

General Meteorology

Lecture 2

Sahraei

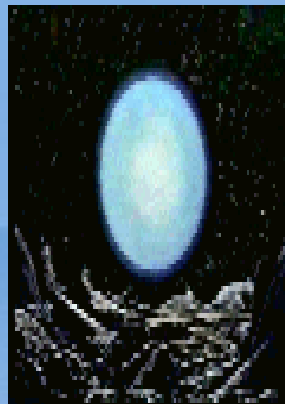
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Evolution of the Atmosphere



The Big Bang Theory is the dominant scientific theory about the origin of the universe. According to the big bang, the universe was created sometime between 10 billion and 20 billion years ago from a cosmic explosion that hurled matter and in all directions.



First Atmosphere

H_2 - Hydrogen

He - Helium

CH_4 - Methane

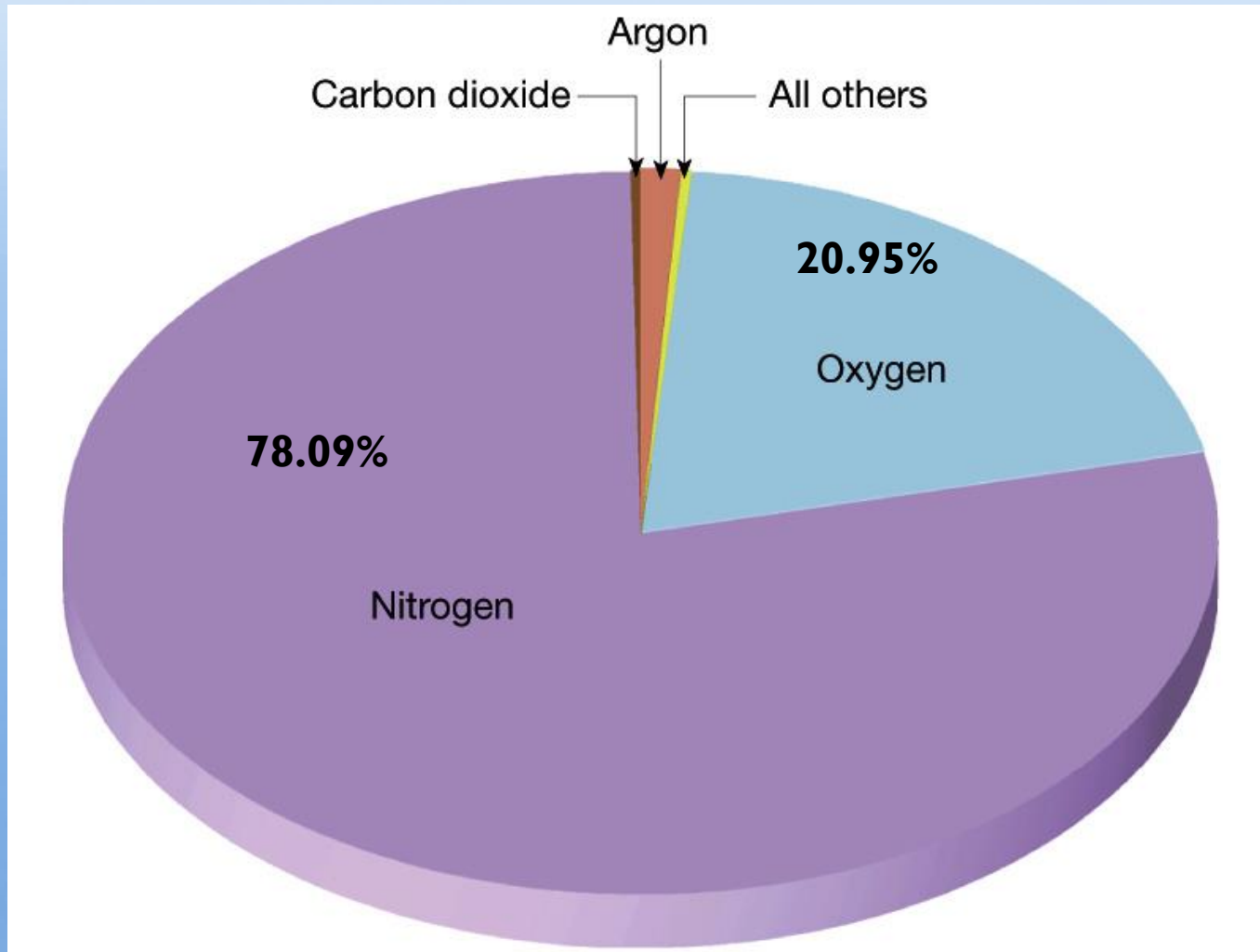
NH_3 - Ammonia

H_2O - Water Vapor

CO_2 - Carbon Dioxide

NO_x - Oxides of Nitrogen

Composition of the Atmosphere



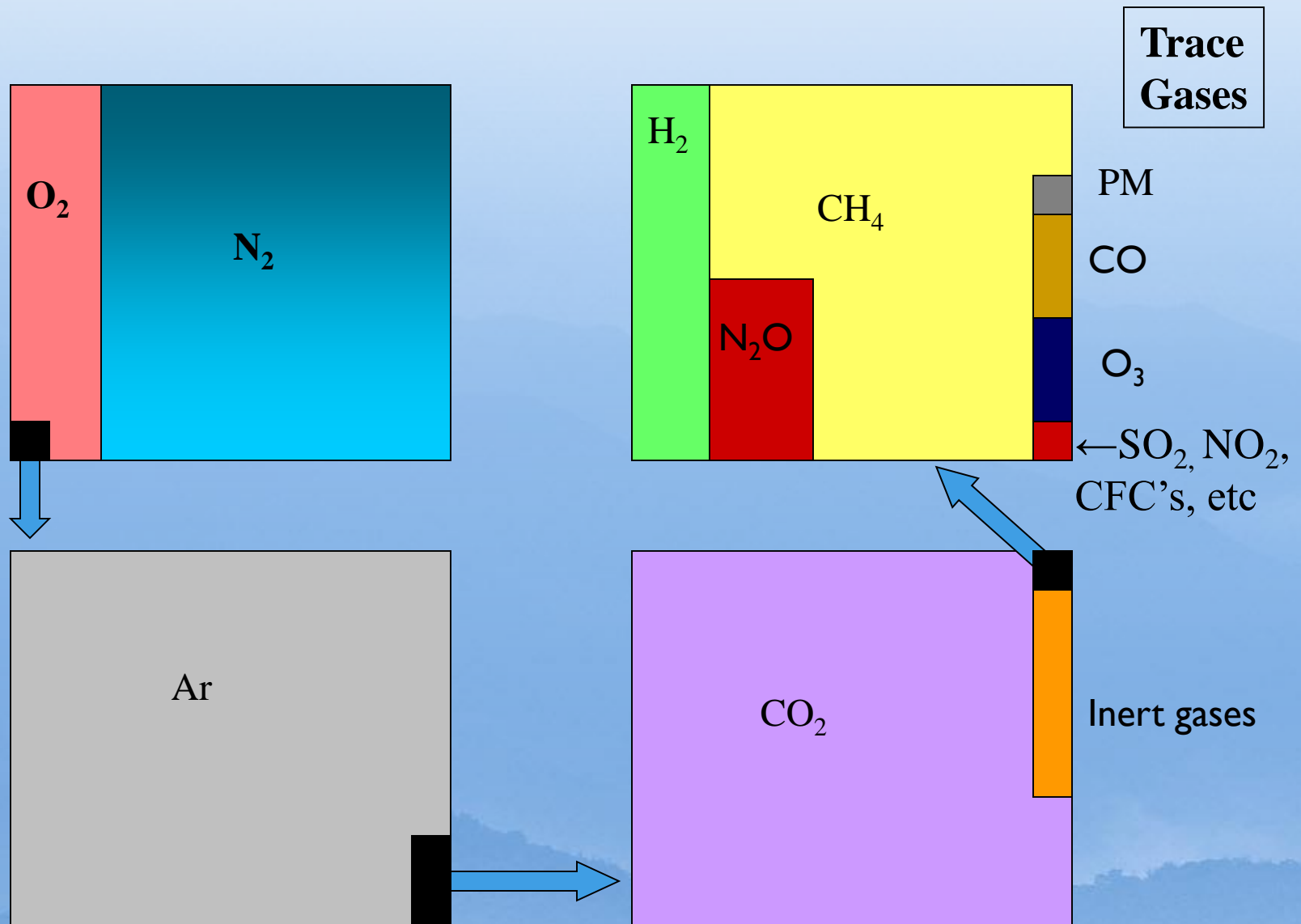
Proportional volume of gases composing dry air.

