

# ENVIRONMENT

THE SCIENCE BEHIND THE STORIES

Jay Withgott • Scott Brennan

## Ch 7

### Environmental Systems and Ecosystem Ecology

Part 1: Foundations of Environmental Science

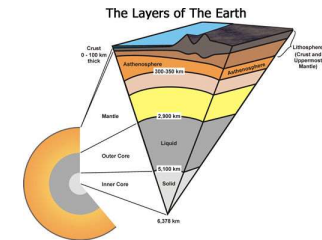
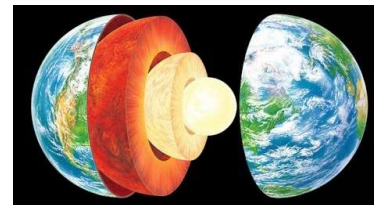
San Andreas Video



Third Edition

## 4 Major Layers of Earth

- **Crust** = thin component of Earth's surface (oxygen, silicon)
- **Mantle** = malleable layer on which the crust floats
  - Lithosphere includes crust & upper mantle
  - Asthenosphere-lower part that is semi-molten
- **Outer Core** = liquid forms of iron and nickel
- **Inner Core** = solid form of iron and nickel



## Plate Tectonics

2 Types of tectonic plates

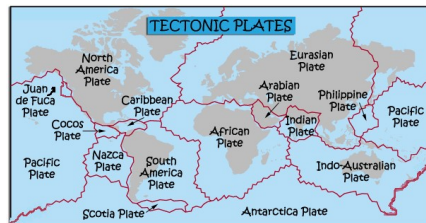
### 1. Oceanic

- Plates under the ocean
- Made of Basalt
- More active

### 2. Continental

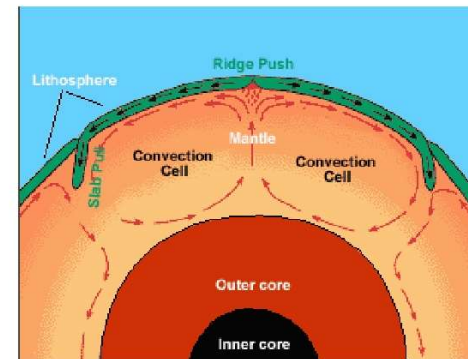
- Plates that make the continents
- Made of rocks (Granite)

- **Plate tectonics** = a theory explaining the movement of lithospheric plates over the underlying mantle.



## Cause of Plate Movement

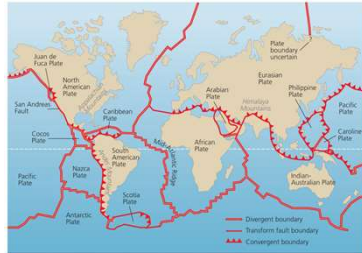
Convection Cell



Plates at our planet's surface move because of the intense heat in the Earth's core that causes molten rock in the mantle to move. It moves in a pattern called a convection current that forms when warm material rises, cools, and eventually sinks down. As the cooled material sinks down, it is warmed and rises again.

## Pangaea: the supercontinent

The Earth has 15 major tectonic plates



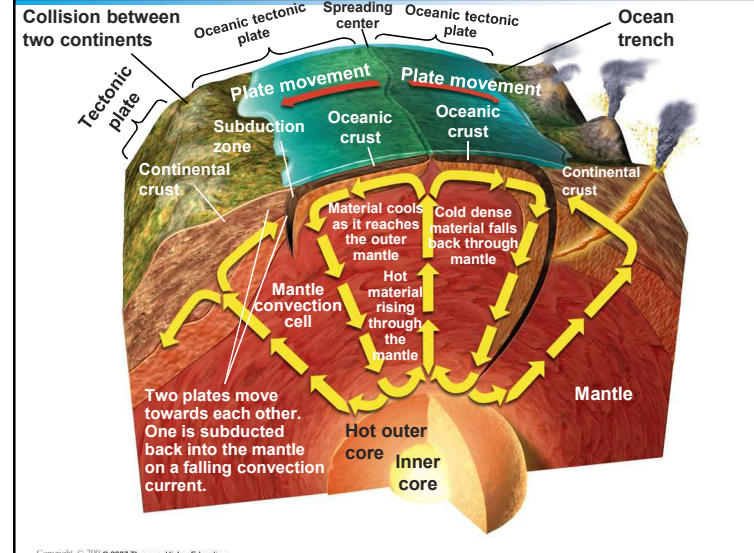
(a) World map of tectonic plates  
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**Pangaea** = at least twice in Earth's history, all landmasses were joined in one supercontinent



