Earth’s Atmosphere

I Earth's Atmosphere

A. What is the atmosphere?

1. A __**thin**____ blanket of air
2. A __**protective**______ layer
3. Weather is a result of __**interaction**_ between the atmosphere and Earth's surface and between Earth's surface and the atmosphere

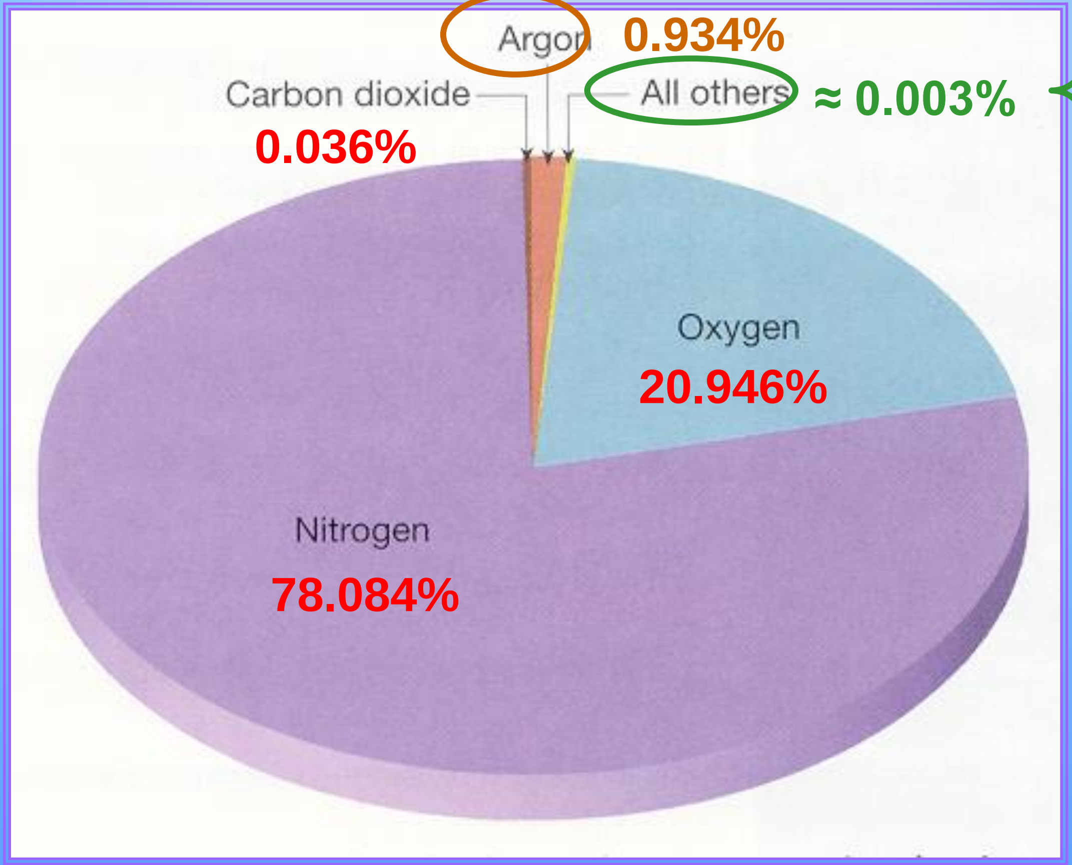
B. Composition of the Atmosphere

1. Air is a ___**mixture**___ of gases.
2. Varying amounts of tiny ___**solid**___ and ___**liquid**___ particles are suspended in the atmosphere.
3. The composition is ___**not**___ constant.

4. Major Components of Dry Air

a. **Nitrogen** (N_2): ≈ 78%
b. **Oxygen** (O_2): ≈ 21%
c. **Carbon Dioxide** (CO_2): ≈ 0.036%

} Percent by Volume



- Ne: 0.00182%
- He: 0.000524%
- CH_4: 0.00015%
- Kr: 0.000114%
- H_2: 0.00005%

Earth Science Reference Tables

The University of the State of New York • THE STATE EDUCATION DEPARTMENT • Albany, New York 12234 • www.nysed.gov

Reference Tables for

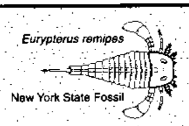
The lowest level of the atmosphere

Average Chemical Composition of Earth's Crust, Hydrosphere, and Troposphere

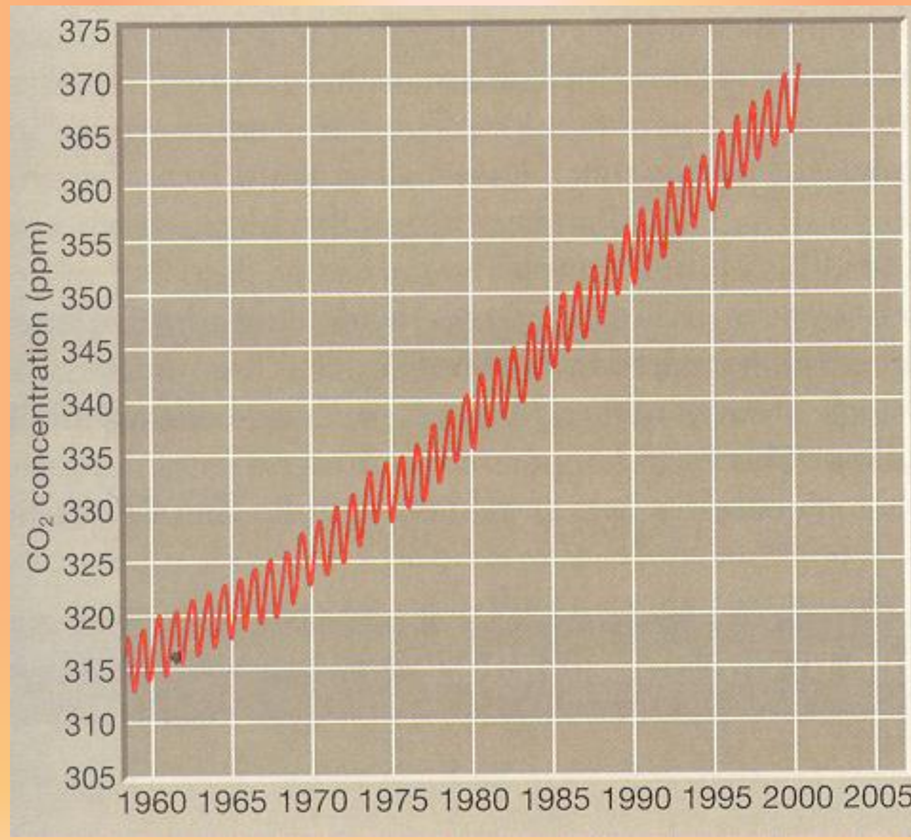
ELEMENT (symbol)	CRUST		HYDROSPHERE	TROPOSPHERE
	Percent by mass	Percent by volume	Percent by volume	Percent by volume
Oxygen (O)	46.10	94.04	33.0	21.0
Silicon (Si)	28.20	0.88		
Aluminum (Al)	8.23	0.48		
Iron (Fe)	5.63	0.49		
Calcium (Ca)	4.15	1.18		
Sodium (Na)	2.36	1.11		
Magnesium (Mg)	2.33	0.33		
Potassium (K)	2.09	1.42		
Nitrogen (N)				78.0
Hydrogen (H)			66.0	
Other	0.91	0.07	1.0	1.0

2010 EDITION

This edition of the Earth Science Reference Tables should be used in the classroom beginning in the 2009–2010 school year. The first examination for which these tables will be used is the January 2010 Regents Examination in Physical Setting / Earth Science.



Carbon Dioxide



CO_2 measurements at Hawaii's Mauna Loa Observatory (Oscillations are caused by season variations in plant growth and decay.)

- **Meteorologically important despite its presence in minute amounts.**
- **Proportion is relatively uniform, but the percentage has been steadily rising for more than a century.**

5. Variable Components

a. ___**Water Vapor**_________

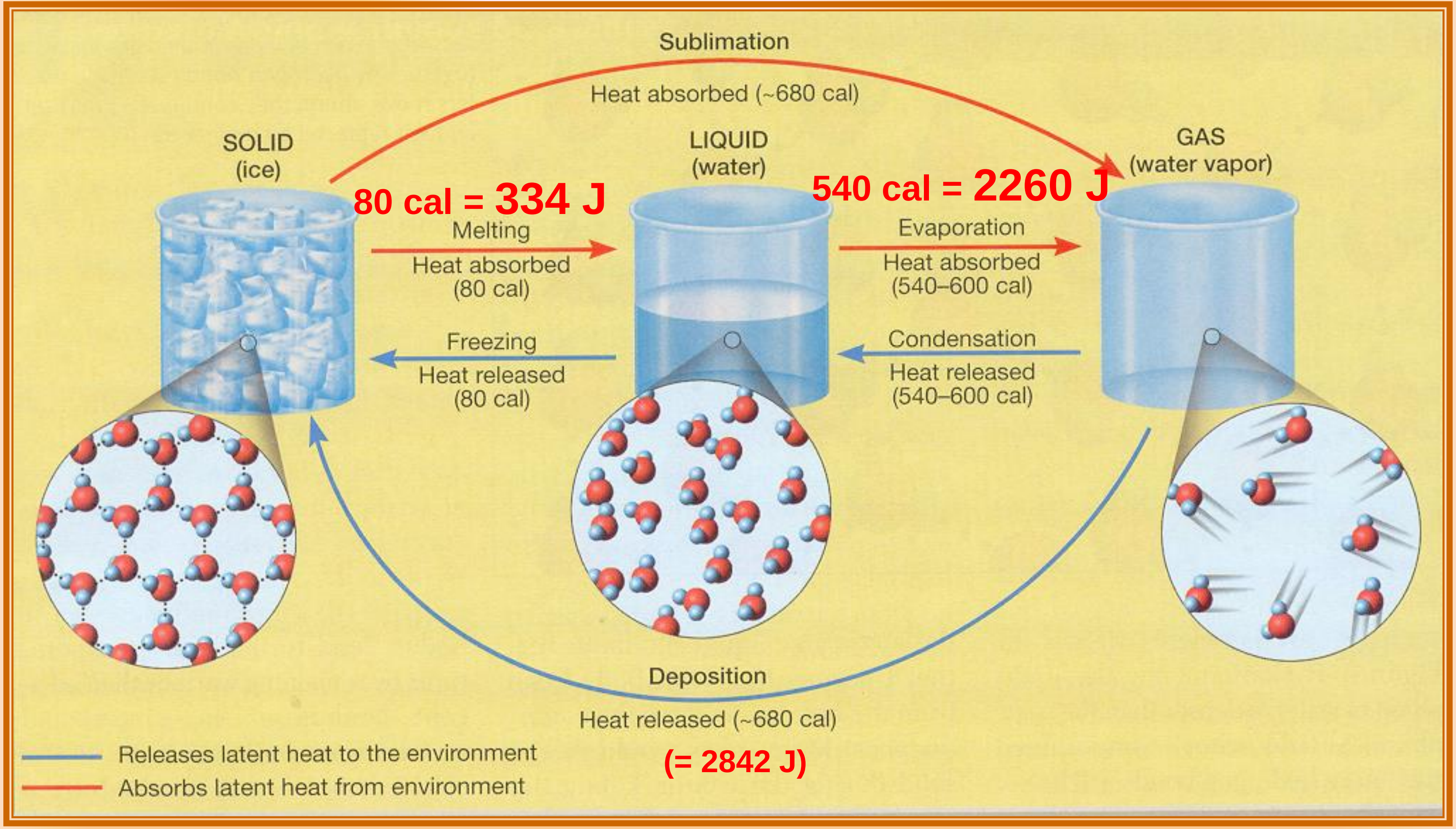
(1) Varies from almost zero to about four percent by volume.

(2) Significance:

(a) It's a good heat ___**absorber**_____.

(b) It's a source of _**heat energy**_ for many storms.

Latent Heat



i) When water changes from one phase to another, it __**gains**__ or __**loses**__ heat.

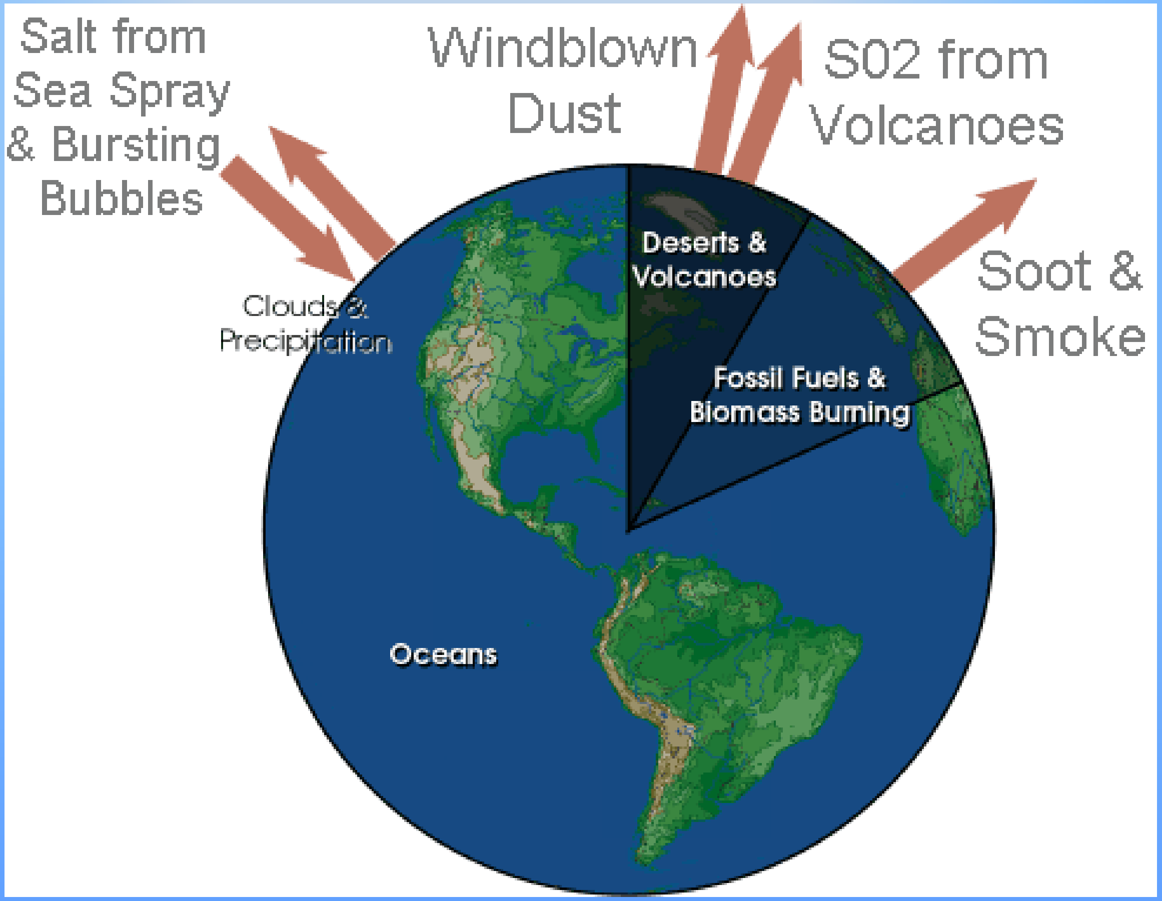
ii) This "hidden" heat is termed _***latent***_ *heat.*

b. **Aerosols**

(1) Suspended **liquid** and **solid** particles

(a) Most are microscopic

(b) Visible dust can be suspended for short periods of time.



