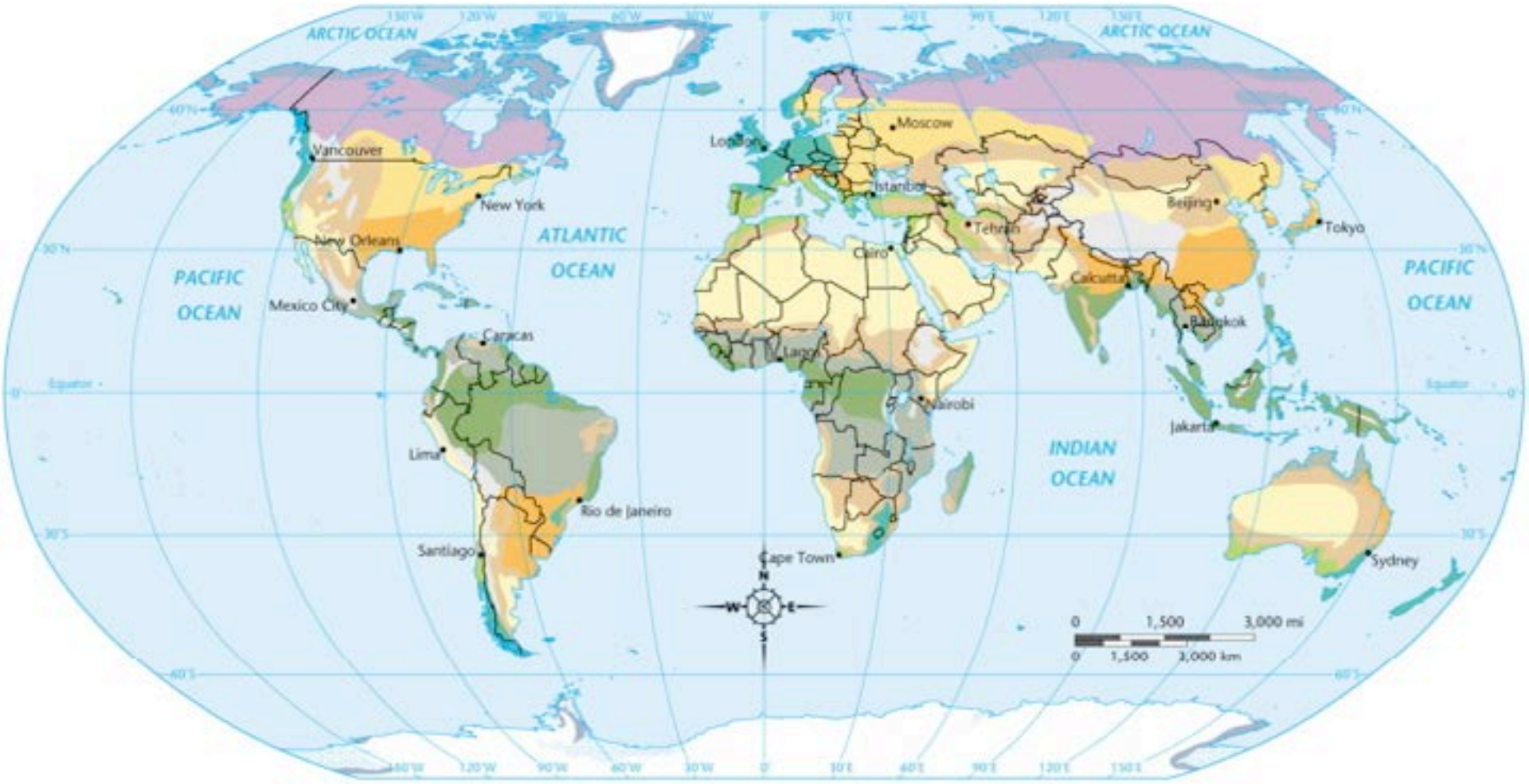


Tropical
- Tropical wet
- Tropical wet and dry

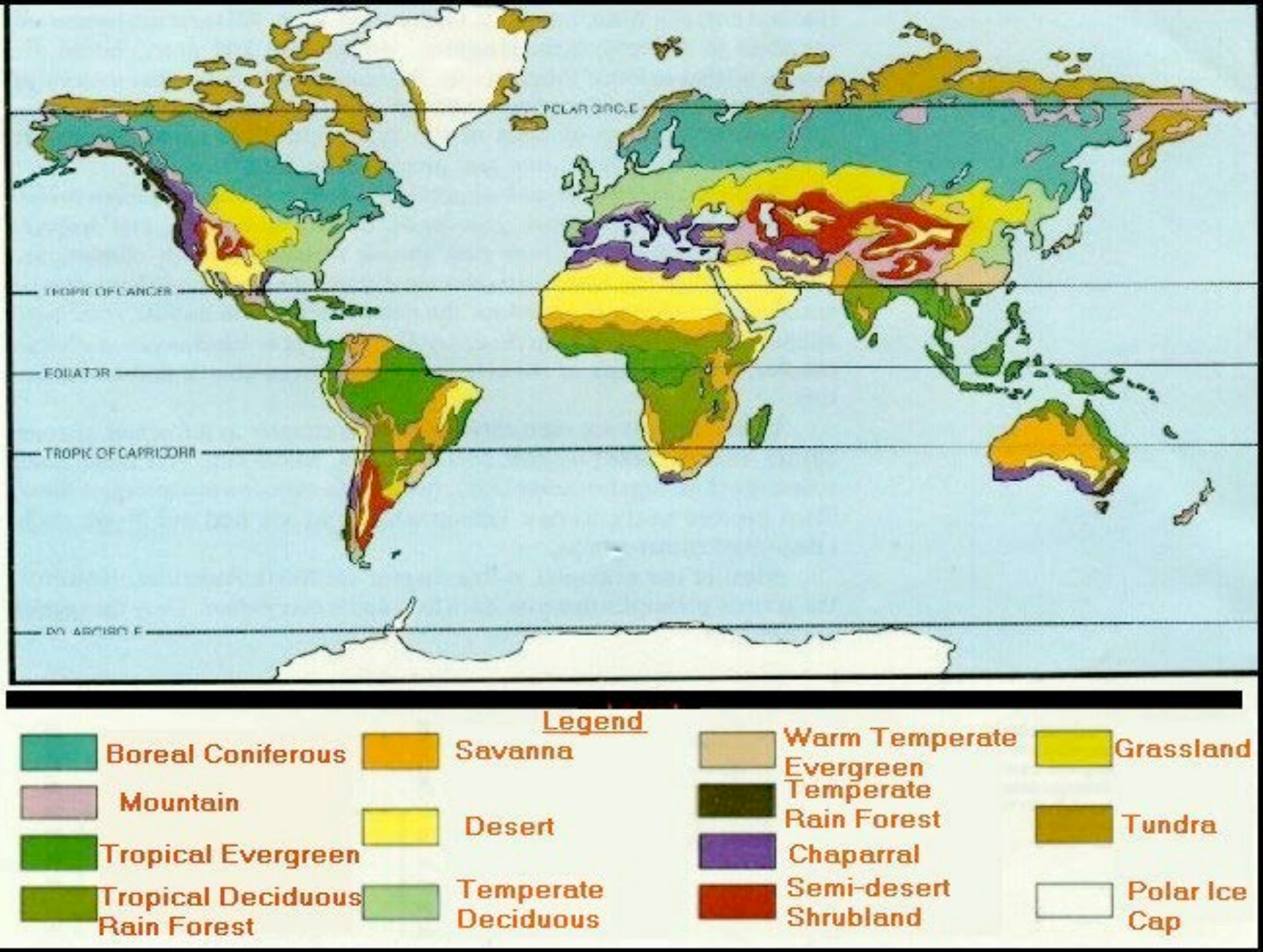
Dry
- Semiarid
- Arid

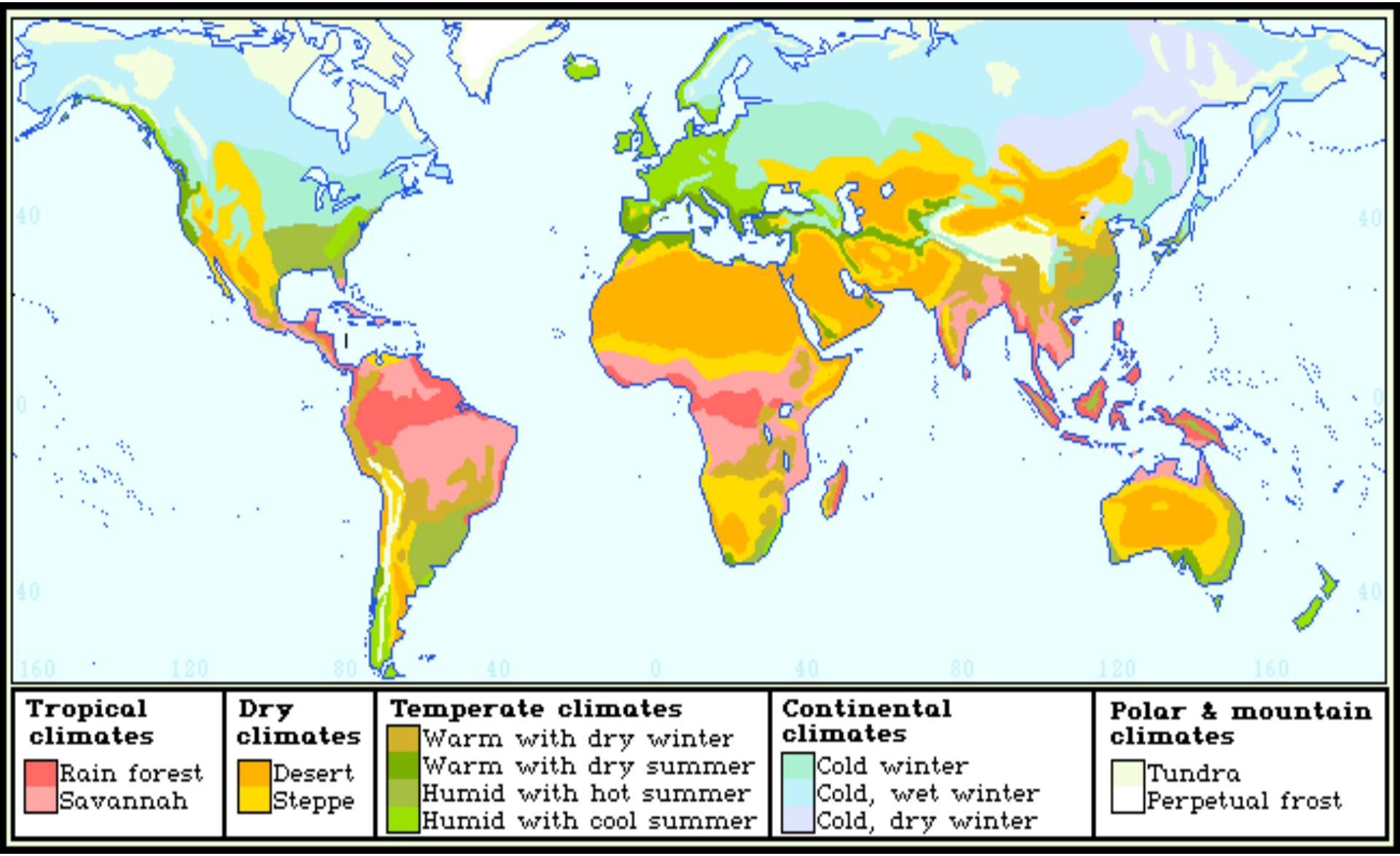
Moderate
- Mediterranean
- Humid subtropical
- Marine west coast

Continental
- Humid continental
- Subarctic

Polar
- Tundra
- Ice cap
- Highlands

- Non-permanent ice


POLAR CIRCLE
TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN
Legend
Boreal Coniferous
Savanna
Warm Temperate Evergreen
Grassland
Mountain
Temperate Rain Forest
Desert
Tundra
Tropical Evergreen
Chaparral
Tropical Deciduous Rain Forest
Temperate Deciduous
Semi-desert Shrubland
Polar Ice Cap


Tropical climates
Rain forest
Savannah
Dry climates
Desert
Steppe
Temperate climates
Warm with dry winter
Warm with dry summer
Humid with hot summer
Humid with cool summer
Continental climates
Cold winter
Cold, wet winter
Cold, dry winter
Polar & mountain climates
Tundra
Perpetual frost

Radius of earth 6380 km
Depth of atmosphere 30 km
Ratio = 0.5%

TABLE 3-2

Major Constituents of Earth's Atmosphere Today	
Name and Chemical Symbol	***Concentration (% by volume)***
Nitrogen, N_2	78
Oxygen, O_2	21
Argon, Ar	0.9
Water vapor, H_2O	0.00001 (South Pole)–4 (tropics)
Carbon dioxide, CO_2	0.037*