(b) Pangaea, the "supercontinent," 225 million years ago  
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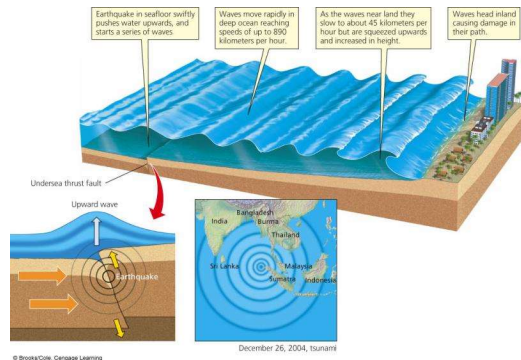
[Video](#)



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## Earthquakes and Tsunami

Earthquakes occur when stress overcomes a locked fault, releasing stored energy



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## 3 types of Boundary Plates

### 1. Divergent plates

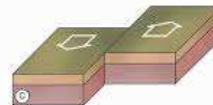
- Rift Valleys
- Volcanoes
- Earthquakes

### 2. Convergent plates

- Mountains
- Island arcs
- Earthquakes
- Volcanoes

### 3. Transform plates

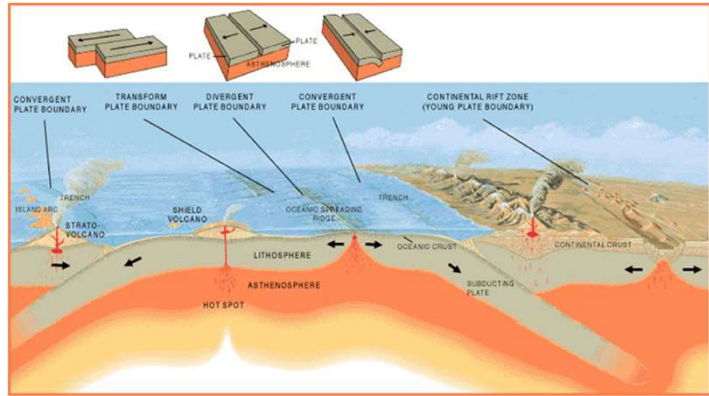
- Faults
- Earthquakes



[Animation](#)

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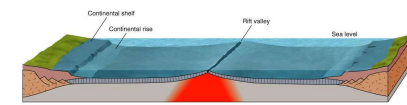
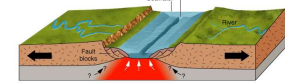
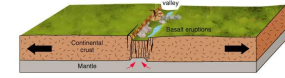
### 3 types of Boundary Plates



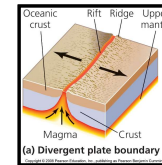
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### Divergent plate boundaries

- Magma surging upward to the surface divides plates and pushes them apart, creating new crust as it cools and spreads apart



- Rift Valleys
- Volcanoes
- Earthquakes



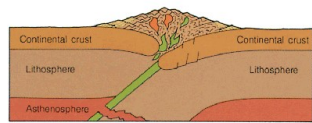
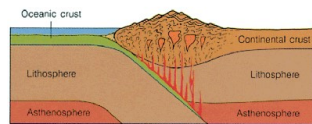
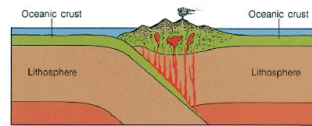
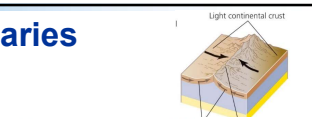
(a) Divergent plate boundary

- Examples:
- Mid-Atlantic Ridge
- African Rift Valley

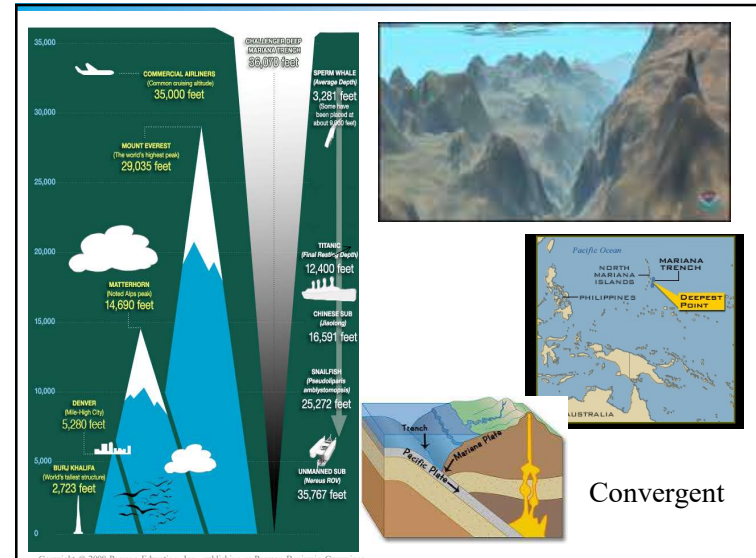
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### Convergent plate boundaries

