Abiotic factors at the global scale: processes and Patterns in the Physical Environment

A. Physical Environment

1. Climate - broad patterns
    a. Patterns of insolation
    b. Hadley Cells
    c. Coriolis Force
2. Seasonality.
    a. Earth-Sun distance
    b. Annual orbit and axis tilt
3. Global patterns of temperature and rainfall
    a. resulting vegetation communities/biomes
    b. climographs
    c. animal distributions

Environment –a species' environment includes
physical factors (temperature, water, light, nutrients)
biological factors (competitors, predators, prey, parasites, mutualists, mates)

Physical and biological factors affect
- *survival* and *reproduction* of *individuals*, and therefore affect
- the *distribution* and *abundance* of *species*

Patterns in the Physical Environment

Most of this course will focus on relations of animals with their *biological* environment, b/c that side of ecology is theoretically more complex. Next few lectures will focus on interactions with the *physical* environment.

Large Scale Physical Patterns

Climate - patterns of sun, wind & water

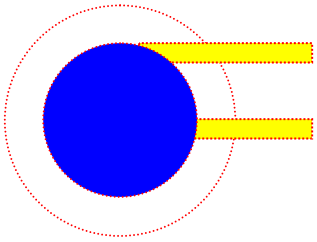
Varies spatially (tropical - temperate- polar regions) and temporally (hot - cold or wet - dry seasons)

Main effects on animals are by determining *temperature* and *availability of water*.

Temperature - low at poles and high at equator, because:

1. Angle of incidence --> area over which energy of light beam is dissipated.

2. angle of incidence --> depth of atmosphere penetrated (deeper at acute angles) --> amount of light energy that is reflected by airborne particles w/o reaching surface



Beam A = deep atmosphere; acute angle, large area, little energy/sq. km

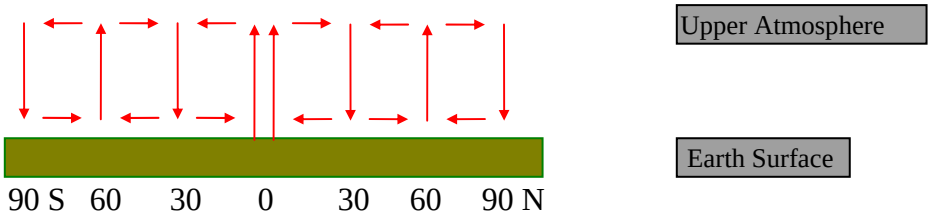
Beam B = perpendicular, small area, more energy/sq. km

Hot at equator --> rising air.

1. Cools as it rises (***adiabatic cooling*** = no loss of total heat, but b/c P ~ T, as P decreases, T decreases).
Lower capacity to hold water.
Rain heavy at equator.

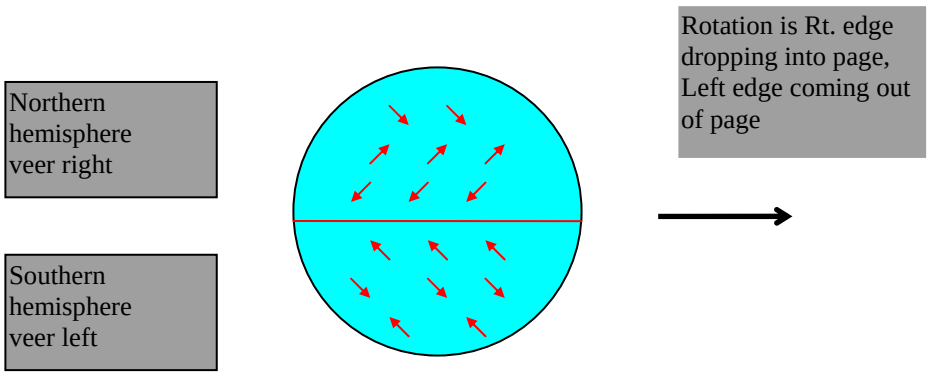
2. Causes circulation pattern of ***Hadley cells***. Closed system, so rising air spreads in upper atmosphere, cools and eventually drops back to surface at ca. 30° N & 30°S. Water-depleted, and gaining capacity to hold water as it drops (***adiabatic heating***) and warms, therefore *desiccating* air. --> Dry at this latitude (many deserts).

(Overhead)



3. Conservation of momentum - ***Coriolis force.*** Superimposes major easterly and westerly patterns in winds blowing N & S within Hadley Cells.

(Overhead & draw arrows by hand)



4. Patterns of air movement described (rising/sinking, N/S, E/W) combine with patterns in ***oceanic currents*** to explain major global climate patterns. Oceanic currents driven by wind & Coriolis force.

Seasonality. Due to position of earth relative to sun

Earth-Sun Distance varies on very long time scales (22,000 yrs) producing glacial and pluvial periods.

Orbit (annual), together with 23.5^{o} tilt in axis of daily rotation, produces seasons due to effect on hours of daylight. Also causes N-S shift in Hadley cells as *thermal equator* moves from 23.5 S (T of Capricorn) to 23.5 N (T of Cancer). E.g. One v. two rainy seasons depending on latitude within the tropics.

Microclimate. Local patterns superimposed on global pattern by *topography* and *geography*.

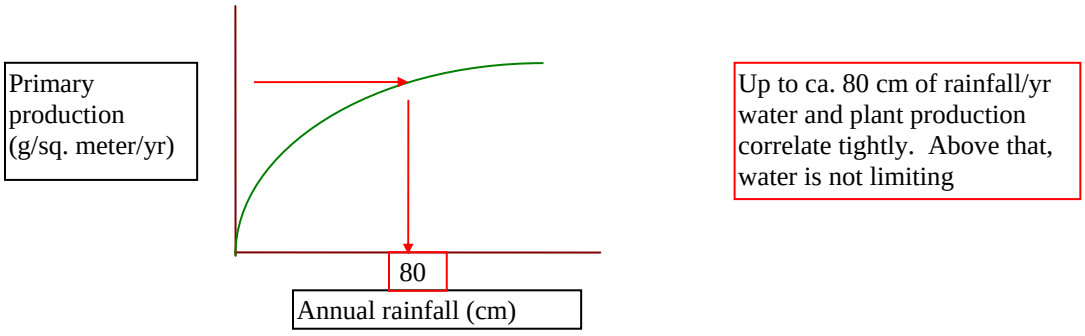
Topographic - rainshadow of mountains affects water availability. Altitude also affects temperature

Geographic - proximity to water bodies, which modulate temperature due to high heat capacity of water relative to air. Also affects precipitation e.g lake effect snow, summer storms in continent centers, winter rain on coasts w/onshore wind

Climate and Vegetation Together with topography and soils, climate determines vegetation type. (Pianka Fig.4.1)

Water and solar energy limit plant *primary production* = energy con verted from solar radiation to chemical energy via photosynthesis.

Photosynthesis requires CO_2, H_20 and solar energy. CO_2 in atmosphere is rarely limiting, so H20 and sunlight are normal limits for plant growth. (Nutrients also can be limiting.)



Evapotranspiration = H_20 from evaporation + H_20 from plant transpiration + H_20 from animal respiration. Gives *combined* measure of water and solar energy available. Correlates very well with primary production.

Under canopy or in aquatic ecosystems, light is often the limiting factor for plan productivity.

In turn, vegetation influences climate: vegetation dampens fluctuations in wind, humidity and temperature.

Consequence of these relationships is that one can (roughly) classify plant communities on a plot of precipitation vs. rainfall.

(Fig. 4.16 p.76 Pianka & Figs. from Krebs text)

Climate & plant community determine distribution of animals

(Figs from Krebs)