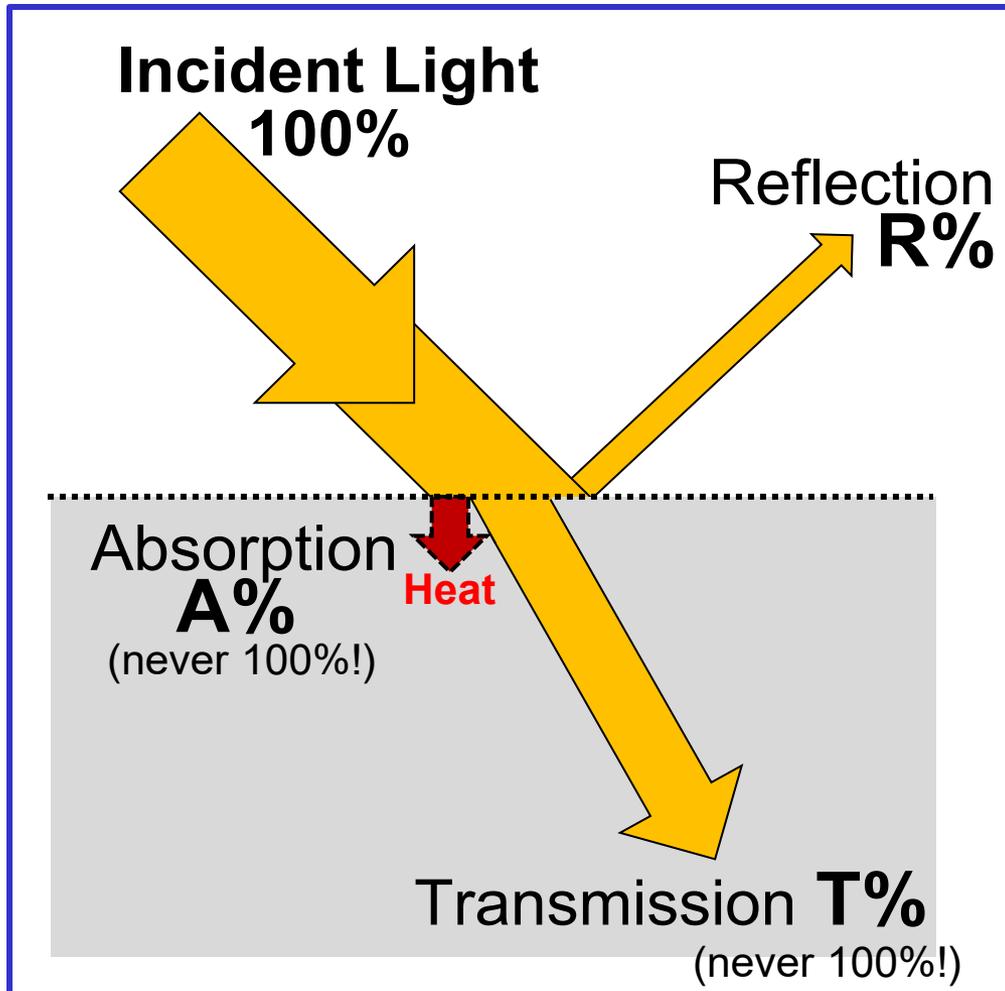


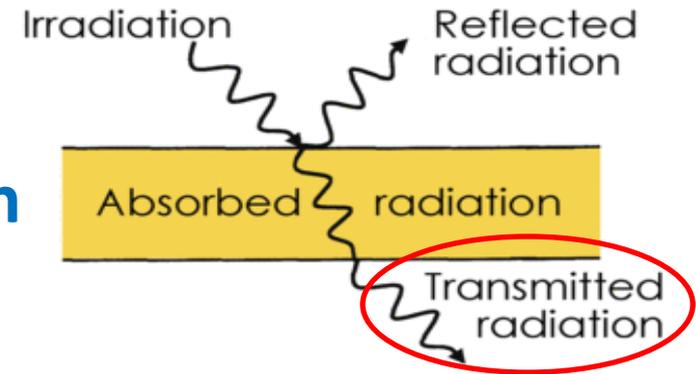
# What (always) happens to light?