*In 2002

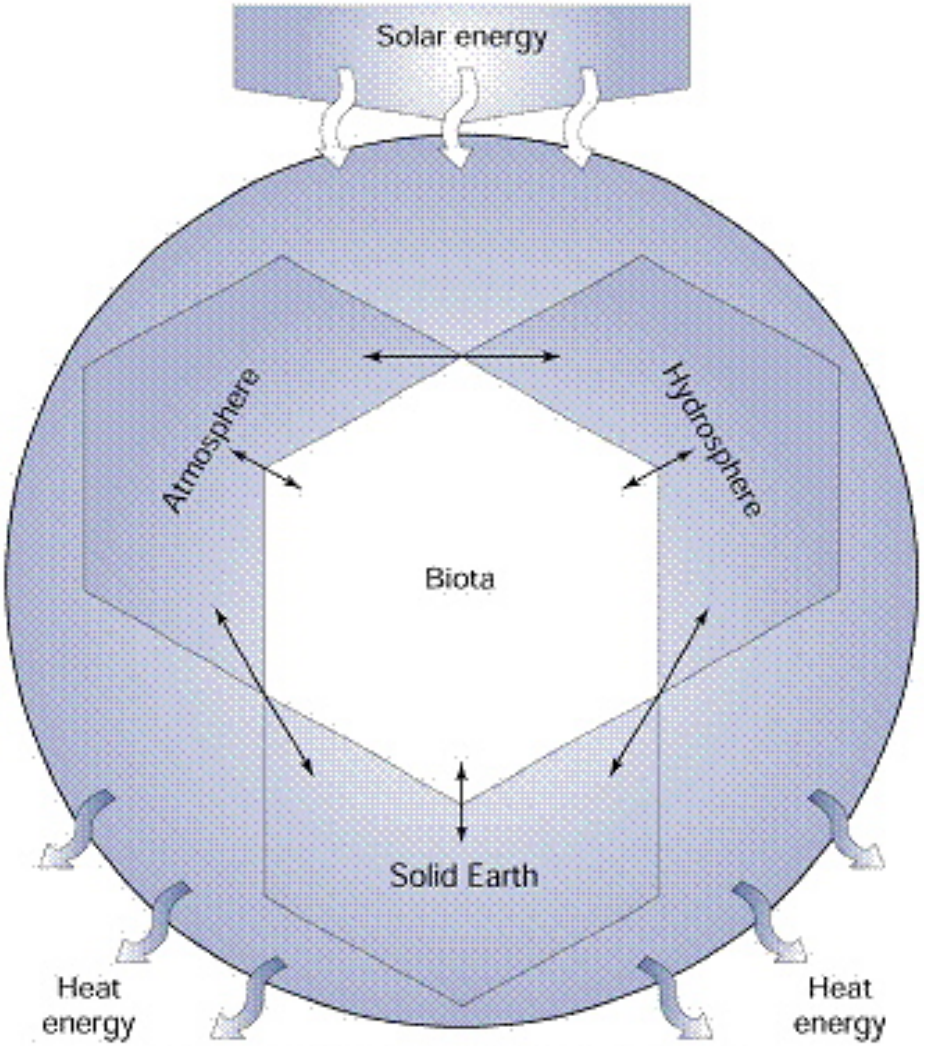
Conservation of Energy

Total energy in=

energy transmitted +

energy absorbed +

energy reflected



Planetary Albedo

