

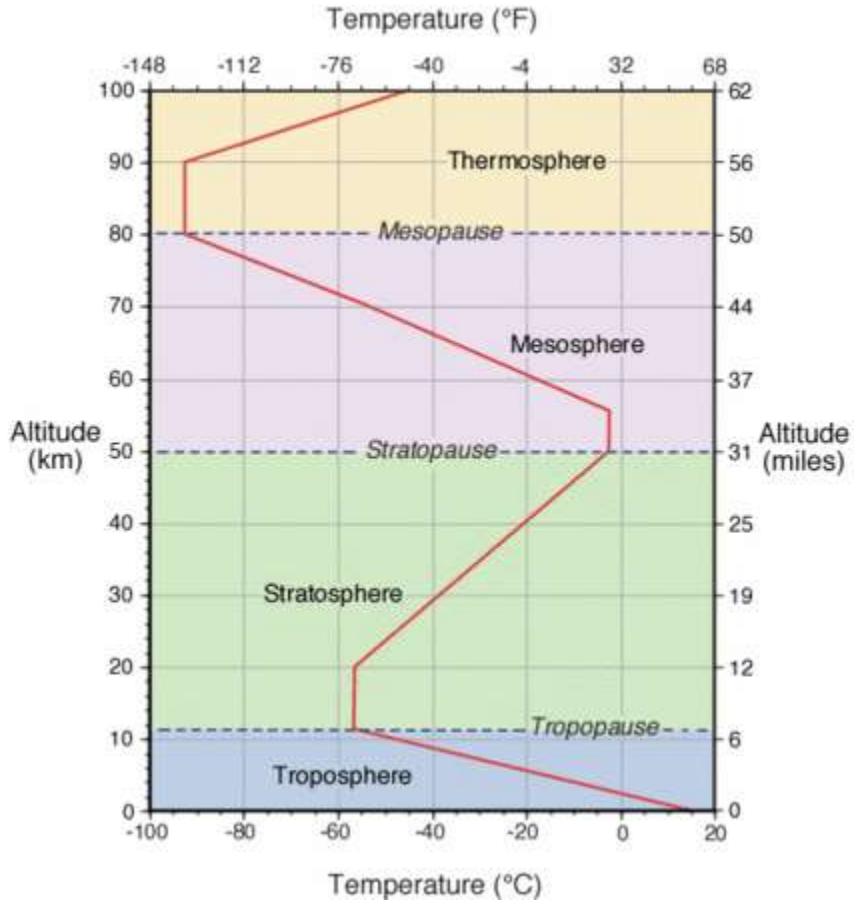
APES CHAPTER 4 NOTES (MRS. BAUCK): GLOBAL CLIMATES AND BIOMES

MODULE 9: The Unequal Heating of Earth

I. Atmospheric Layers

(FYI: 1.61 km = 1 mi)

Source: Royal BC Museum



A. troposphere

- 1) lowest layer: ~10 miles (0 to 16 km) above the surface
- 2) densest layer; air is well-mixed
- 3) temperature decreases with altitude
- 4) contains most of the water vapor and weather
- 5) **tropopause**—top of the troposphere

B. stratosphere

- 1) second layer: 16-31 miles (16-50 km) above the earth's surface
- 2) much less dense than the troposphere
- 3) contains the protective ozone (O_3) layer which absorbs most of UV-B and all of UV-C
- 4) temperature increases with altitude
- 5) **stratopause**—top of the stratosphere

C. mesosphere

- 1) coldest layer
- 2) temperature decreases with altitude
- 3) **mesopause**—top of the mesosphere

Because it lies between the maximum altitude for most aircraft and the minimum altitude for most spacecraft, this region of the atmosphere is only directly accessible through the use of sounding (elevator research) rockets. As a result, the region is one of the most poorly understood in the atmosphere.

