Chapter 4. Global Climates and Biomes

I. Weather & Climate
  A. Weather
    1. short-term conditions (seconds to days) of the atmosphere
    2. include
      a) temperature
      b) humidity
      c) clouds
      d) precipitation
      e) wind speed
      f) atmospheric pressure
    3. not possible to predict more than a couple days in advance
  B. Climate
    1. average weather that occurs in a given region over a long period
    2. can make general observations globally, regionally, and locally
  C. Earth's Atmosphere
    1. Troposphere
      a) atmosphere layer closest to Earth
      b) extends ~16km
      c) densest layer
      d) great deal of circulating gases and liquids
      e) the layer where weather occurs
      f) air temperature decreases with distance from Earth's surface
        (1) varies with latitude
        (2) $-52^{O}C$ near the top of the layer
    2. Stratosphere
      a) extends ~16km to ~50km above the Earth's surface
      b) less dense than the troposphere
      c) air temperature increases with elevation
      d) Ozone (O_3) layer
        (1) absorbs ultraviolet (UV) light
          (a) all UV-C
          (b) most UV-B
        (2) critical because UV light can damage DNA and cause cancers in organisms
    3. Mesosphere
      a) less dense than stratosphere
      b) temperature decreases with increasing elevation

4. Thermosphere
    a) less dense than mesosphere
    b) temperature increases with increasing elevation
        (1) can reach 1750^{O}C
    c) blocks UV-radiation and X-rays
    d) contains charged gas molecules that glow when hit by solar energy
        (1) driven most intensely at the poles
            (a) Aurora borealis
                (i) northern lights
            (b) Aurora australis
                (i) southern lights
5. Exosphere
    a) extends from 600 km out to space

D. Unequal heating of Earth
1. Angle of incidence for Sun's rays
    a) perpendicular near the equator
        (1) less atmosphere for the solar radiation to penetrate
    b) oblique and mid-latitude and polar regions
        (1) more atmosphere for the solar radiation to penetrate
2. Distribution of solar radiation over the Earth's surface
    a) smaller surface area near the equator
        (1) more solar energy per square meter
    b) larger surface are at mid latitude and polar regions
        (1) less solar energy per square meter
3. Albedo
    a) the percentage of incoming light reflected from the surface
    b) average for Earth - 30%
    c) tropics (with dark green foliage) = 10%-20%
    d) polar regions (with snow cover) = 80% -95%

E. Atmospheric convection currents

uneven heating drives the circulation of air in the atmosphere

1. Properties of Air
    a) density
        (1) less dense air rises
        (2) more dense air sinks
        (3) at constant atmospheric pressure
            (a) warm air has a lower density
            (b) cold air has a higher density
    b) water vapor capacity

(1) warm air has a higher capacity for water vapor than cold air
(2) saturation point
(a) the maximum amount of water vapor that can be in the air at a certain temperature
(b) temperature decreases - saturation point decreases

c) adiabatic cooling and heating
(1) a response to changes in air pressure
(2) adiabatic cooling
(a) lower pressure allows air to rise and expand in volume
(i) this expansion lowers the temperature of the air
(3) adiabatic heating
(a) higher pressure allows air to sink and decrease in volume
(i) this decrease raises the temperature of the air

d) latent heat release
(1) whenever water vapor condenses, energy is released
(2) in the atmosphere, this warms the air
(a) the warm air then rises

2. formation of convection currents
a) convection currents
(1) global patterns of air movement initiated by the unequal heating of the Earth.
(2) air rises at the equator
(3) air sinks at the poles

b) Hadley Cells
(1) convection currents that cycle between the equator and 30^{O}N and S latitude

c) intertropical convergence zone (ITCZ)
(1) the area of the Earth that receives the most intense sunlight
(2) where the ascending branches of Hadley cells converge
(3) typified by dense clouds and inense thuderstorms
(4) not located at a fixed latitude
(a) follows the path of the most intense sunlight
(b) shifts between 23.5^{O}N and 23.5^{O}S

d) polar cells
(1) similar to Hadley cells
(2) air rises at ~60^{O}N and S and sinks at 90^{O} N and S