Aerosols

(2) Important in cloud formation as the surfaces on which water vapor may condense.

(3) Can be a type of pollutant and can reduce the amount of sunlight reaching Earth’s surface.

(4) Contribute to varied hues of red and orange sunrise and sunset.

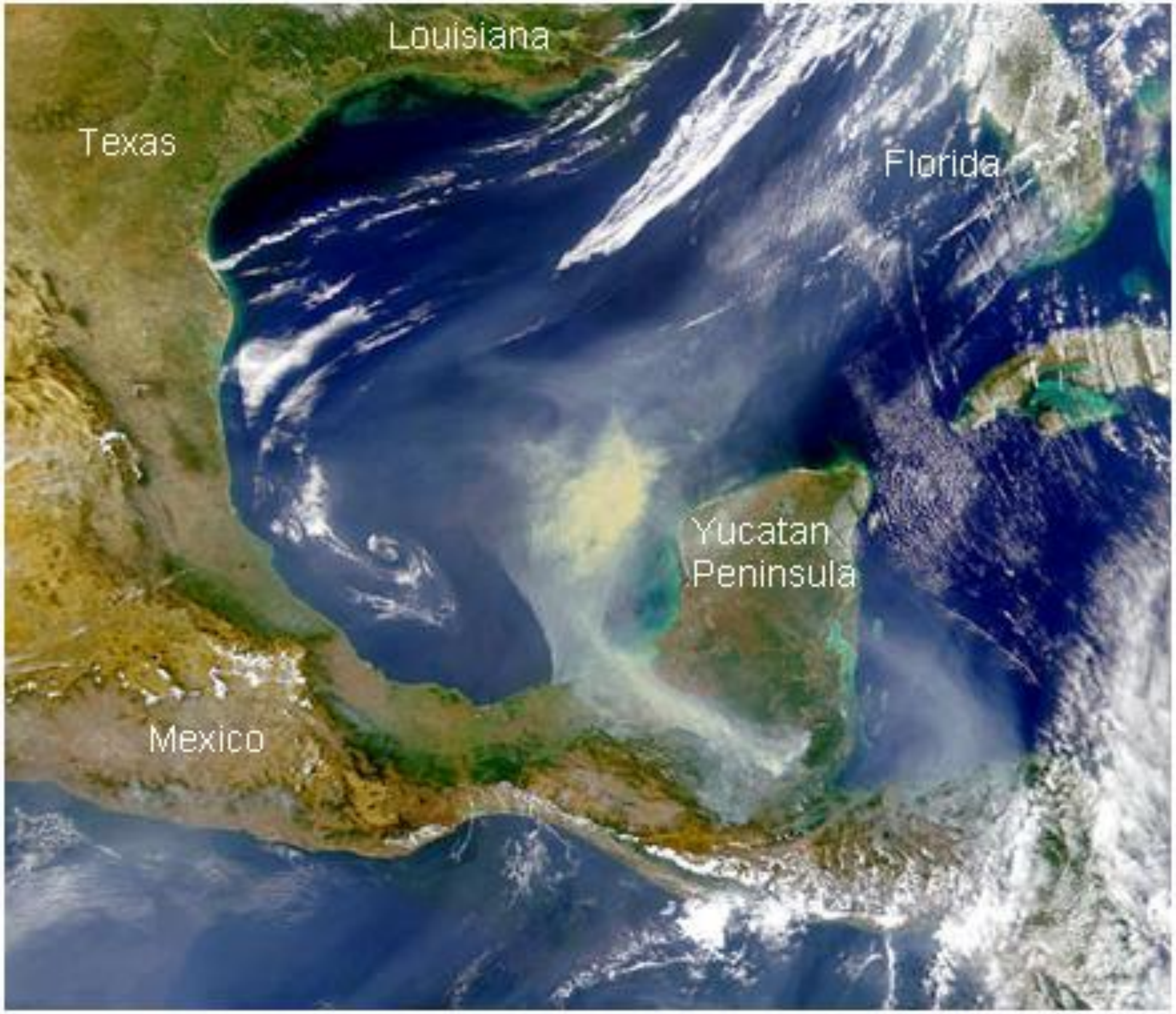
Sunset Affected by Volcanic Ash

Sidney, Australia after the eruption of Mt. Pinatubo

5. Originate from__**natural**__ and__**human-made**__ sources

(a) Sulfur dioxide and dust from volcanic eruptions

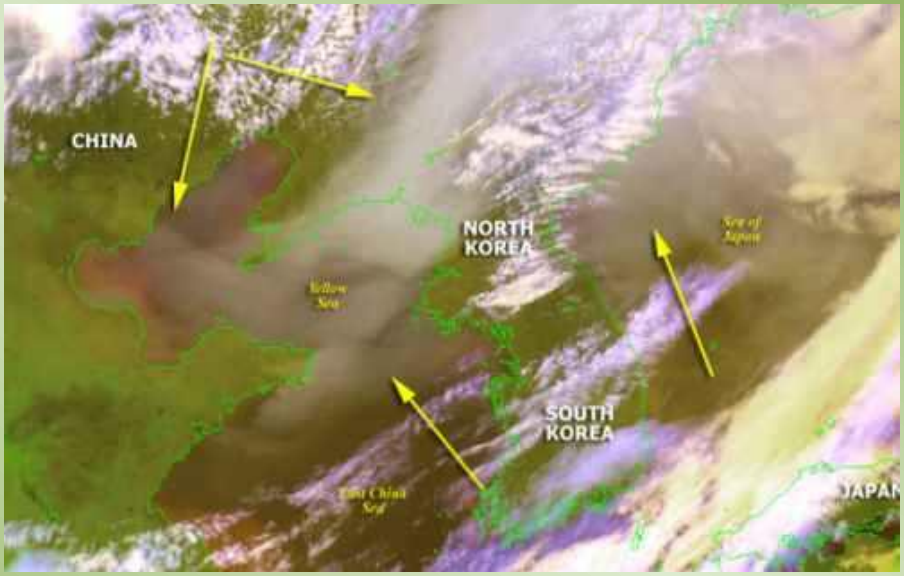
(b) Smoke and soot from fires



Satellite image of smoke aerosols (milky white areas) from forest burning in Mexico and Central America (NASA).

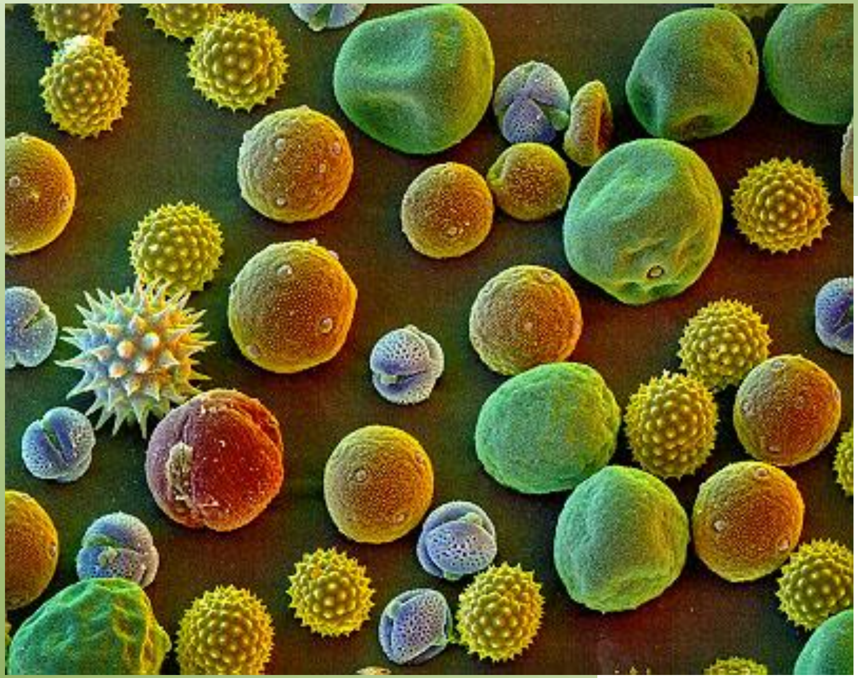
Industrial Sources

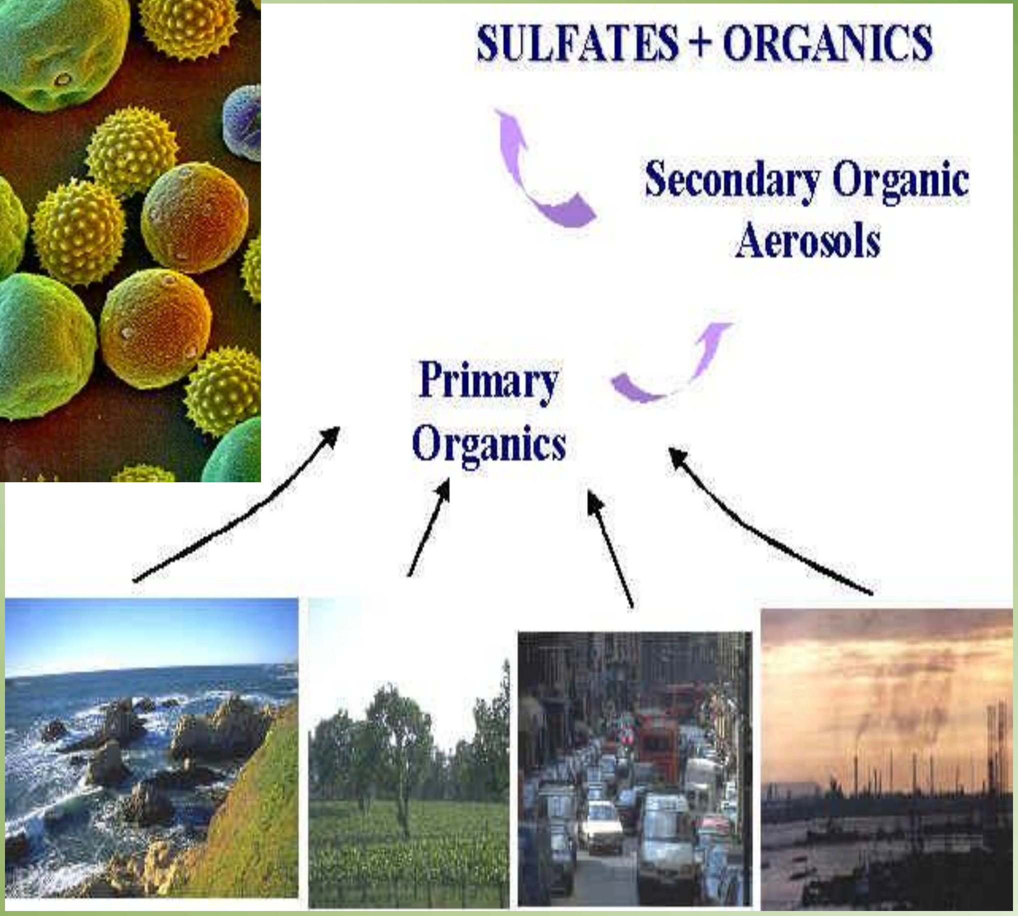
(c) Fine soil particles



(d) Sea Salts from breaking waves

(e) Pollen and other microorganisms





c. Ozone

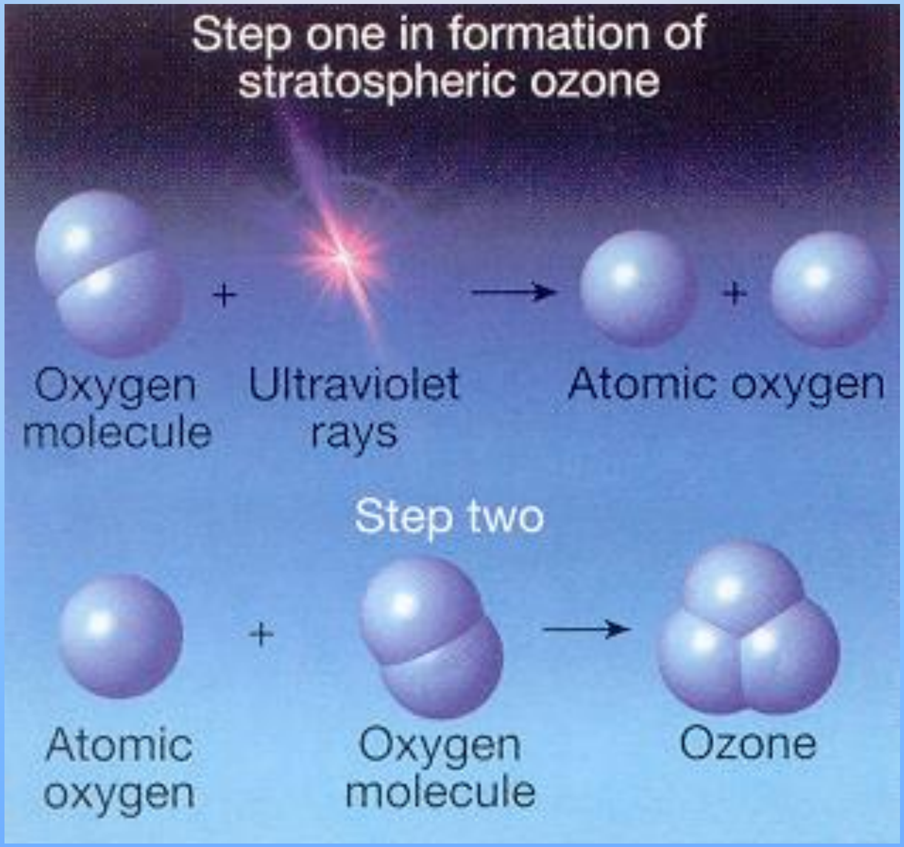
(1) Triatomic form of Oxygen (**O_3**)

(2) Forms as a result of the collision of an atom of oxygen (O), a molecule of oxygen (O_2). Reaction is a result of **short-wave ultraviolet** solar radiation splitting molecules of oxygen.