D. **thermosphere**

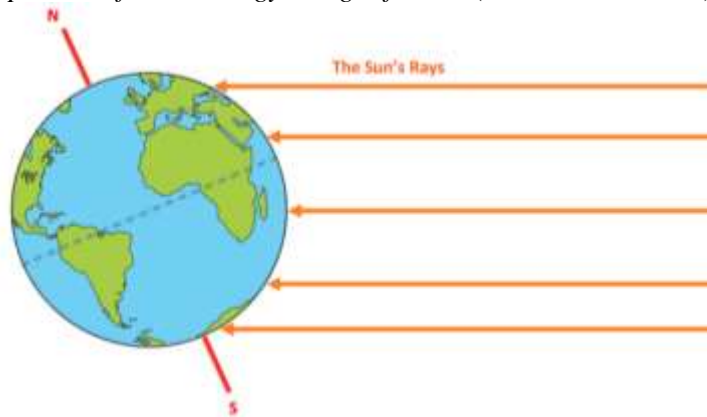
- 1) hottest layer
- 2) *temperature increases with altitude*
- 3) *ionosphere*—ion layer; contribute to auroras

E. **exosphere**

- 1) beyond Earth's atmosphere; merges with interplanetary gases
- 2) primarily low-density H₂ and He

II. Solar Energy – Causes of Fluctuations

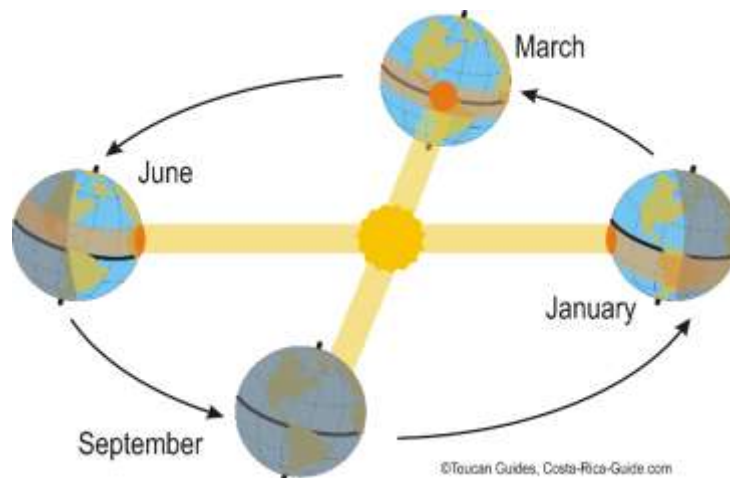
- A. solar angle—more direct at equator than poles
- B. surface area—more concentrated at equator than poles
- C. **albedo** – *percent of solar energy being reflected* (albedo α reflection)



Source: Qora

III. Earth's Inclination – seasonal changes

- A. Summer solstice – around June 20-21
- B. Vernal equinox – around March 20-21
- C. Autumnal equinox – around September 22-23
- D. Winter solstice – around December 20-22



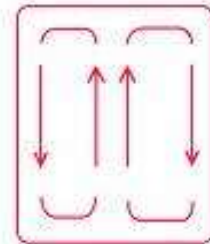
©Toucan Guides, Costa-Rica-Guide.com

MODULE 10: Air Currents

- I. Properties of Air
 - A. **Density**
 - 1) $D = M/V$
 - 2) less dense air rises; denser air sinks
 - 3) warm air is less dense than colder air (at constant pressure, $V \propto T$)
 - B. **Water vapor capacity**
 - 1) **saturation point**—*maximum amount of water vapor in air at a given temperature*
 - 2) warmer air can hold more moisture; colder air can hold less moisture
 - 3) examples – Florida’s humidity, dew forming overnight, condensation on a cold can
 - C. **Adiabatic heating and cooling**
 - 1) **adiabatic heating**—*the warming effect of the increase in pressure of sinking air*
 - 2) **adiabatic cooling**—*the cooling effect of the reduction in pressure of rising air*
 - D. **Latent heat release**—*the liberation of energy when atmospheric water vapor condenses into liquid water*

Latent heat is thermal energy released or absorbed, by a body or a thermodynamic system, during a constant-temperature process, usually a phase change. Latent heat can be understood as heat energy in hidden form which is supplied or extracted to change the state of a substance without changing its temperature. Examples are latent heat of fusion and latent heat of vaporization involved in phase changes— a substance condensing or vaporizing at a specified temperature and pressure.

