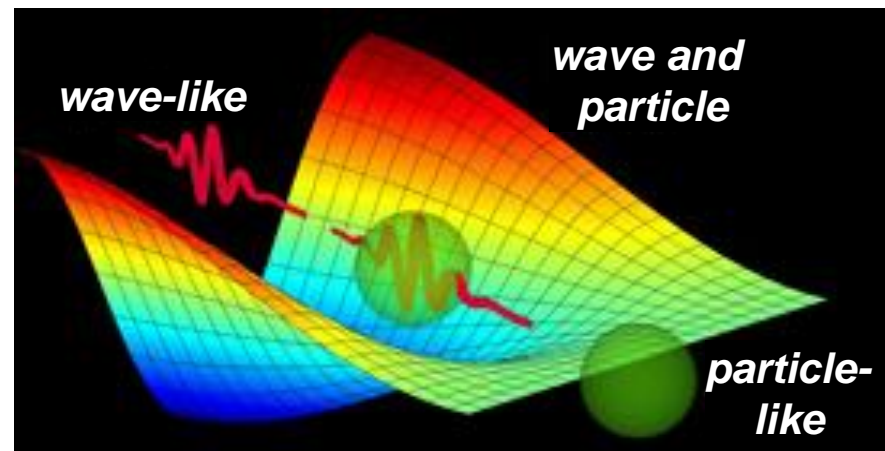


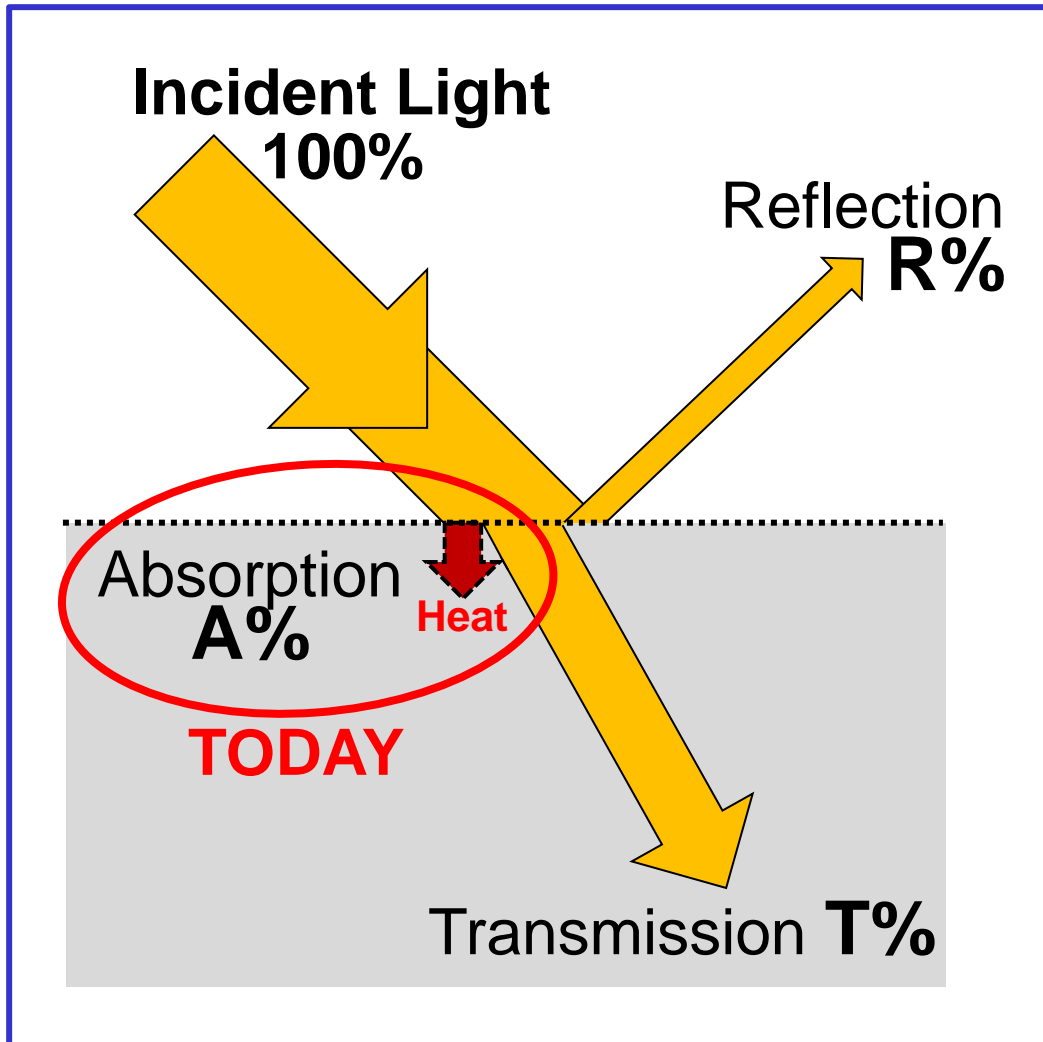
What is Light: reminder

- Light is a form of energy that travels.
- Light has a dual nature:
 - wave properties (propagation)
 - particle properties (emission/absorption)
- Light waves do not need a medium to propagate.
- Light waves are electromagnetic radiation.
- Light particle, called a photon, has *zero mass*.

*The **actual nature of the photon** is not really describable in terms that are very descriptive...
...and **not fully understood** yet.*



