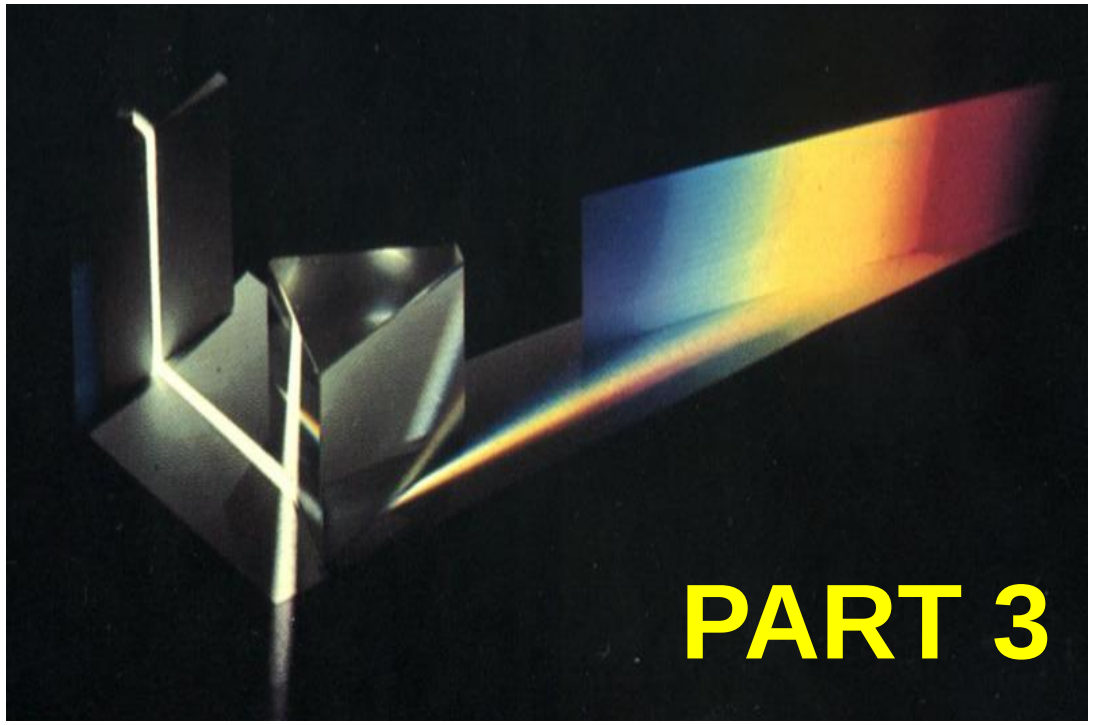