- Plates collide
- 1. Ocean-Ocean**
    - Subduction= one plate slides beneath another (One is heavier)
    - Island arc
  - 2. Ocean-Continental**
    - Volcanoes
    - Ring of Fire
    - Trenches (Mariana)
  - 3. Continental-Continental**
    - Same density
    - Mountains (Himalaya)



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Convergent



## Ocean- Continental- Ring of Fire

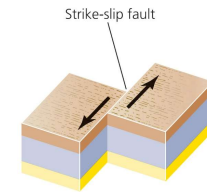
- Earthquakes
- Volcanic activity
- Trenches



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## Transforms plate boundary

- Two plates meet, slipping and grinding alongside one another
  - Friction spawns **earthquakes** along slip-strike faults
  - Earthquake epicenter



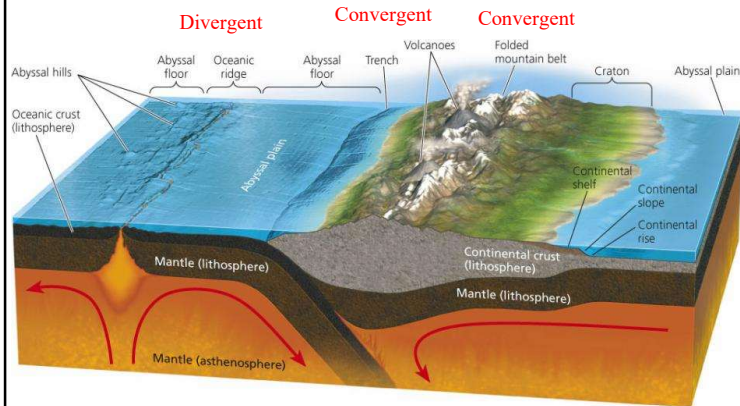
- The San Andreas Fault in California



(b) Transform plate boundary

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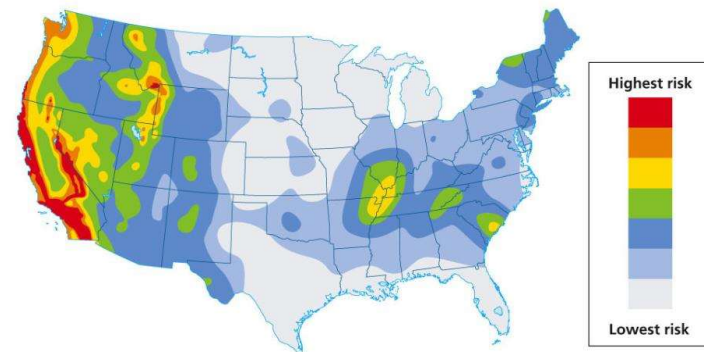
## Major Features of the Earth's Crust and Upper Mantle



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## Areas of Greatest Earthquake Risk in the United States



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## Plate tectonic Activity

### Divergent Plate    Convergent Plate    Transform Plate


1 visuals

3 visuals

1 visuals

- Create a visual for each of the boundaries. Draw arrows showing the direction of movement
- List of real world examples
- Explain what happens at the boundary.

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**Chapter 17**

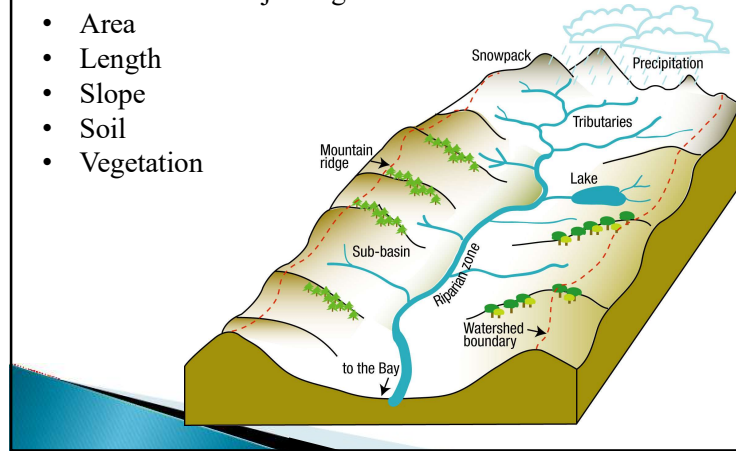
# Weather & Atmosphere

Video

### Characteristics of a watershed:

- Divides with adjoining watersheds
- Area
- Length
- Slope
- Soil
- Vegetation

## Watershed



## 4 Spheres of Life



- **1) Atmosphere**
- Troposphere is the bottom layer—where weather occurs (78% N, 21% O and 1% other gases—mainly Ar)
- Greenhouse gases are here...
- Next layer up—stratosphere contains ozone which O<sub>3</sub>