(3) Concentrated in the upper **stratosphere**.

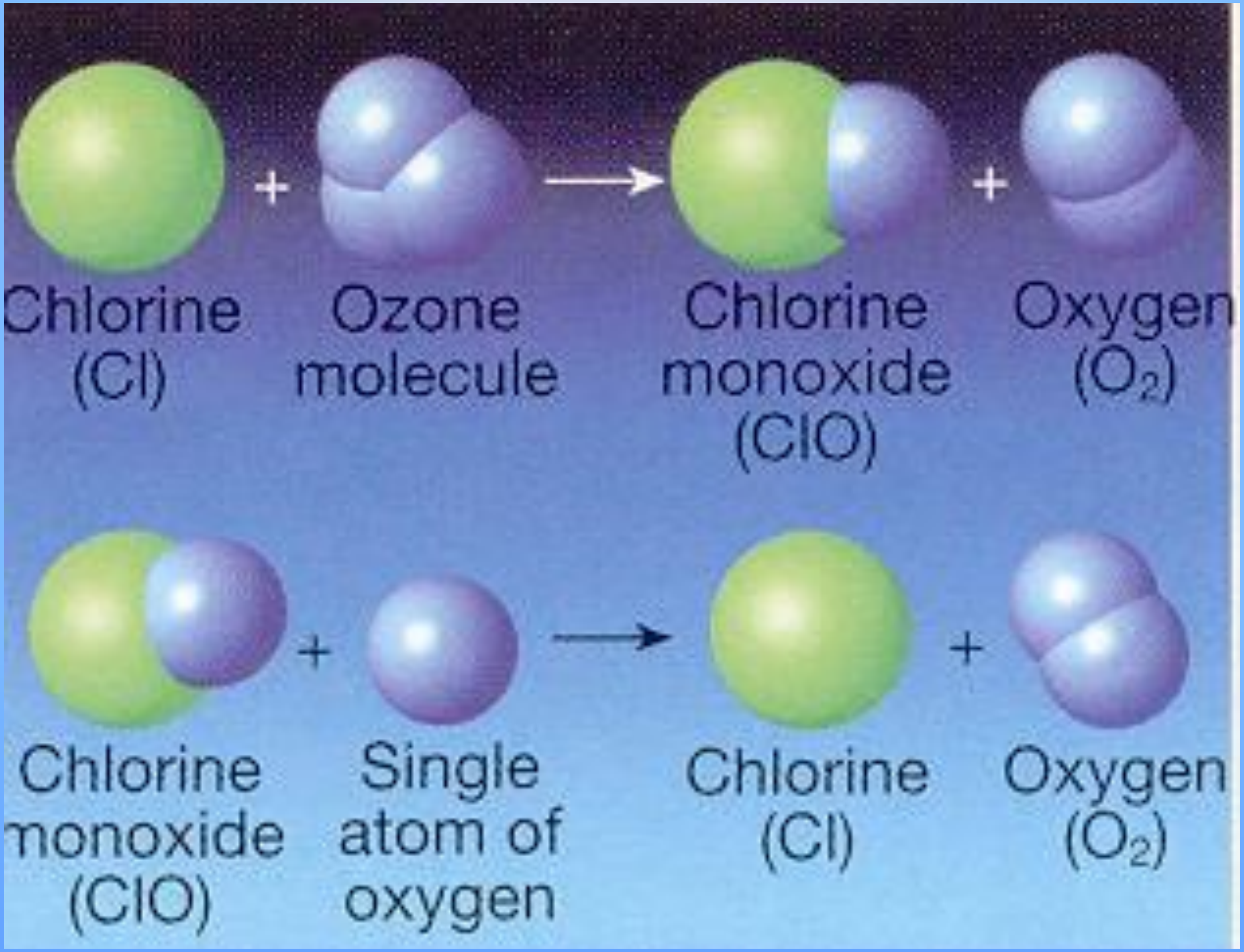
(4) Also a photochemical pollutant at Earth's surface.

Formation of Ozone in the Stratosphere (10 to 50 km altitude)

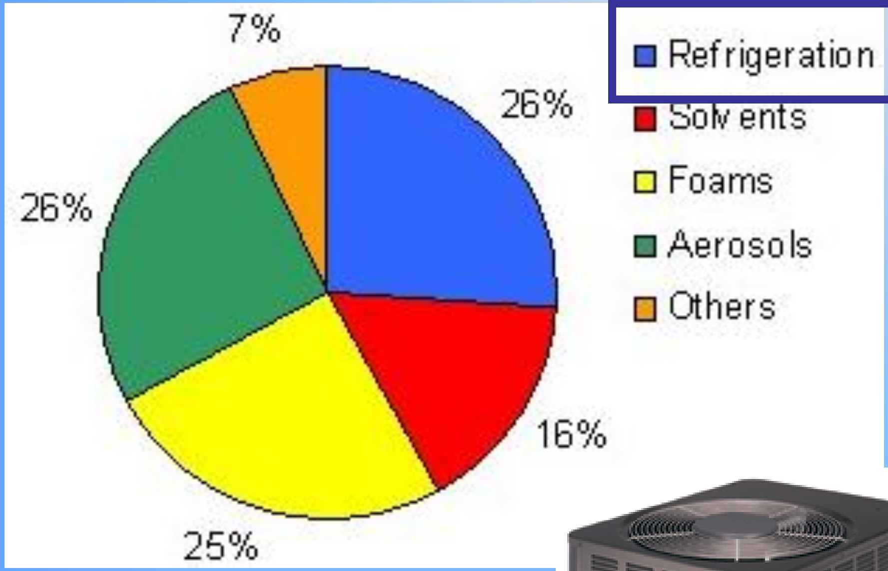


The *Ozone-Oxygen Cycle*

Destruction of Ozone by Free Chlorine Atoms



Source of Chlorine – Chlorofluorocarbons (CFC's)



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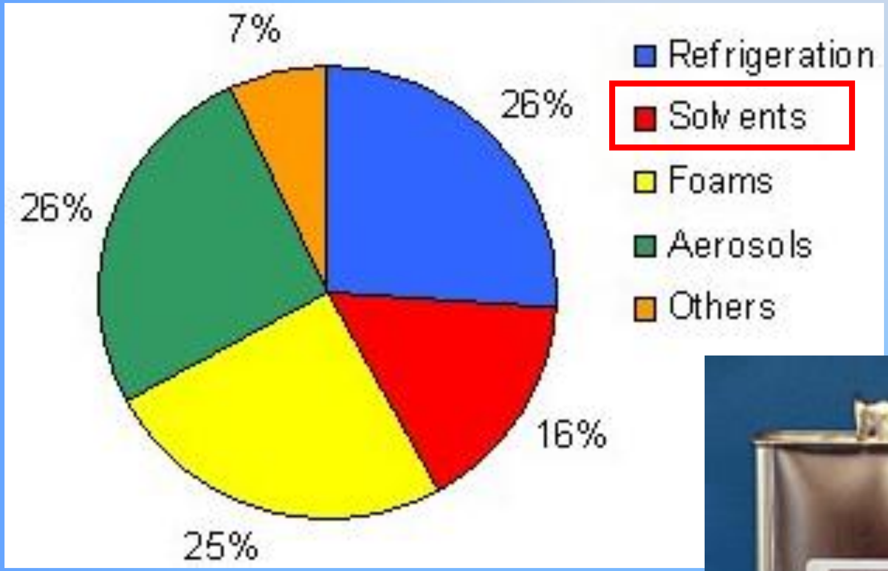

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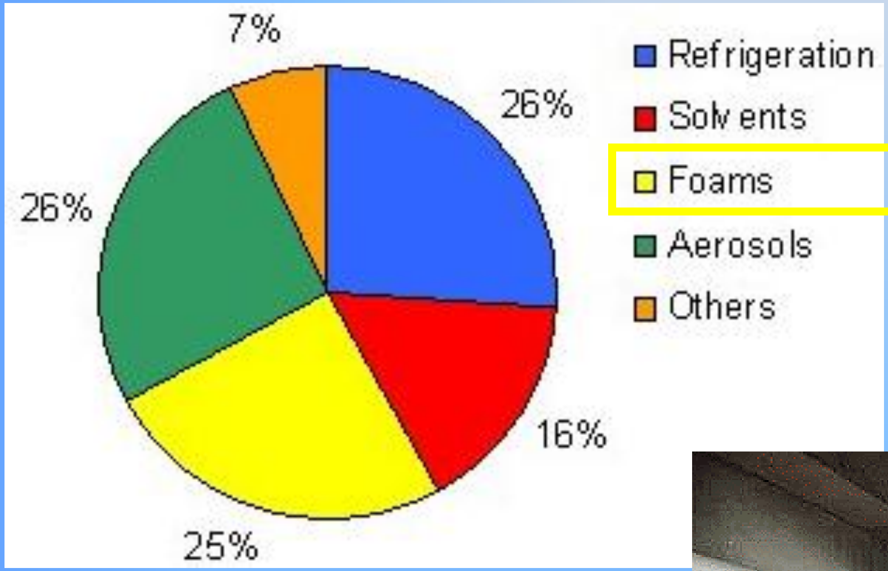
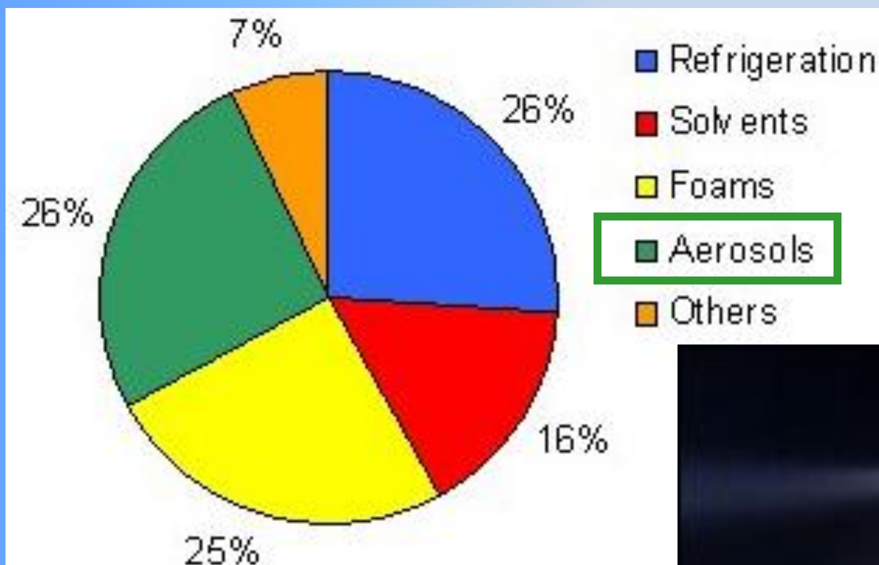
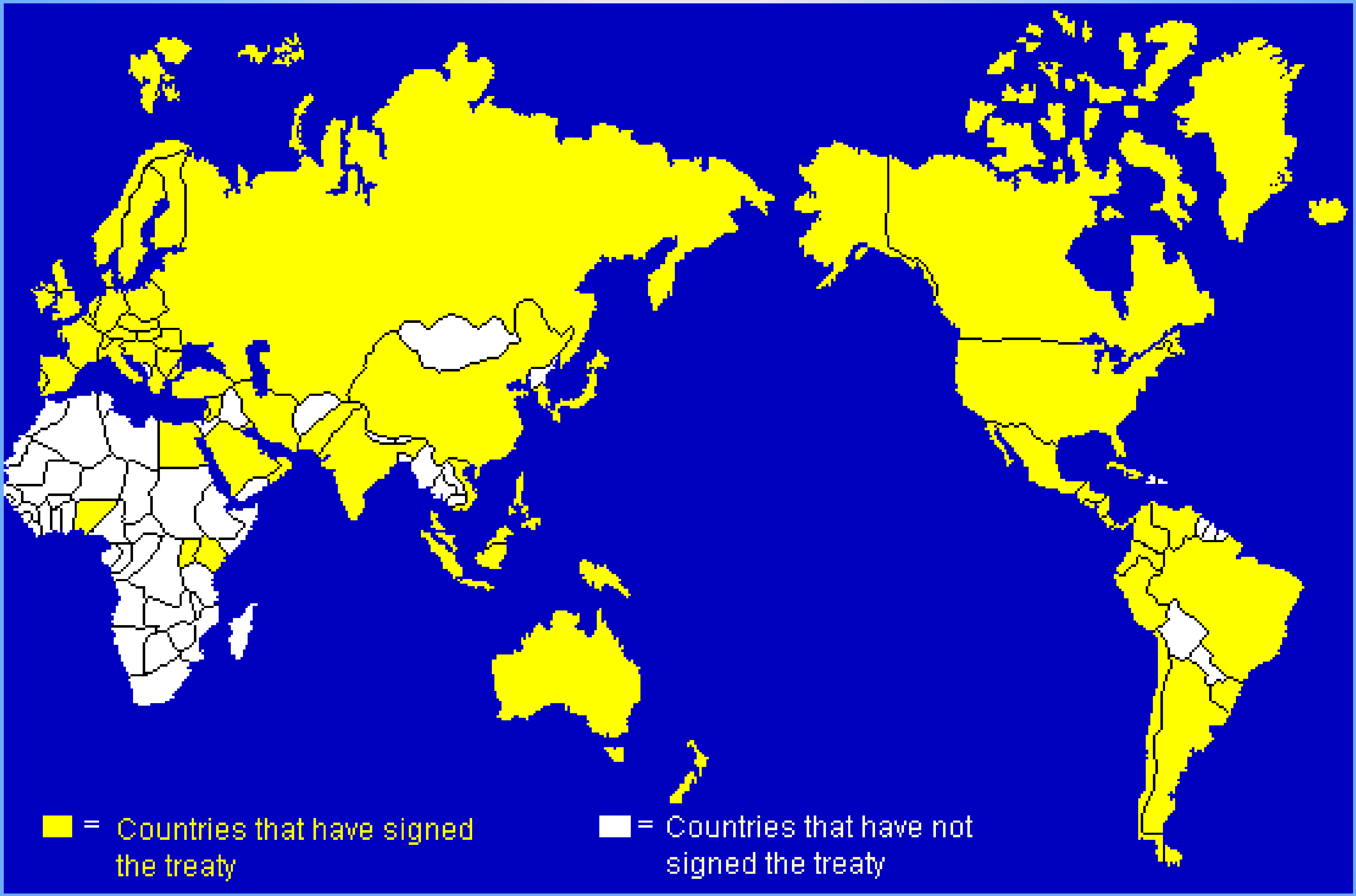