Total energy in =

Energy reflected + Energy absorbed

Albedo =

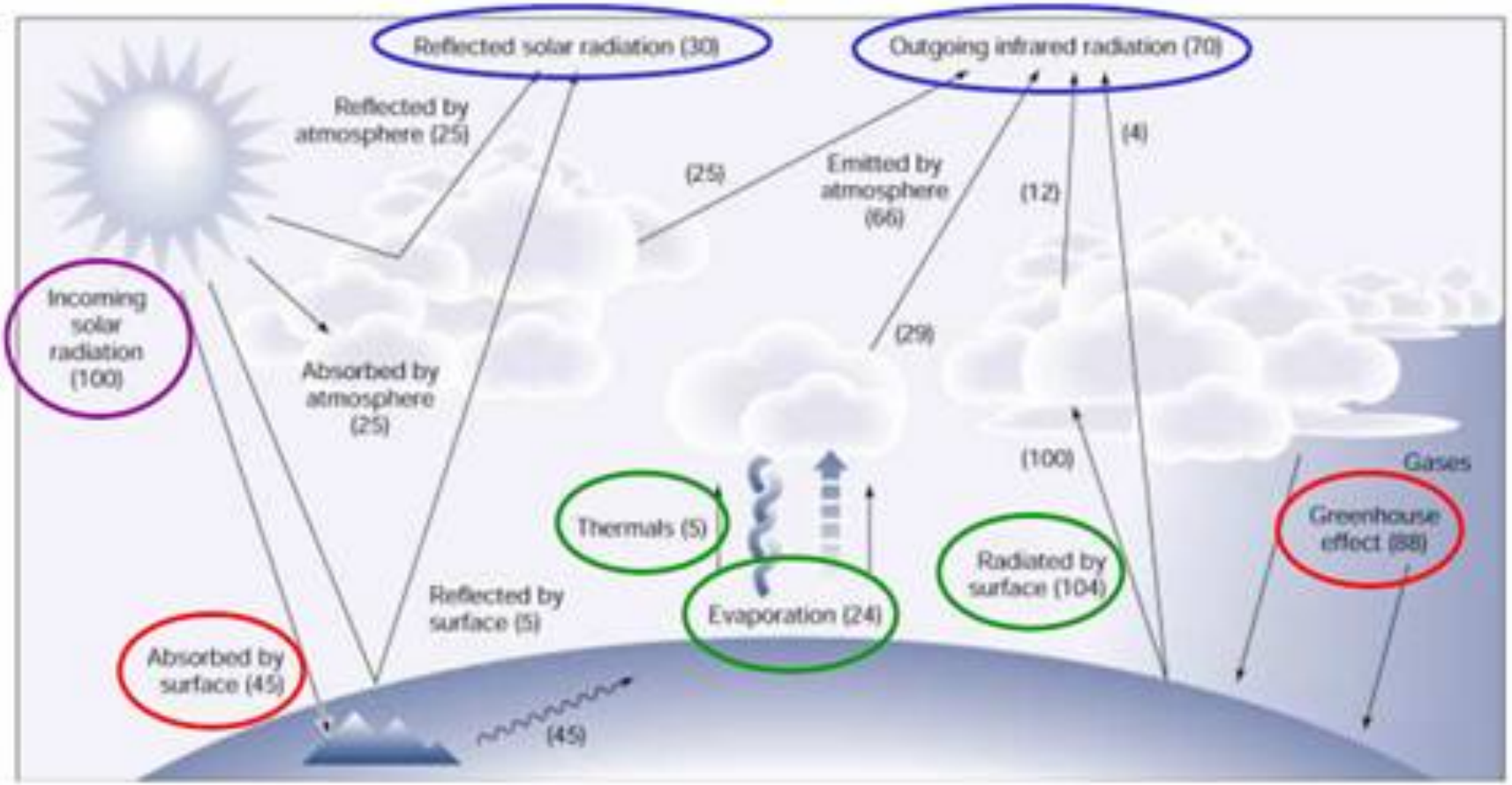
$$\frac{\text{Energy reflected}}{\text{Energy in}}$$