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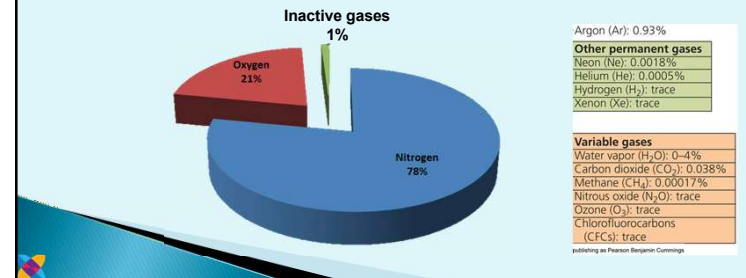
## 4 Spheres

- **2) Hydrosphere**
- **3) Geosphere:** Earth's crust, mantle and core—rock systems non renewable fuels...soil that contains nitrates, phosphates—support life
- **4) Biosphere**
- Includes all layers of the atmosphere, hydrosphere and geosphere where life exists
- Divided into Biomes—distinct climate regions, unique animal and plant life....

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## Earth's Atmosphere

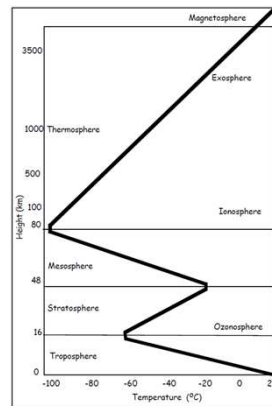
- Layer of gases surrounding the planet Earth and retained by the Earth's gravity.
- It contains roughly 78% nitrogen, 21% oxygen, and 1% other.
- Its five layers differ in temperature, density and composition
- Human activity is changing the amounts of some gases



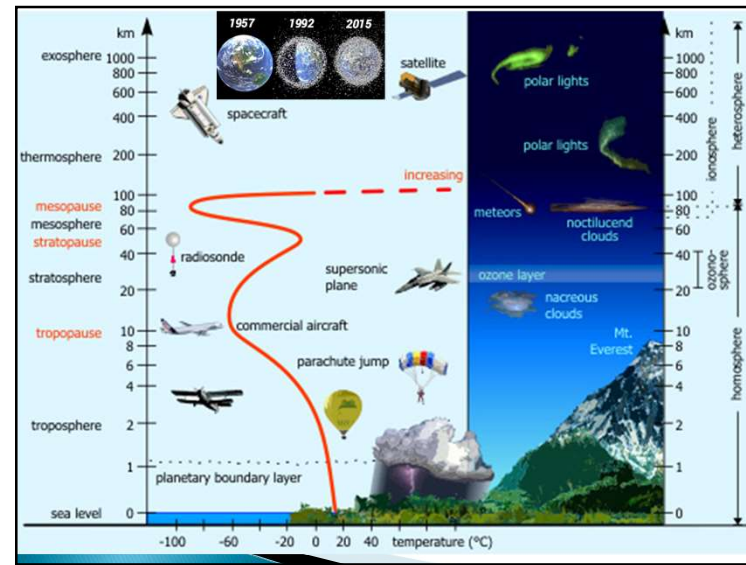
## Layers of Atmosphere

Earth's atmosphere can be divided (called atmospheric stratification) into five main layers. From highest to lowest, these layers are:

1. **Exosphere:** atmosphere merges with outer space (>440 miles)
2. **Thermosphere:** International Space station orbits, aurora borealis (50 to 440 miles)
3. **Mesosphere:** coldest, meteors burn here (31 to 50 miles)
4. **Stratosphere:** ozone layer (7 to 31 miles)
5. **Troposphere:** weather (0 to 7 miles)



Space Junk



# Weather and Climate

Weather is a short-term atmospheric condition in an area. They include:

- Temperature
- Humidity
- Precipitation
- Cloud cover
- Happens in the Troposphere

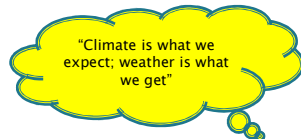
What is the weather today here?



What is the climate for here?

Climate is a region's general pattern of atmospheric condition over a long period of time (**at least 30 years**). The two major factors contributing to a region's climate:

- ▶ average temperature
- ▶ average precipitation



Mark Twain

# What Determines Climate

- ▶ Climate is determined by:
  - Atmospheric Circulation Patterns
  - Oceanic Circulation Patterns
  - Local geography
  - Solar activity
  - Volcanic Activity



Which is most important?

