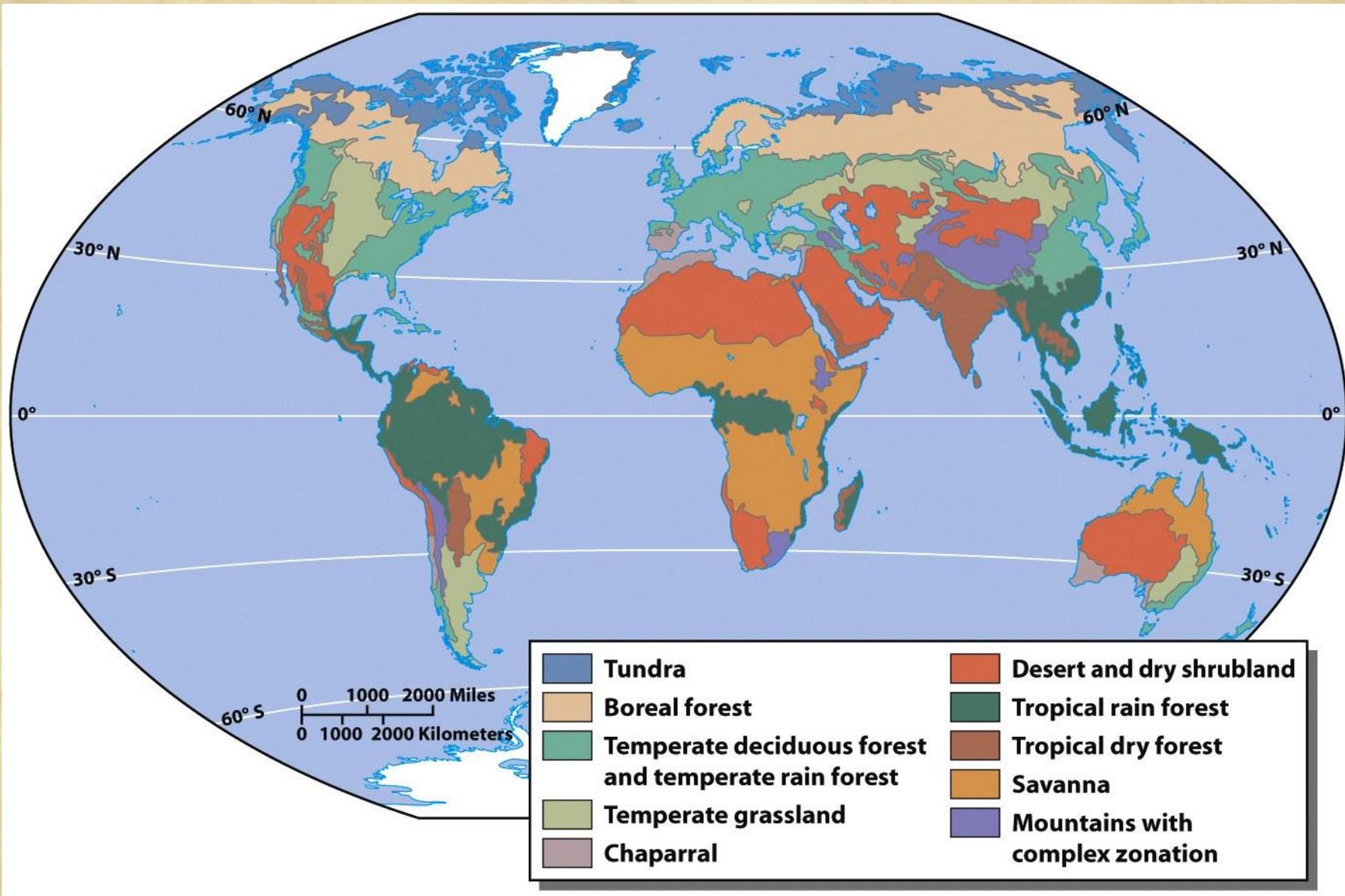


Desert biome

Terrestrial Biomes

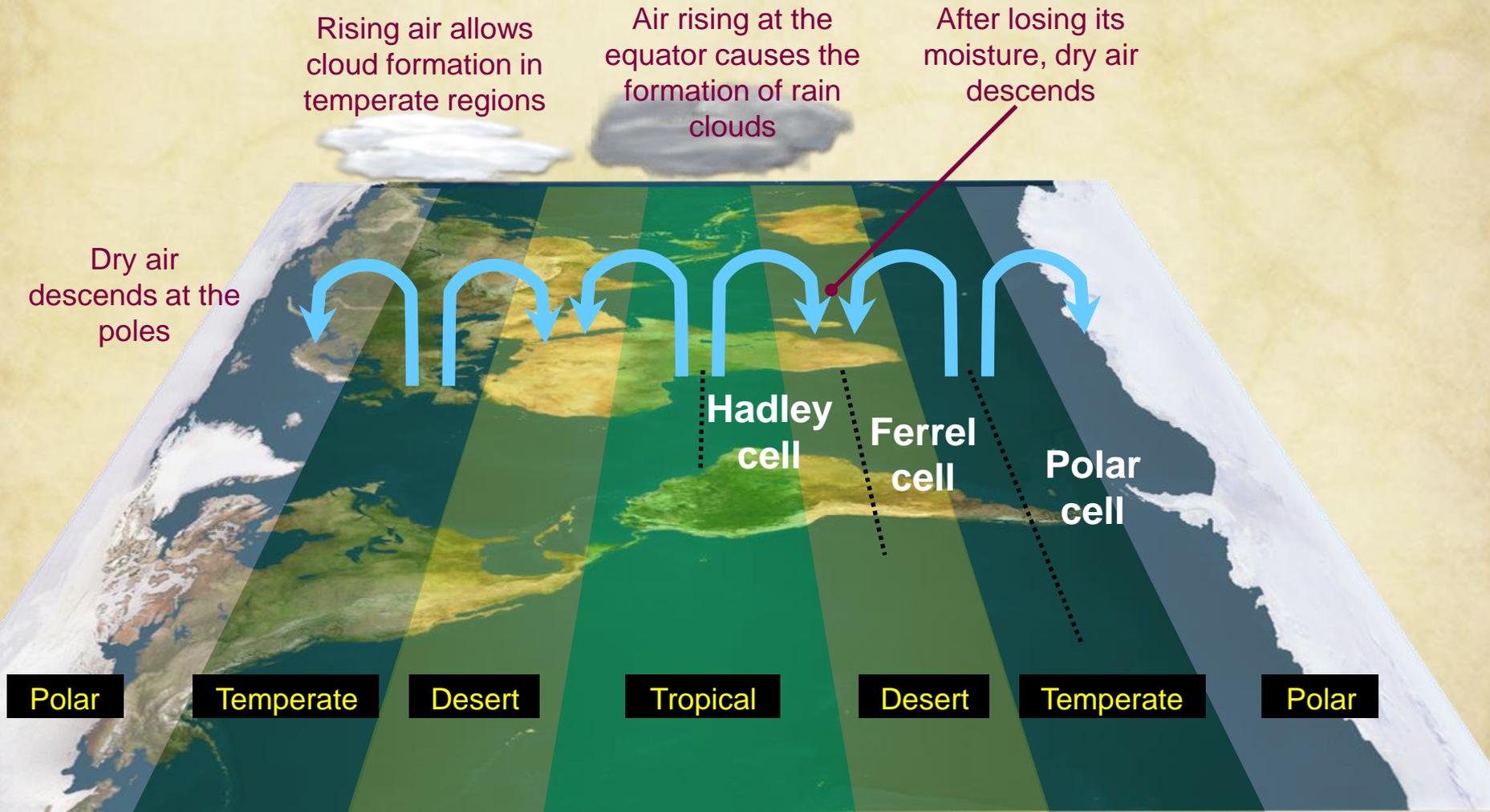
- ▶ Terrestrial **biomes** are recognized for all the major climatic regions of the world and are classified on the basis of their predominant **vegetation type**.
 - The same biome may occur in widely separated regions.