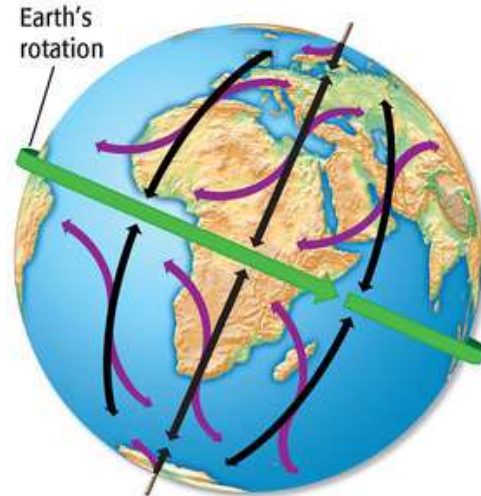
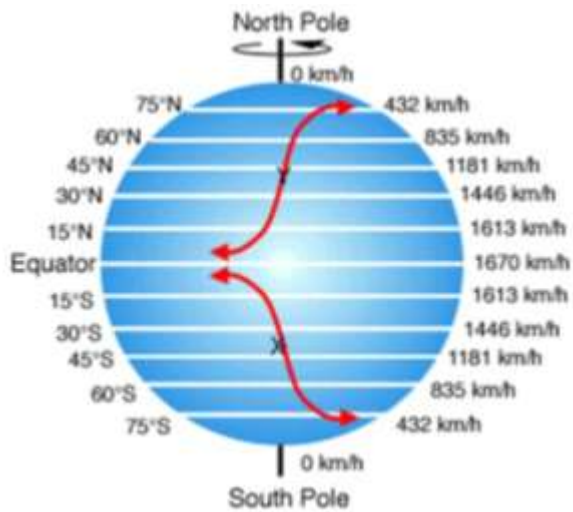
- II. Convection currents
 - A. **Atmospheric convection currents**— *global air movement patterns, due to unequal heating of Earth’s surface*
 - 1) **Hadley cells**— *convection currents located between 0-30° N and 0-30° S latitude*
 - a) **ITCZ**—**intertropical convergence zone**
 - b) *latitude receiving the most intense solar rays, which causes the rising branches of the Hadley cells to converge*
 - c) *latitude fluctuates between 23.5° N to 23.5° S*
 - 2) **polar cells**
 - a) *air rising from 60° N and sinking at 90° N*
 - b) *air rising from 60° S and sinking at 90° S*
 - 3) **Ferrell cells**
 - a) *located between Hadley and polar cells*
 - b) *no distinct convection current cells form*
 - c) *driven by neighboring cells*



- III. Earth’s rotation and the Coriolis Effect
Coriolis effect—*deflection of objects moving directly north of south*