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



# Transmission

passage of light in forward direction



All objects around us can be classified as:

## Transparent



(Large T%)



## Translucent

partial or selective transmission

## Opaque

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



(T%=0)

# Shadows

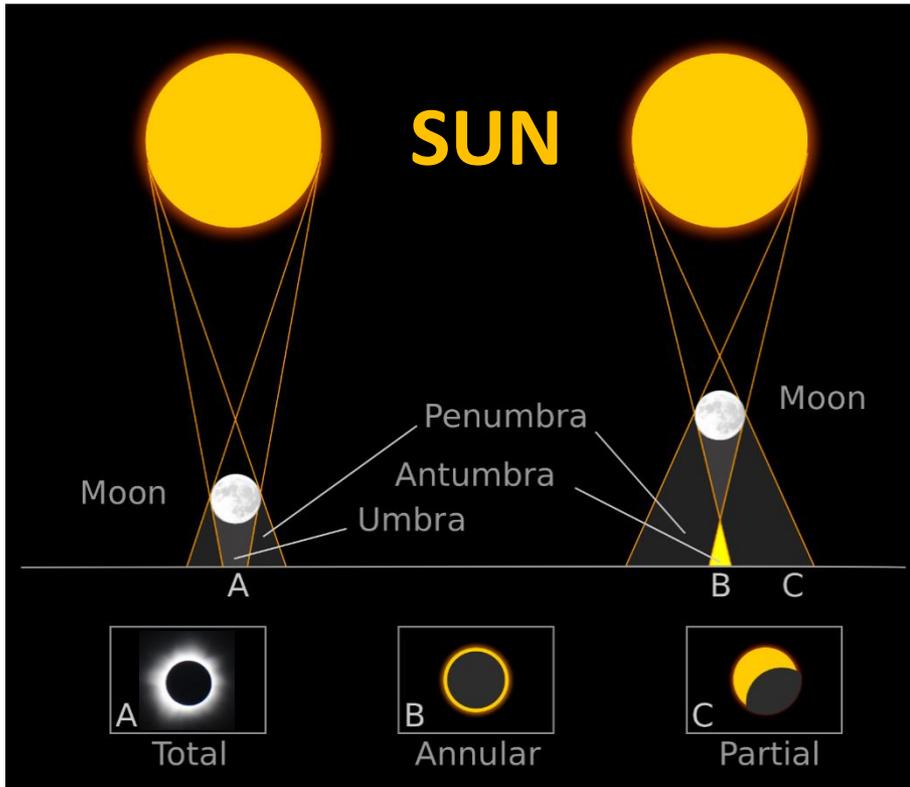


- Light rays travel in straight lines, radiating out from the light source.
- If rays are blocked by an opaque object, a **shadow** forms where the light cannot reach.
- If the light source is moved relative to the object, different amount of light is blocked, and a different shadow is formed.



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

# Solar Eclipse



# Translucent Creatures

*(partial transmission)*



Mantis shrimp larva



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

**You become  
see-through!**

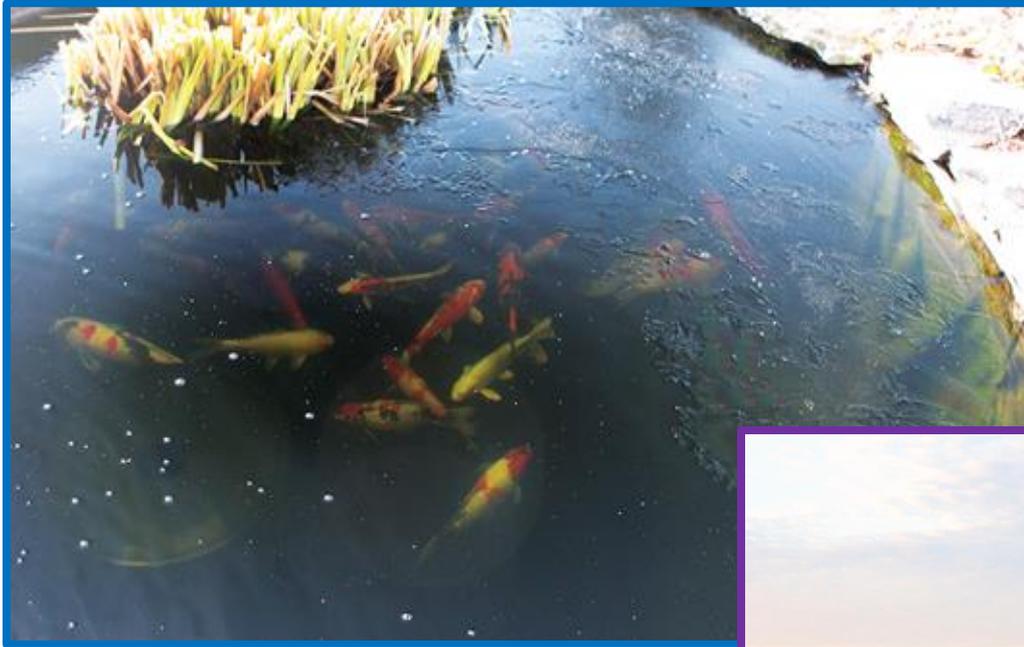
# Light Filters *(selective transmission)*