F. Earth's rotation & Coriolus Effect

1. due to the nature of a rotating sphere, the equator is rotating faster than the poles
2. the equator's faster rotation speed causes the deflection of objects moving north or south
    a) combined with atmospheric convection currents this causes prevailing wind systems
        (1) northeats & southeast trade winds
        (2) westerlies
        (3) easterlies

G. Earth's Tilt and Seasons

H. Ocean Currents
1. driven by temperature, gravity, prevailing winds, Coriolus Effect, and continent locations
2. temperature and gravity
    a) heating at the tropics expands the water volume
        (1) surface elevation of the oceans at the equator is ~8 cm higher than at mid-latitudes
            (a) gravity causes water to flow down th eelevational gradiant (i.e., water flows away from the equator)
3. Gyres
    a) large-scale patterns of waterflow driven by prevailing wind patterns
    b) Northern hemisphere - clockwise movement of water
    c) Southern hemisphere - counter-clockwise movement of water
    d) redistribute heat in the ocean
4. upwelling
    a) upward movement of water toward the surface along the western coasts of most continents
    b) nutrients are brought up from the ocean bottom
        (1) support large numbers of producers
            (a) support large populations of fish
5. thermohaline circulation
    a) "thermohaline" = "heat-salt"
    b) a global oceanic "conveyor belt"
    c) driven by surface waters that have high concentrations of salt
    d) helps mix the waters of all oceans
        (1) crucial for the global distribution of heat and nutrients
    e) a single round-trip can take hundreds of years to complete
6. heat transport
    a) ocean temperatures affect the temperature of nearby landmasses

(1) vast amounts of heat energy are transported to cooler regions, thus moderating temperatures in much "colder" latitudes

7. El-Niño-Southern Oscillation (ENSO)
    a) trade winds weaken or reverse direction
        (1) causes a periodic (every 3-7 years) reversal of tropical Pacific Ocean surface currents
    b) halts upwelling off the coast of South America
    c) causes:
        (1) cooler and wetter conditions in the southeast US
        (2) unusually dry weather in southern Africa and Southeast Asia

I. Rain Shadows
1. caused when air moving inland from the ocean encounters a mountain range
2. when the air meets the *windward* side of the mountains
    a) the air rises and experiences lower pressures (causing adiabatic cooling)
    b) clouds form
    c) rain falls
    d) therefore, lush vegetation
3. when the air continues over to the *leeward* side of the mountain
    a) the air descends and experiences higher pressures (causing adiabatic heating)
    b) increased vapor capacity pulls more moisture from the landscape
    c) very dry conditions
    d) therefore, more sparse, arid-adapted vegetation

II. Climate determines terrestrial biomes

A. Biomes
1. terrestrial geographic regions that possess similar temperature and precipitation patterns and contain distinctive plant growth forms adapted for those conditions.
2. Climate diagrams
    a) graph monthly average temperatures and precipitation
    b) show relationship between temperature precipitation and plant growth
        (1) indicate growing season (when conditions are conducive for plant growth)
    c) help us understand how humans use different biomes
3. Three categories:
    a) tundra and boreal forest
    b) temperate
    c) tropical

B. Tundra
1. Temperature: cold

2. Precipitation patterns: very little precipitation but enough to support some vegetative growth avg. monthly ppt. 30-80mm
3. Geographic Distribution
    a) arctic tundra
        (1) northernmost regions of the Northern Hemisphere
    b) antarctic tundra
        (1) the edges of Antarctica and nearby island
    c) alpine tundra
        (1) high mountains
4. permafrost
    a) impermeable, permanently frozen layer of soil that prevents water from draining and roots from penetrating
5. Typical plant growth forms
    a) small woody shrubs, mosses, heaths, and lichens

C. Boreal Forest (a.k.a. Taiga)
1. Temperature: cold
2. Precipitation patterns: avg mnthly ppt. 40-100mm
3. Geographic Distribution
    a) between ~50^{O} and ~60^{O}N
    b) Europe, Russia, and North America
4. Typical plant growth forms
    a) plant growth contrained more by temperature than by precipitation
    b) coniferous (cone-bearing) evergreen trees (pine, spruce, and fir)
    c) some deciduous trees (birch, maple, aspen) can be found at times