Light Interaction with Non-Luminescent Matter



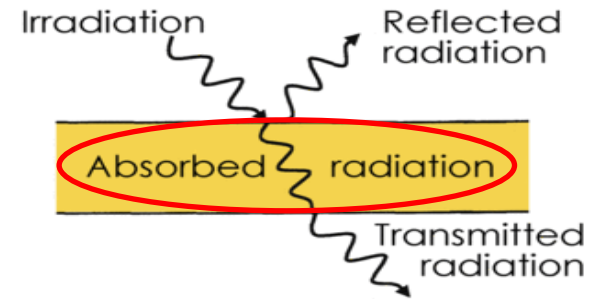
- Combination of transmission, reflection, and absorption:

$$T\% + R\% + A\% = 100\%$$

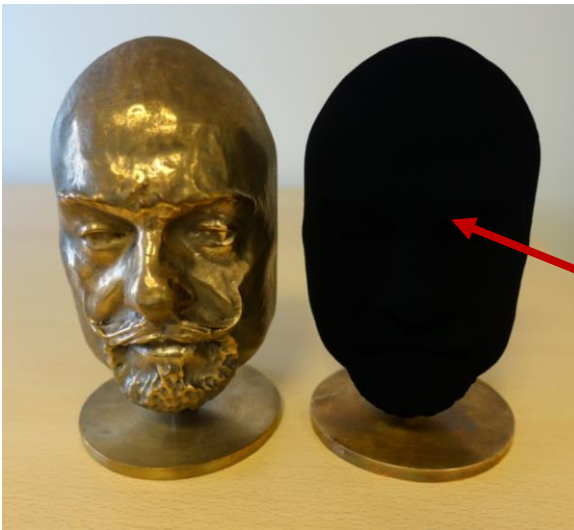
- No material is 100% transparent.
- No material is 100% absorbing either.

Absorption

disappearance of a light wave



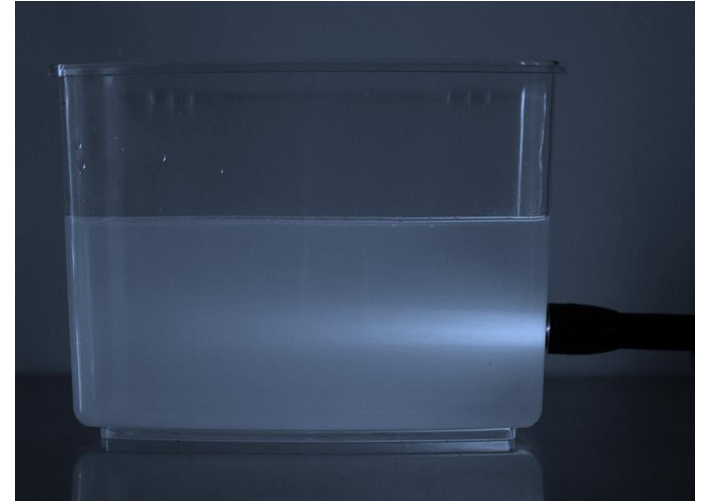
- The energy of a light wave is taken up by matter and in most cases converted into heat.
- **Dark opaque** objects absorb most of the incident light.