**Rose Window  
St. Patrick's Cathedral, New York**



# Water: a transparent...mirror?



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

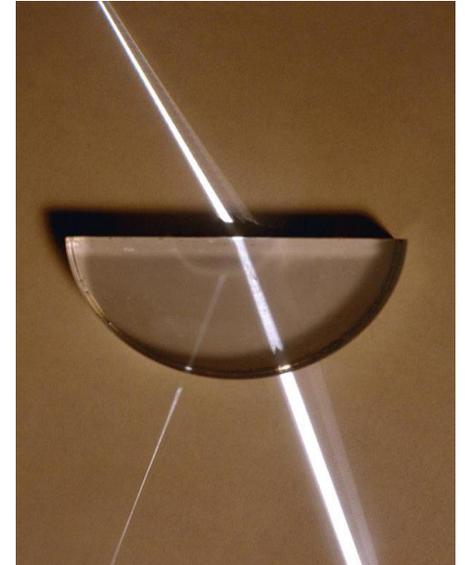
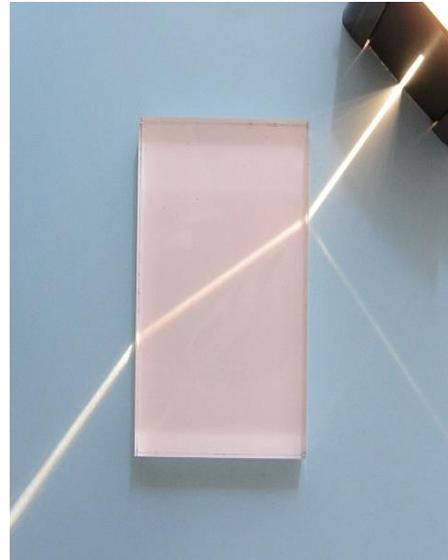
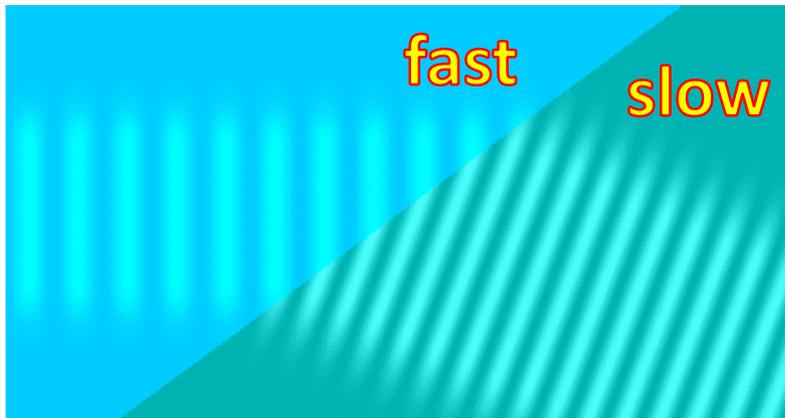
- If light rays strike the surface at some angle, more of the light is reflected (*larger angle results in more reflection*).