Latitude

(How far above/below you are from the equator)

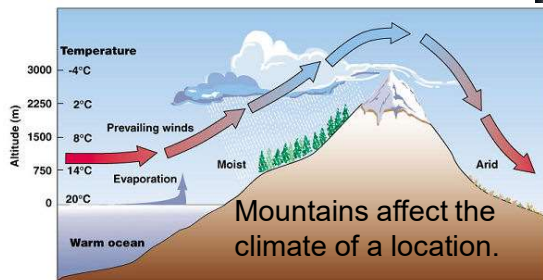


Video

# RAIN SHADOW

•A region of land that has become drier because of higher elevation area blocks precipitation from reaching the land.

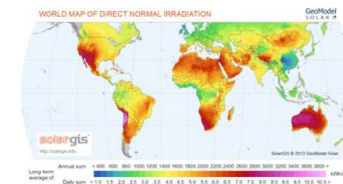
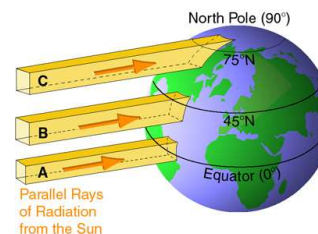
- Dry area on the eastern side of mountains
- The smaller the mountains, the weaker the rain shadow effect, and vice versa.



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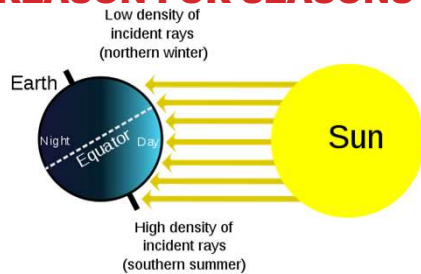
# SOLAR RADIATION

- Solar Radiation (Insolation) is Earth's main source of energy and is dependent on season and latitude.
- Angles of sun's rays determine the intensity of solar radiation.
- Tilt of Earth's axis of rotation causes the number of hours of daylight in particular location.