Albedo of water or Asphalt = 0.2

Albedo of snow or white paint = 0.8

Energy Budget: TOA and surface

Top-of-Atmosphere budget: IN = OUT



Surface budget: IN = OUT

Heat transfer

Conduction

Convection

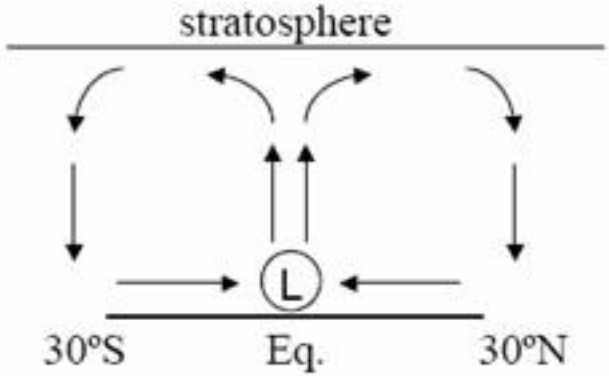
Radiation

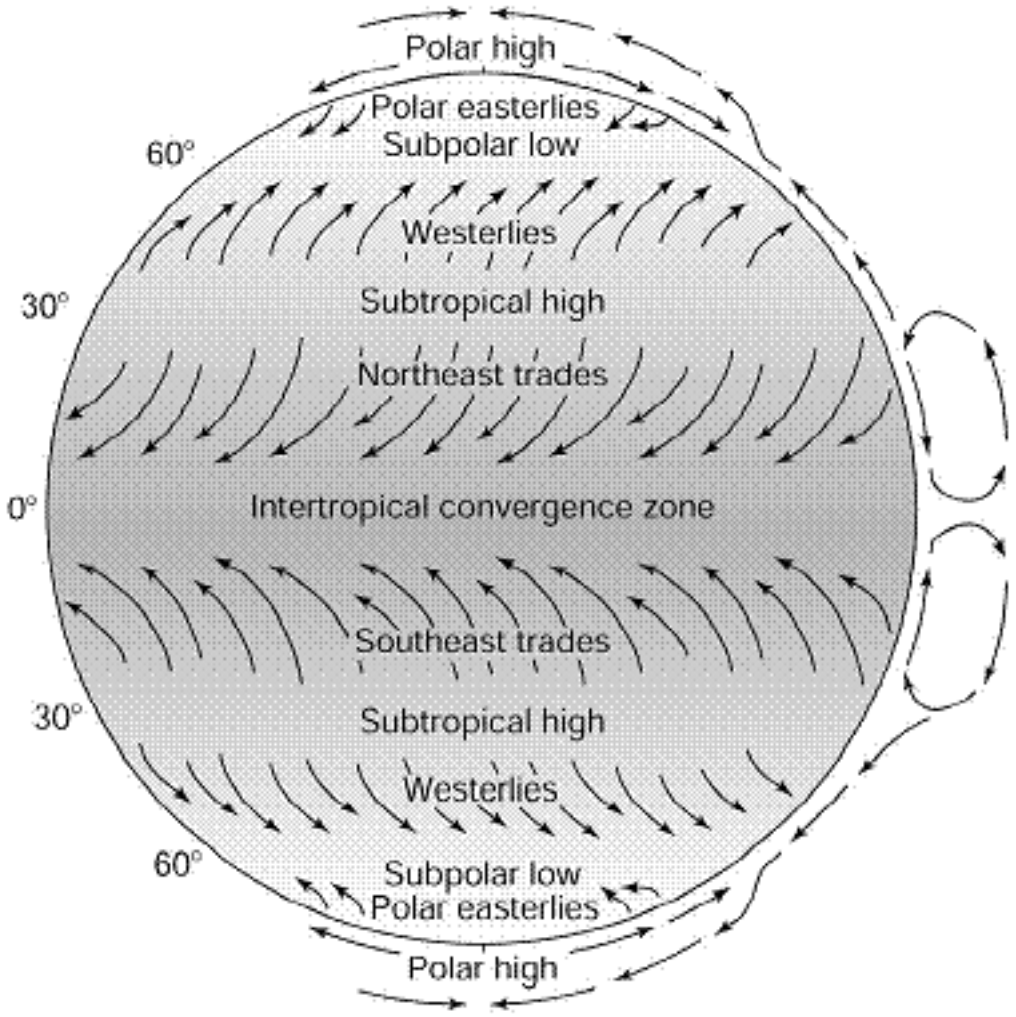
Phase Change

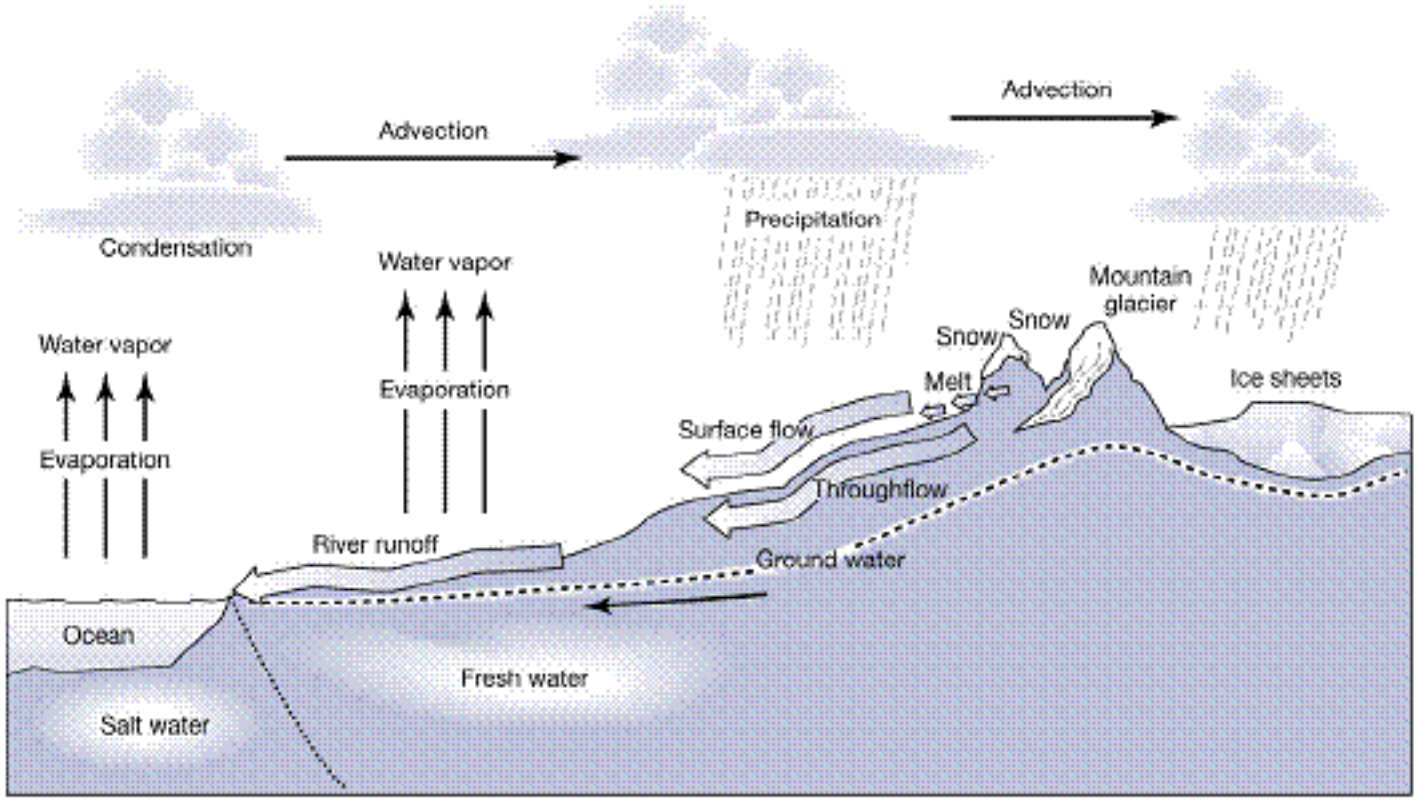
Hadley Circulation - 4

conservation of matter ... >>>>> **CIRCULATION**

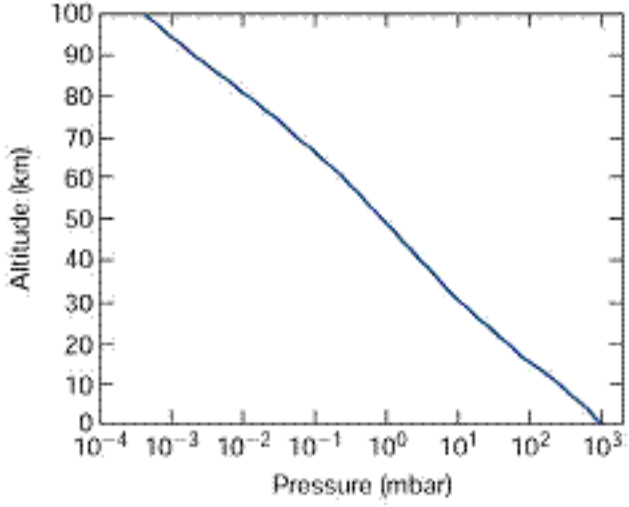
The Hadley Circulation

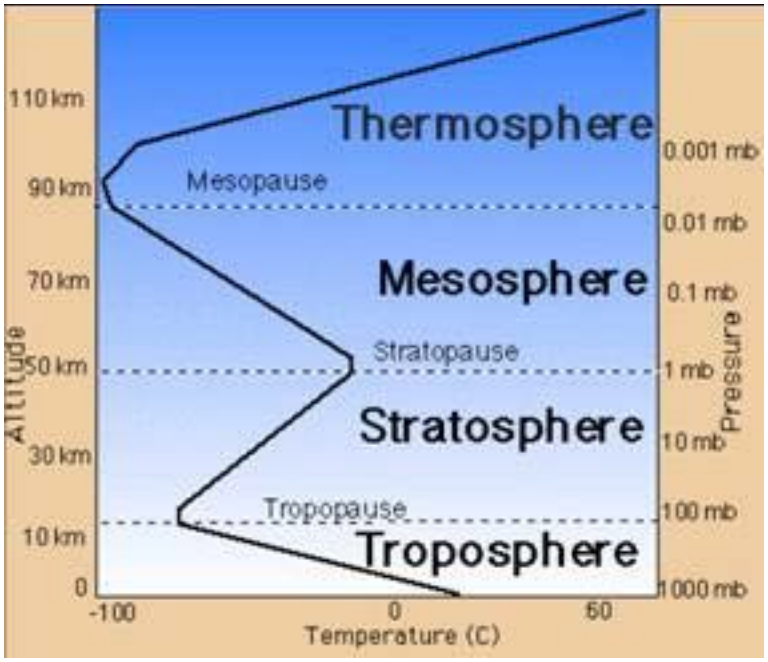