# Transmission: Refraction

change in the direction of travel at the boundary

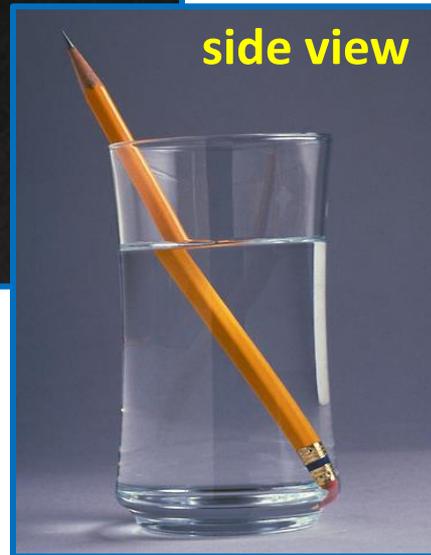
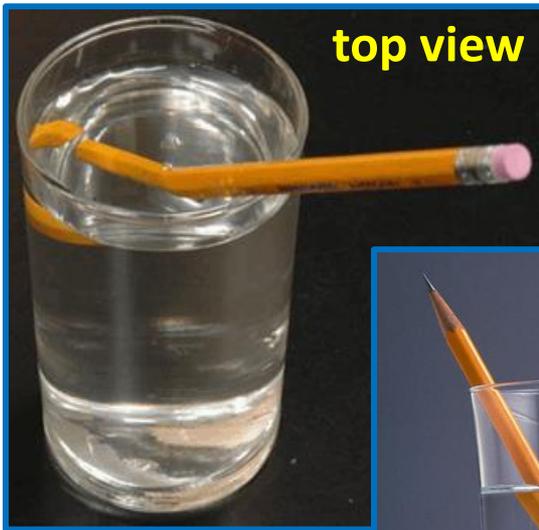
Different materials transmit light at different speeds.



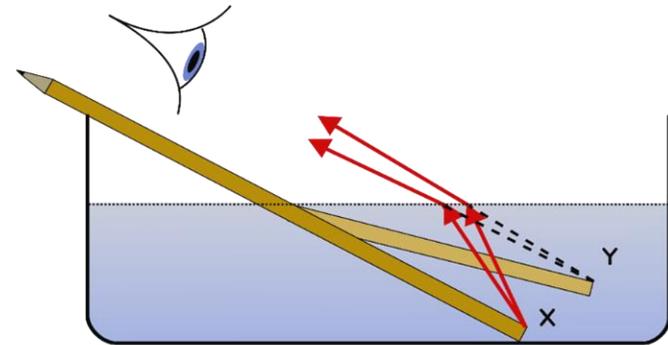
Refraction depends on:

- 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 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**: our 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...because when we are babies our brain learns exactly that!

# Refraction in Water

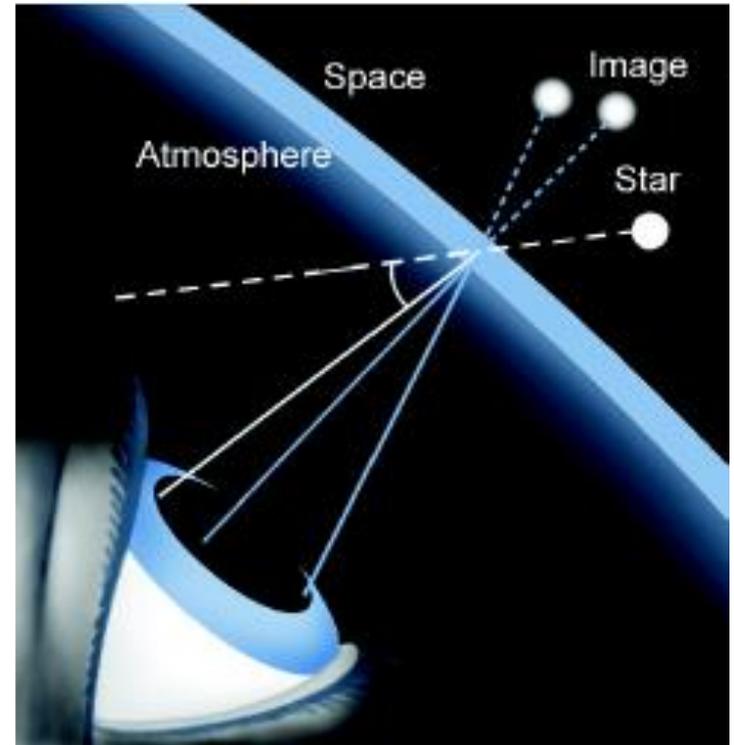


by Jantina Peperkamp



# 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?