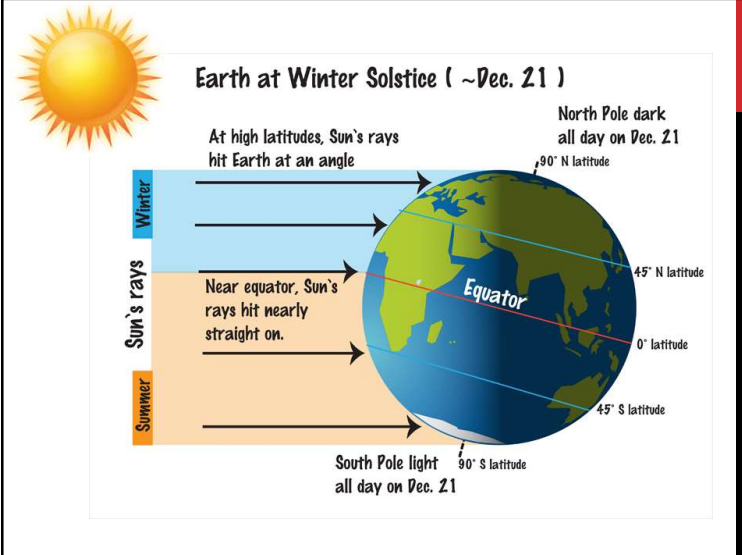


## REASON FOR SEASONS

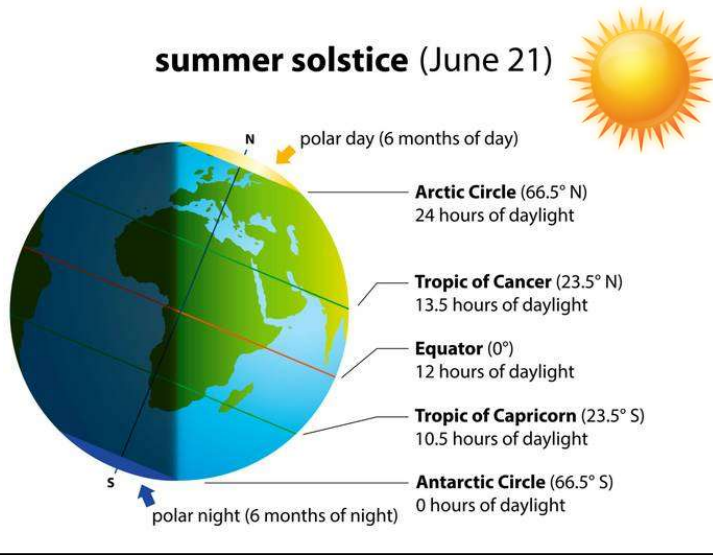


**Latitude** is the distance north or south of the equator. Measured in degrees.

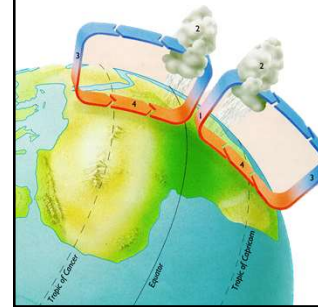
- Equator is 0 degrees, the poles are 90 degrees (Horizontal to solar radiation)
- Low Latitudes – get the strongest, most concentrated sunlight.
  - Night and Day are 12 hours, all year round
  - High temps all year round
- High Latitudes – sunlight is spread over a greater area, weaker, less energy
  - Daylight hours vary
    - At the poles the sun sets for only a few hours during the summer
    - Dark almost all day during winter
  - Average annual temperatures lower than at equator.



## summer solstice (June 21)



## Convection cells



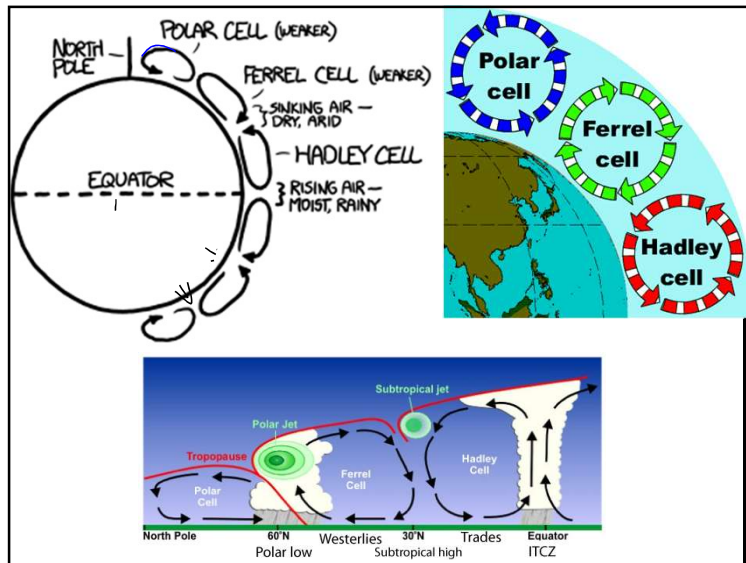
Three basic rules:

1. Cold air sinks – but pressure is stronger at lower levels so cold air gets compressed and thus warms.
2. Warm Air Rises – lower pressure lets it expand and it cools down
3. Warm Air holds more water vapor than cold air – so as it rises the water vapor cools and condenses

How do we get wind?

1. Sun heats the earth surface.
2. Hot Air Rises
3. Cold Air replaces it.....wind!

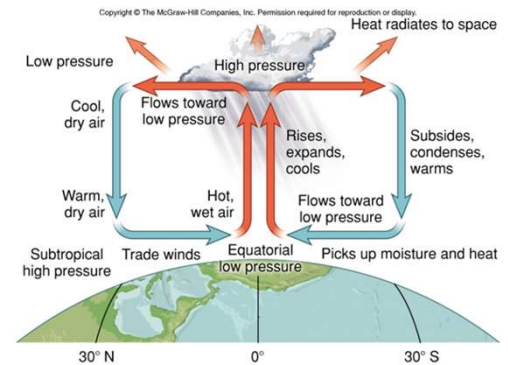




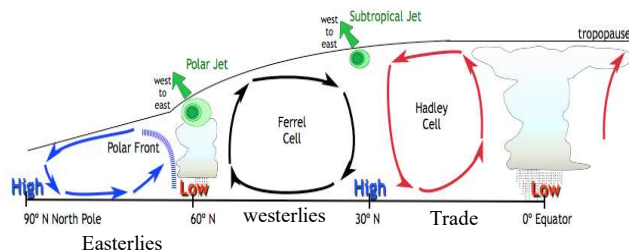
## Convection cells: Hadley Cells

- **Hadley Cells** are the low-latitude overturning circulations that have air rising at the equator and air sinking at roughly 30° latitude.

- Causes trade winds.
- A lot of rain at equator.
- Dry warm air at 30°



## Convection cells: Ferrel and Polar cells



- **Polar cell** - Air rises at 60° travels toward the poles and sinks at 90°. Causes easterly winds
- **Ferrel Cell** - sinking cool air near 30° and rising warm air farther poleward at 60°. Precipitation at 60°. Cause westerly winds

## CORIOLIS EFFECT

**Coriolis effect = the north-south air currents of the convective cells appear to be deflected from a straight path**

- Results in curving global wind patterns

Because the Coriolis effect increases with an item's increasing speed, it significantly deflects airflows and as a result the wind.