Composition of the atmosphere

Current composition reached about 500 million years
ago

Gas	% by volume	
N ₂	78.09	} Dry air
O ₂	20.95	
Ar	0.93	
CO ₂	0.03	
All other gases (Ne, He, Kr, H, etc)	0.01	
H ₂ O, O ₃ , CO ₂	Variable	

Composition of the Earth's Troposphere



Greenhouse Gases

High
Conc.

$\text{H}_2\text{O} = 1\text{-}3\%$
 $\text{CO}_2 = .035\%$

Naturally
occurring

Trace

CH_4
 N_2O
 O_3
CFC's

Anthropogenic

The greenhouse effect

- So what is it? The greenhouse effect is a naturally occurring phenomenon that raises the global average temperature due to the insulating effect of certain gases in the atmosphere.
- An understanding of the greenhouse effect requires a knowledge of the structure of the atmosphere, as well as the energy balance of the earth – atmosphere system.
- If one was to determine the global average surface temperature based solely on the amount of insolation the earth receives, the result would be a chilly -18 C.
- We know from observation that the global average surface temperature is 15 C, meaning that the greenhouse effect raises the temperature 33 C.

Greenhouse effect

- Earth is not the only planet that has a greenhouse effect. The hypothesis of how the greenhouse effect works can be tested by looking at the two planets nearest earth.

- According to the IPCC report (1990), both Venus and Mars have a measurable greenhouse effect.

Planet	Surface pressure	Main gases	SFC T w/o GHG	Observed SFC T	Effective warming
Venus	90	>90% CO ₂	-46 C	477 C	523 °C
Earth	1	~0.04% CO ₂ ~0.1% H ₂ O	-18 C	15 C	33 °C
Mars	0.007	>80% CO ₂	-57 C	-47 C	10 °C

The Atmosphere

- The sum of all inhalations and exhalations from the Earth over time
- Mixture of gases that filter sun's rays
- 500 km in height - exosphere beyond to 1000 km (scarce H and He atoms)
- Air pressure due to weight of atmosphere above (1 kg/cm² or 101.32 kPa)
- Atmosphere is most dense in the troposphere (90% of total mass)

Atmospheric Composition

Heterosphere (above 80 km)

The hetero-sphere is characterized by variation in the composition and the mean molecular weight of constituent gases.

