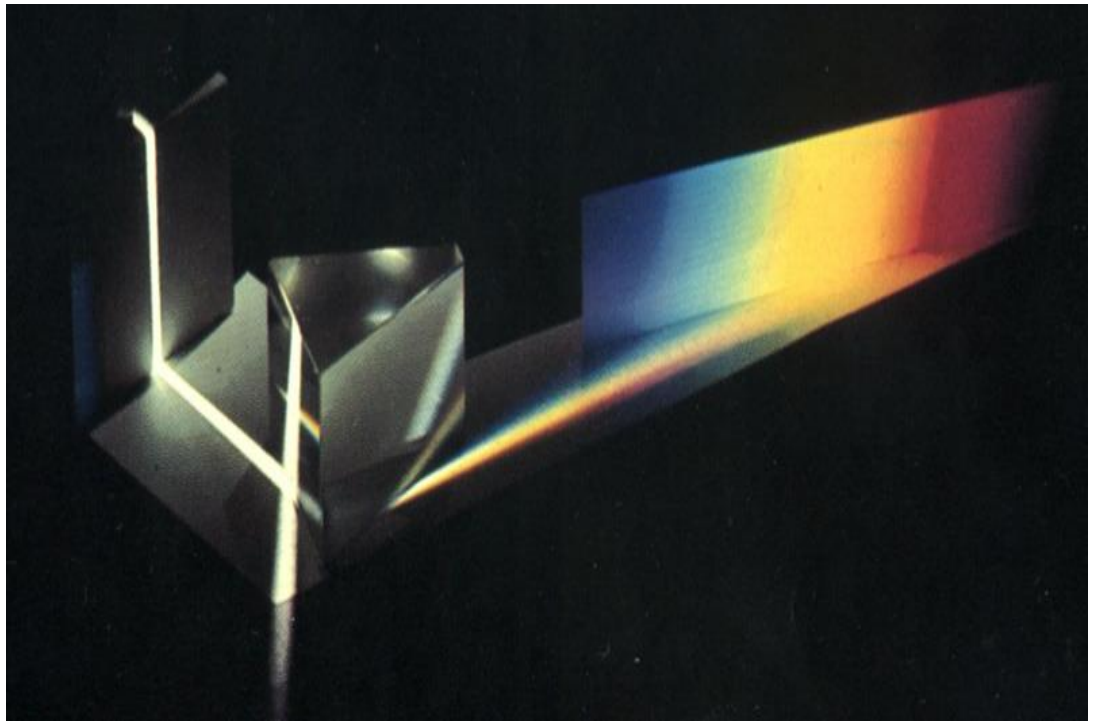
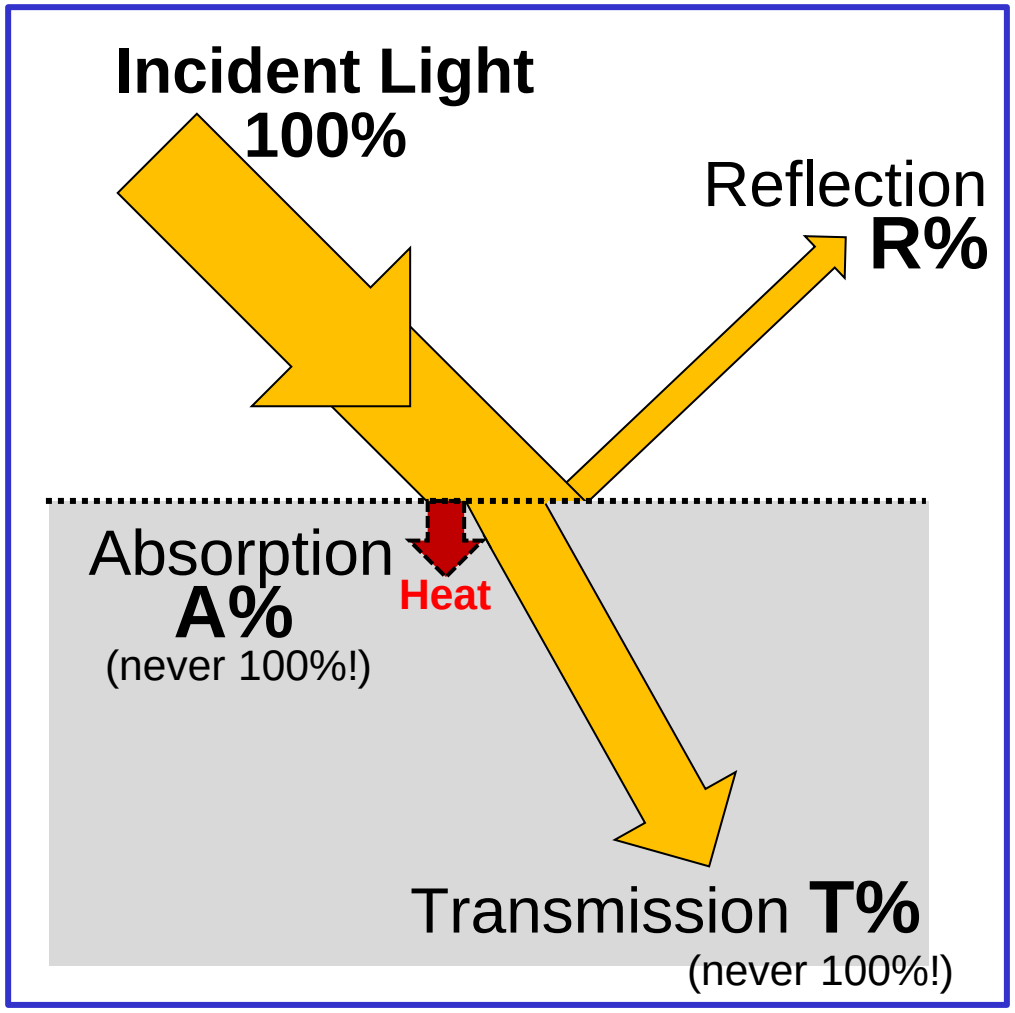
Light meets Matter