In the Northern Hemisphere these winds spiral to the right and in the Southern Hemisphere they spiral to the left. This usually creates the westerly winds moving from the subtropical areas to the poles.

### Planetary Winds

Global scale winds are winds that are created in the different Global circulation Cells.

- The polar easterlies blow from the Pole to 60
- The Prevailing Westerlies blow from 60 to 30
  - Near the equator
- The Trade Winds blow from 30 to 0

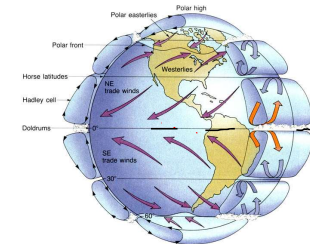
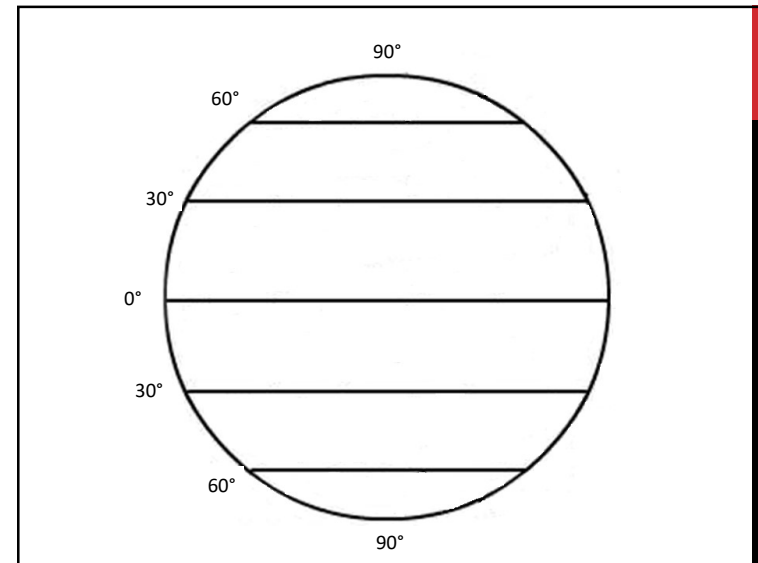
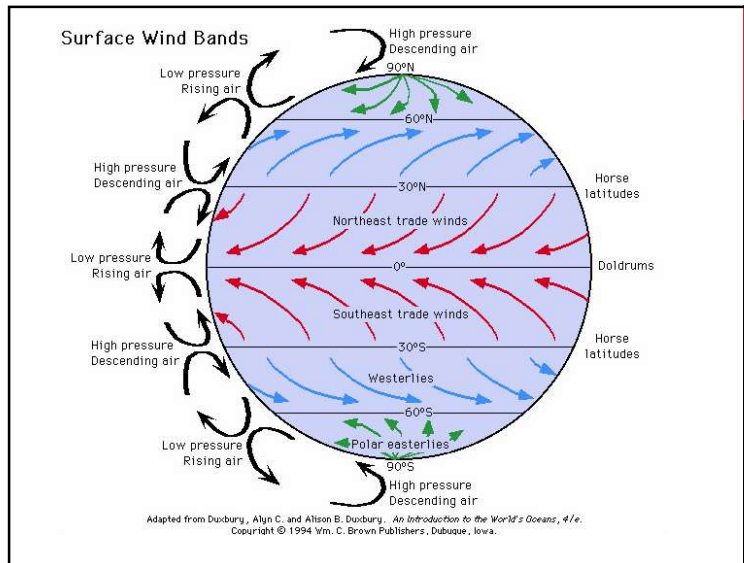


Figure 9-1 Idealized global circulation proposed for the three-cell circulation model.

[Video](#) [Current Animation](#) [GPS video](#)



## OCEAN CIRCULATION PATTERNS

- An **ocean gyre** is a large system of circular **ocean** currents formed by global wind patterns and forces created by Earth's rotation.

**GYRES**  
Whirlpools of water trapping huge collections of trash in their currents

- Home of 'The Great Pacific Garbage Patch'
  - Estimated 1.2 million tonnes of trash
  - About the size of Texas by some accounts
  - Located between Hawaii and California
- Research ships between Bermuda and Azores document floating garbage
  - Swag of micro-particles similar to the Great Pacific Garbage Patch
- 48% of all seabird species documented with plastic in or around their bodies
- Plastics have entangled birds and turned up in fish bellies
- Searchers for Malaysia Airlines Flight 370 have found ocean garbage instead of crash evidence