D. Temperate Rainforest
1. Temperature: moderate (avg: 5^{O}-20^{O}C)
2. Precipitation patterns: high (avg. monthly ppt. 50-280mm/year)
3. Geographic Distribution
    a) coastal biome
    b) North America: northern California to Alaska
    c) southern Chile
    d) west coast of NewZealand
    e) Tasmania
4. Typical plant growth forms
    a) nearly 12 month growing season
    b) fir, spruce, cedar hemlock
    c) ferns and mosses

E. Temperate Seasonal Forest
1. Temperature: 0^{O}-18^{O}C

2. Precipitation patterns: average monthly ppt. 50-100mm (often >1m annually)
3. Geographic Distribution
    a) eastern United States
    b) Japan
    c) China
    d) Europe
    e) Chile
    f) eastern Australia
4. Typical plant growth forms
    a) temperate deciduous forest
    b) broadleaf trees
        (1) beech, maple, oak, hickory
    c) some coniferous trees

F. Woodland/shrubland
1. Temperature: 12^{O}-20^{O}C
2. Precipitation patterns: avg. monthly ppt. 0-110mm
3. Geographic Distribution
    a) coast of southern California (chaparral)
    b) southern South America (matorral)
    c) southwestern Australia (mallee)
    d) southern Africa (fynbos)
    e) large region surrounding the Mediterranean Sea (maquis)
4. Typical plant growth forms
    a) drought-resistant and fire-tolerant species
        (1) yucca, scrub oak, sagebrush

G. Temperate Grassland/Cold Desert (a.k.a. temperate desert)
1. Temperature: 1^{O}-28^{O}C
2. Precipitation patterns: avg. monthly ppt. 50-120mm
3. Geographic Distribution
    a) Great Plains of North America (prairie)
    b) South America (pampas)
    c) central Asia and eastern Europe (steppe)
    d) tallgrass - sufficient rainfall for trees but they are supressed by wildfire
    e) shortgrass - too dry to support tall grasses or trees
4. Typical plant growth forms
    a) grasses and nonwoody flowering plants

H. Tropical Rainforest
1. Temperature: 21^{O}-28^{O}C
2. Precipitation patterns: avg. monthly ppt. 90-400mm

3. Geographic Distribution
    a) between 20^{O}N and 20^{O}S of the equator
    b) Central and South America
    c) Africa
    d) southeast Asia
    e) northeastern Australia
    f) large tropical islands
4. Typical plant growth forms
    a) more diversity per hectare than any other terrestrial biome
        (1) ⅔ of Earth's terrestrial species
    b) canopy
        (1) large trees that shade the underlying vegetation
    c) subcanopy/understory
        (1) several layers of successively shorter trees
    d) epiphytes
        (1) small parasitic plants that grow on the living trees, taking advantage of their host's height to obtain access to sunlight
    e) lianas
        (1) woody vines, rooted in the soil which often grow into the canopy of the rainforest

I. Tropical Seasonal Forest (a.k.a. Tropical Decisuous Forest)/Savanna
1. Temperature: 16^{O}-24^{O}C
2. Precipitation patterns: avg. monthly ppt. 0-250mm
3. Geographic Distribution
    a) Central America
    b) Atlantic coast of South America
    c) southern Asia
    d) northwestern Australia
    e) sub-Saharan Africa
4. Typical plant growth forms
    a) acacia and baobab trees
    b) grasses

J. Subtropical Desert (a.k.a. hot desert)
1. Temperature: 16^{O}-22^{O}C
2. Precipitation patterns: avg monthly ppt. 0-2mm
3. Geographic Distribution
    a) ~30^{O}N & S of the equator
    b) Southwestern US (Mojave Desert)
    c) Africa (Sahara Desert)

d) Middle East (Arabian Desert)
e) Australia (Great Victoria Desert)

4. Typical plant growth forms
    a) cacti, euphorbs, and succulent plants

III. Aquatic Biomes

-freshwater & marine
-characterized by salinity, depth, and water flow
-temperature determines which species may exist in an aquatic biome
-however, it is not a factor in their categorization

A. Streams & Rivers
1. flowing fresh water
    a) can originate underground or as run-off from precipitation
2. Streams: narrow with relatively low amounts of water
3. Rivers: wide with large amounts of water
4. it is not particularly clear as to when a stream becomes a river
5. streams and rapidly flowing rivers have few plants or algae
    a) base of the food web is often organic matter from adjacent terrestrial ecosystems
6. as streams and rivers widen and become more slow moving sediment settles to the bottom
    a) this provides suitable subtrate for rooted plants and algae to grow
7. rapids: turbulent water
    a) mixes water and air
        (1) atmospheric oxygen is able to dissolve into the water
        (2) such high oxygen water supports fish such as trout and salmon
8. lower oxygen environments support fish such as catfish