What (always) happens to light?

The material world around us can be viewed as objects (substances, materials) and boundaries (surfaces, interfaces).



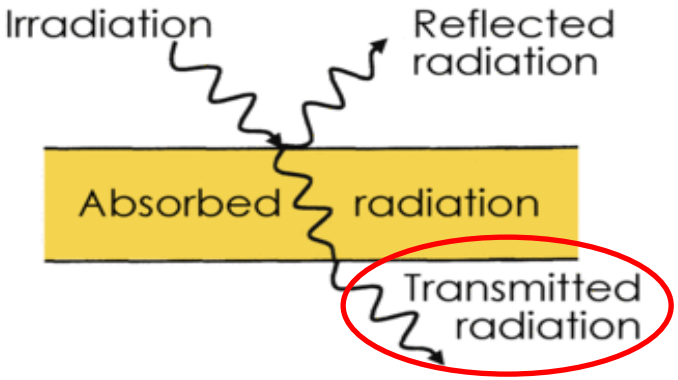
Light (energy!) can be reflected, transmitted or absorbed by matter.

T%+R%+A%=100%

What *exactly* happens to light waves depends on the nature of the material, the smoothness of the surface, the angle of incidence, and the light wavelength.

Transmission

passage of light in forward direction



All objects around us can be classified as:

Transparent

allow transmission of light

(Large T%)

Translucent

partial or selective transmission

Opaque

(most materials) do not allow transmission of light, form shadows

(T%=0)