Source: Jennifer Kim

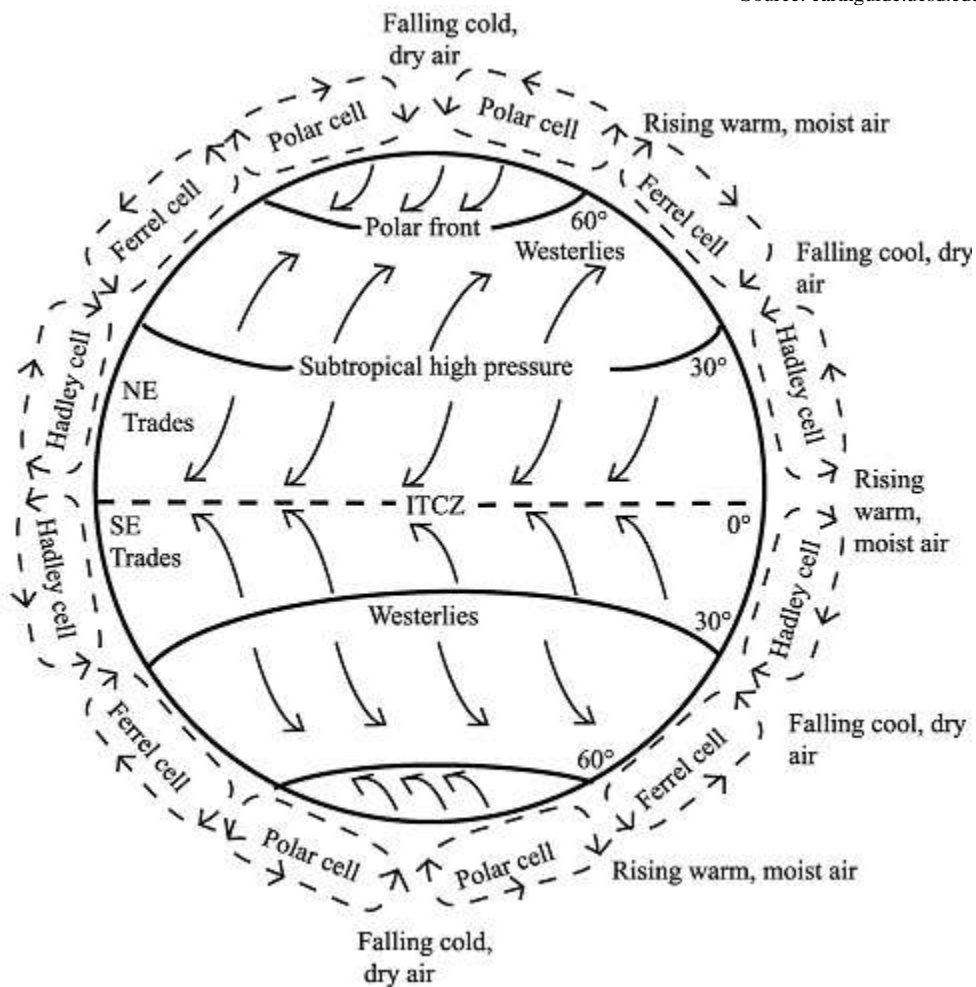


— Path of wind without Coriolis effect
 — Approximate path of wind

Source: teacherspayteachers

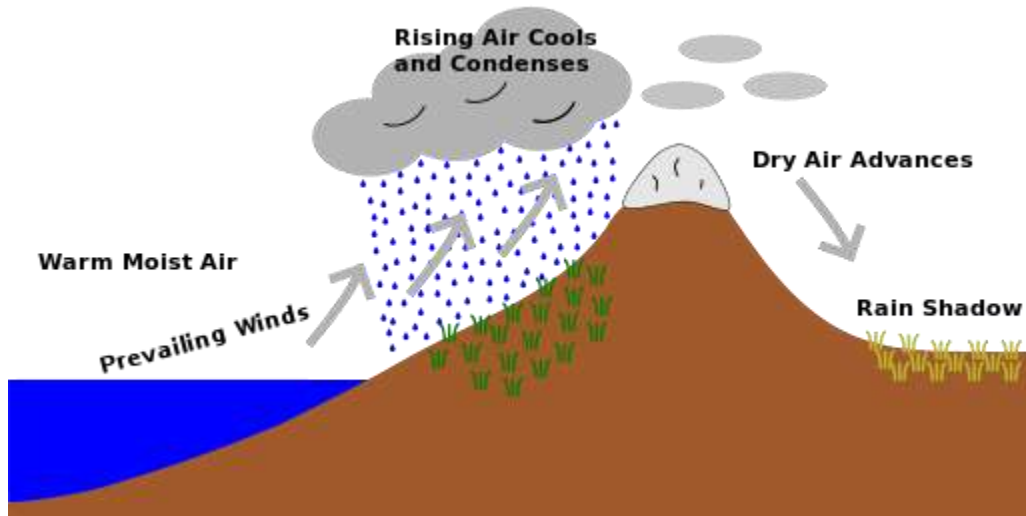
CONVECTION CURRENTS AND GLOBAL WIND BELTS

Source: earthguide.ucsd.edu



IV. **Rain Shadow Effect**

- A. *Windward*— the side of a mountain which receives moist air
- B. *Leeward*— the opposite side of a mountain which receives drier air
- C. Rain shadow deserts form on the leeward side
- D. Example: Seattle and Spokane, WA



Source: MTPR.org

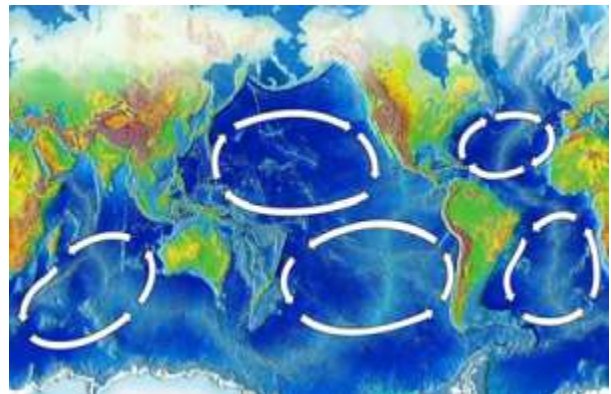
MODULE 11: Ocean Currents

- I. Factors affecting movement of ocean currents
 - A. Gravity
 - B. Coriolis effect
 - C. Prevailing winds
 - D. Temperature
 - E. Location of land masses
 - F. Salinity
 - G. Friction

