Atmosphere

1. Insulator—maintains our T balance
   (500 degrees F, T changes without it)
2. Shield—from meteors
3. Ocean of air—dynamic, distributes heat

Look at Mr. Moon:

1. Temps—light side- 400 degrees F
   dark - 250 degrees F
2. No sound wave travel—no molecules of air

Characteristics of Atmosphere—extends 480 Km up
(300 miles up)

Density stratified like the earth itself
(97% air is concentrated in the first 25 Km)
>exerts atmospheric pressure=1034 g/cc, 14.0l b/square inch

Composition of the Atmosphere

Permanent		VS.	Variable	(PPM)
N_2	78.08%	H_2O	0% to 4%	
O_2	20.95%	Cu_2	0.0037%	368
Ar	0.93%	CH_4	0.00017%	1.7
Ne	0.0018%	N_2O	0.00003%	0.3
He	0.0005%	O_3	0.000004%	0.04
H_2	0.00006%	crap	0.000001%	0.01 – 0.05
Xe	0.000009%	CFCs	0.0000002%	0.0002

Nitrogen—supports plant growth
O_2—breathe & burn (oxidation) food
Figure 4.1

Carbon Dioxide: absorbs heat from the Earth
>Part of the Carbon Cycle
>Figure 4.2: Light+Water+CO_2---->Carbohydrate+O_2
>Plants use it in Photosynthesis
(convert it to Energy (sugar))

Ozone (O_3): Forms in the upper atmosphere, O_2 is split and then rejoins as O_3
>Blocks uv radiation
>Pollutant at low elevation
>CFCs break it down (Freon)

Other Stuff: Water, Liquids and Solids
>Water vapor is also an important insulator. Water has a high heat capacity, and can exist as a solid, liquid or gas on Earth.
>dust, smoke, pollen and spores, ash, bacteria, and salts

Vertical Layers of the Atmosphere

>Less dense as you go up

From the bottom (surface) upward:

Troposphere: closest to the surface

- ♦Tropo-to turn (mixing zone)
- ♦8-16 km, varies seasonally
- ♦Thickest at the equator, thinnest at the poles
- ♦All particulates are here
- ♦Temperature decreases according to the Environmental Lapse Rate (or Normal Lapse Rate), which is 6.5°C/1000 m or 3.6°F/ 1000 feet

Tropopause: the altitude at which temperature ceases to drop with increased altitude.

- ♦Separates Troposphere from Stratosphere

Stratosphere

- ♦Lower part has a relatively constant temperature (about -57°C or -70°F) (to an altitude of 32 km (20 miles)
- ♦Ozone Layer: absorbs UV radiation and releases heat, which increases the temperatures in the upper Stratosphere

Stratopause: about 50 km or 30 miles up

- ♦Temperatures are near that of the surface

Mesophere: Temperature drops with increasing altitude

Mesopause: separates Mesosphere from Thermosphere

Thermosphere (or Ionosphere): Temperature increases until you reach 1100°C (or 2000°F)

- ♦Ionization of molecules by UV, X-rays and Gamma radiation
- ♦Result: the auroras

In these upper layers, the air is so thin that little heat can be transferred anywhere.

Controls of Temperature on the Surface of the Earth

1) Latitude: the most important (Table 4.2)

- ♦There is one exception. **Why?**

2) Land-Water Distribution

- ♦The specific heat for water is higher than that for land
- ♦Transferability is greater in water: mixing

Example: Seattle: 64°F in July, 40°F in January,
Minneapolis: 70°F in July, 4°F in January

3) Ocean Currents: Figures 4.4 and 4.5
- ♦Clockwise in the northern hemisphere
- ♦warm water goes to northern latitudes (like the Gulf Stream)

Examples:
- ♦Colder ocean currents keep CA a little cooler and drier

4) Altitude
- ♦Temperatures decrease with altitude

Example: Quito, Ecuador (55°F average annual T) **Why?**

5) Landform Barriers
- ♦Himalayas keep cold winter Asiatic air out of India
- ♦North facing and South Facing Slopes

Examples:

6) Human Activities
- ♦Building cities-urban heat island
- ♦Desertification

The Role of Water (Figure 4.6: The States of Water)

----------Sublimation ----------

	Freezing		Condensation	
	‹----------		‹----------	
SOLID	(80 cal/g)	LIQUID	(590 cal/g)	GAS
	----------›		----------›	
	Melting		Evaporation	

----------Sublimation ----------

----------› Energy is added (endothermic)

‹---------- Energy is released (exothermic)

Effects of the Atmosphere on Solar Radiation

The amount of radiation is dependant upon:
1) Latitude
2) Time of Day (Items 1-3 are all related to the sun angle)
3) Time of Year
4) Transparency of the Atmosphere

Summary of Figure 4.7:
1) 26% of the incoming energy is reflected directly back to space by clouds and the ground.
2) 8% is scattered by minute atmospheric particles and returned to space as diffuse radiation

Why is the sky blue?

