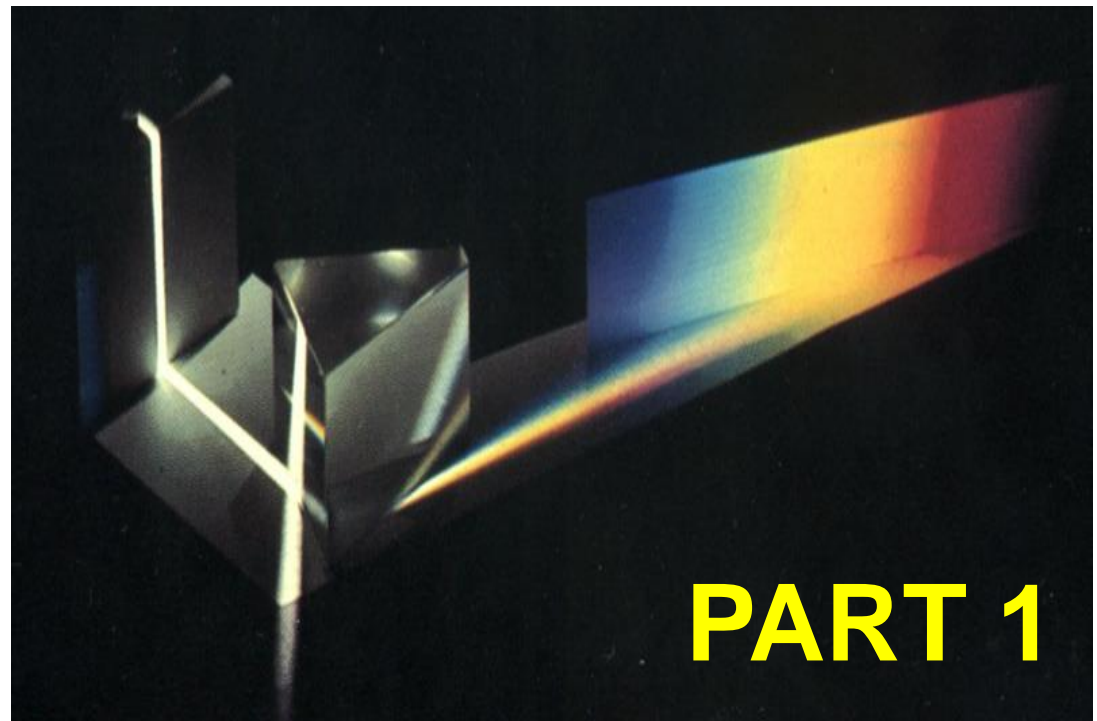


Light meets Matter

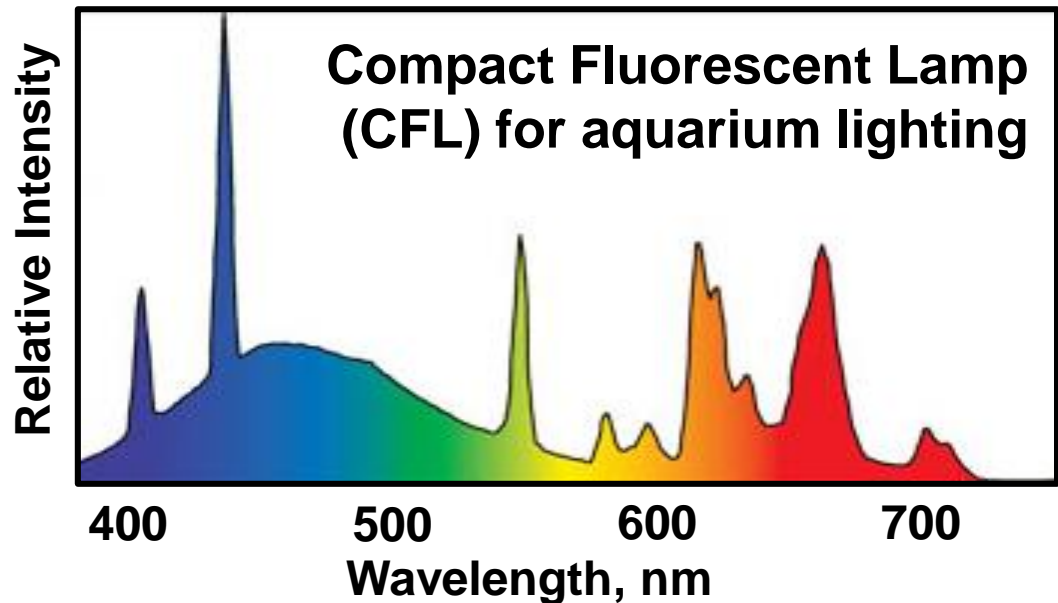
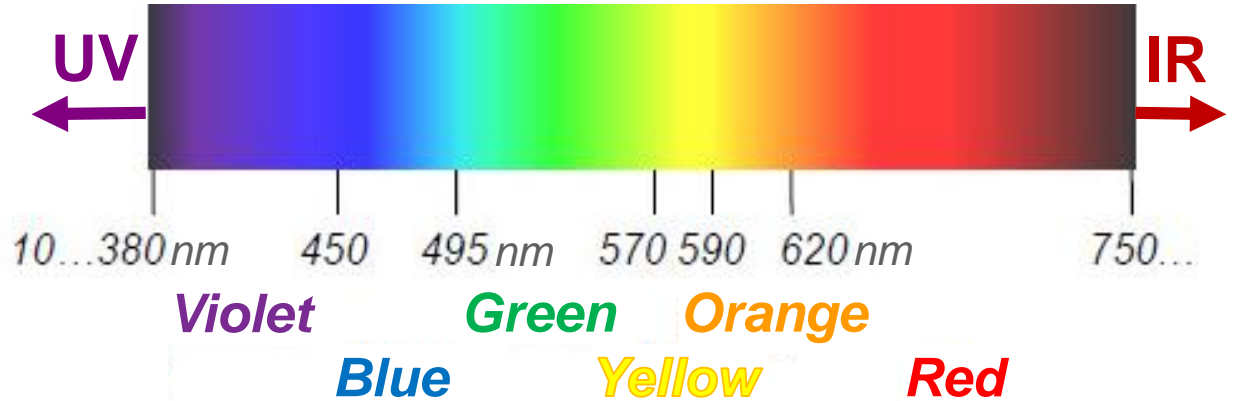


Describing Light

1. Wavelength:
type of photon

2. Intensity:
amount of
photons

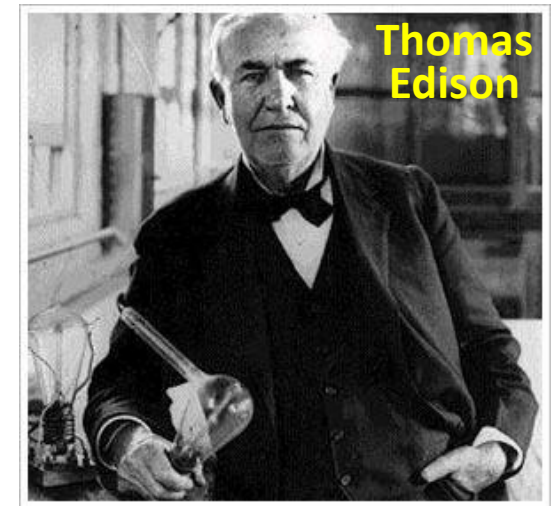
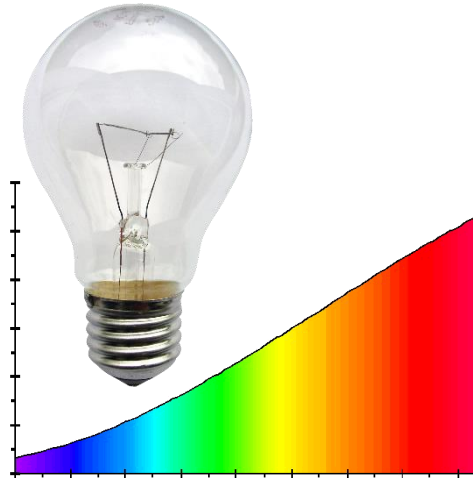
3. Spectrum:
composition
of light;
types of
photons and
their relative
abundance



Incandescence

Incandescence (from Latin “glowing white”) is a special case of thermal radiation, specifically **emission of visible light by a hot body.**

Sunlight is the incandescence of the “white hot” surface of the Sun.