Source of Chlorine – Chlorofluorocarbons (CFC's)



The Montreal Protocol - 1987

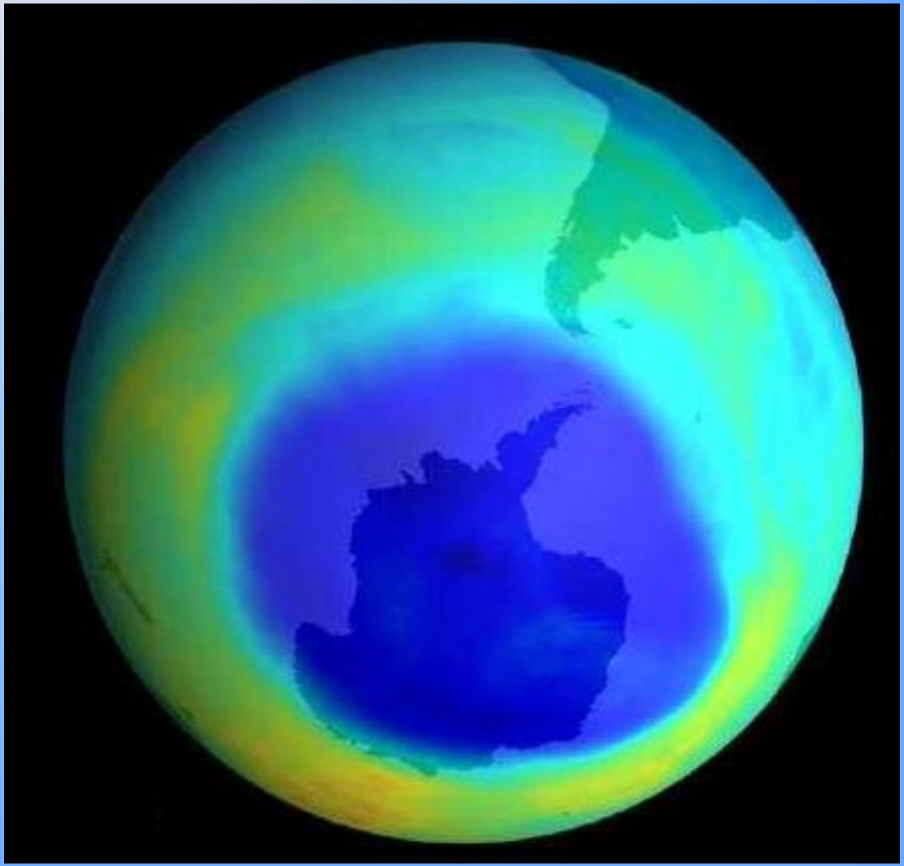


- Signed in 1987, more than 40 countries agreed to phase out ozone depleting compounds by 2000.

The Antarctic Ozone Hole

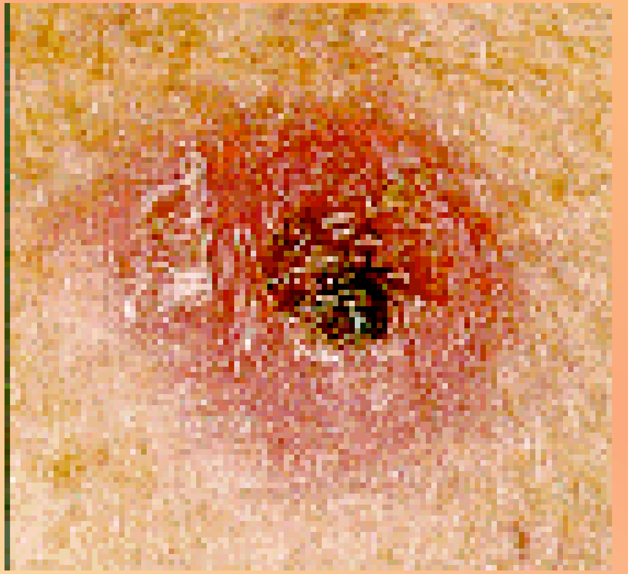
- Caused in part by abundant ice particles in the Antarctic stratosphere.
- Ice increases ability of CFCs to destroy ozone.
- Maximum depletion is confined to the Antarctic by a swirling in upper-level wind pattern in the southern hemisphere spring.

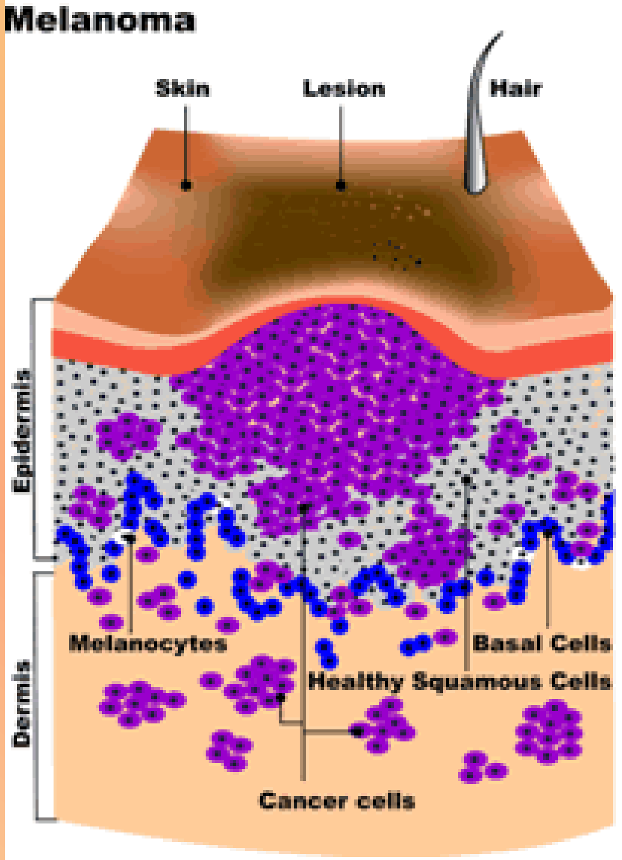
Sept. 17, 2001- The ozone hole covers an area about the size of North America.



Blue colors = sparsest ozone
Light blue, **green**, and **yellow** indicate progressively more ozone

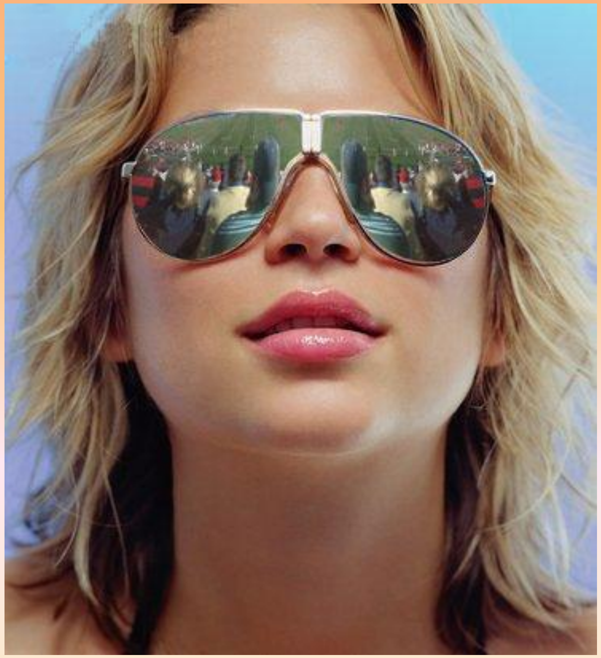
Effects of Increased UV Radiation Concentrations – Skin Cancer





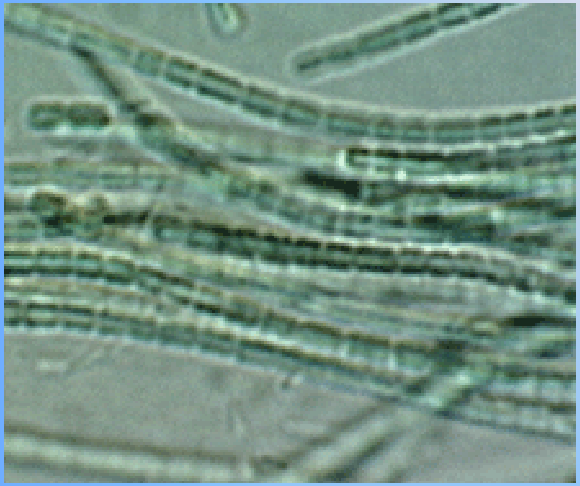
Additional cases of skin cancer, especially among fair-skinned people and those who spend considerable time in the Sun

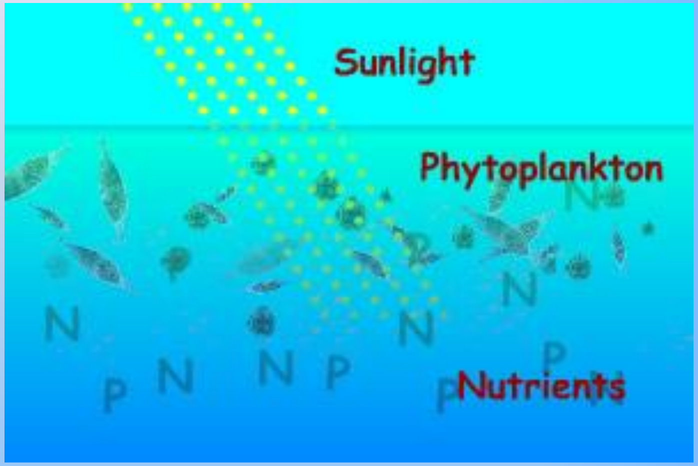
Cataracts – A Clouding of the Eye



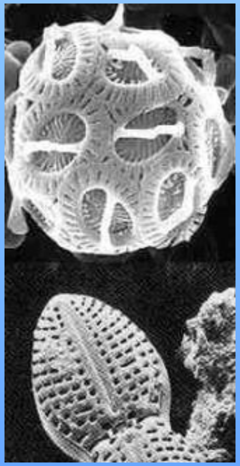
Reduction in Crop Yields and Quality

Antarctic Phytoplankton Could Be Impaired or Destroyed



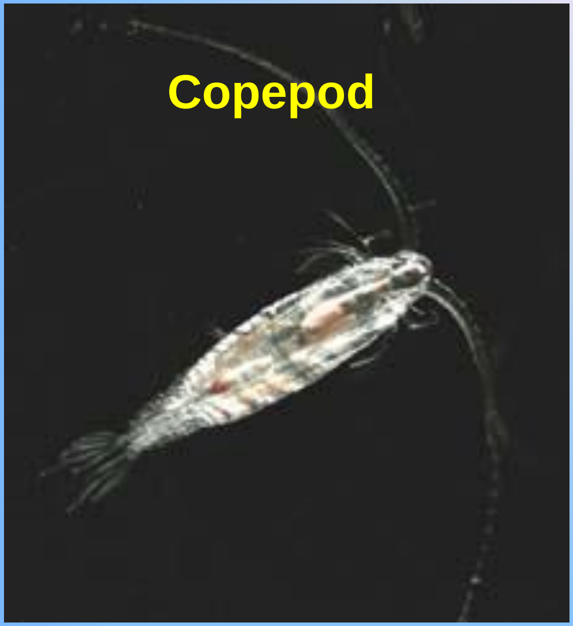


- These microscopic plants are the base of the food chain.
- Could reduce the krill and copepods that sustain fish, whales, and other marine life in higher latitudes of the Southern Hemisphere



