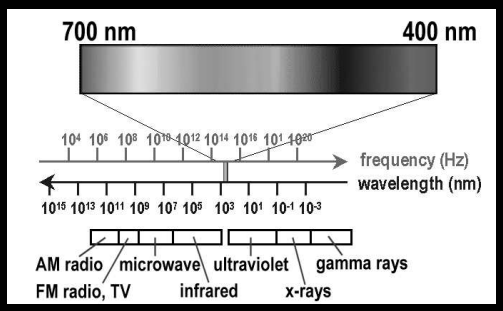
Physics of Light and Color

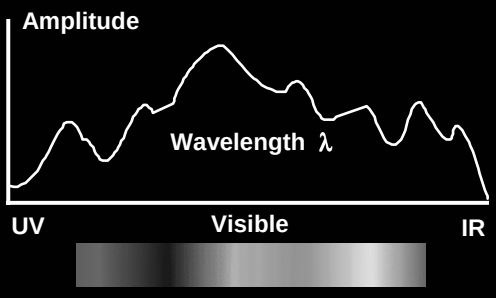
- It's all electromagnetic (EM) radiation
  - Different colors correspond to different ***wavelengths*** λ
  - Intensity of each wavelength specified by ***amplitude***
  - ***Frequency*** $\nu = 2\pi / \lambda$
    - long wavelength is low frequency
    - short wavelength is high frequency



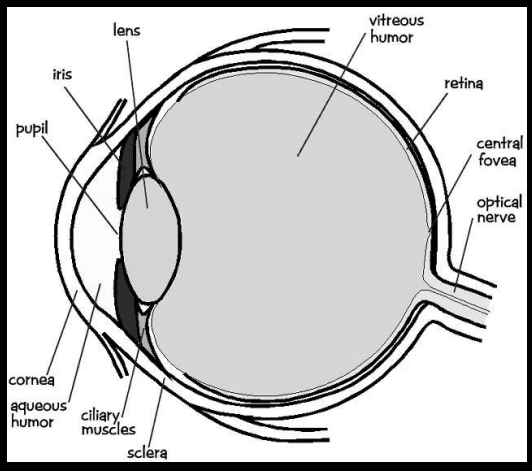
We perceive EM radiation with λ in the 400-700 nm range

Color: What's There vs. What We See

- Human eyes respond to "visible light"
  - tiny piece of spectrum between infra-red and ultraviolet
- Color defined by emission spectrum of light source
  - amplitude vs wavelength (or frequency) plot

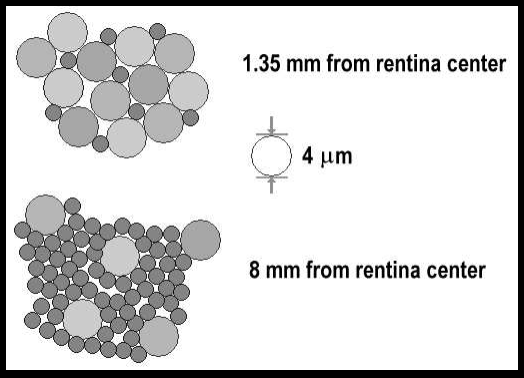


The Eye

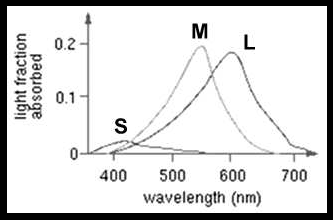


- The image is formed on the ***retina***
- Retina contains two types of cells: ***rods*** and ***cones***
- Cones measure color (red, green, blue)
- Rods responsible for monochrome night-vision

The Fovea



Cones are most densely packed within a region of the retina called the *fovea*



- Three types of cones: S,M,L
  - •Corresponds to 3 visual pigments
- Roughly speaking:
  - S responds to blue
  - M responds to green
  - L responds to red
- Note that these are not uniform
  - more sensitive to green than red
- Colorblindness
  - deficiency of one cone/pigment type

Color Filters

- Rods and cones can be thought of as filters
  - Cones detect red, green or blue parts of spectrum
  - Rods detect average intensity across spectrum
- To get the output of a filter
  - Multiply its response curve by the spectrum, integrate over all wavelengths
- A physical spectrum is a complex function of wavelength
  - But what we see can be described by just 3 numbers—the color filter outputs
  - How can we encode a whole function with just 3 numbers?
    - A: we can't! We can't distinguish certain colors--*metamers*