Incandescent bulb:

- electricity passes through a thin piece of metal wire called a filament
- the filament heats up and gives off thermal radiation composed of ~5% visible light and **~95% heat...**
- **...very low energy efficiency!**

Luminescence

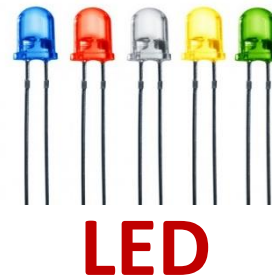
Luminescence is emission of light by a substance not resulting from heat:

- *Chemiluminescence* (including *bioluminescence*), a result of a chemical reaction.

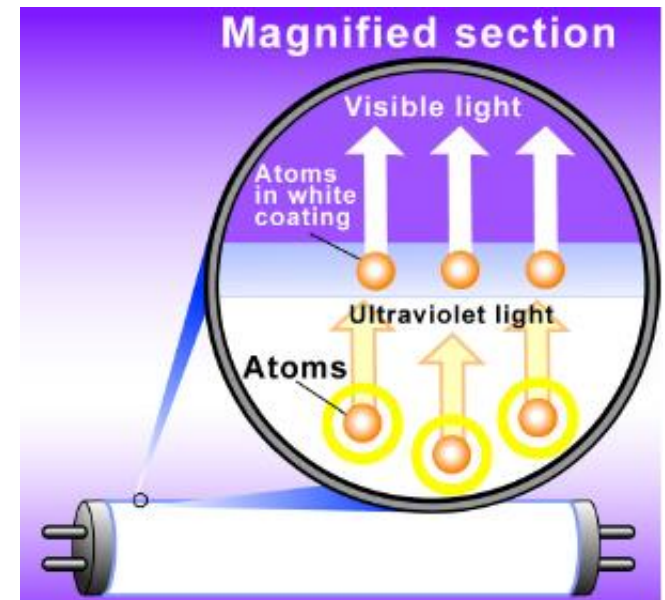


Glow Sticks

- *Electroluminescence*, emission of light due to electric current passed through a substance.



- *Photoluminescence* (*fluorescence* and *phosphorescence*) due to absorption of photons with subsequent re-emission.

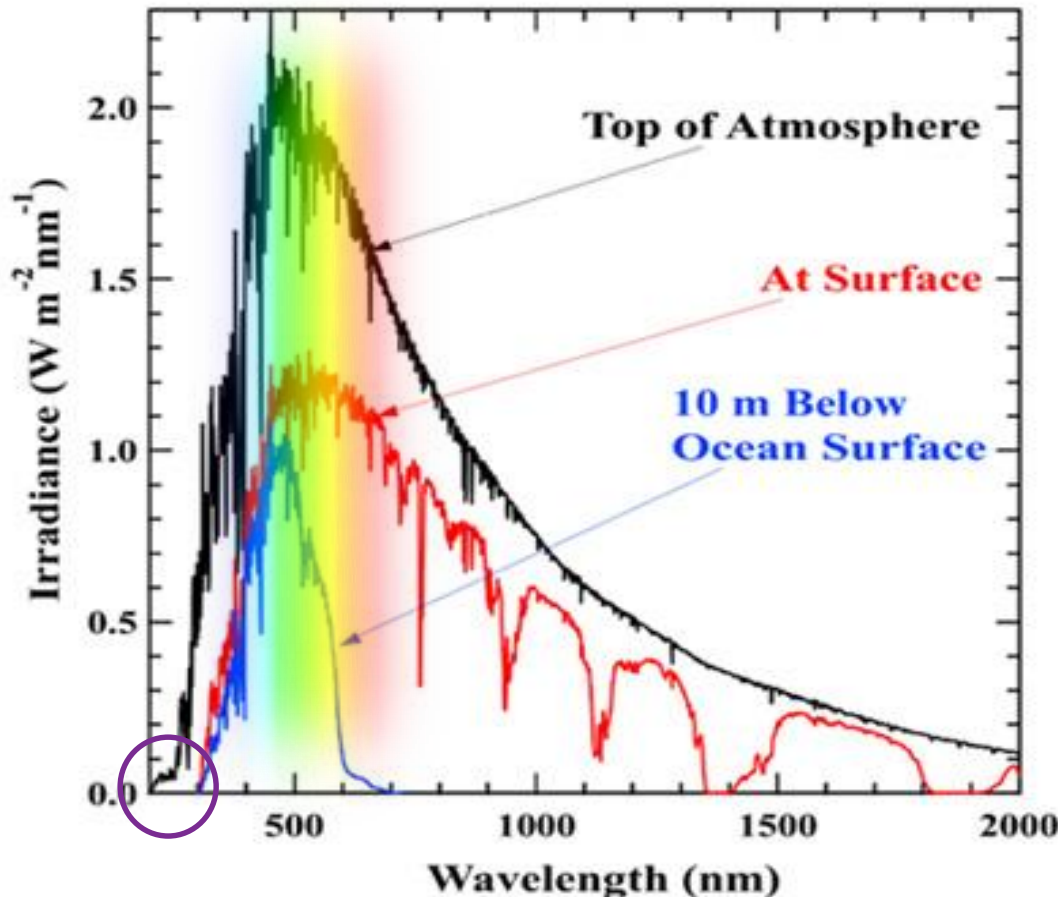


Fluorescent Lamps

- Some other types.