Biomes and Weather Cells

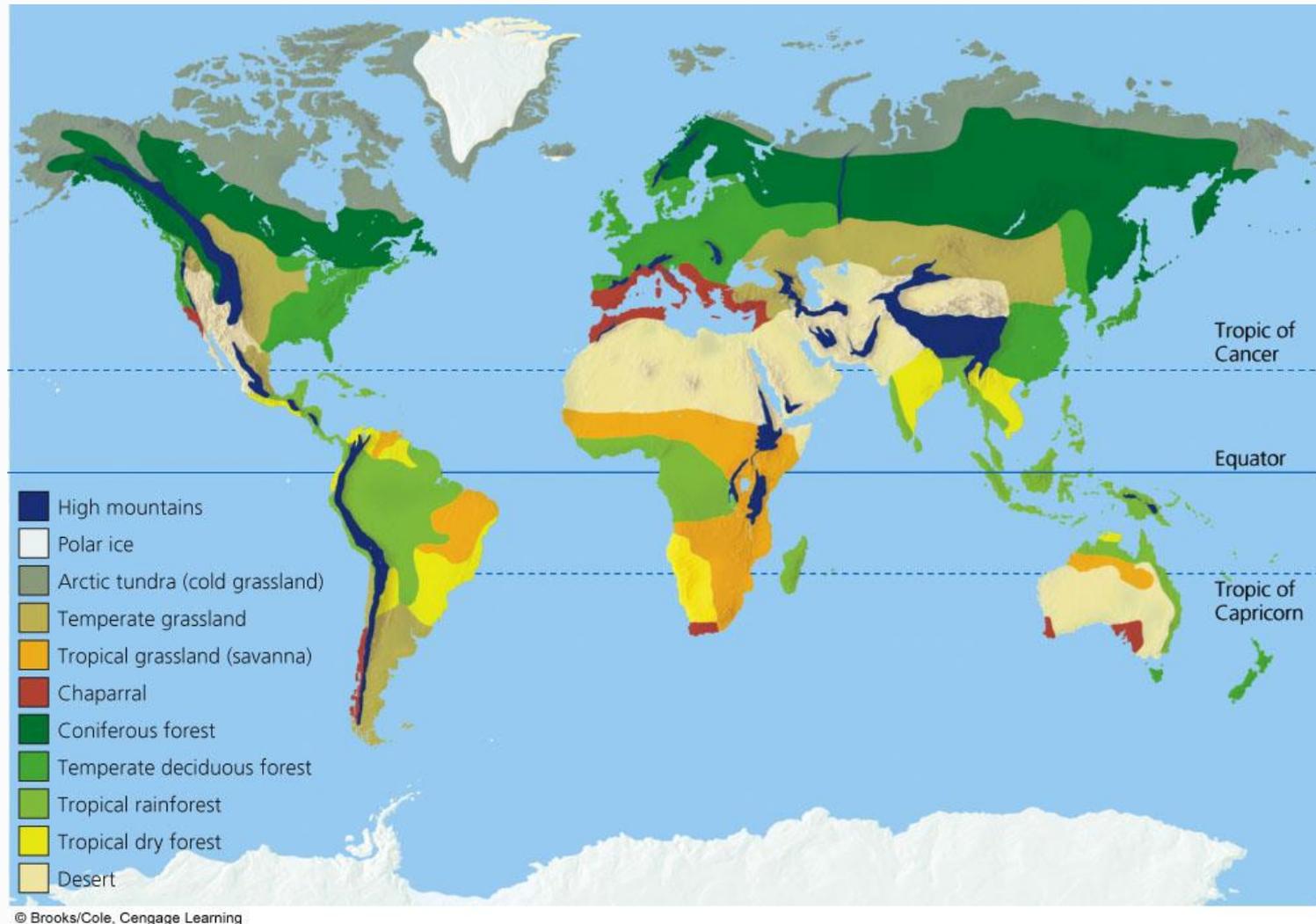
- ▶ Three air cells circle each hemisphere of the Earth.
 - The interaction of these cells is a major contributor the formation of biomes.



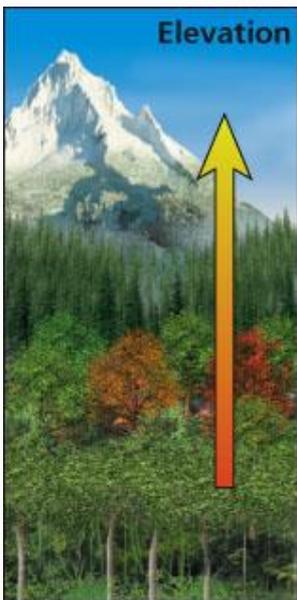
Climate Affects Where Organisms Can Live

- Major biomes (Fig. 7-8)
 - Latitude and elevation (Fig. 7-9)
 - Annual precipitation (Fig. 7-10)
 - Temperature (Fig. 7-10)
-

The Earth's Major Biomes



Generalized Effects of Elevation and Latitude on Climate and Biomes



Mountain
ice and snow

Tundra (herbs,
lichens, mosses)