Common marine phytoplankton

Marine Food Chain Interupted



C. *Height and Structure of the Atmosphere*

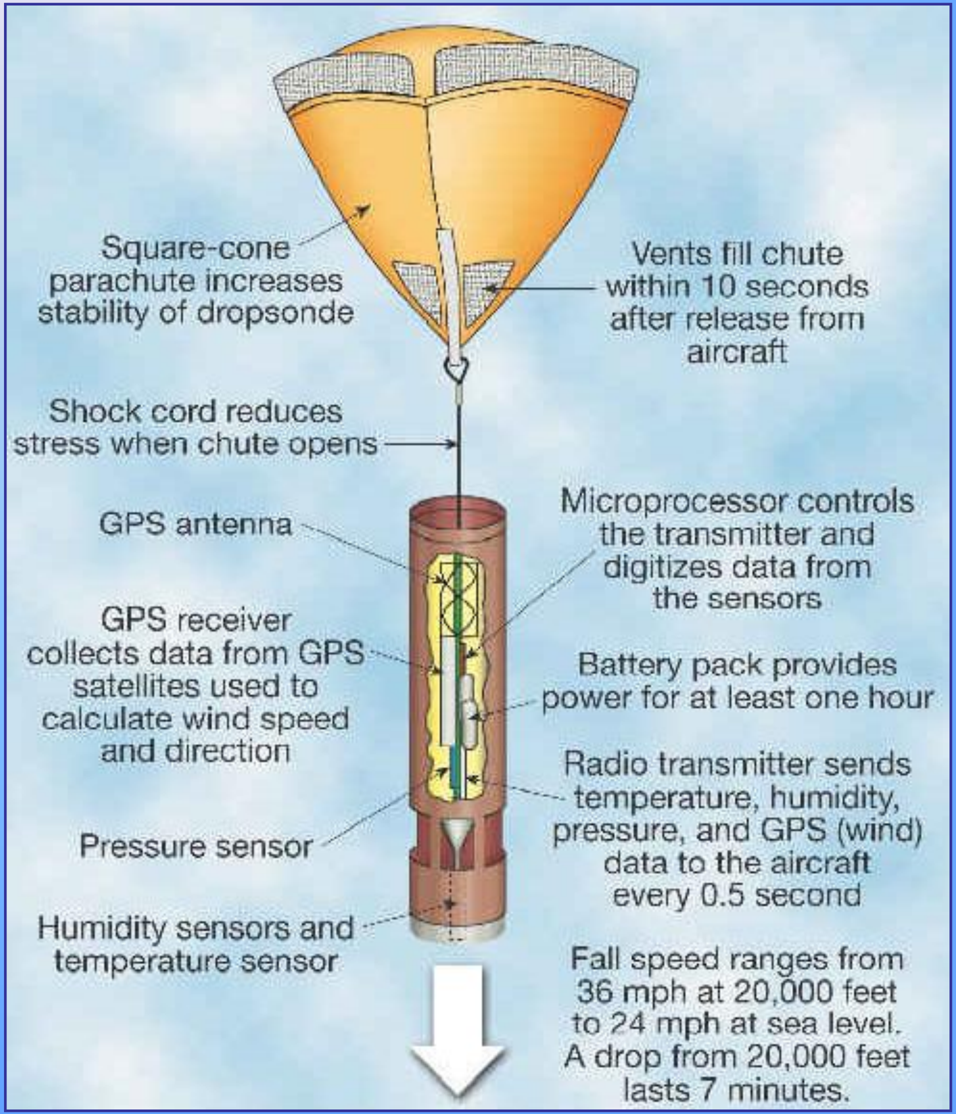
1. Data Collection

Balloons and Radiosondes

Radiosondes are lightweight instrument packages that transmit data. They are released twice daily.

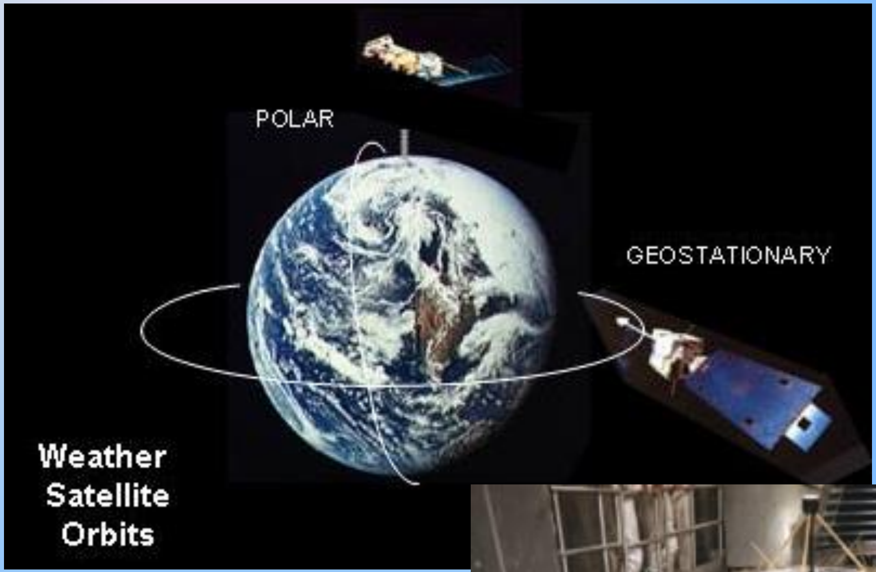
Airplanes

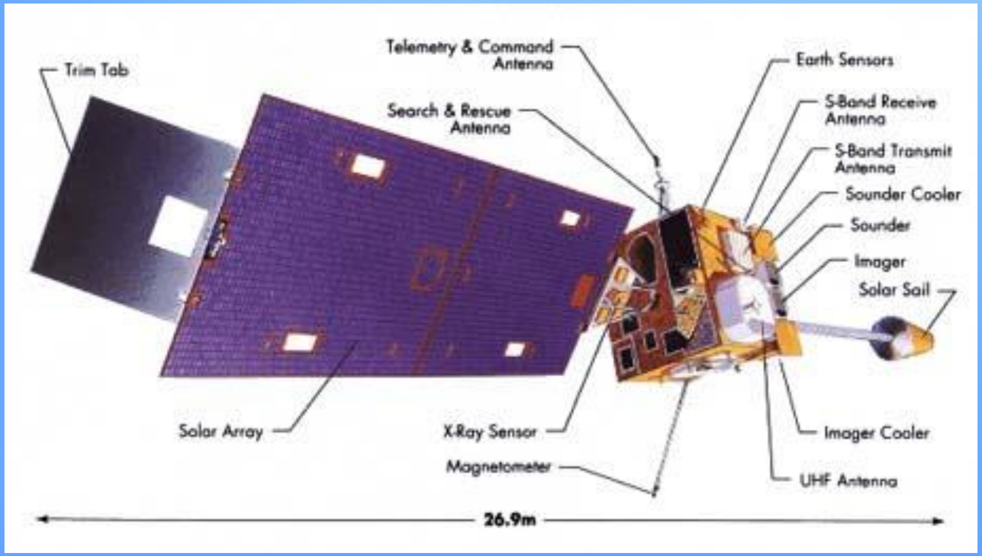
Dropwindsonde (Dropsonde)



Rockets

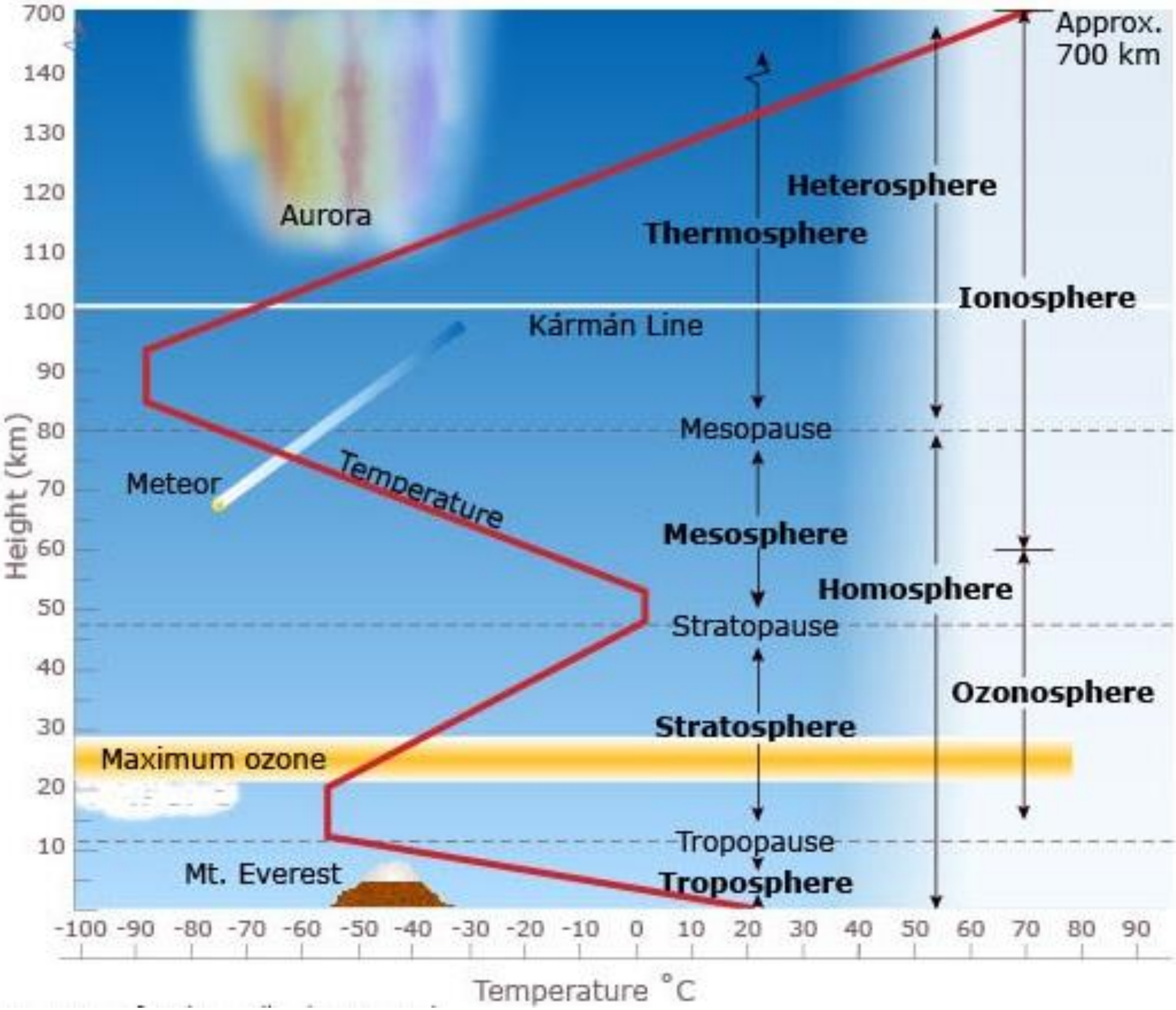
Satellites


POLAR
GEOSTATIONARY
Weather Satellite Orbits


Trim Tab
Telemetry & Command Antenna
Search & Rescue Antenna
Earth Sensors
S-Band Receive Antenna
S-Band Transmit Antenna
Sounder Cooler
Sounder
Imager
Solar Sail
Solar Array
X-Ray Sensor
Magnetometer
Imager Cooler
UHF Antenna
26.9m

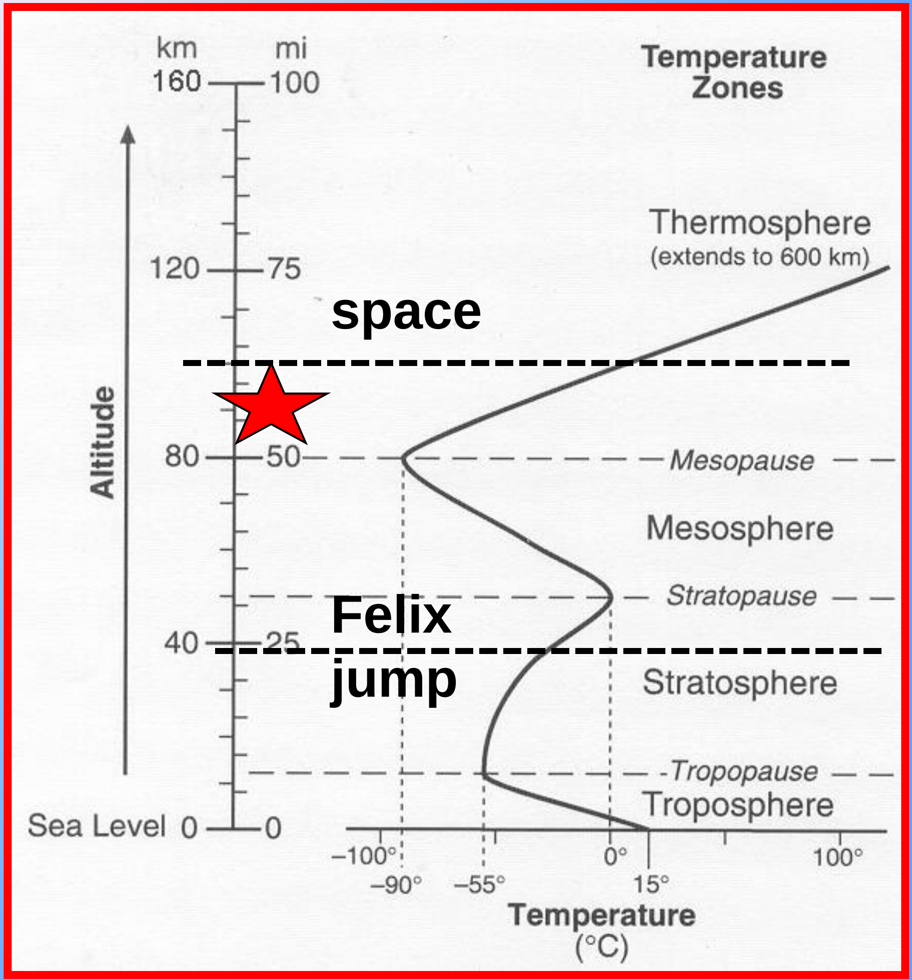
2. The Vertical Extent of the Atmosphere

a. There is __**no sharp boundary**___defining the end of the atmosphere and the beginning of space.
b. A majority of the atmosphere is __**very near**_Earth's surface and the gases gradually merge with the void of space.
c. __**One-half**_____of the atmosphere is below an altitude of 5.6 km (3.5 mi)
d. __**90**__percent lies below 16 km (10 mi.)
e. Above 100 km (62 mi.): 3.0 x 10 -5 of gases remain. This is the official altitude of __**space**_____.