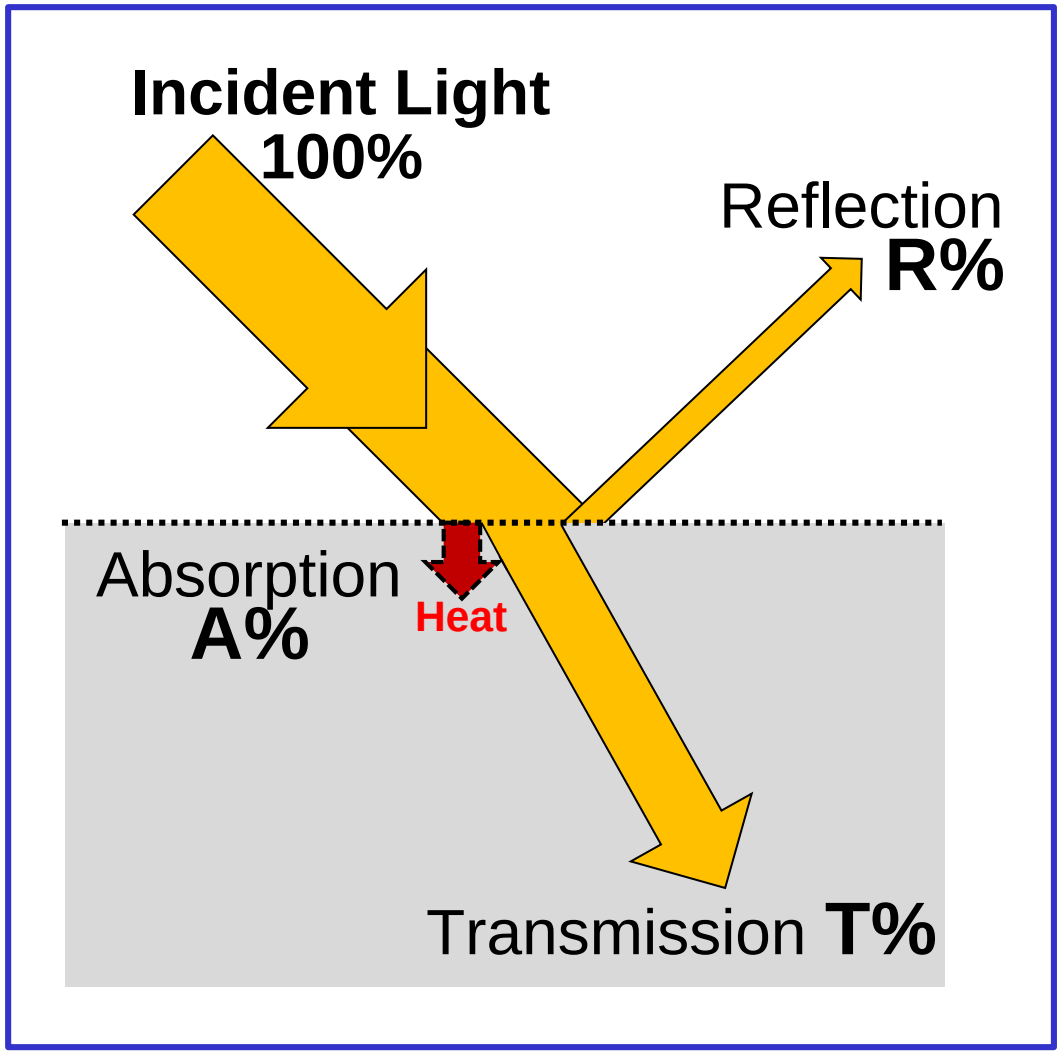
Light meets Matter