Why are sunsets red?

3) 20% reaches the Earth's surface as diffuse radiation after being scattered.
4) 27% reaches the Earth's surface as direct radiation.
5) 19% is absorbed by the ozone layer and by water vapor in the clouds of the atmosphere.

In other words:
47% makes it here
19% gets stuck in the atmosphere
34% returned to space

(All percentages represent an oversimplification. Everything can vary.)

Heating the Atmosphere

Processes of Heat Energy Transfer
1) Radiation: the process by which EM is transferred from the sun.

- ♦Generally, warmer objects give off more E in smaller wavelengths
- ♦So, the Sun emits Short Wave radiation and the Earth emits Long Wave radiation, which heats up the atmosphere from the ground up.

Examples of the Short Wave/Long Wave Relationship:

2) Conduction: heat is transferred from one part of an object to another or from two touching objects.

- ♦Heat flow form warmer objects to the colder parts

Examples:

- ♦Conduction typically occurs at the boundary between the surface and the atmosphere
- ♦Air is a good insulator, not a good conductor

3) Convection: the vertical transfer of heat through the atmosphere

- ♦Convection Currents: the boiling pot

4) Advection: Horizontal heat transfer

- ♦Agents: wind and ocean currents
- ♦Generally from the equator to the poles, very important for the heat distribution of the Earth

5) Latent Heat of Condensation: Helps warm the atmosphere and is a source of energy for storms (Exothermic)

- ♦Latent Heat of Evaporation: Energy is added and helps cool the atmosphere (Endothermic)

The Heat Energy Budget
Now what happens to the 47% that gets here?
1) 14% is emitted as Long Wave Radiation
    (6% loss, 8% recapture by the atmosphere)
2) 10% Net transfer back to atmosphere via conduction or convection
3) 23% returns to the atmosphere through the release of the Latent Heat of Condensation

Thus, the overall temperature of the Earth's Surface is in a state of dynamic equilibrium.

Input?

Input=Output

Output?

When the Earth's Dynamic Equilibrium is disturbed, GLOBAL CLIMATE change:
1) Greenhouse Effect: the trapping of radiation by gases in the atmosphere
2) Meteor Impact: bouncing of radiation off of the atmosphere

Figure 4.9: Latitudinal Variation in the Energy Budget
- ♦Surplus at low latitudes
- ♦Deficit at high latitudes
- ♦Only at 38 degrees latitude is it balanced
- ♦The Earth's oceans and atmosphere keep everything in balance

Air Temperature

Heat and Temperature Review
- ♦Heat is a form of energy, the total kinetic energy of all atoms in a substance
- ♦Temperature is the average kinetic energy of the individual atoms of a substance

Difference: A match has a high temperature, the ocean has a high heat capacity

Scales	Freezing Point	Boiling Point	Absolute Zero
Fahrenheit			
Celsius			
Kelvin			

Short Term Variations in Temperature (Figure 4.11)
Example: Why does it get hotter later in the afternoon, after the maximum noon sun angle?

Factors Influencing Daily Temperature:

1) Cloud Cover
2) Differential Heating of Land (continental) and Water (maritime)
3) Reflection
    - ♦Albedo-capacity of a surface to reflect the sun's energy
        - **>High albedos:**
        - **>Low albedos:**
    - ♦Angle of the sun can change the reflectivity of a surface
4) Horizontal Air Movement
    - ♦From oceans over the continent and back (Land/Sea Breezes)

Vertical Distribution of Temperature

1) Normal Lapse Rates: can vary according to the gradient of temperature\
    (Figure 4.14)

2) Temperature Inversions: Occurs when temperature increases with altitude for a few thousand meters
    - ♦Common around the latitudes of 30-35 degrees
    - ♦Especially in LA: serves as a trap for smog

3) Surface Inversions: Frost and Fog
    - ♦cold dense air flows down a valley
    - ♦farmers have to improvise: fans, smudge pots, straw

Temperature Distribution at Earth's Surface
Isotherms: equal lines of temperature

Figures 4.19-4.20

Temperature maximums and minimums occur about 30 day after the solstices.
Why? The Annual Lag of Temperature (similar to the daily cycle)

Annual March of Temperature: Figure 4.21

Weather and Climate

Weather: refers to the condition of atmospheric elements at a given time for a specific area.
    - ♦Specialist: Meteorologist

Climate: average of the weather conditions over time
    - ♦Specialist: Climatologist

The Five Basic Elements of the atmosphere serve as the "ingredients" of weather and climate:

1) Solar Energy (insolation)
2) Temperature
3) Pressure
4) Wind
5) Precipitation