There are 5 major gyres  
 Trap trash in ocean

**Video**

## Ocean currents

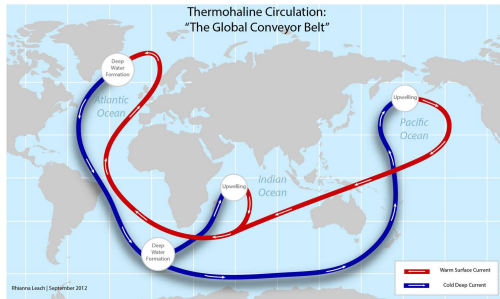
- Currents** = the upper waters of the ocean composed of vast riverlike flows
- Caused by winds and the movement of the earth
- The ocean currents move **heat** around the globe.
- Gulf Stream** currents are rapid and powerful
  - The warm water moderates Europe's climate

**El Niño**

Water temperatures in °C: 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30

## OCEAN CIRCULATION PATTERNS

**Thermohaline circulation** is a part of the large-scale ocean circulation that is driven by global density gradients created by surface heat and freshwater fluxes.

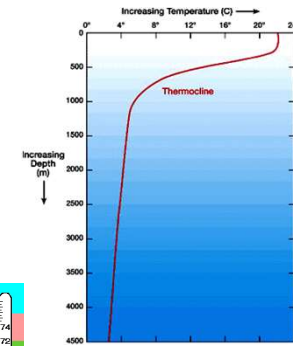


## Ocean water is vertically structured

- Oceans regulate the earth's climate
  - They absorb and release heat
  - Ocean's surface circulation

### Thermal Stratification

- Epilimnion**- at the surface and warm water
- Thermocline**-transition layer between the mixed layer at the surface and the deep water layer.
- Hypolimnion**- deeper water and cold

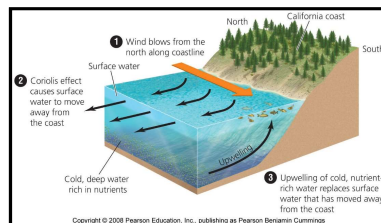
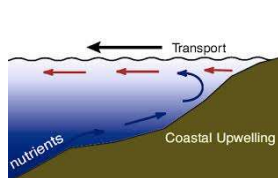


### Thermal Stratification

- Epilimnion - warm lighter water
- Thermocline - prevents mixing
- Hypolimnion - cool heavy water

## Ocean currents

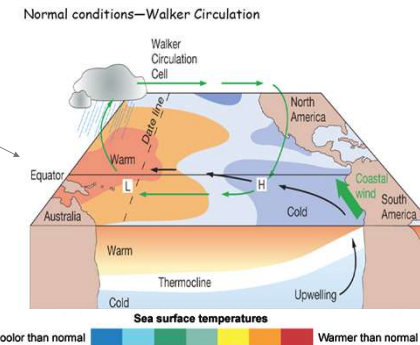
- Surface winds and heating create vertical currents**
- Upwelling** = the vertical flow of cold, deep water towards the surface
  - High primary productivity and lucrative fisheries
  - Also occurs where strong winds blow away from, or parallel to, coastlines



Simulation

## Normal Ocean currents

- Strong trade winds** keep warm water near New Guinea and Australia
- Nutrient-rich water **upwells** along the west coast of the Americas
- Heavy rains** are concentrated in the western Pacific Ocean.



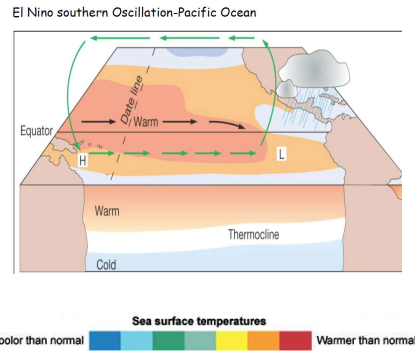
- These nutrients support large populations of phytoplankton, zooplankton, fish, and fish-eating sea birds.
- El Niño and La Niña are changes in climate patterns that can trigger mild to extreme weather changes over at least 1/3 of the globe.



# ENSO

## El Niño/Southern Oscillation

- Warm pool migrates eastwards
- High pressure in eastern Pacific weakens
- Weaker trade winds
- Thermocline deeper in eastern Pacific
- Downwelling
- Lower biological productivity
  - Corals particularly sensitive to warmer seawater
- Occur every two to seven years



[Simulation](#)  
[El Niño Animation](#)

# La Nina

- Trade winds increase, blowing stronger from east to west
  - Western Pacific Ocean becomes warmer
  - Eastern Pacific Ocean near coast of South America becomes colder
  - Warm ocean waters, clouds and moisture are pushed away from North America. Causes hurricanes and tornadoes in US.
- Causes
  - Hot, dry weather with droughts in southern US
  - Cold weather and excess rainfall in the northeastern US.
  - Enhanced upwelling
  - Enhanced trade winds
- **Similar to normal conditions, just enhanced.**
- Occur every few years and can persist for as long as two years