Light Interaction with Non-Luminescent Matter

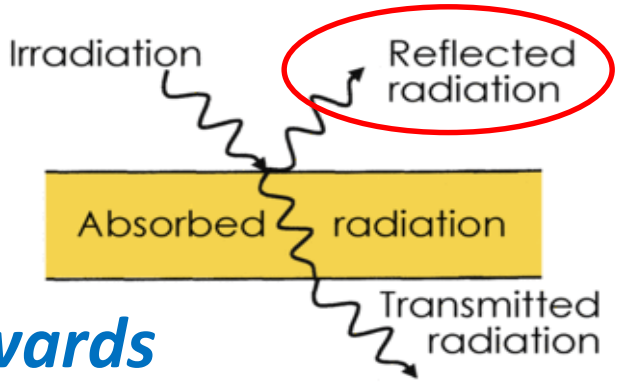


- **Combination of transmission, reflection, and absorption:**

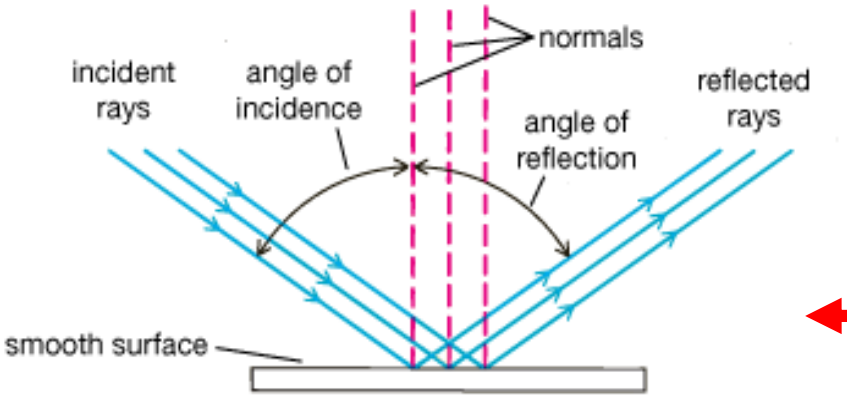
T%+R%+A%=100%

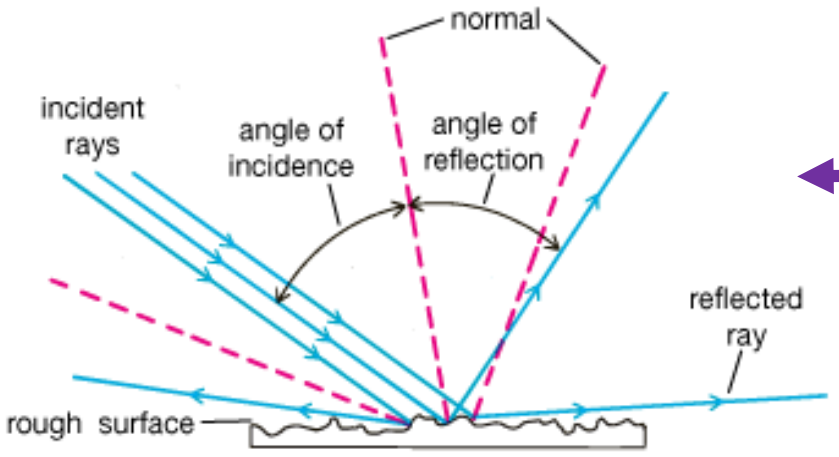
- **No material is 100% transparent.**
- **No material is 100% absorbing either.**

Reflection



bouncing of light off the surface, change in the direction of travel *backwards*





- **Reflection is <u>re-radiation of light by the electrons</u> in the reflecting material.**

Specular reflection: if a surface is perfectly smooth, rays of light move out in definite directions.

Diffuse reflection: if a surface is not smooth, the light rays are *scattered* in many random directions by microscopic irregularities.

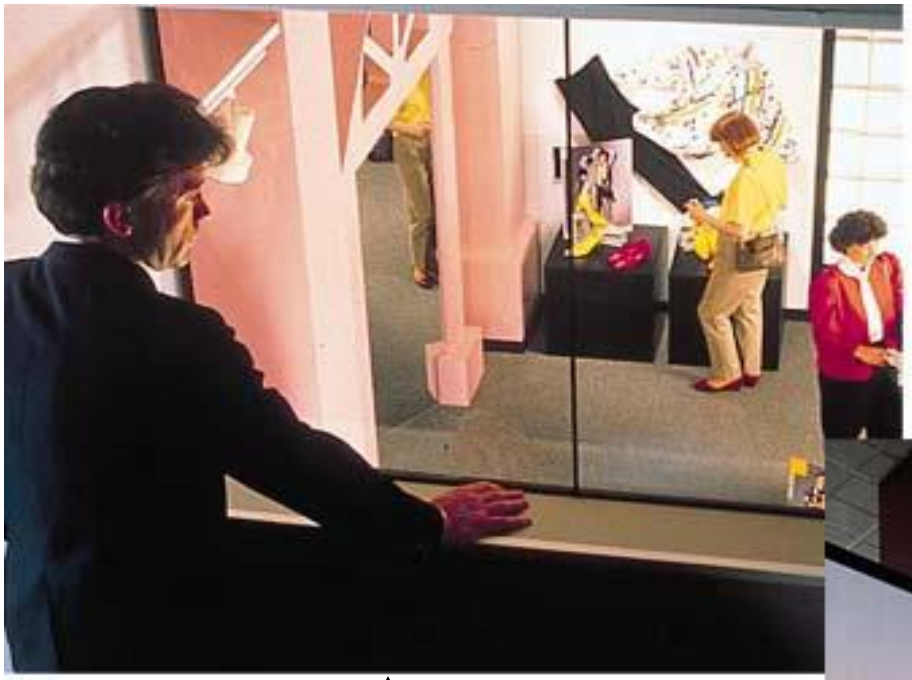
How do we see?

- **When we see, we *sense light*.**
- **When we see an object, the light that reaches our eyes can come from two different processes:**

1. **The light can be emitted directly from the object (object=light source), like a light bulb or glow stick.**
2. **The light can come from somewhere else, like the Sun, and get reflected by the object.**

Most of the objects that we see are visible from diffuse reflection.