Coniferous
Forest

Deciduous
Forest

Tropical
Forest



Tropical
Forest

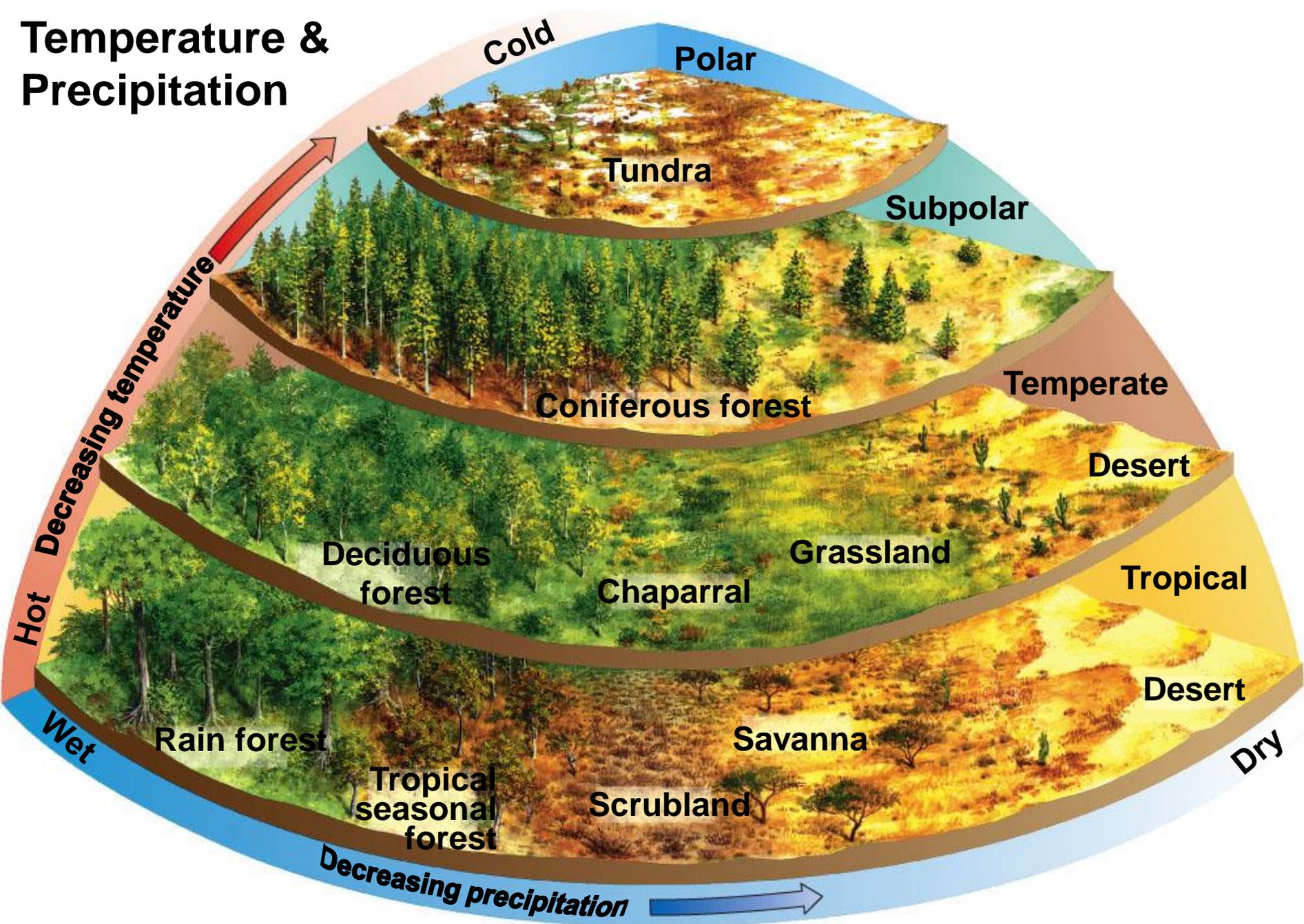
Deciduous
Forest

Coniferous
Forest

Tundra (herbs,
lichens, mosses)

Polar ice
and snow

Temperature & Precipitation

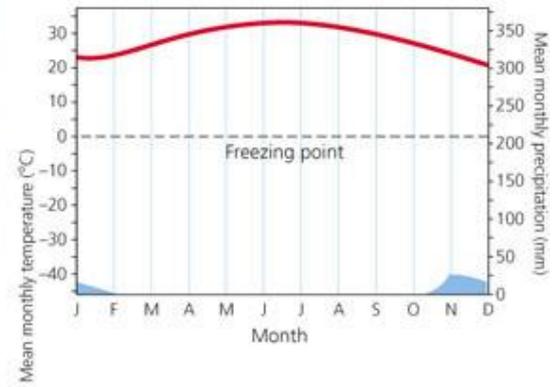


There Are Three Major Types of Deserts

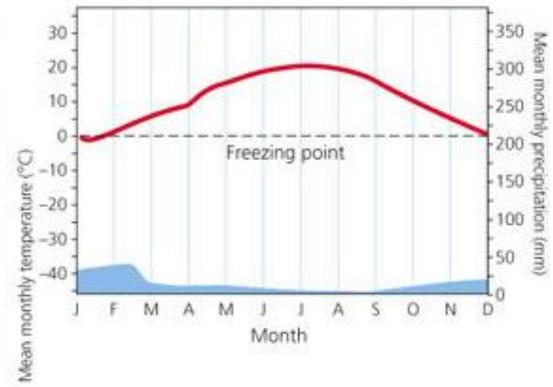
- Tropical deserts
 - Temperate deserts
 - Cold deserts
 - Fragile ecosystem (poor resilience)
 - Slow plant growth
 - Low species diversity
 - Slow nutrient recycling
 - Lack of water
-