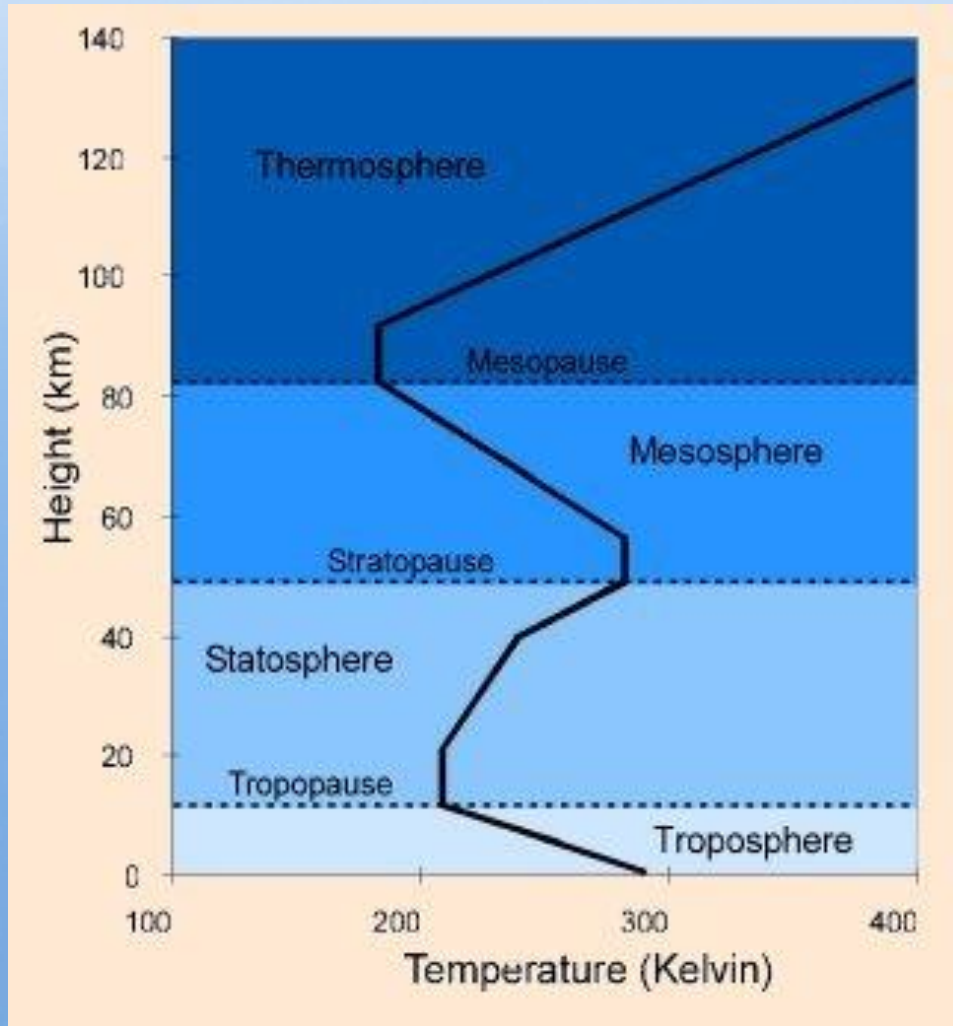
Homosphere (surface to 80 km)

The atmosphere up to 80 km (50 mi) in which there is no great change in its composition .

- more evenly mixed (except ozone layer and near surface trace gases)

Structure of the Atmosphere

THERMAL PROFILE



Thermosphere (90 - 500 km)

Mesosphere (50-90 km)
from 0°C to -90°C

Stratosphere (11 km to 50 km)
(-57°C to 0°C)

Troposphere
(from surface to 11 km)

Normal lapse rate is 6.4°C per km,
but environmental lapse rate varies

Atmospheric Function

Ionosphere

- absorbs cosmic rays, gamma rays, X-rays and short UV wavelengths
- atoms are changed to positive ions
- auroral lights occur here

Ozonosphere

- Contains elevated levels of ozone (O_3)
- Absorbs UV light (0.1-0.3 μm)
- Has been stable for several hundred million years but has been destabilized.

The Sun, Earth, and Radiation

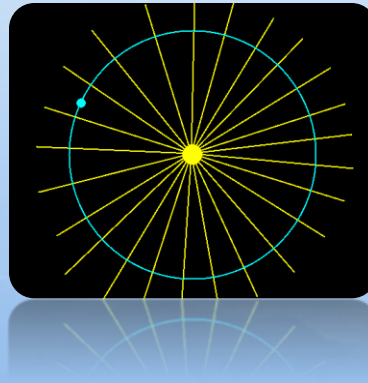
The *sun* is the *main* energy *source* for *our planet*

The Sun support life on Earth

Features of the Sun

- ▣ Average Density = 1.4 g/cm^3
- ▣ Mass $2 \times 10^{30} \text{ kg}$ (about 330000 times the mass of Earth)
- ▣ 70% Hydrogen
- ▣ 28% Helium
- ▣ 2% Metals
- ▣ Surface Temperature = 5800 K
- ▣ Core Temperature = 15,000,000 K

The luminosity of the Sun is $L_{\text{sun}} = 4 \times 10^{26} \text{ W}$



Luminosity

The energy an object radiates per unit time. So, it is a measure of **power**.