One-way Mirror
(reflection+transmission)

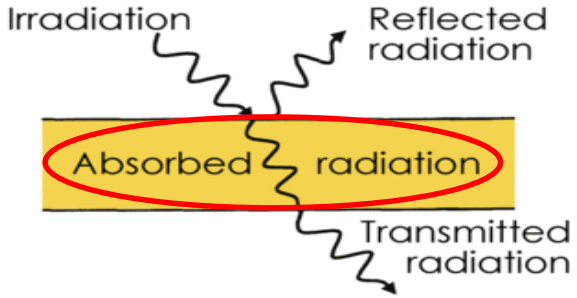


A one-way mirror reflects most of the light that strikes its surface

It also transmits some light to a person behind the mirror in a darkened room.

Absorption

disappearance of a photon

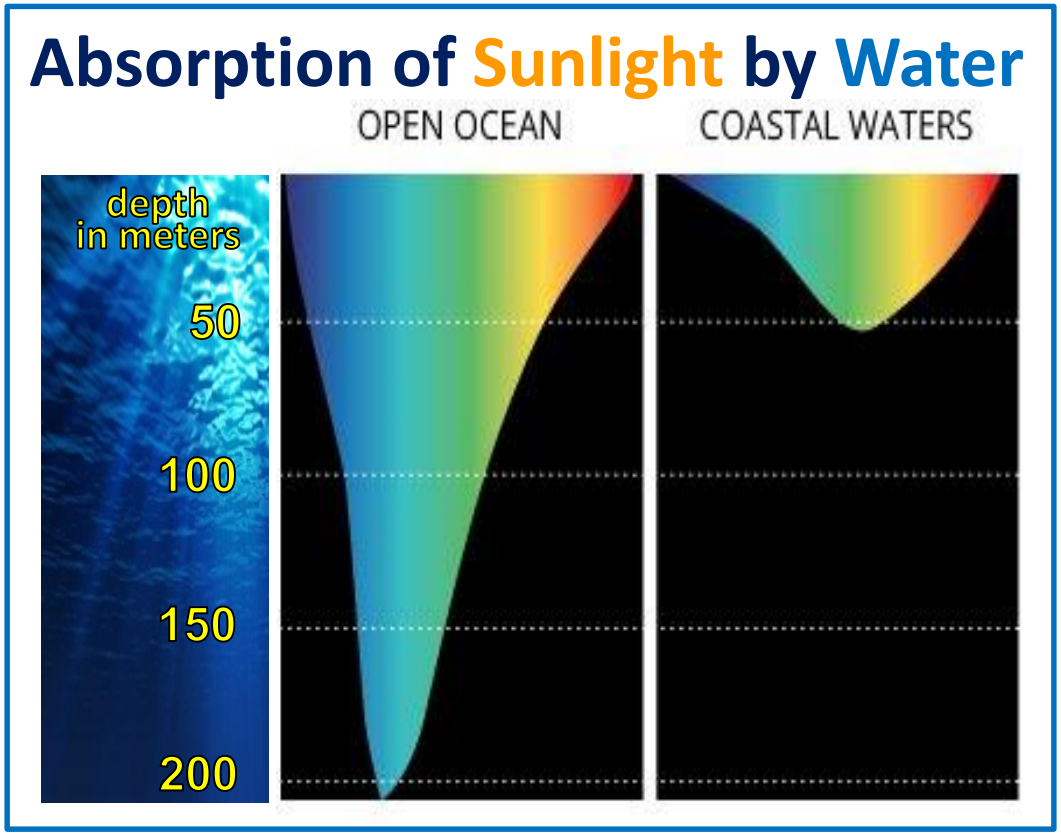


- **Absorption of electromagnetic radiation is the process in which the energy of a photon is taken up by matter, typically the electrons of an atom.**