II. Surface Ocean Currents

A. **Gyres**

- 1) currents rotating *clockwise in Northern Hemisphere*
- 2) currents rotating *counterclockwise in Southern Hemisphere*
- 3) major gyres
 - a) North Pacific Gyre
 - b) South Pacific Gyre
 - c) North Atlantic Gyre
 - d) South Atlantic Gyre
 - e) Indian Ocean Gyre



Source: beachapedia

- 4) smaller equatorial gyres in the Atlantic, Pacific, and Northern Indian Oceans

B. Upwelling

- 1) movement of deep water upward toward the surface
- 2) redistributes nutrients

“Upwelling occurs when winds push surface water away from the shore and deeper water rises to fill the gap. During upwelling, wind-displaced surface waters are replaced by cold, nutrient-rich water that wells up from below.” (Source: NOAA)

“Upwelling occurs in the open ocean and along coastlines. The reverse process, called ‘downwelling,’ also occurs when wind causes surface water to build up along a coastline and the surface water eventually sinks toward the bottom.

Upwelling is most common along the west coast of continents (eastern sides of ocean basins). In the Northern Hemisphere, upwelling occurs along west coasts (e.g., coasts of California, Northwest Africa) when winds blow from the north (causing transport of surface water away from the shore). Winds blowing from the south cause upwelling along continents' eastern coasts in the Northern Hemisphere, although it is not as noticeable because of the western boundary currents.

Water that rises to the surface as a result of upwelling is typically colder and is rich in nutrients. These nutrients ‘fertilize’ surface waters, meaning that these surface waters often have high biological productivity. Therefore, good fishing grounds typically are found where upwelling is common.” (Source: beachapedia)

III. Deep ocean currents

- A. **thermohaline circulation** (THC)—*circulation pattern driving the mixing of surface water and deep water*
- B. part of the large-scale ocean circulation that is driven by global density gradients created by surface heat and freshwater fluxes
- C. also called the *ocean conveyor belt, the great ocean conveyor, or the global conveyor belt*

IV. El Niño-Southern Oscillation (ENSO)

- A. irregularly periodic variation in winds and sea surface temperatures over the tropical eastern Pacific Ocean
- B. affects the climate of much of the tropics and subtropics
- C. three phases
 - 1) *warming phase = El Niño*
 - 2) *cooling phase = La Niña*
 - 3) *neutral phase = temperature variation from climatology is within 0.5 °C (0.9 °F)*