Approx.
700 km
Heterosphere
Aurora
Thermosphere
Ionosphere
Kármán Line
Mesopause
Meteor
Temperature
Mesosphere
Homosphere
Stratopause
Ozonosphere
Stratosphere
Maximum ozone
Tropopause
Mt. Everest
Troposphere
Height (km)
700
140
130
120
110
100
90
80
70
60
50
40
30
20
10
-100 -90 -80 -70 -60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60 70 80 90
Temperature °C

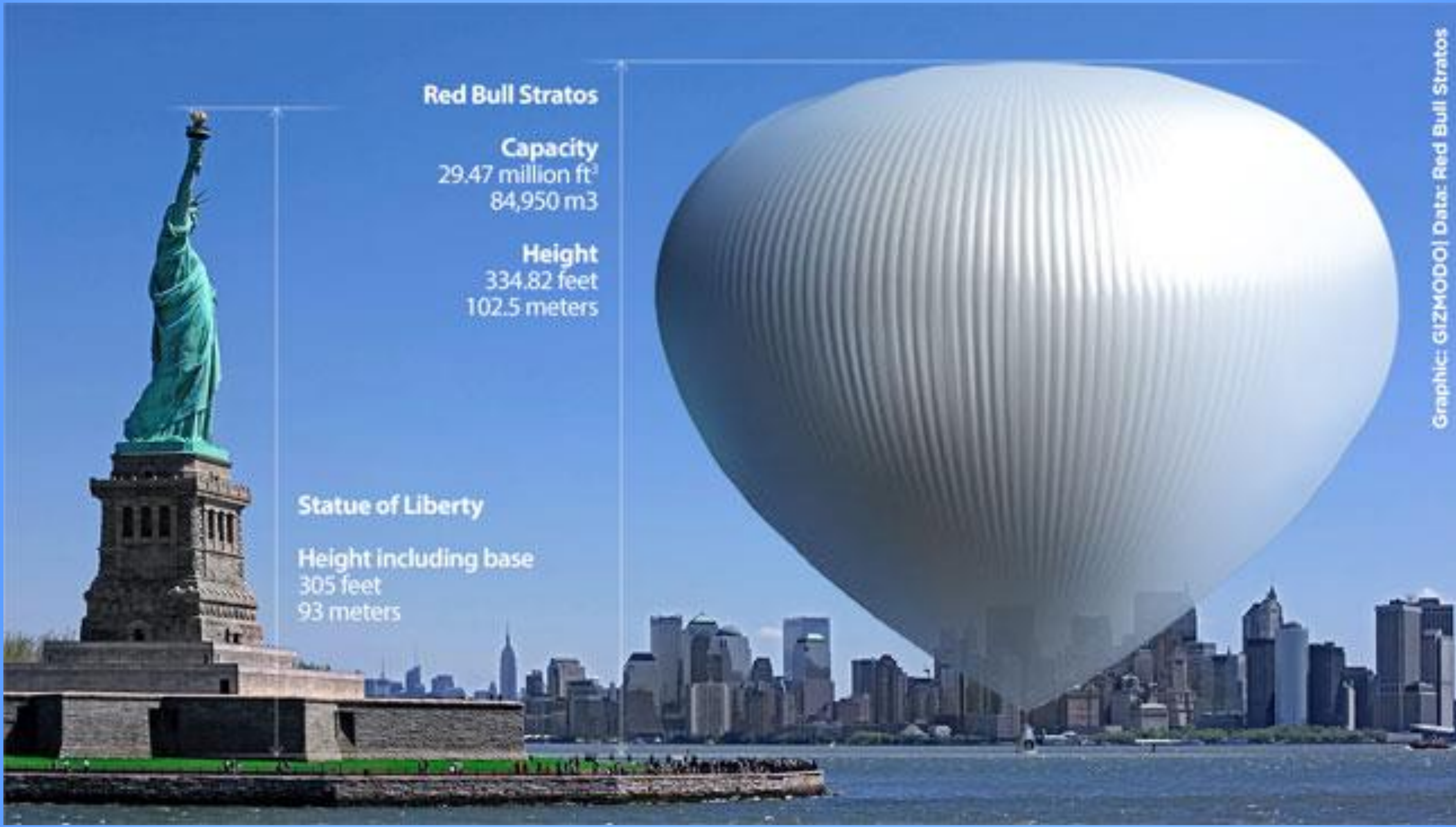
The X-15 Flew to the Edge of Space



- The X-15 was released at high altitudes from a B-52
- It made 199 flights between 1959 and 1968.
- Maximum altitudes of flights ranged from 81.5 km to 107.0 km

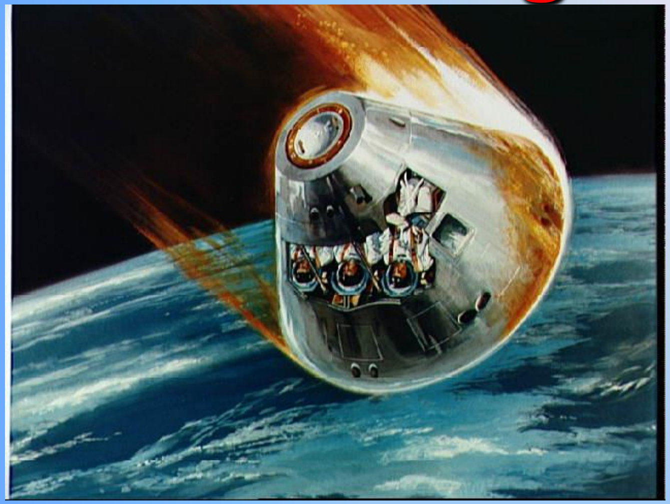
Jumping from 'space'

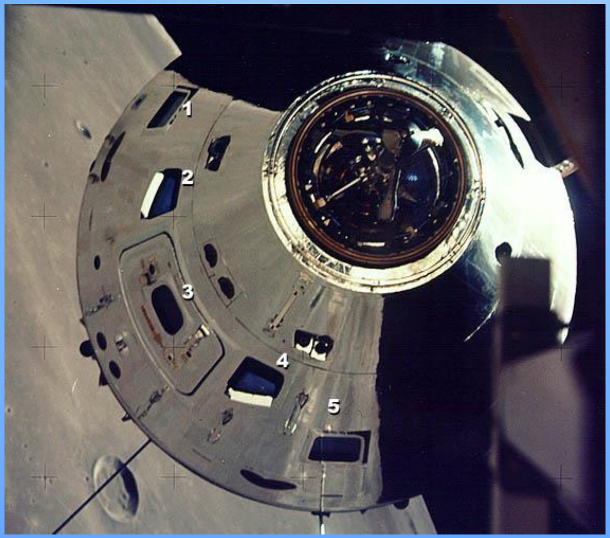
- After flying to an altitude of 39,045 meters (128,100 feet) in a helium-filled balloon,
- **Felix Baumgartner** completed a record breaking jump from the edge of space, on 14 October 2012, and became the first person to break the sound barrier (833 mph), or Mach 1.24, without vehicular power on his descent
- **Felix reached a maximum of speed of 1,342.8 km/h (833mph) through the near vacuum of the stratosphere before being slowed by the atmosphere later during his 4:20 minute long freefall.**
- **(speed of sound = 768 mph)**
- **The 43-year-old Austrian skydiving expert also broke two other world records (highest freefall, highest manned balloon flight), leaving the one for the longest freefall to project mentor Col. Joe Kittinger**
- **https://www.youtube.com/watch?v=FHtvDA0W34I**



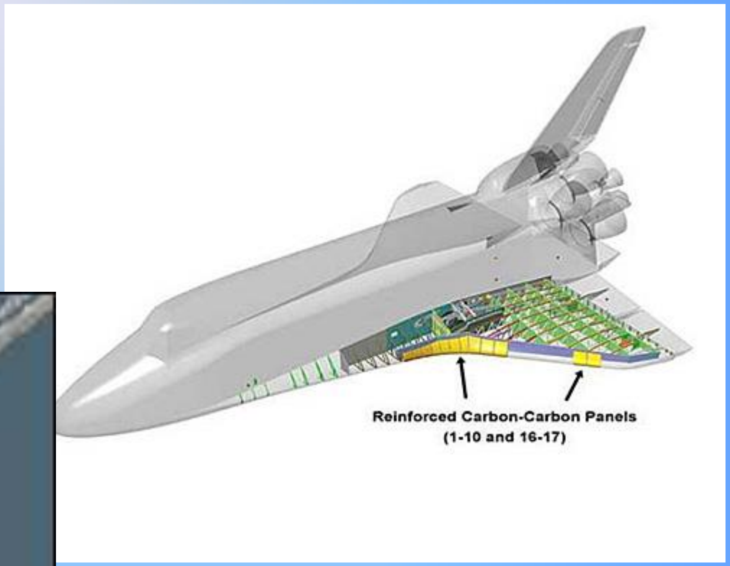
A comparison of the Statue of Liberty to the balloon Felix Baumgartner used to ascend his capsule to 39 km, when he completed a record breaking jump from the edge of space, on 14 October 2012.

Even at High Altitudes There's Air





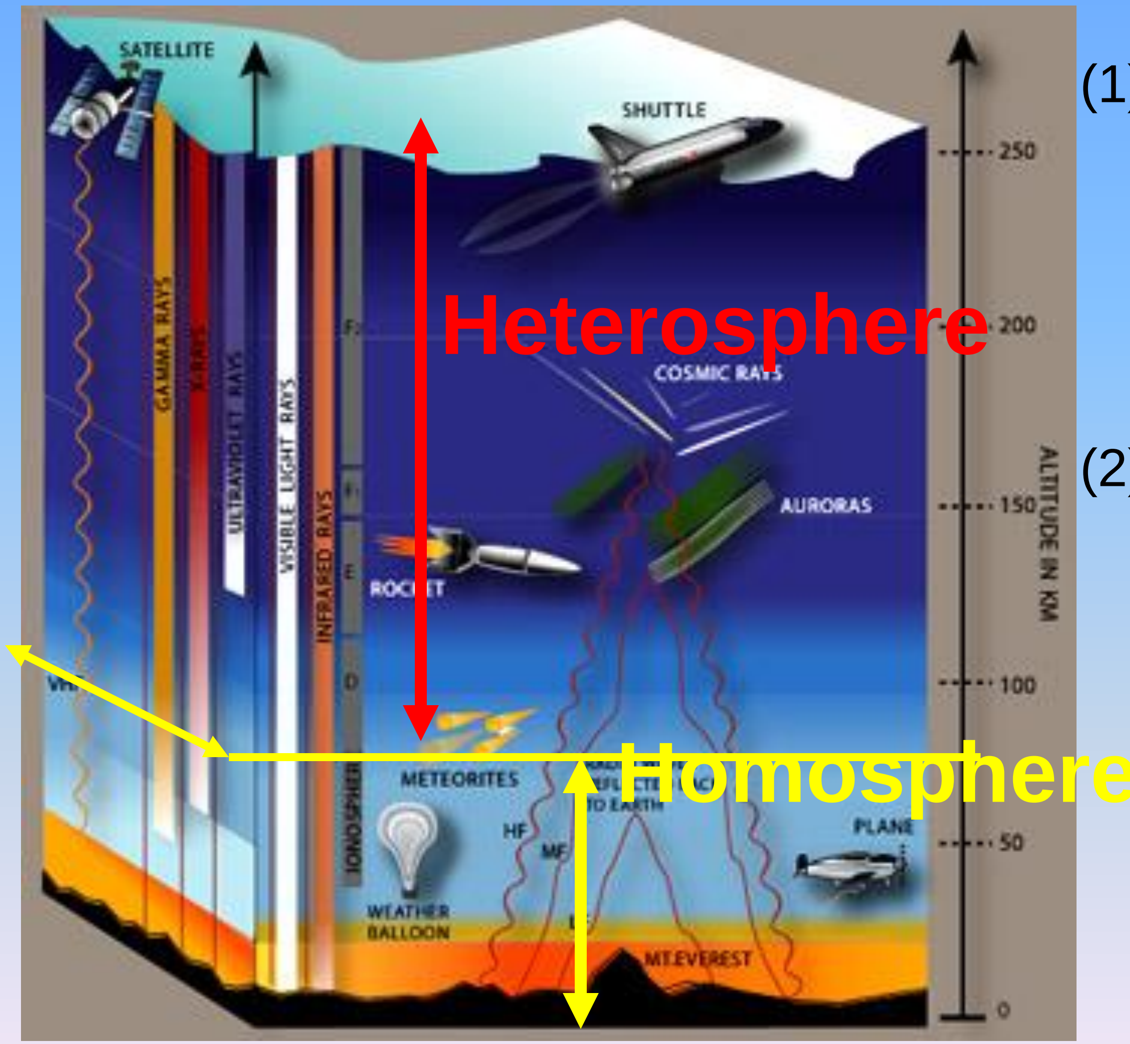
Space Shuttle Columbia



- As Columbia descended from space into the atmosphere at 120 km, the heat produced by air molecules colliding with the Orbiter typically caused wing leading-edge temperatures to rise steadily, reaching an estimated 2,500 degrees Fahrenheit (1400 °C).