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

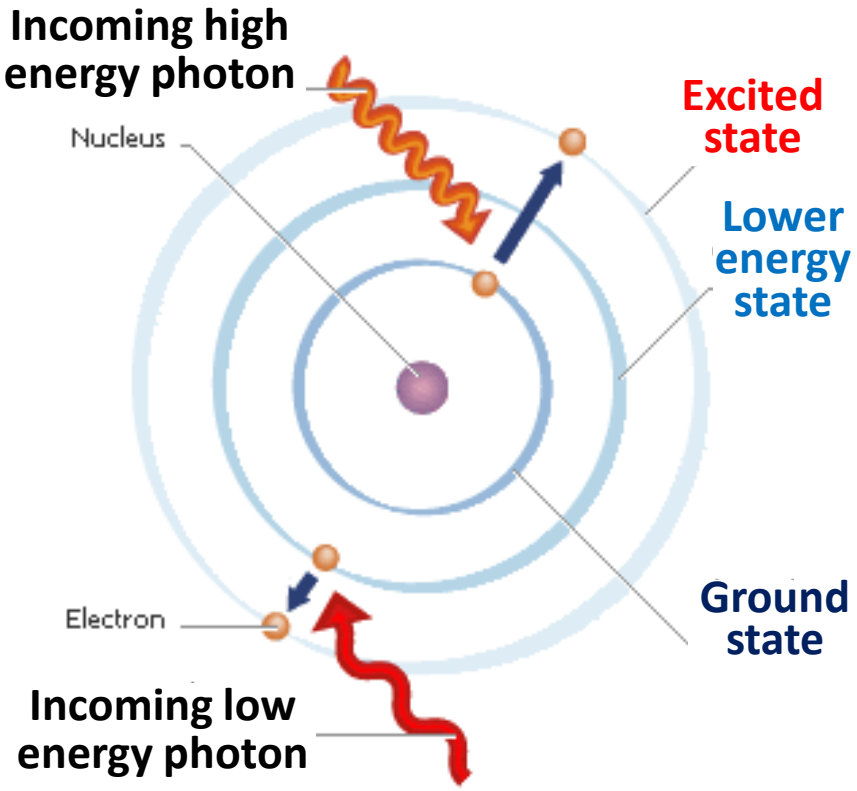
- **Dark opaque objects absorb most of the incident light.**

- **In most cases, energy of the absorbed photon is converted to *heat*.**

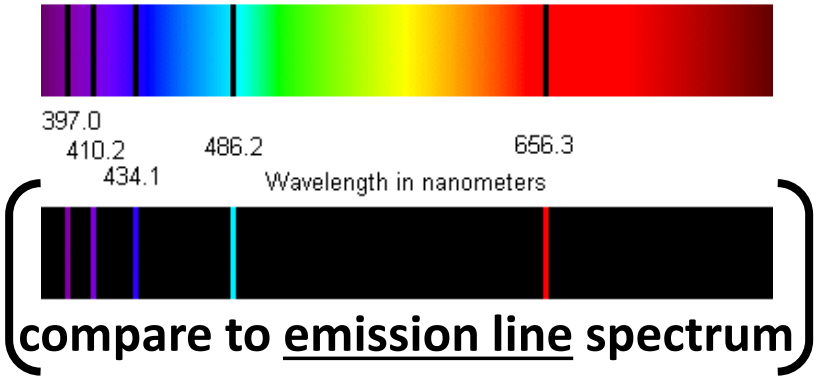


Absorption Spectrum

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.