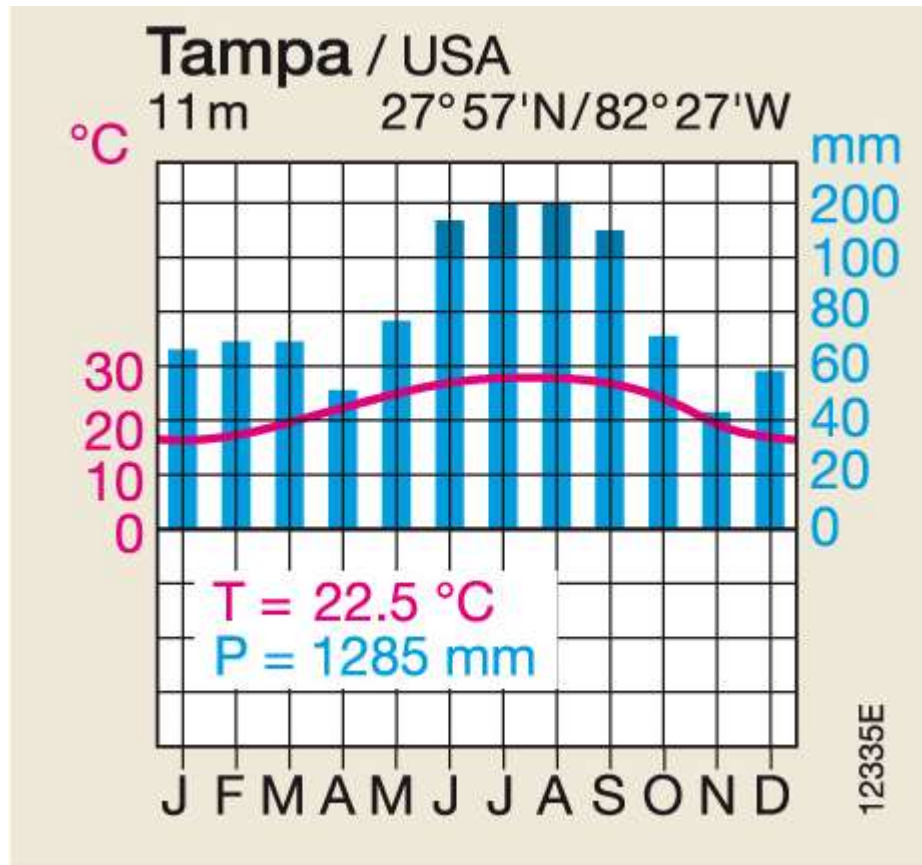
Neutral conditions are the transition between warm and cold phases of ENSO. Ocean temperatures, tropical precipitation, and wind patterns are near average conditions during this phase. Close to half of all years are within the neutral period.

- D. The *Southern Oscillation* is the accompanying atmospheric component, coupled with the sea temperature change
 - 1) *El Niño* is accompanied by high air surface pressure in the tropical western Pacific
 - 2) *La Niña* is accompanied by low air surface pressure in the tropical western Pacific

MODULE 12: Terrestrial Biomes

I. General Information

- A. **biomes**—large ecosystems of the world
- B. **terrestrial biome**—geographic area classified by annual precipitation, average annual temperature, and distinctive land plants
- C. **climatogram (climate diagram, climograph)**— a visual representation of precipitation and temperature patterns <https://www.weather.gov/tbw/cpc30daygraph>



Source: Diercke.com

II. Terrestrial Biomes

A. tundra

- 1) *Arctic tundra*: near Arctic Circle; parts of Russia, Alaska, Scandinavia, Canada
- 2) *alpine tundra*: high mountaintops
- 3) *Antarctic tundra*: edges of Antarctica and nearby islands
- 4) **permafrost**—permanently frozen subsoil
- 5) cold
- 6) no trees; low-lying vegetation

B. boreal forest / taiga

- 1) *coniferous forest with evergreens*
- 2) cold, low precipitation, nutrient-poor soil
- 3) 50-60° N in North America, Europe, Russia

- C. temperate rainforest**
- 1) known for moderate temperature and high precipitation
 - 2) *coastal biome*: North America west coast, Southern Chile,, east coast Australia, west coast New Zealand
 - 3) *conifers* (fir, spruce, cedar); very tall trees
 - 4) nutrient-poor soil
- D. temperate seasonal forest / temperate deciduous forest**
- 1) warm summers, cold winters
 - 2) rapid decomposition; richer soil than other forests
 - 3) broad leaf trees (maple, oak, beech)
 - 4) eastern U.S., Chile, Japan, China, Europe, eastern Australia
 - 5) plants adapted to fires and drought
- E. temperate grassland / cold desert**
- 1) hot and dry summers, cold winters
 - 2) grasses, flowering plants
 - 3) grassland areas
 - a) *Great Plains* – North American prairies
 - i. tall grass prairie (Eastern and Midwest U.S.)
 - ii. short grass prairies (Rocky Mtn. areas)
 - b) *pampas* – South American
 - c) *steppes* – Central Asia and Eastern Europe
 - 4) **cold desert**—leeward side of Rocky Mtns.
- F. woodland/shrubland**
- 1) hot, dry summers and mild, rainy winters
 - 2) plants adapted to fires and drought
 - 3) wood/shrubland areas
 - a) *chaparral* – southern California coast
 - b) *matorral* – southern South America
 - c) *mallee* – SW Australia
 - d) *fynbos* – South Africa
 - e) *maquis* – Mediterranean
- G. tropical rainforest**
- 1) high precipitation, small variation in temperature
 - 2) 0- 20° N and 0-20° S
 - 3) Central and South America, SE Asia, Africa, NE Australia
 - 4) *highest biodiversity of all terrestrial biomes*
 - 5) layered vegetation: canopy, subcanopy (understory), epiphytes, woody vines (lianas)
 - 6) rapid decomposition and uptake by plants; therefore, nutrient-poor soil
- H. tropical seasonal forest (tropical deciduous forest) / savanna**
- 1) warm temperatures, distinct wet and dry seasons
 - 2) Central America, east coast South America, NW Australia, southern Asia, sub-Saharan Africa
 - 3) **savanna**—open grassland with sparse deciduous trees
- I. subtropical desert (hot desert)**
- 1) hot, very dry, sparse vegetation
 - 2) 0- 30° N and 0-30° S