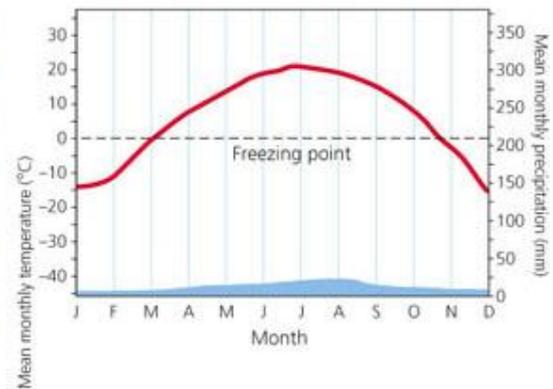
Tropical desert



Temperate desert



Cold desert



There Are Three Major Types of Grasslands (1)

- Tropical
 - Temperate
 - Cold (arctic tundra)
-

There Are Three Major Types of Grasslands (2)

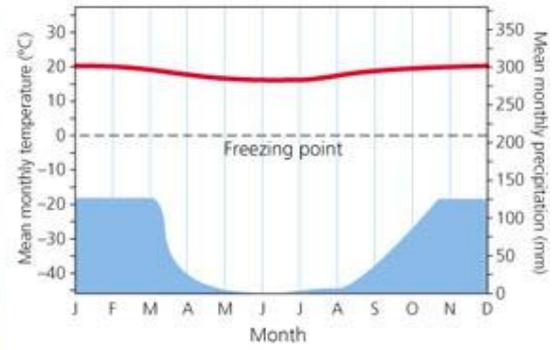
- Tropical
 - Savanna
 - Grazing animals
 - Browsing animals
 - Temperate
 - Tall-grass prairies
 - Short-grass prairies
-

There Are Three Major Types of Grasslands (3)

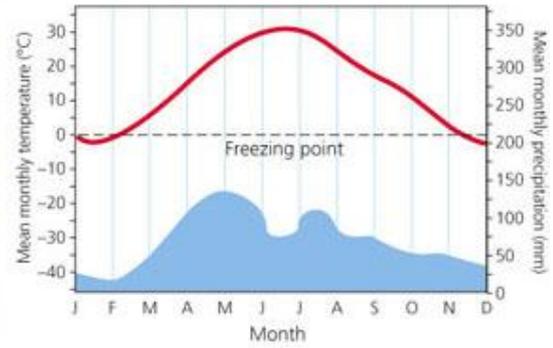
- Arctic tundra: fragile biome
 - Adaptations of plants and animals
 - **Permafrost**
 - Alpine tundra
-



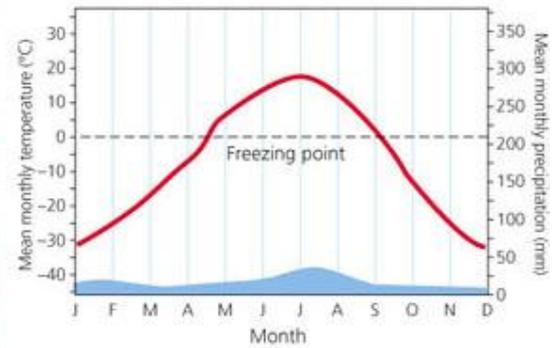
Tropical grassland (savanna)