Shadows

Sculpture by Diet Wiegman, Netherlands

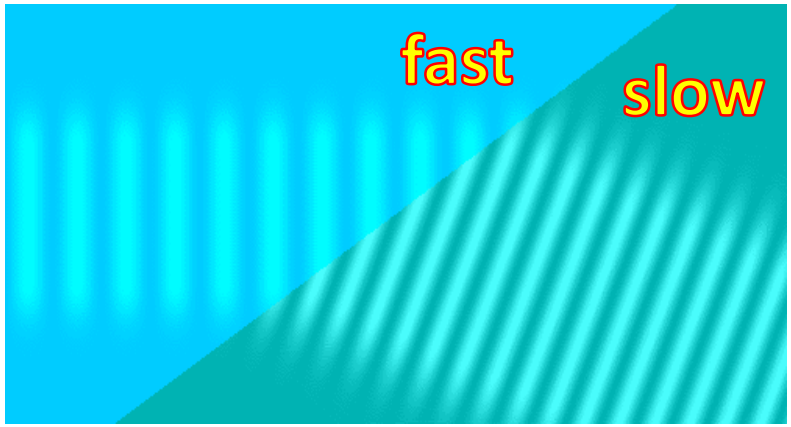
- Light rays travel in straight lines, radiating out from the light source.
- If rays are blocked by an opaque object, a shadow forms where the light cannot reach.
- If the light source is moved relative to the object, different amount of light is blocked, and a different shadow is formed.

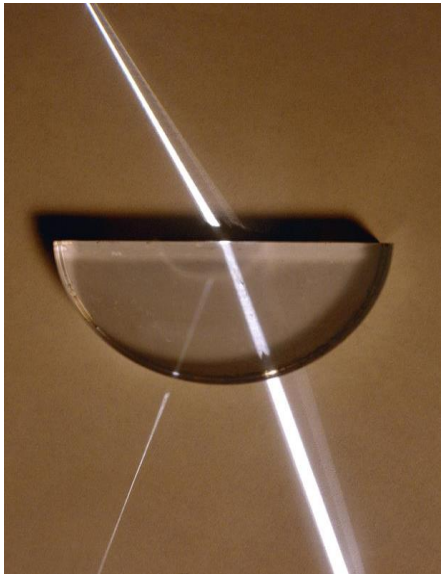
Egyptian obelisk at St. Peter's Square, Vatican City

Transmission: Refraction

change in the direction of travel at the boundary

Different materials transmit light at different speeds.