Sunlight

The Sun emits EM radiation across most of the electromagnetic spectrum. On Earth, solar radiation is obvious as **daylight** when the Sun is above the horizon.



Sunlight composition at top of atmosphere:

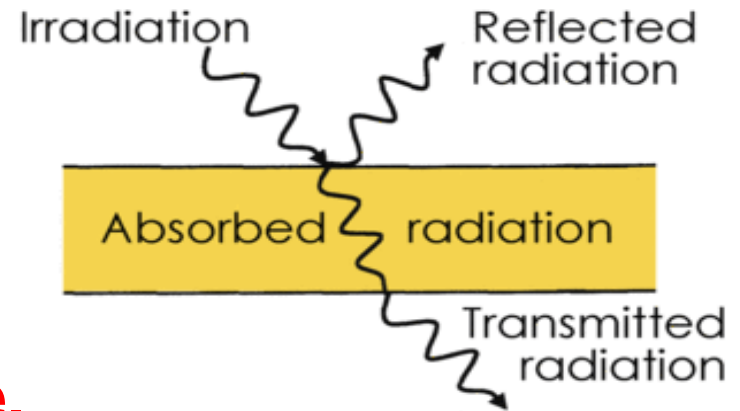
- ~9% ultraviolet radiation
- ~40% visible light
- ~51% infrared radiation
- a very small amount of extreme ultraviolet and X-ray radiation from solar corona

Filtered Sunlight at Earth's surface:

- ~5% ultraviolet radiation
- ~43% visible light
- ~52% infrared radiation

Light Interaction with Matter

- A ray of light travels in a straight line from a source until it encounters some object or particles of matter.
- The material world around us: **substances** (materials) and **boundaries** (surfaces, interfaces).
- In general, light can be reflected off, scattered, transmitted through or absorbed by materials.

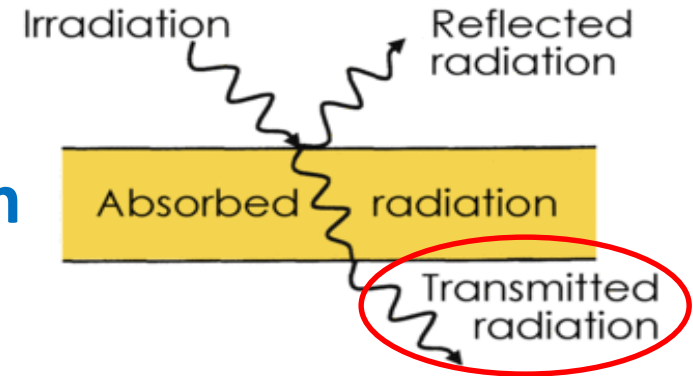


Any combination can take place.

- What *exactly* happens to the light depends on the nature of the material, the smoothness of the surface, the angle of incidence, and the light wavelength.
- A particular substance is usually characterized by what it mostly does to light.

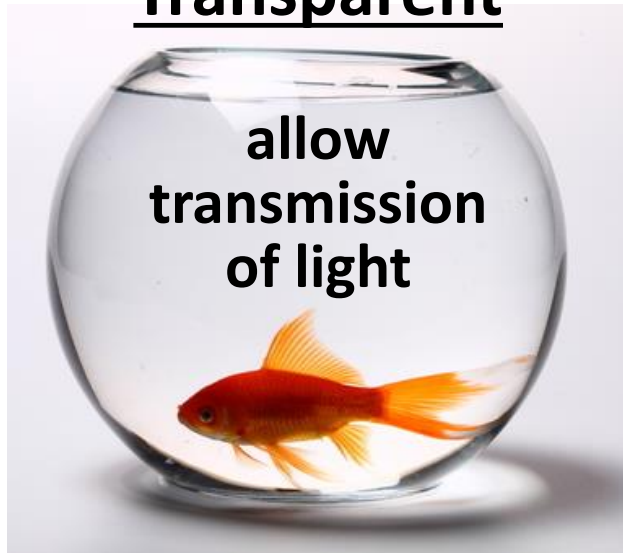
Transmission

passage of light in forward direction



All objects around us can be classified as:

Transparent



Translucent
materials in
between (partial
transmission)

Opaque

(**most materials**)
do not allow
transmission of light



Water: a transparent...mirror?