Temperate grassland



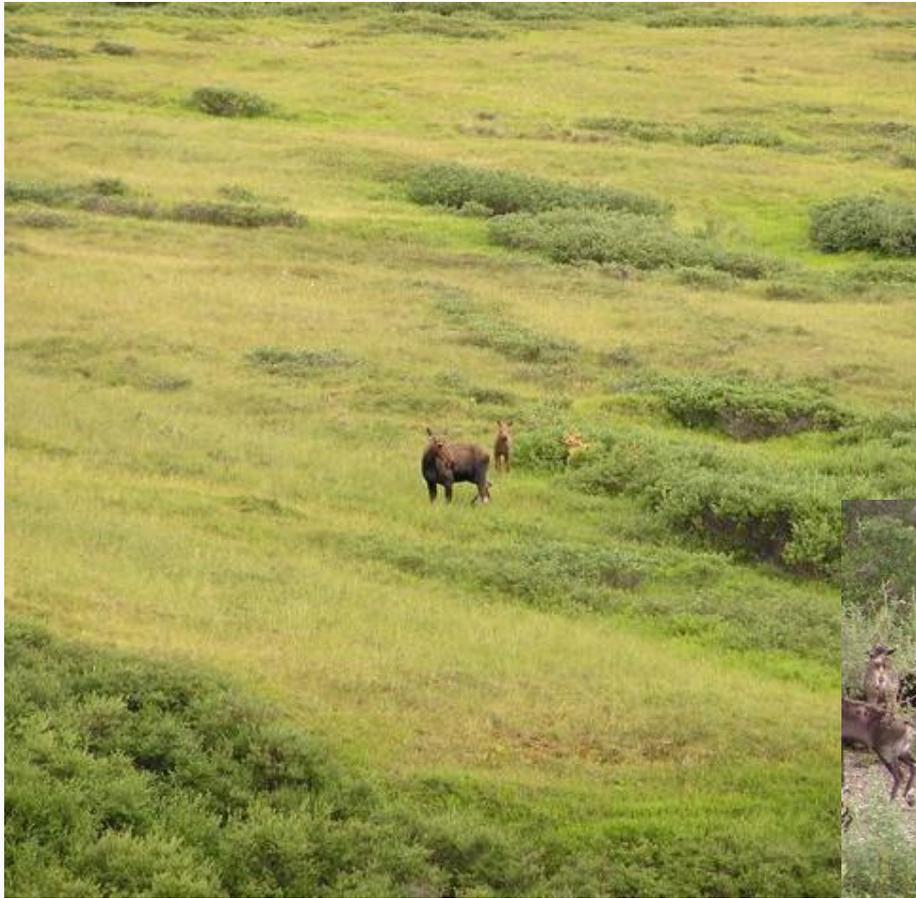
Cold grassland (arctic tundra)



Video: Caribou on tundra



Arctic Tundra Grazers: Moose and Caribou near Nome, Alaska



Monoculture Crop Replacing Biologically Diverse Temperate Grassland



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Temperate Shrubland: Nice Climate, Risky Place to Live

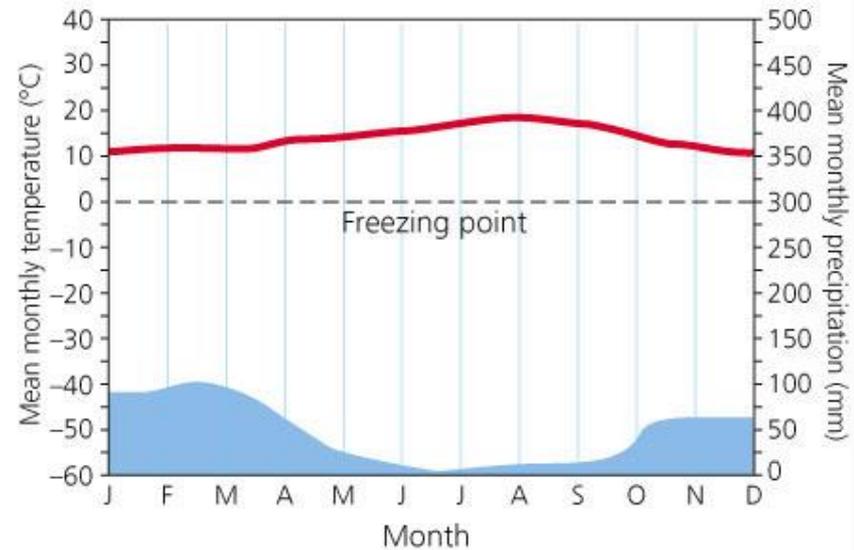
- **Chaparral**
 - Near the sea: nice climate
 - Prone to fires in the dry season
-

Chaparral Vegetation in Utah, U.S.