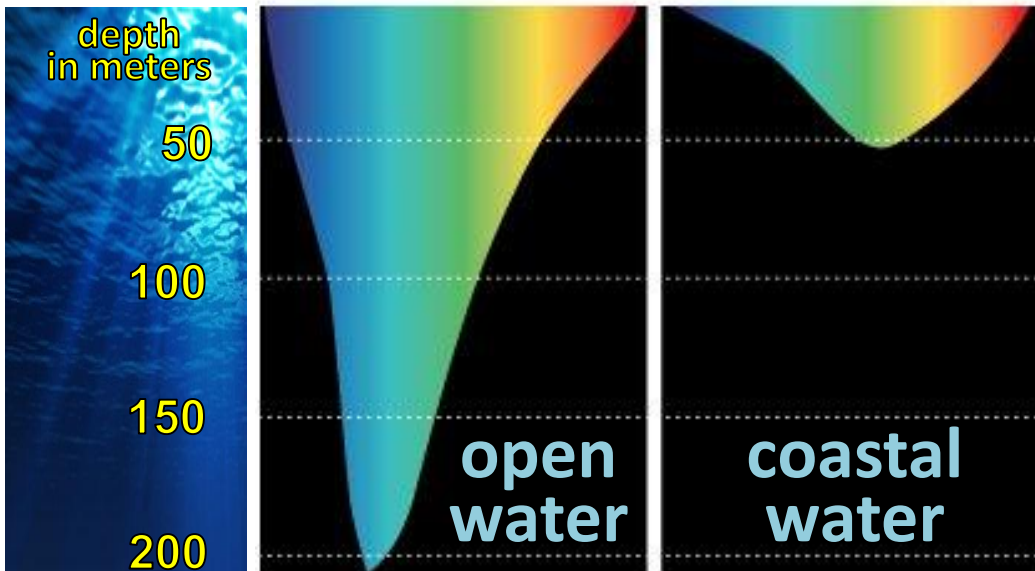
Vantablack – one of the darkest substances known, absorbing up to 99.965% of visible light!



Transparent and translucent objects absorb some part of the incident light.

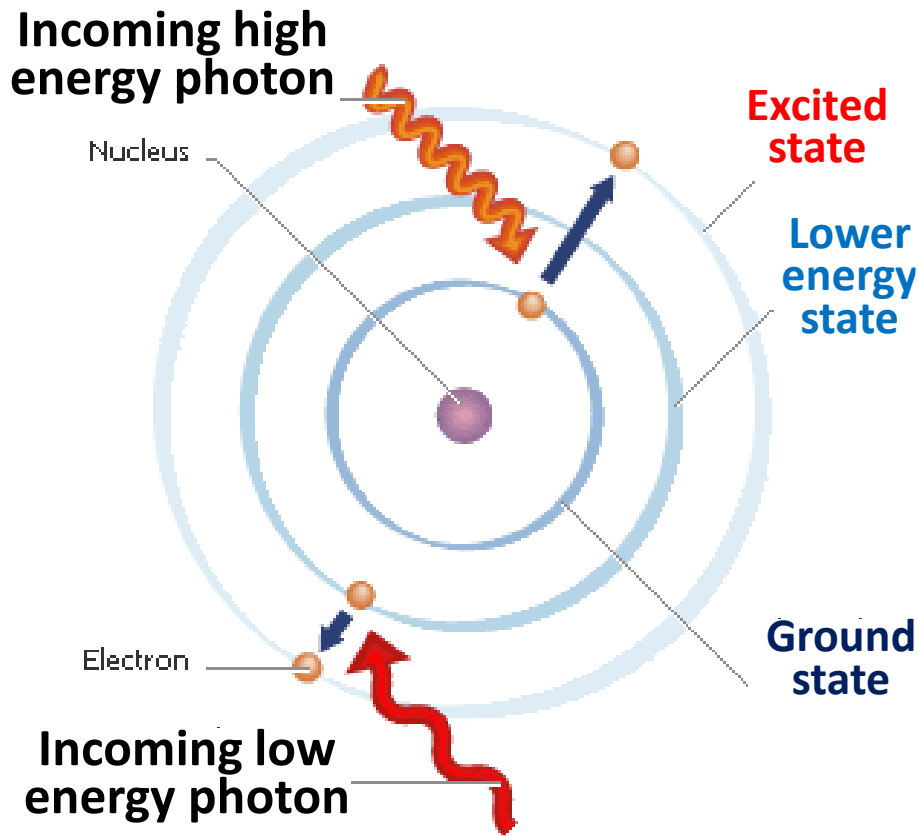


Absorption of Sunlight by Water



Absorption Spectrum

Absorption of light can happen when the **photon energy** (i.e. *frequency*) **matches** one of the **allowed transitions** between energy levels of that particular atom.