Watt

Unit of power. One watt is one *Joule* per *second*.

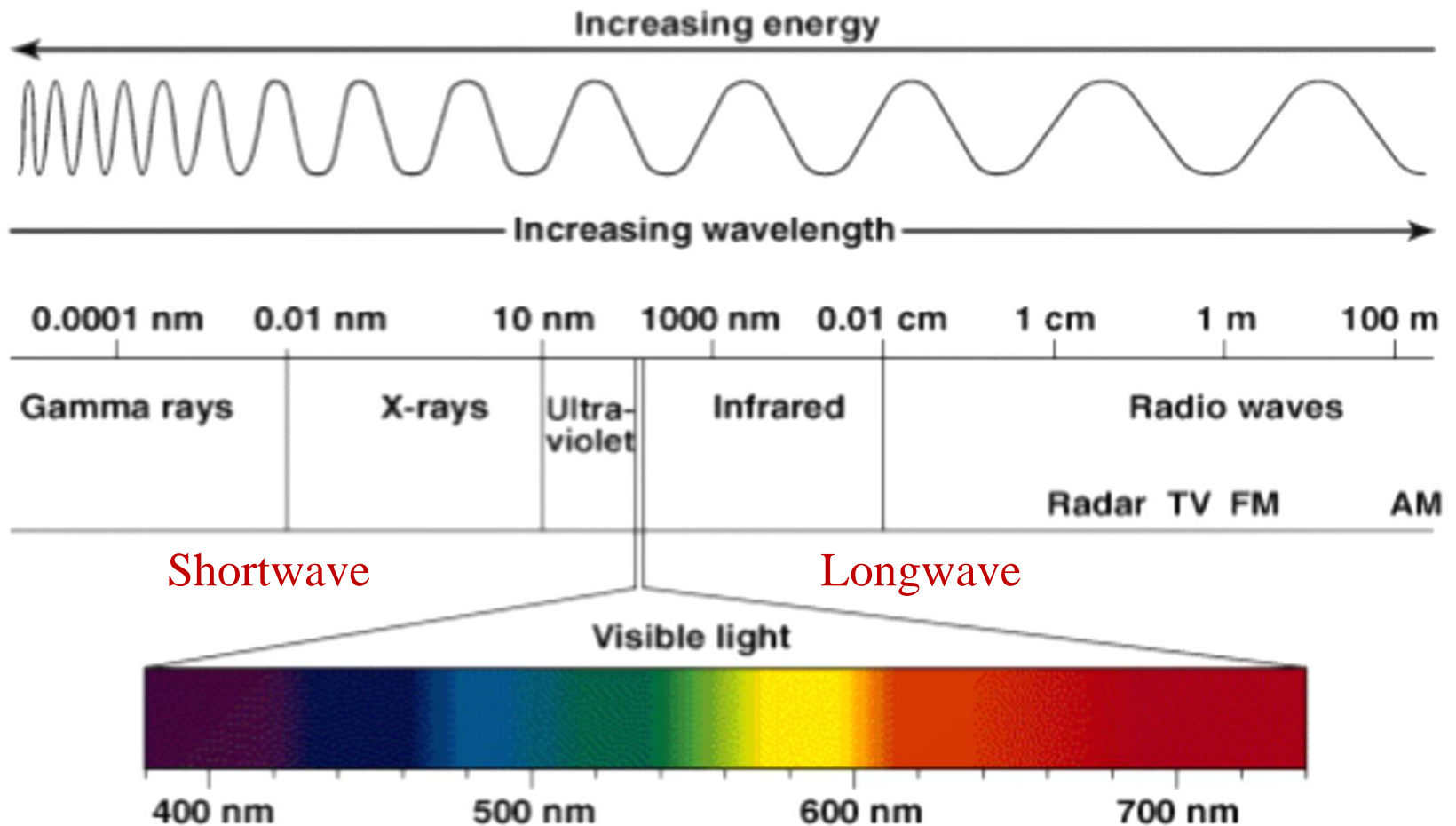
Radius (R_{Sun})