3. Classification of the Atmosphere

a. By *Composition*



(1) Homosphere:

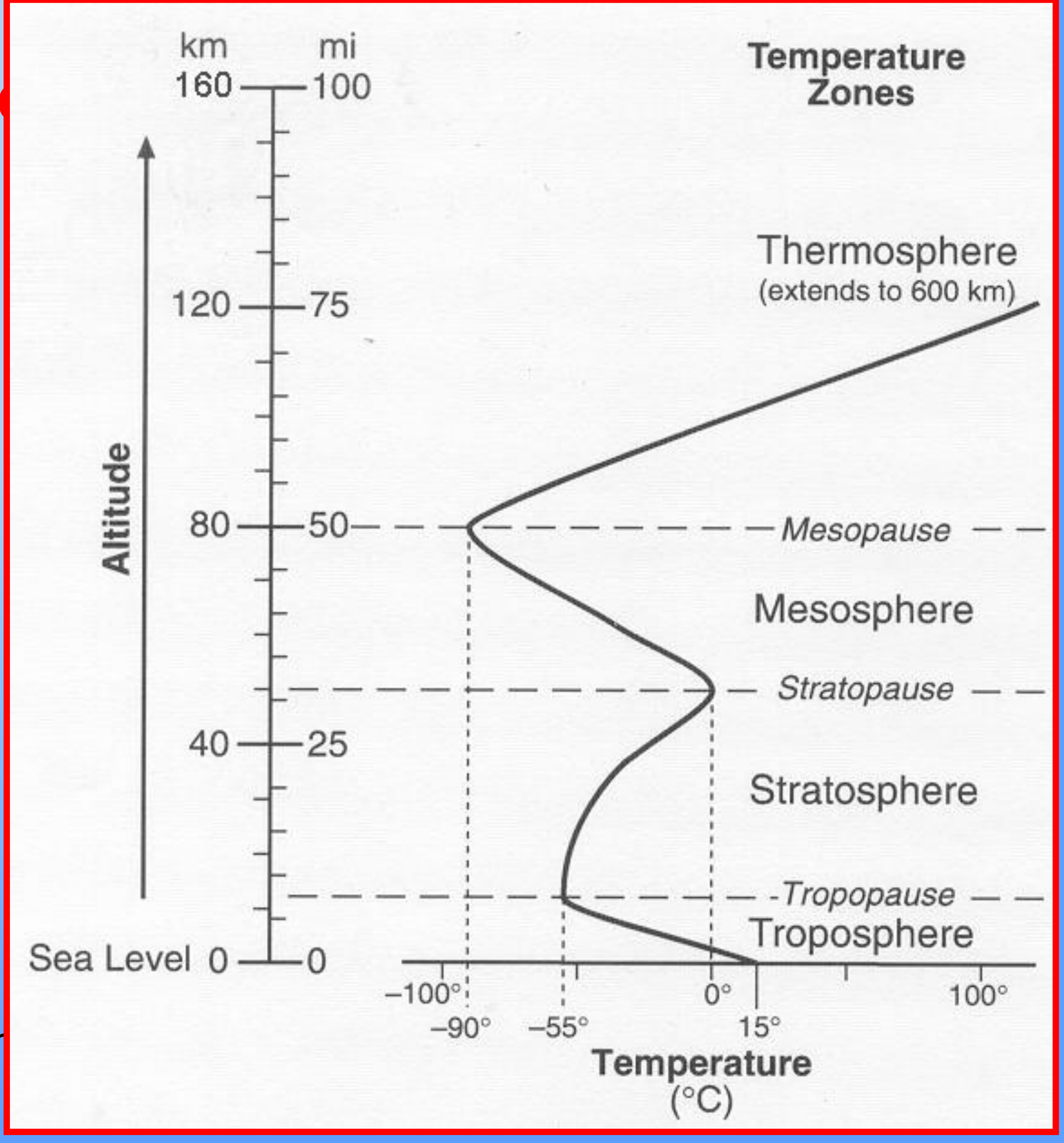
Up to an altitude of about 80 km (50 mi) makeup of the air is uniform in terms of the proportions of its component gases.

(2) Heterosphere

(a) Above 80 km composition is not uniform

(b) Four roughly spherical shells (lowest is nitrogen, then atomic oxygen, followed by a layers of helium, and hydrogen).

b. By Tempe



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b. By Temperature

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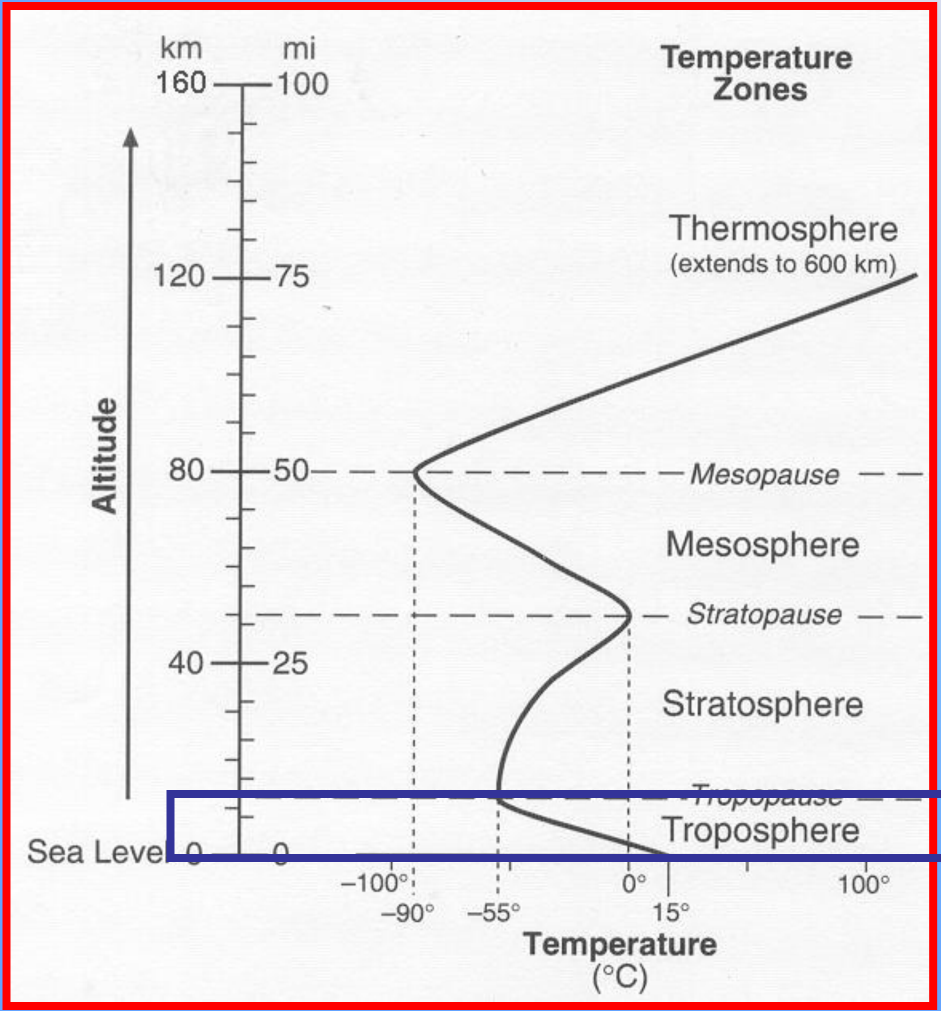


(1) **Troposphere**:

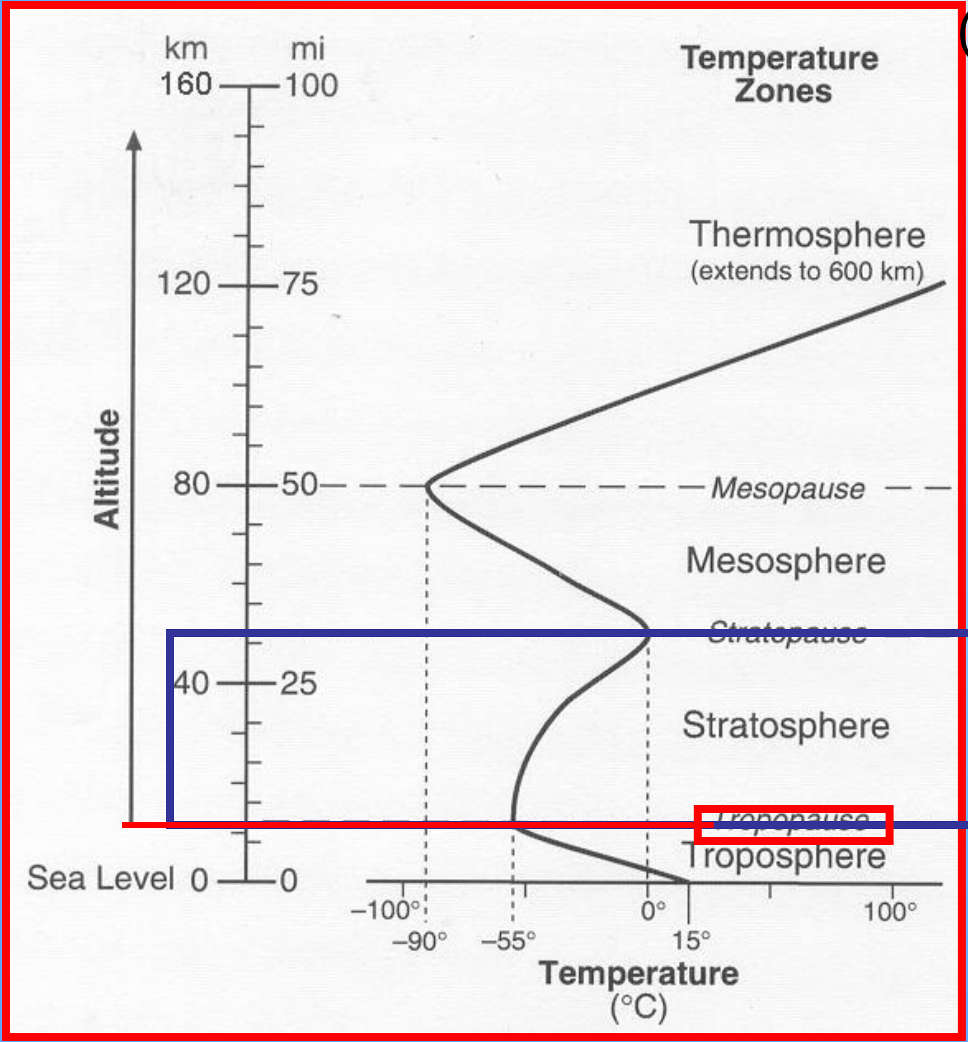
(a) The bottom layer in which we live.

(b) Temperatures **decrease** with altitude ("environmental lapse rate")on the average of 6.5º C per kilometer (3.5º F per mile).

(c) Temperature decrease continues to about 12 km but is thickest at the equator (16 km or about 10 miles) and thinnest at the poles (9 km or about 5.5 miles)

(d) This is the **chief focus of meteorologists because it is in this layer that all important weather phenomenon occur**.

b. By Temperature



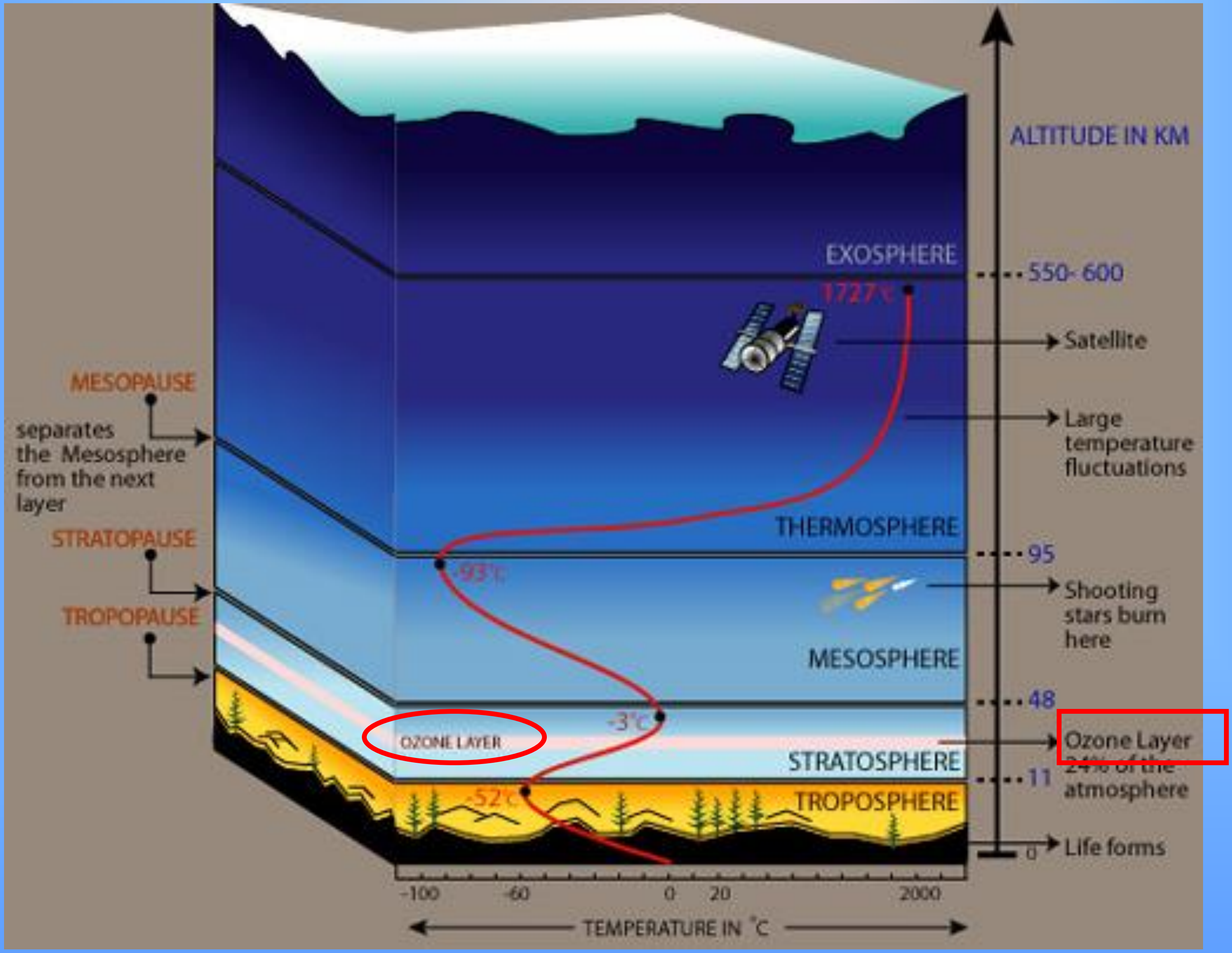
(2) **Stratosphere**:

(a) Above the troposphere

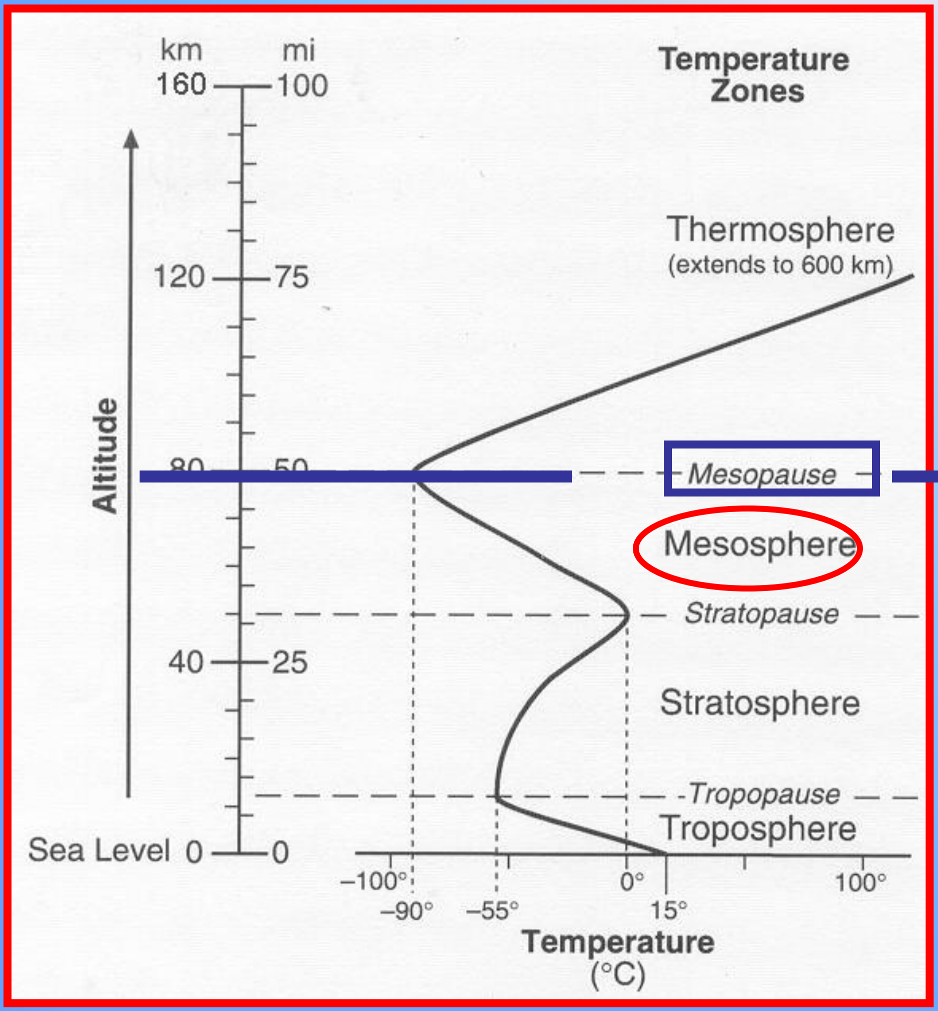
(b) The **Tropopause** is the boundary between the troposphere and stratosphere.

(c) Temperature remains constant to about 20 km (12 mi) and then sharply increases.

d. The cause of temperature increase in upper stratosphere is the concentration of atmospheric __**ozone**__.



b. By Temperature



(3) **Mesosphere**

(a) Temperatures **decrease** ` with height.

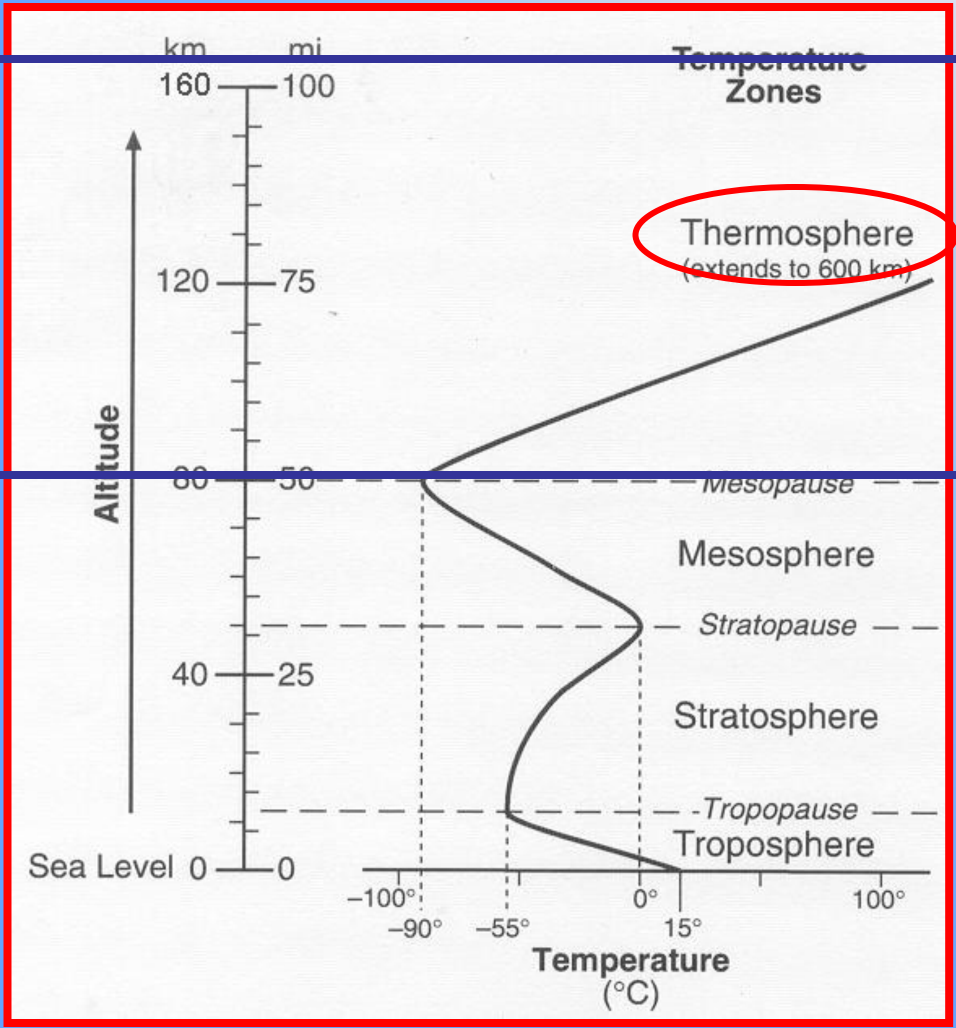
(b) The coldest temperatures anywhere in the atmosphere are at the **Mesopause**.

(c) One of the least explored regions of the atmosphere.

(i) Balloons can't go that high.

(ii) Not accessible to lowest orbiting satellites.

b. By Temperature



(4) **Thermosphere**

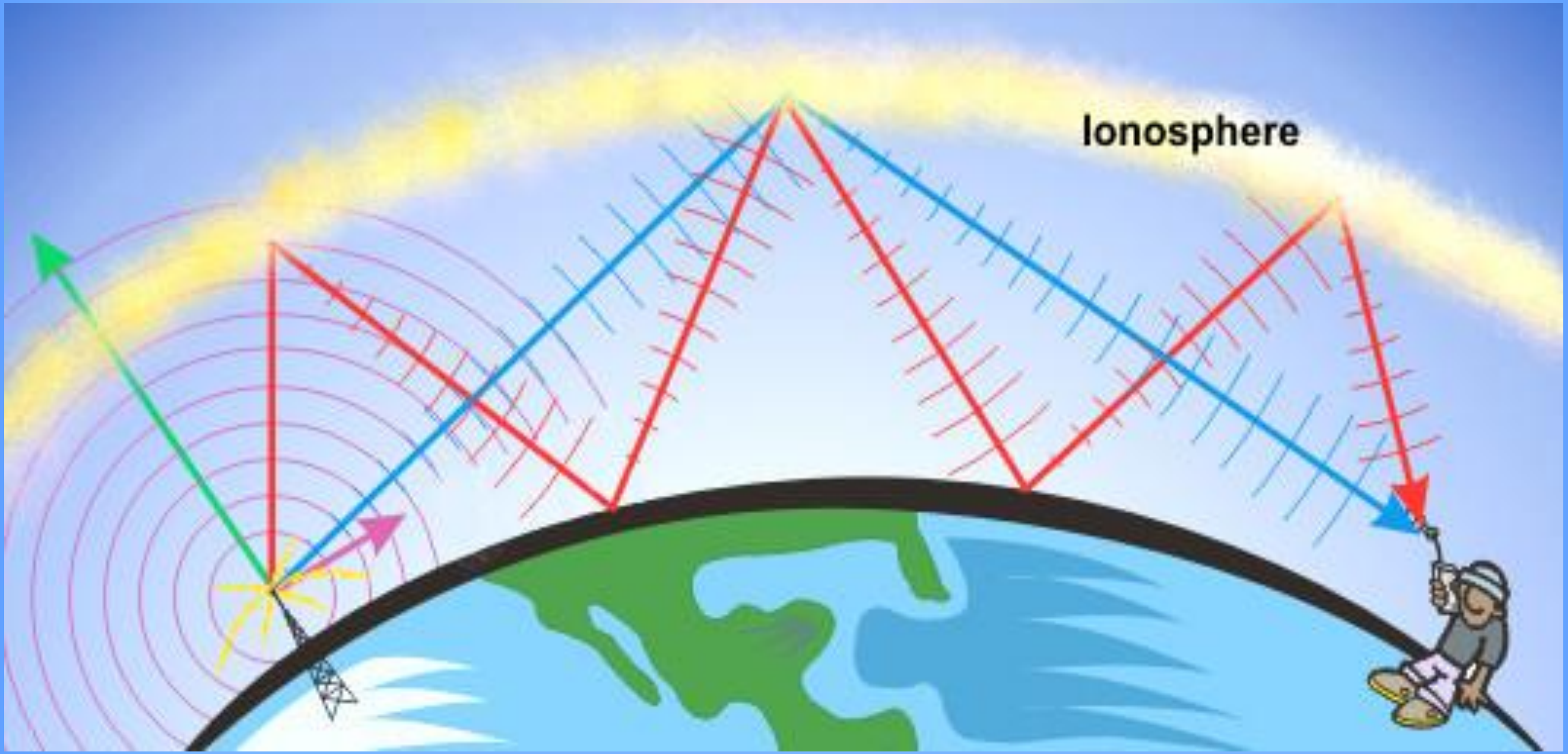
(a) No well-defined upper limit.

(b) Contains only a minute fraction of the atmosphere's total mass (rarefied and considered a vacuum.

(c) Temperatures increase due to absorption of very shortwave, high-energy solar radiation by atomic oxygen and nitrogen.

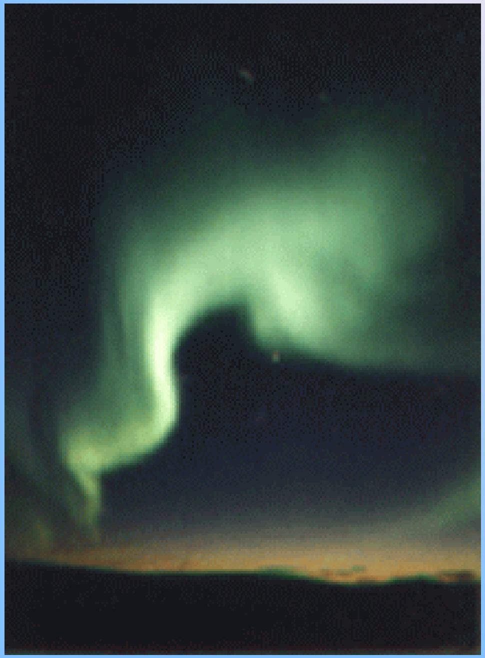
(d) While **temperatures may be extremely high, the total amount of heat is very low because the gases are so sparse. As a result, an object (such as a satellite) exposed to the air in this layer would not feel hot.**

(c) The Ionosphere



(1) Electrically Charged layer (located in the Thermosphere)
(2) Shortwave solar radiation ionizes molecules of nitrogen and oxygen
(3) Between 80 to 400 km altitude (50 to 250 mi) is zone of the greatest density
(4) Shortwave solar radiation ionizes molecules of nitrogen and oxygen.
(5) Actually three layers (D, E, and F which is the highest). D and E layers weaken at night.
(6) Little impact on daily weather.
(7) Used for short-wave radio communications.

Aurora Borealis, the northern lights and Aurora Australis, southern lights



- Correlated with solar-flare activity and in geographic location with Earth's magnetic poles.
- Clouds of protons and electrons streaming from the Sun are guided by the magnetic field towards the poles.
- The ions energize atoms of oxygen and nitrogen causing them to emit light – the glow of the auroras which is often multicolored streamers.