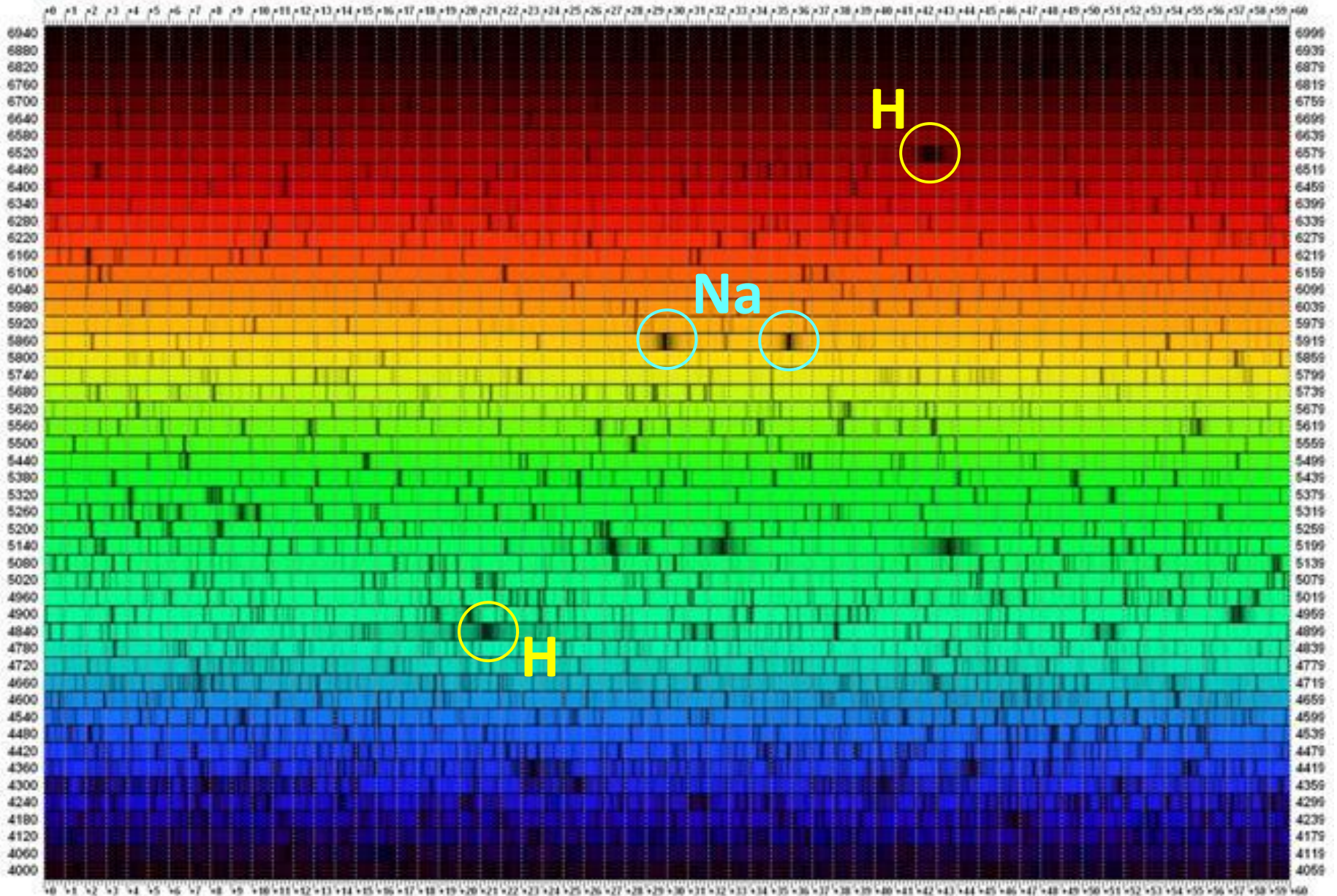


Example: Hydrogen



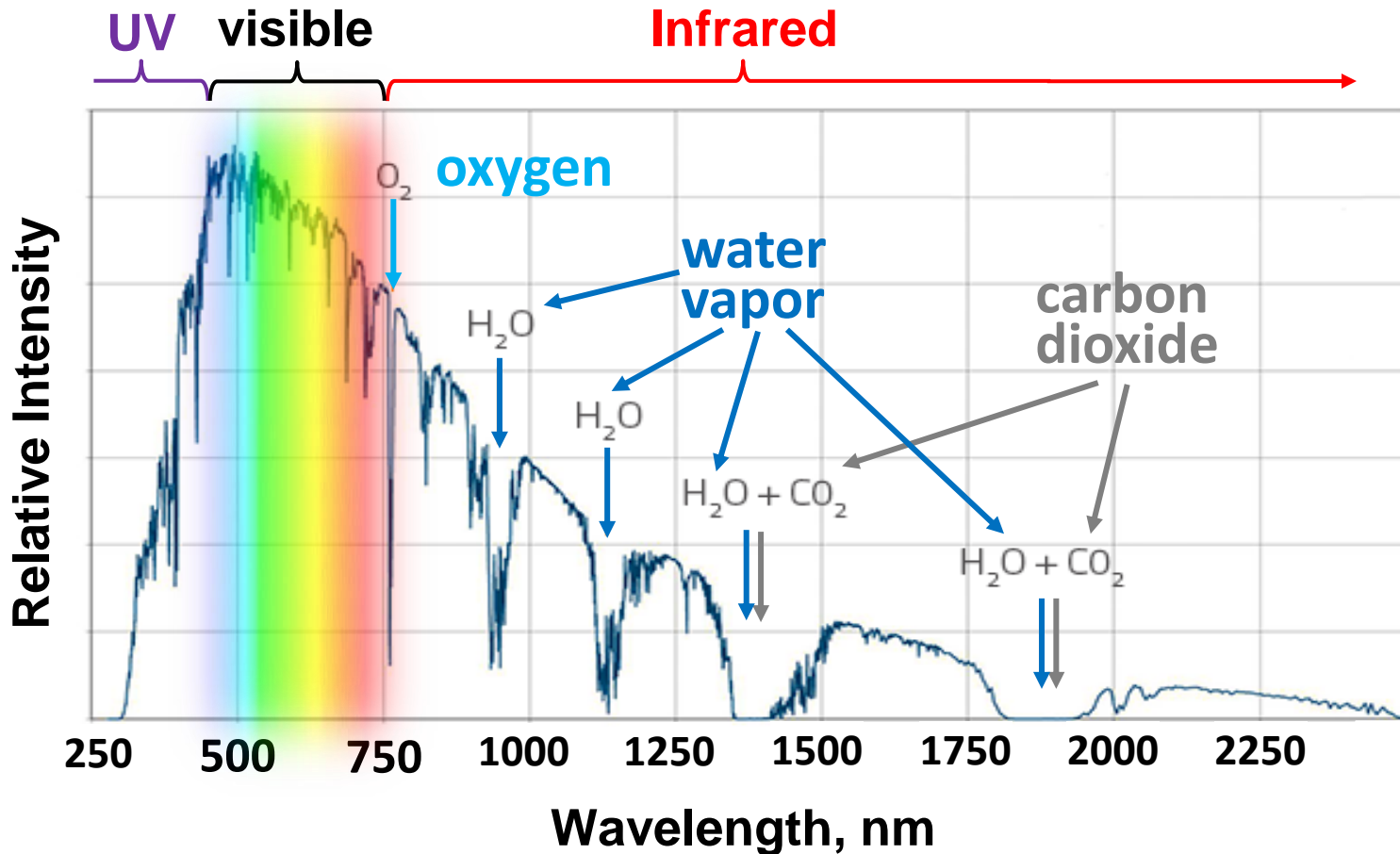
A **star** will create an absorption line spectrum because the continuous spectrum emitted by the dense, opaque gas that makes up most of the star passes through the cooler, transparent atmosphere of the star.