- 3) Mojave Desert (SW U.S.), Sahara Desert (Africa), Arabian Desert, Great Victoria Desert (Australia)
- 4) succulent plants
- 5) desert blooms when the rains come, but the plants wither quickly

III. Microclimate and other abiotic factors

- A. **microclimate**—conditions in a *localized area* of a biome
- B. some abiotic factors
 - 1) soil contents / types of soil separates (sand, clay, silt)
 - 2) topography—the layout of the land; elevations and depressions
 - 3) temperature
 - 4) precipitation / water quality
 - 5) available living space
 - 6) pH
 - 7) light intensity / shade
- C. biotic factors
 - 1) predator-prey ratio
 - 2) amount of plant growth, for food or for shelter
- D. physical barriers
 - 1) mountain ranges
 - 2) bodies of water

MODULE 13: Aquatic Biomes

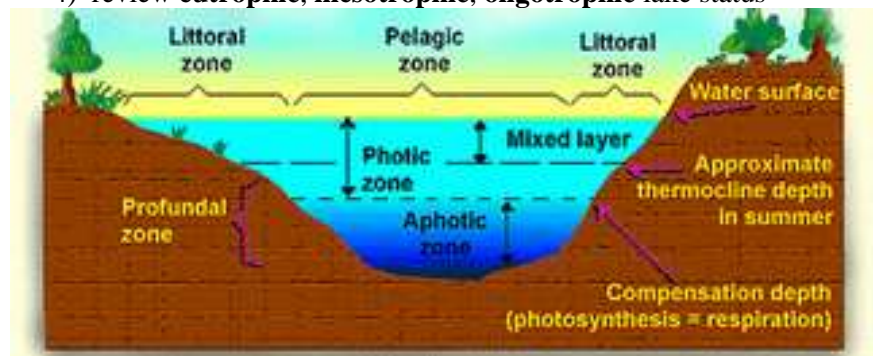
I. Freshwater biomes (low salinity)

A. **rivers and streams**

- 1) flowing fresh water
- 2) *rapids* – fast-moving water, highly oxygenated water
- 3) rivers are larger than streams

B. **ponds and lakes**

- 1) standing water
- 2) lakes are larger than ponds
- 3) zones (see diagram below)
 - a) **littoral zone**—shallow shoreline
 - b) **limnetic (photic) zone**
 - c) **profundal (aphotic) zone**
 - d) **benthic zone**—muddy bottom layer
- 4) review **eutrophic, mesotrophic, oligotrophic** lake status



Source: www.aquatic.uoguelph.ca

C. **freshwater wetlands:** swamps, bogs, marshes

- 1) submerged part of the year but emergent vegetation present
- 2) *swamp*—wetlands containing emergent trees (Okefenokee)
- 3) *bog*—acidic wetlands with spruce trees and moss
- 4) *marsh*—wetlands with nonwoody vegetation such as cattails

II. Marine biomes (high salinity)

A. **mangrove swamps**

<http://www.mangrovesgy.org/home/index.php/2014-04-27-16-39-08/types-of-mangroves>

“The word ‘Mangroves’ refers to a group of plants which may actually belong to several families (species that distinctly belong to their own evolutionary group). *The term therefore indicates an ecological rather than a taxonomical (scientific classification) grouping - the species are not related.* They are unique plants because of their ability to grow in unstable tough environments.