- Vertical rays of light are mostly transmitted through a transparent material (with *just a little reflection and absorption*).

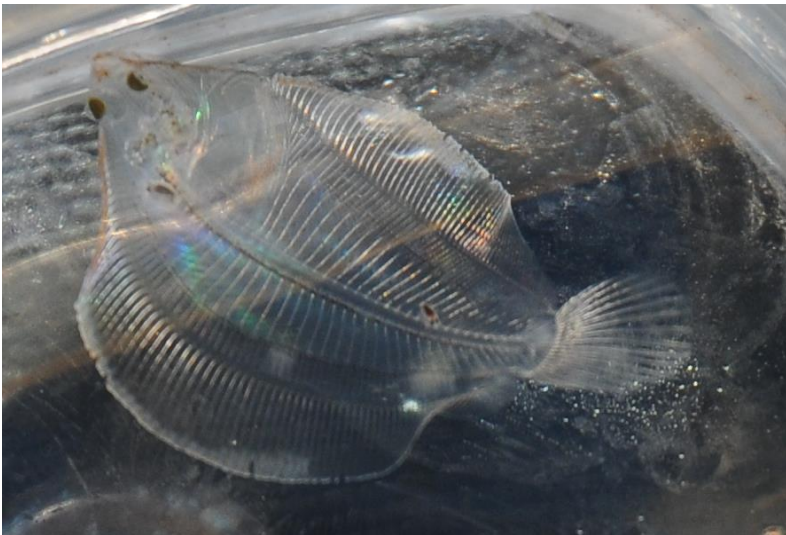


- If light rays strike the surface at some angle, more of the light is reflected (*larger angle results in more reflection*).

Translucent Creatures



Mantis shrimp larva



**How do you
hide in the
ocean?**

**You become
see-through!**

Shadows



- Light rays travel in straight lines, radiating out from the light source.
- If rays are blocked by an opaque object, a **shadow** forms where the light cannot reach.
- If the light source is moved relative to the object, different amount of light is blocked and a different shadow is formed.

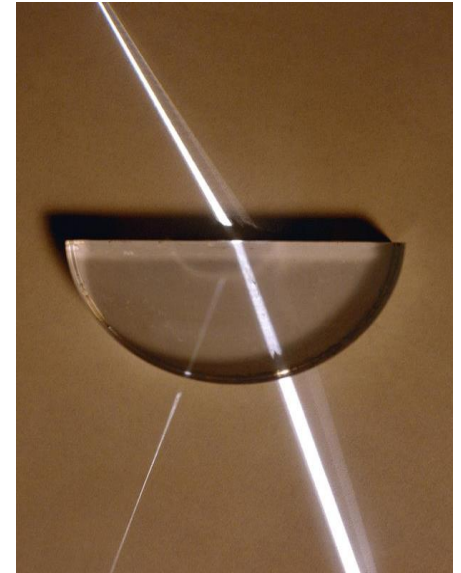
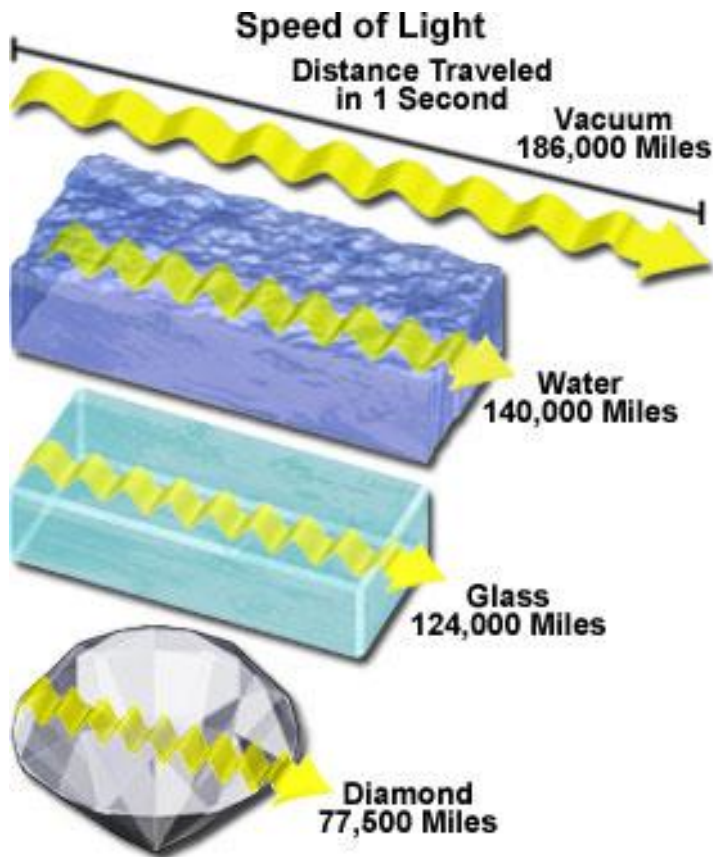