696,000 km (about 109 times
the radius of Earth)

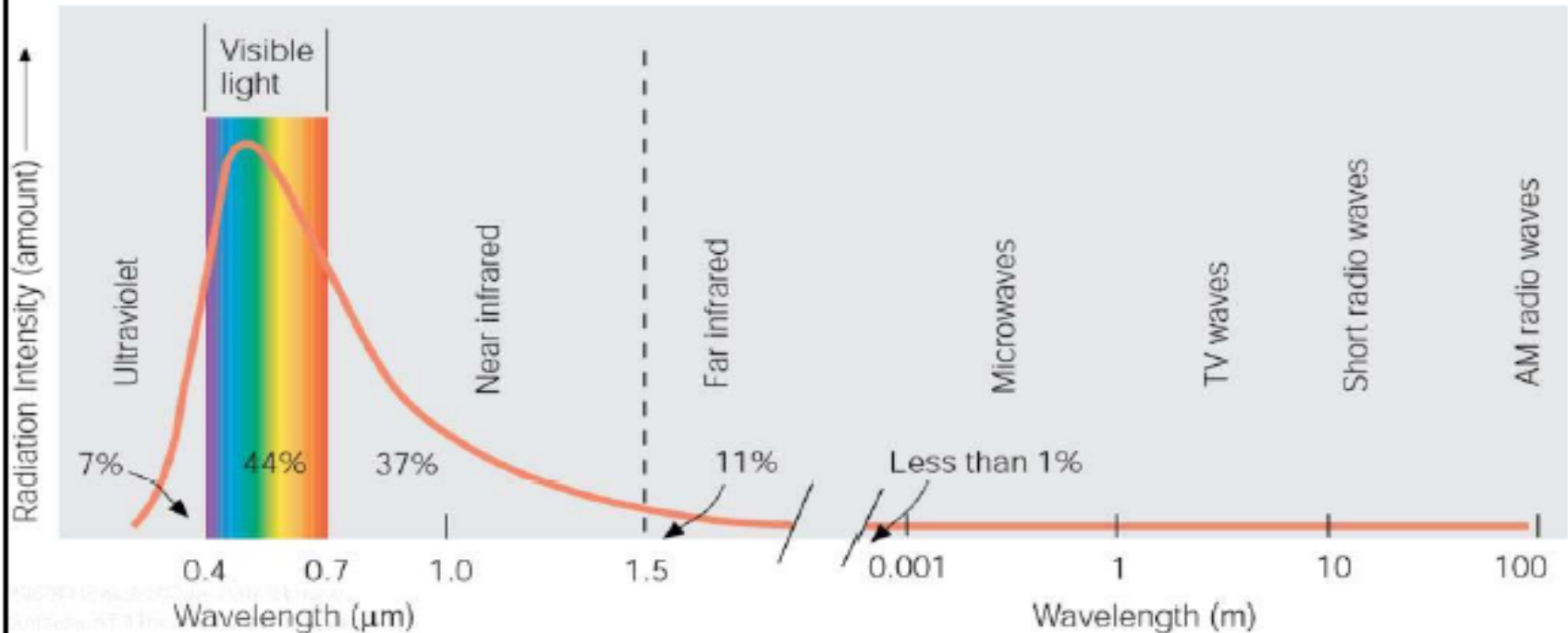
The Electromagnetic Spectrum **(Seven Forms of Light)**

- ▣ **Radio Waves** - *communication*
- ▣ **Microwaves** - *used to cook*
- ▣ **Infrared** - *“heat waves”*
- ▣ **Visible Light** - *detected by your eyes*
- ▣ **Ultraviolet** - *causes sunburns*
- ▣ **X-rays** - *penetrates tissue*
- ▣ **Gamma Rays** - *most energetic*

Electromagnetic Spectrum



Solar Spectrum



Solar radiation has peak intensities in the shorter wavelengths, dominant in the region we know as visible, but extends at low intensity into longwave regions.