© Brooks/Cole, Cengage Learning

Chaparral



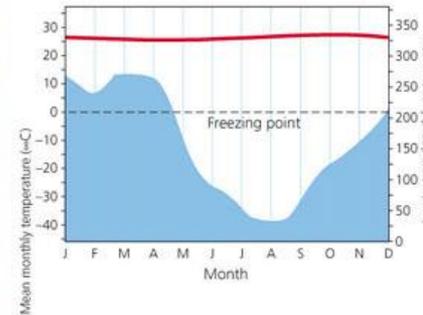
There Are Three Major Types of Forests (1)

- Tropical
 - Temperate
 - Cold
 - Northern coniferous and **boreal**
-

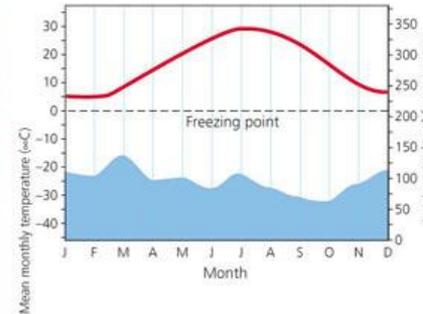
Climate Graphs of Tropical, Temperate, and Cold Forests



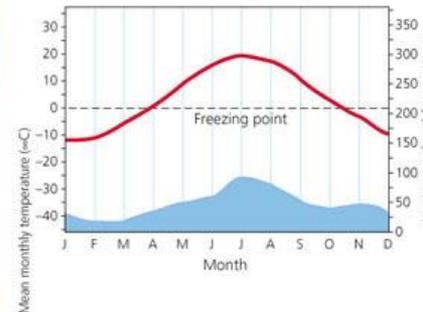
Tropical rain forest



Temperate deciduous forest



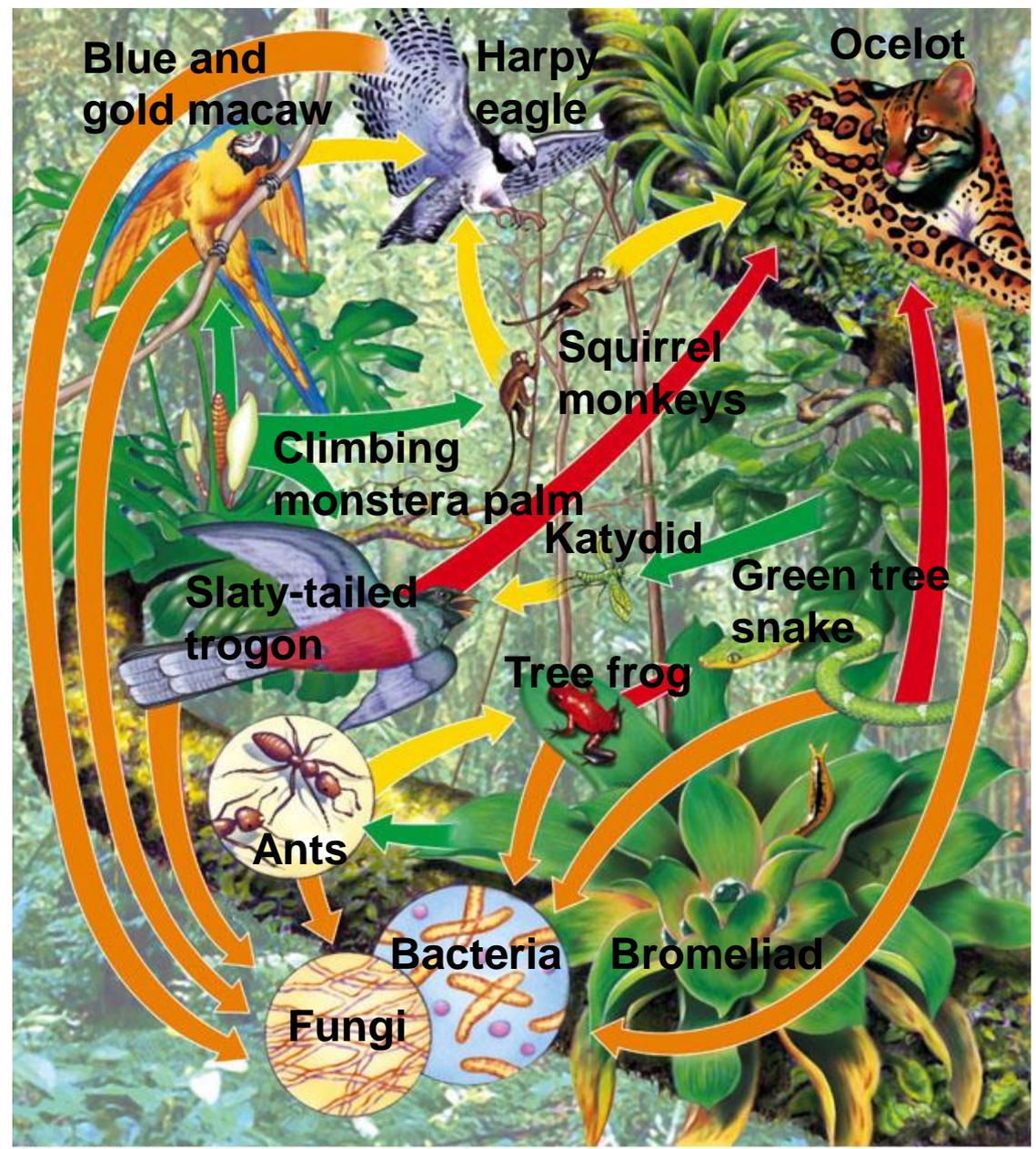
Northern evergreen coniferous forest (boreal forest, taiga)