Egyptian obelisk at St. Peter's Square, Vatican City

Refraction

change in the direction of travel at the boundary

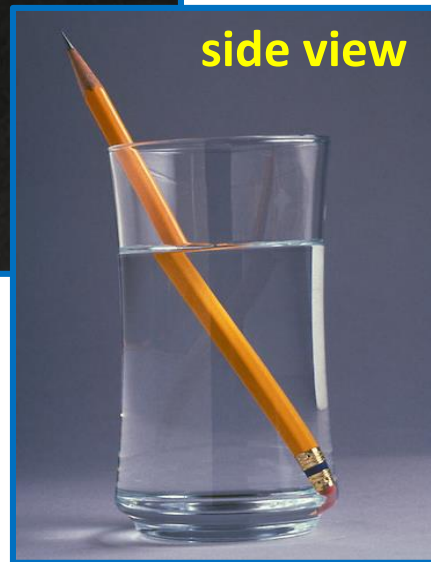
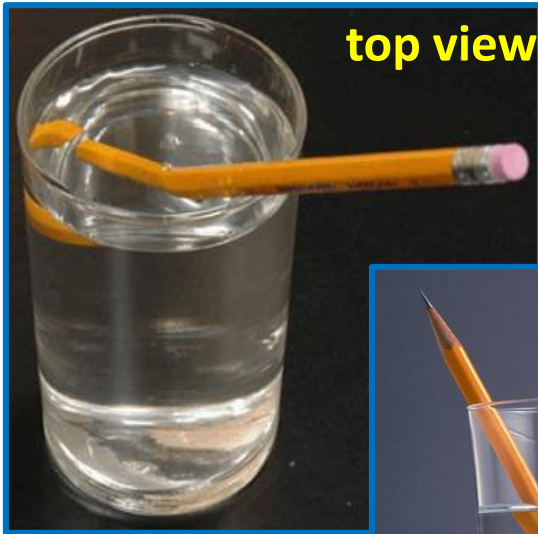
Different materials transmit light at different speeds.



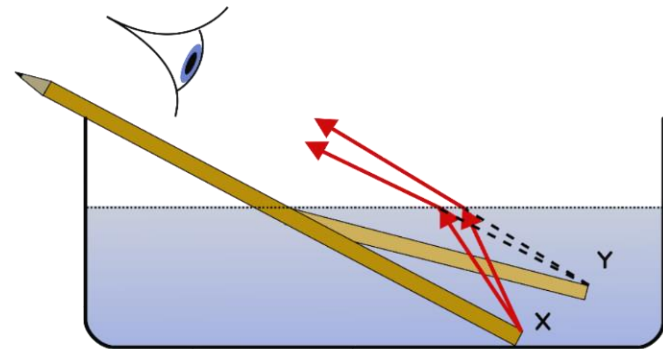
Refraction depends on:

- the **angle of incidence**
- the **ratio of the speed of light** in the two materials
- a ray of light that is **perpendicular** to the surface **is not refracted** at all.

Pencil Experiment



- The light rays from the upper part of the pencil travel straight to the eye.
- The light rays from the submerged portion of the pencil travel:



1. through the water,
2. across the water-air boundary, where they refract,
3. through the air ultimately to the eye.

The **eye-brain interaction cannot account for the refraction of light**: the brain judges the object location to be the location where light rays appear to originate from assuming that light rays always travel in straight lines.

Refraction in Water



Bent, Broken, Magnified...