Advection
Advection
Condensation
Precipitation
Water vapor
Water vapor
Evaporation
Evaporation
Mountain glacier
Snow
Snow
Melt
Ice sheets
Surface flow
Throughflow
River runoff
Ground water
Ocean
Fresh water
Salt water

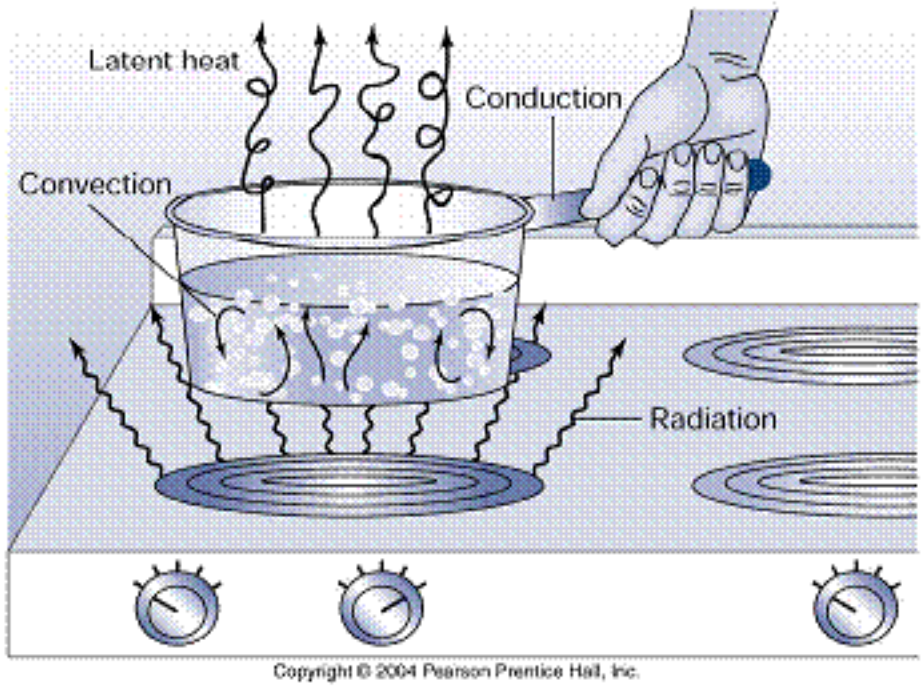
(a)





Lapse rate- Rate at which temperature changes with height

Lapse Rate



Stable-warm fluid on top of cold fluid

Unstable-cold fluid on top of hot fluid

Latent Heat of Vaporization

1 BTU to raises 1 Lb. water 1° F.

180 BTU raises 1 lb. H_20 from 32° to 212°F

970 BTU to convert 1lb H_20 from liquid to vapor

Condensation of water releases 970 BTU/lb.

Drying takes energy

Condensation releases energy

How do clouds form?

Start with air parcel containing water vapor

Lift parcel up

Parcel cools by rising

Parcels cool because they do “work” by expanding as

They rise due to pressure differences

Parcel temperature reaches saturation vapor pressure

Condensation occurs => cloud forms

Slow rise makes low energy clouds

Rapid rise makes high energy clouds