There Are Three Major Types of Forests (2)

- Tropical rain forests
 - Temperature and moisture
 - Stratification of specialized plant and animal niches
 - Little wind: significance
 - Rapid recycling of scarce soil nutrients
 - Impact of human activities
-

Tropical Rain Forest

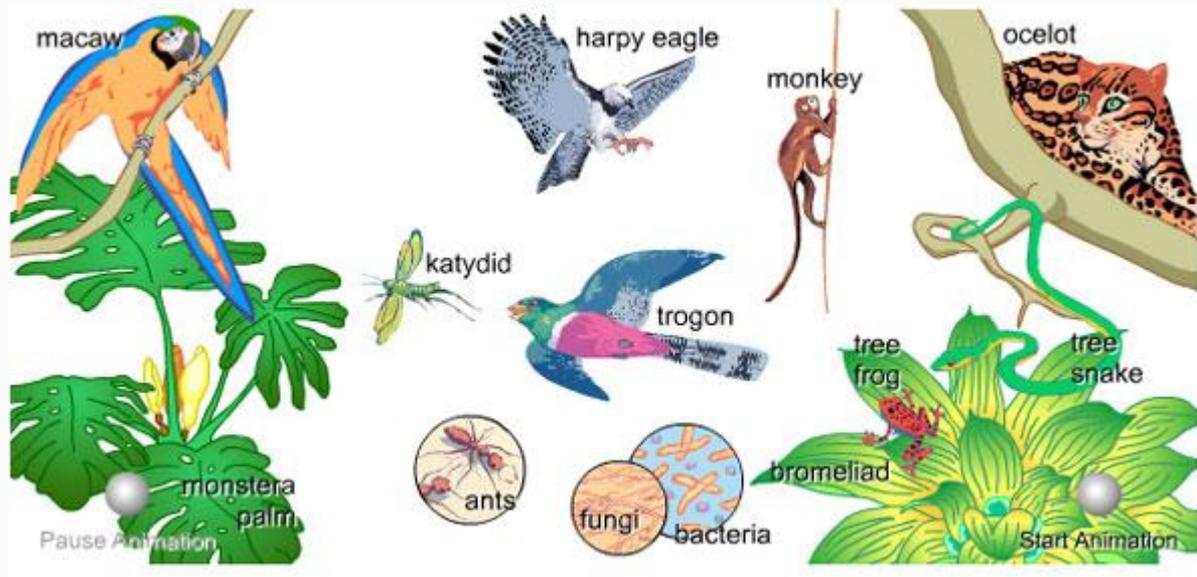


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Fig. 7-16, p. 155

Active Figure: Rainforest food web



Stratification of Plant and Animal Niches

45
40
35
30
25
20
15
10
5
0

Height (meters)



Emergent layer

Canopy

Under story

Shrub layer

Ground layer

There Are Three Major Types of Forests (3)

- Temperate deciduous forests
 - Temperature and moisture
 - Broad-leaf trees
 - Slow rate of decomposition: significance
 - Impact of human activities
-

There Are Three Major Types of Forests (4)

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

Temperate Rain Forest in Washington State, U.S.



Mountains Play Important Ecological Roles

- Majority of the world's forests
 - Habitats for endemic species
 - Help regulate the earth's climate
 - Can affect sea levels
 - Major storehouses of water
 - Role in hydrologic cycle
-

Mount Rainier National Park in Washington State, U.S.



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7-3 How Have We Affected the World's Terrestrial Ecosystems?

- ***Concept 7-3*** *In many areas, human activities are impairing ecological and economic services provided by the earth's deserts, grasslands, forests, and mountains.*
-

NATURAL CAPITAL DEGRADATION

Major Human Impacts on Terrestrial Ecosystems

Deserts



Large desert cities

Soil destruction by off-road vehicles

Soil salinization from irrigation

Depletion of groundwater

Land disturbance and pollution from mineral extraction

Grasslands



Conversion to cropland

Release of CO₂ 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 extraction

Mineral extraction

Hydroelectric dams and reservoirs

Increasing tourism

Urban air pollution

Increased ultraviolet radiation from ozone depletion

Soil damage from off-road vehicles