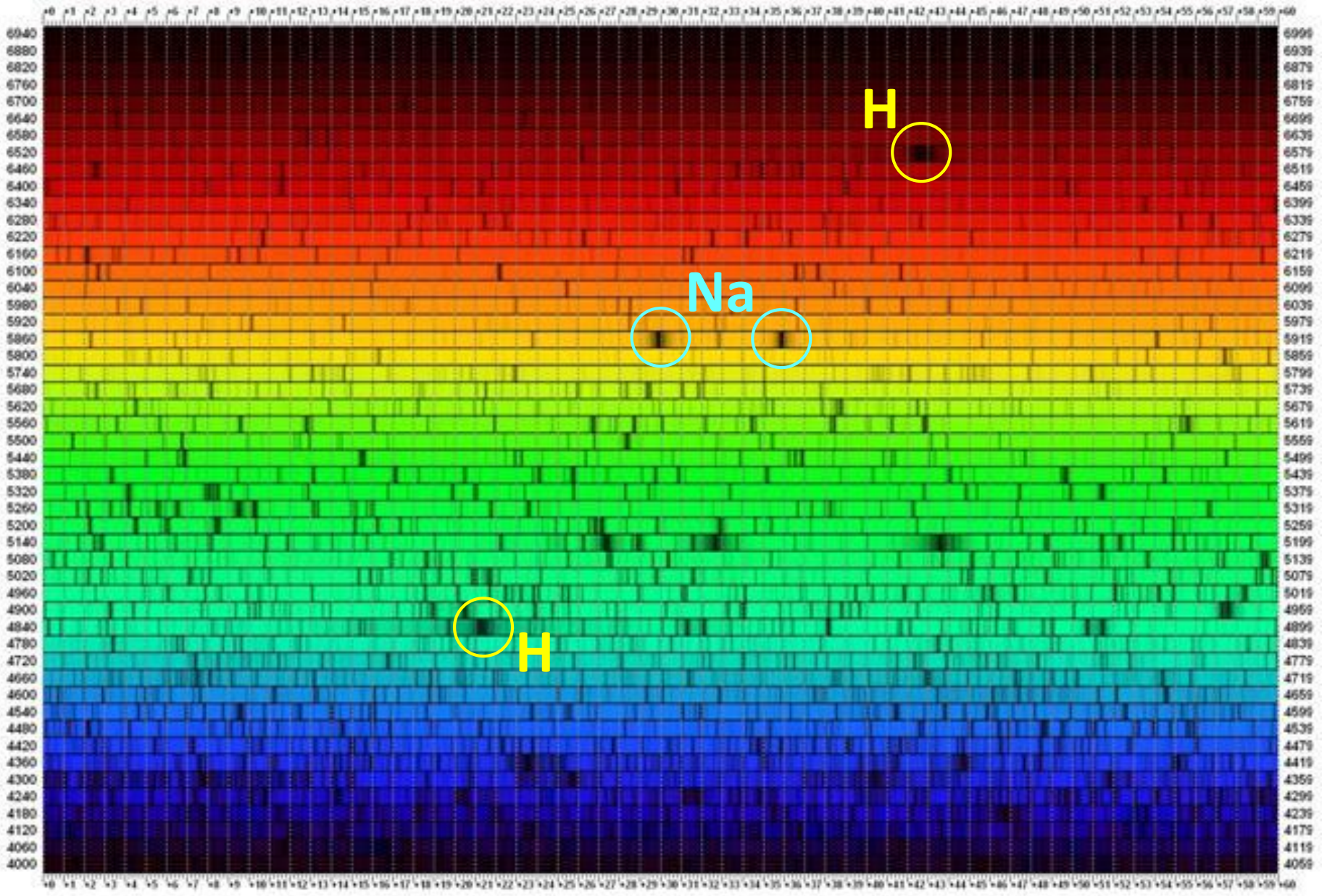
Example: Hydrogen



compare to <u>emission line</u> spectrum

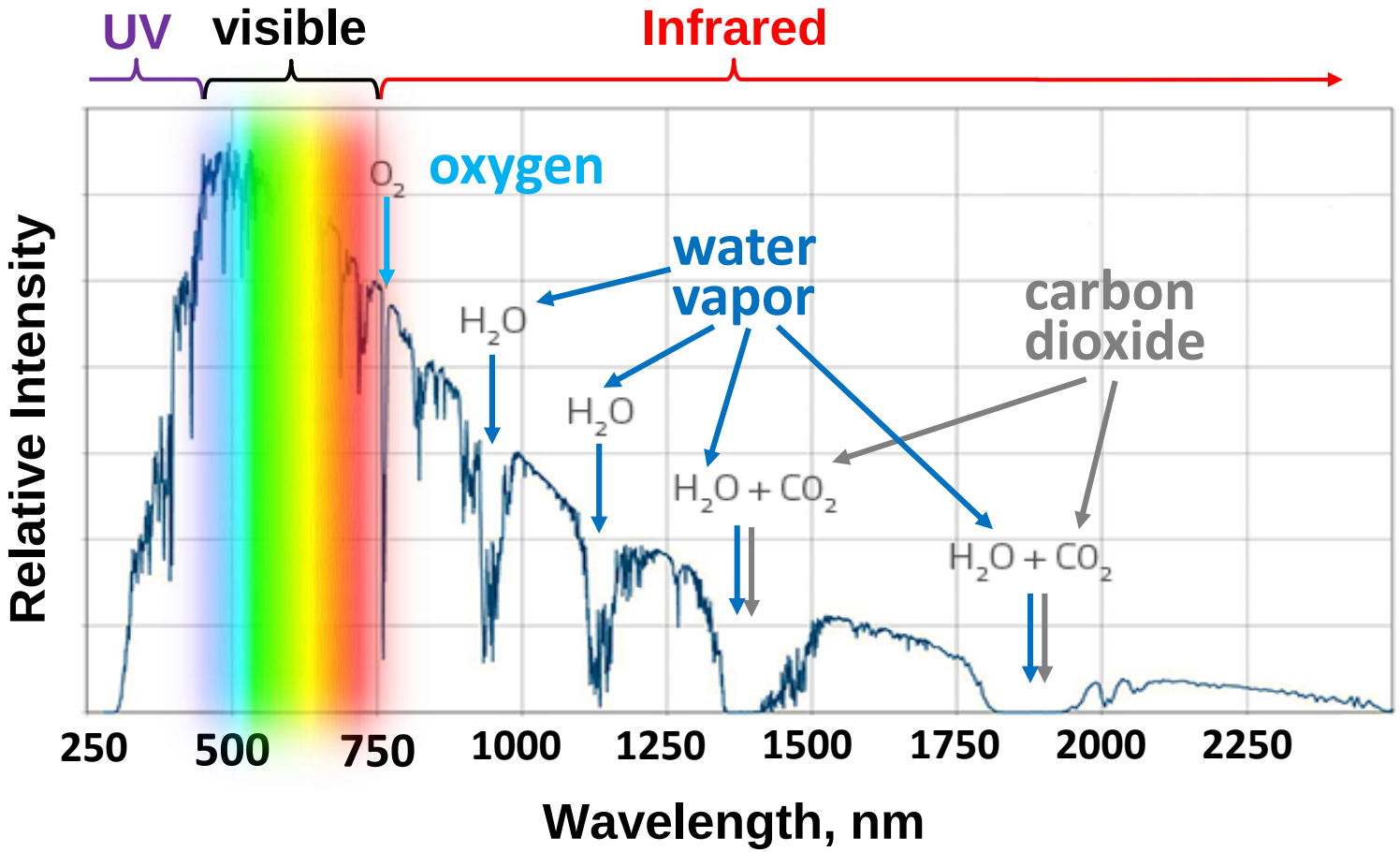
A star will create an absorption line spectrum because the continuous spectrum emitted by the dense, opaque gas that makes up most of the star passes through the cooler, transparent atmosphere of the star.

Absorption Spectrum of the Sun

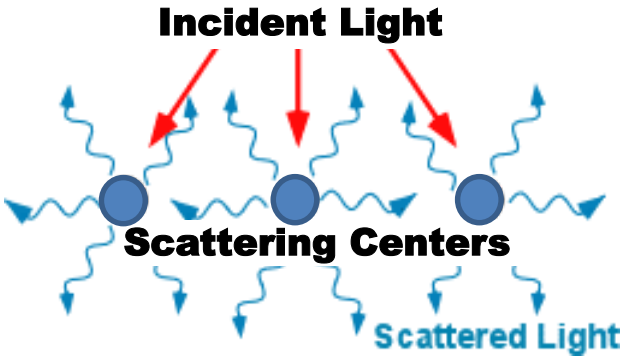


Sunlight Filtered through Atmosphere

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 (called *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.
- Major types:
  - Mie (relatively large spherical particles, clouds)
  - Rayleigh (gas molecules)
  - Tyndall (fog, smoke)

I See Skies of Blue…

Sunlight contains all the colors.

Atmospheric molecules scatter light (Rayleigh).

Longer path through atmosphere means more scattering.

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

Violet and blue are scattered most…

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

…and Red Sunsets too!

Do you see what I see?