B. Lakes & Ponds
1. standing water, too deep to support emergent vegetation
    a) emergent vegetation
        (1) plants rooted to the bottom, which emerge above the surface
2. zones
    a) littoral zone
        (1) shallow area of soil asn water near the shore
            (a) algae and emergent plants grow here
            (b) most photosynthesis of the system happens here
    b) limnetic zone
        (1) rooted plants can no longer survive in these water depths
        (2) phytoplankton (floating algae) arethe primary producers
        (3) extends as seep as light can penetrate

c) profundal zone
    (1) zone below the limnetic zone
    (2) exists in ver deep lakes
    (3) producers cannot survive in this zone
    (4) bacteria decompose materials that enter from the limnetic zone
        (a) this depletes O_2 so that many organisms cannot exist in the profundal zone
d) benthic zone
    (1) the muddy bottom of a lake or pond

C. Freshwater Wetlands (***Get wetland ID guide***)
1. land that is submerged or saturated by water for at least part of each year
2. shallow enough to support emergent vegetation
3. types:
    a) swamp
        (1) wetland that contains emergent trees
        (2) Great Dismal Swamp (Virginia); Okefenokee Swamp (Georgia)
    b) marsh
        (1) wetlands that contain primarily non-woody vegetation
    c) bog
        (1) very acidic wetland that contain sphagnum moss (and sometimes, spruce trees)
4. among the most productive biomes on the planet
5. provide many ecosystem services
    a) filter pollutants
    b) regulate floods and droughts
    c) migratory and breeding locations for birds
6. more than half of US wetlands have been drained
    a) agriculture
    b) development
    c) eliminate mosquito habitat

D. Salt Marshes
1. found along coastlines in temperate climates
2. non-woody emergent vegetation
3. estuaries
    a) areas where fresh water from rivers mixes with the ocean salt water
    b) highly productive due to the nutrients being delivered by rivers
    c) abundant plant life helps filter out contaminants
4. provide important spawning habitat for fish and shellfish
    a) ⅔ of fish and shellfish species larvae inhabit estuaries

E. Mangrove Swamps
    1. occur along tropical and subtropical coasts
    2. contain emergent trees
    3. mangrove trees are salt tolerant
    4. trees help protect coastline from erosion and storm damage
    5. provide habitat for fish
    6. mangrove leaves produce a nutrient rich environment

F. Intertidal Zone
    1. narrow band of coastline between high-tide and low-tide
    2. environmental conditions are
        a) stable when submerged during high tide
        b) harsh when exposed during low tide
    3. Typical organisms:
        a) barnacles, sponges, algae, mussels, crabs, and sea stars

G. Coral Reefs
    1. found in warm shallow waters beyond the shoreline
    2. most diverse marine biome
    3. coral
        a) tiny marine invertebrates that secrete calcium carbonate to form an exoskeleton
            (1) a hollow tube with tentacles that filter feed on plankton and detritus
    4. reef
        a) the accumulated exoskeletons of many generations of coral colonies
    5. Great Barrier Reef (Australia)
        a) 2600 km^2
    6. a large diversity of fishe and invertebrates inhabit reefs
        a) for shelter and food
    7. challenging situations for reefs that impact coral survival
        a) pollutants and sediment
        b) coral bleaching
            (1) algae associated with the reef die - followed by the coral
                (a) likely due to lower ocean pH and high water temperatures

H. Open Ocean
    1. Deep water zones
        a) photic zone
            (1) the upper layer of water that receives enough sunlight for photosynthesis

(2) algae is the major producer

b) aphotic zone
   (1) deeper layer of water which lacks sunlight
   (2) no photosynthesis
   (3) chemosynthesis
      (a) capturing energy obtained from the chemical bonds of methane and hydrogen sulfide
   (4) bioluminescence
      (a) life that can generate it own light to help them feed in the dark
         (i) crustaceans, jellyfish, squid, and fish

c) benthic zone
   (1) ocean floor