Mangroves are unique because they are able to thrive in areas where the water is poor in oxygen content, in salt water, in fresh water and in brackish water (a mixture of salt and fresh water). Mangroves are fast-growing trees taking several years to reach up to 25 meters when they are fully grown. Of the seven types of mangroves, three are most dominant-- *the red, black and white types.*”

<http://www.earthisland.org/> archives

“Mangroves are the rainforests by the sea. The majority of the subtropical and tropical coastline is dominated by mangroves, estimated to cover an area of 22 million hectares. However, over the past several decades, *the global area in mangroves has increasingly diminished as a result of a variety of human activities, such as overharvesting, freshwater diversion and conversion to other uses...*

Mangrove forests are comprised of taxonomically diverse, salt-tolerant tree and other plant species which thrive in inter-tidal zones of sheltered tropical shores, ‘overwash’ islands, and estuaries. Mangrove trees have specially adapted aerial and salt-filtering roots and salt-excreting leaves that enable them to occupy the saline wetlands where other plant life cannot survive.”

B. **salt marshes**

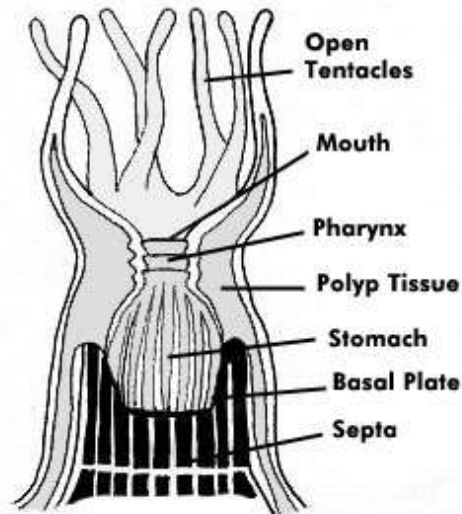
- 1) nonwoody emergent vegetation
- 2) temperate coastal areas
- 3) very productive biome; spawning fish
- 4) many are found in **estuaries**

C. **intertidal zones**

- 1) area between high tide and low tide
- 2) can be steep and rocky or sloping and muddy

D. coral reefs

- 1) corals are small invertebrate animals (Cnidarians), of varying size
- 2) coral reefs are the second most productive ecosystem (rainforest is first)
 - a) **hard coral** build reefs
 - b) **soft coral** do not build reefs; they are tree-like and look like vegetation
- 3) coral anatomy – a living *polyp*, from MarineReef archives



4) zooxanthellae from <http://www.uvi.edu> archives

“Zooxanthellae are unicellular yellow-brown (dinoflagellate) algae which live symbiotically in the gastrodermis of reef-building corals. It is the nutrients supplied by the zooxanthellae that make it possible for the corals to grow and reproduce quickly enough to create reefs. Zooxanthellae provide the corals with food in the form of photosynthetic products. In turn, the coral provides protection and access to light for the zooxanthellae.”

5) coral bleaching from <http://www.uvi.edu> archives

“Coral bleaching is the whitening of coral colonies due to the loss of symbiotic zooxanthellae from the tissues of polyps. This loss exposes the white calcium carbonate skeletons of the coral colony. Corals naturally lose less than 0.1% of their zooxanthellae during processes of regulation and replacement. However, adverse changes in a coral’s environment can cause an increase in the number of zooxanthellae lost. *There are a number of stresses or environmental changes that may cause bleaching including disease, excess shade, increased levels of ultraviolet radiation, sedimentation, pollution, salinity changes, and increased temperatures.*”

- 6) *Anthropogenic exploitation of coral reefs due to human development*
 - a) *increased runoff: sediments, pollutants, etc.*
 - b) *overfishing for “tropical” fish – disrupts ecosystem balance*
 - c) *use of coral for knickknacks and jewelry*
 - d) *commercial and private marine vessels: fuel spills, etc.*
- 7) Natural threats to coral reefs
 - a) hurricanes and typhoons
 - b) predators and fish, notably the crown-of-thorns starfish, *Acanthaster planci*, which inverts its stomach onto parts of a reef to digest it

E. open ocean (pelagic zone)

- 1) any part of the ocean away from shore
- 2) **photic zone**—area receiving sunlight (photosynthesis occurs)
- 3) **aphotic zone**—area not receiving sunlight (chemosynthesis occurs)