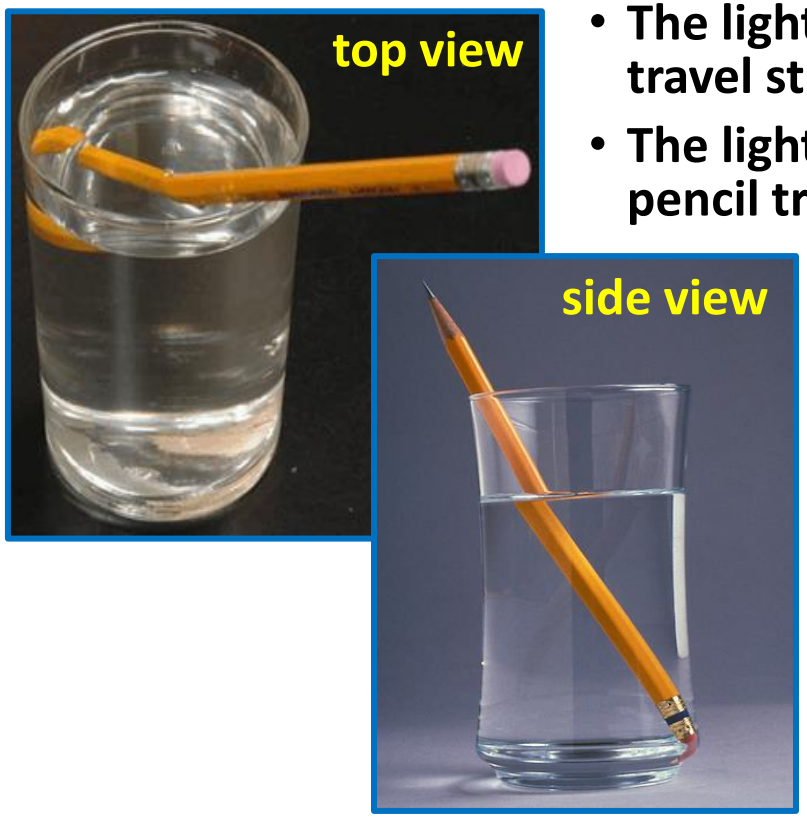




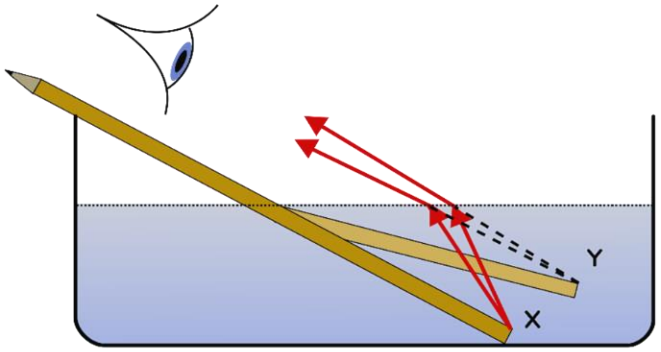
Refraction depends on:

- **the ratio of the speed of light in the two materials (compared to its speed in the air, in a diamond visible light travels about 2.4 times slower; in water – about 1.33 times slower; in glass – about 1.5 times slower)**
- **the angle of incidence; a ray of light that is perpendicular to the surface is not refracted at all.**

Pencil Experiment



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

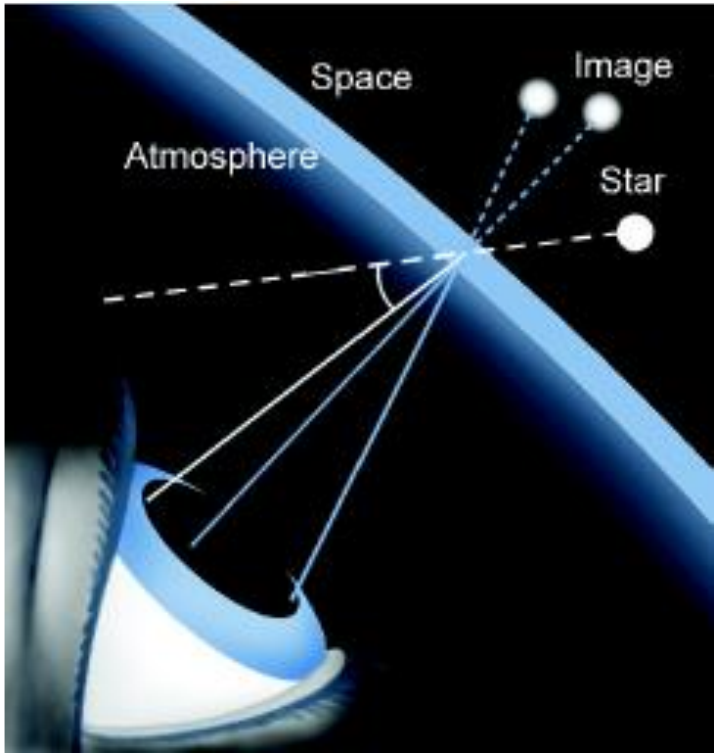


1. through the water,
2. across the water-air boundary, where they <u>refract</u>,
3. through the air ultimately to the eye.

The eye-brain interaction cannot account for the refraction of light: our brain judges the object location to be the <u>location where light rays *appear* to originate from assuming that light rays always travel in straight lines</u>…because when we are babies our brain learns exactly that!