Absorption Spectrum of the Sun



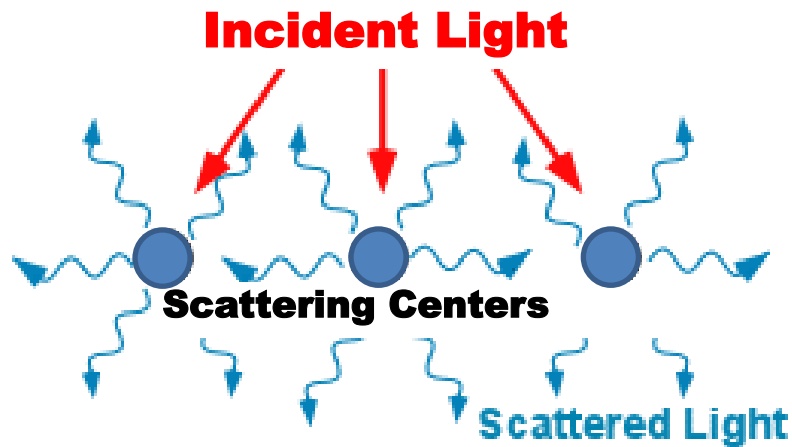
Sunlight Filtered through Atmosphere

Absorption of sunlight by various **gas molecules** that are present in the Earth's atmosphere is seen as **absorption bands** in the Sun spectrum.

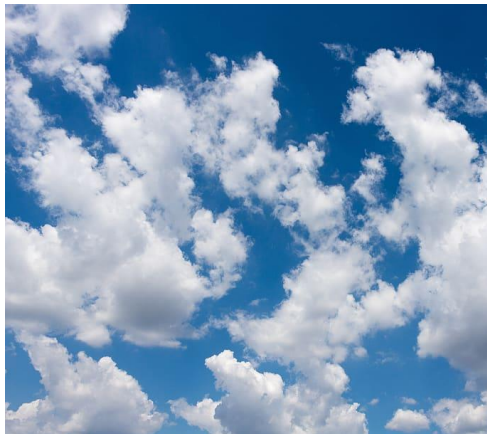


Scattering

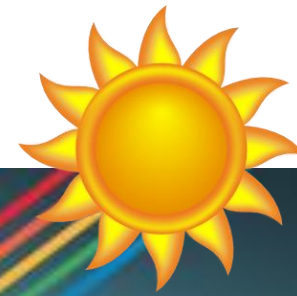
light ray moves over to the side
in all directions rather than forward,
backward or being absorbed



- Scattering is due to **localized non-uniformities (scattering centers)** in the medium through which light passes.
- The **most critical factor** is the scattering centers size relative to the wavelength of the light being scattered.
- Amount of the **scattered light can strongly depend on the wavelength of light**.



I See Skies of Blue...



Sunlight contains all the colors.

Atmospheric molecules scatter light

Longer path through atmosphere means more scattering.

Violet and blue are scattered most...

At sunset, violet, blue and green are completely scattered away, but red and orange are still there!

...we see blue because our sensitivity to violet is very low!



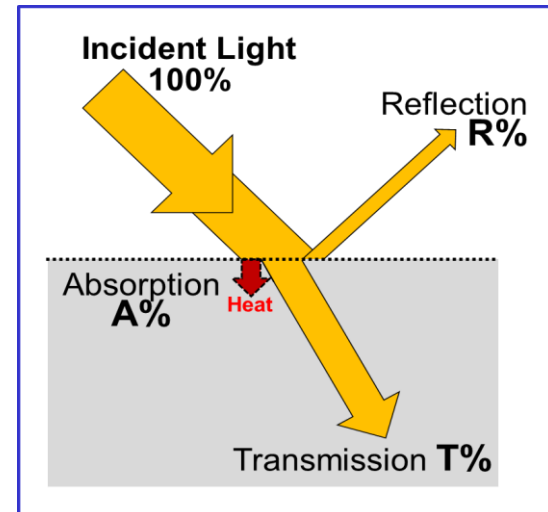
...and Red Sunsets too!



Guess an object !



T=0
R~70%
A~30%



T=0
R~5%
A~95%



T~95%
R~5%
A~0%

Transmitted%+Reflected%+Absorbed%=100%