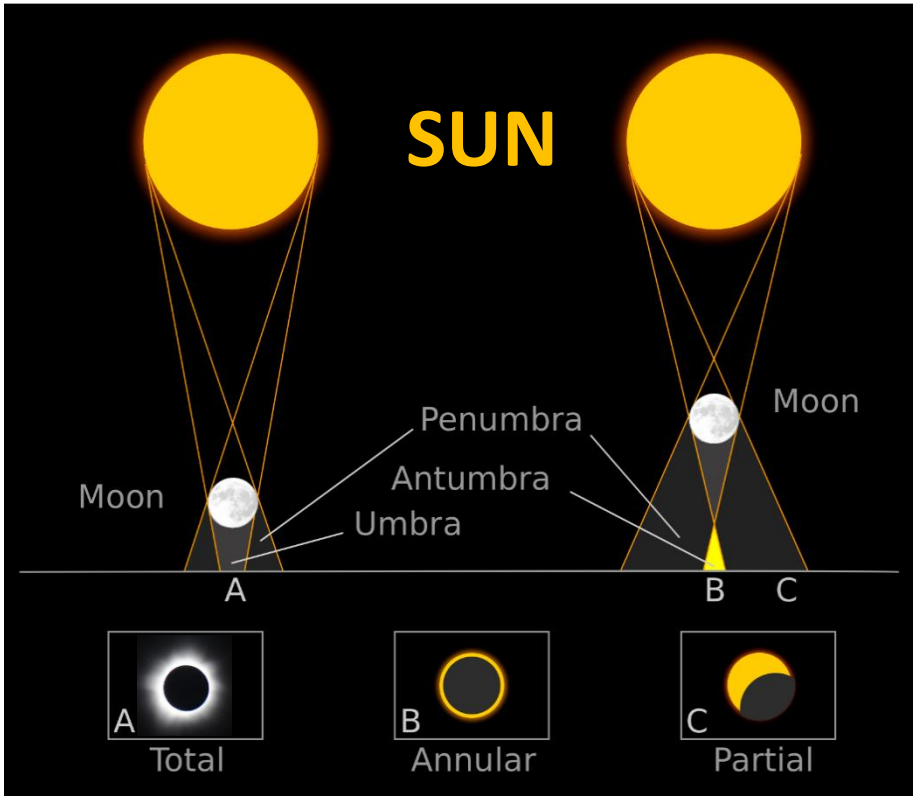
Twinkle, twinkle, little star…

- The scientific term is "astronomical scintillation".
- Observed from the Earth, a star is essentially a pin-point light source.
- As starlight travels from space into the Earth's atmosphere, the rays are refracted.
- Since the atmosphere is constantly changing due to turbulence, the amount of refraction also constantly changes.



- This causes the image of a star to form in a slightly different part of our eye retina every moment – we perceive it as twinkling.
- Planets usually do not twinkle – why?
- You might actually see a planet twinkling if it appears low at the horizon – why?

Solar Eclipse



Translucent Creatures

(partial transmission)

Mantis shrimp larva

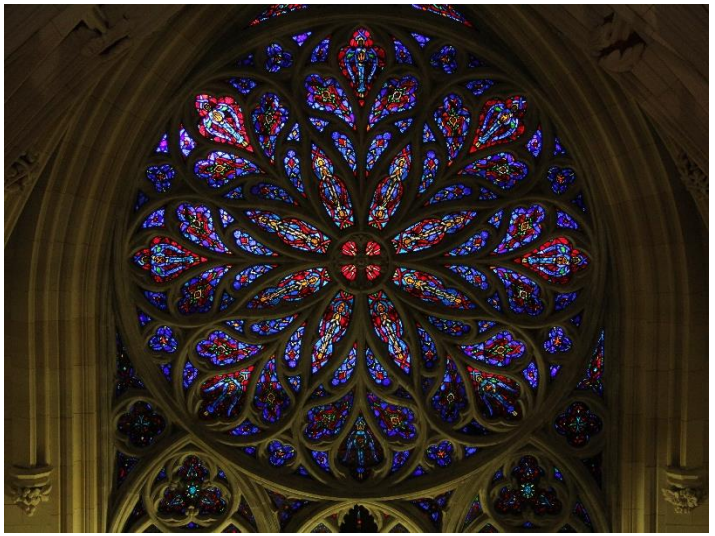
How do you hide in the ocean?

You become see-through!

Light Filters *(selective transmission)*

Rashad Alakbarov, Azerbaijan

Tom Fruin, USA



Rose Window
St. Patrick's Cathedral, New York

Refraction *in Water*