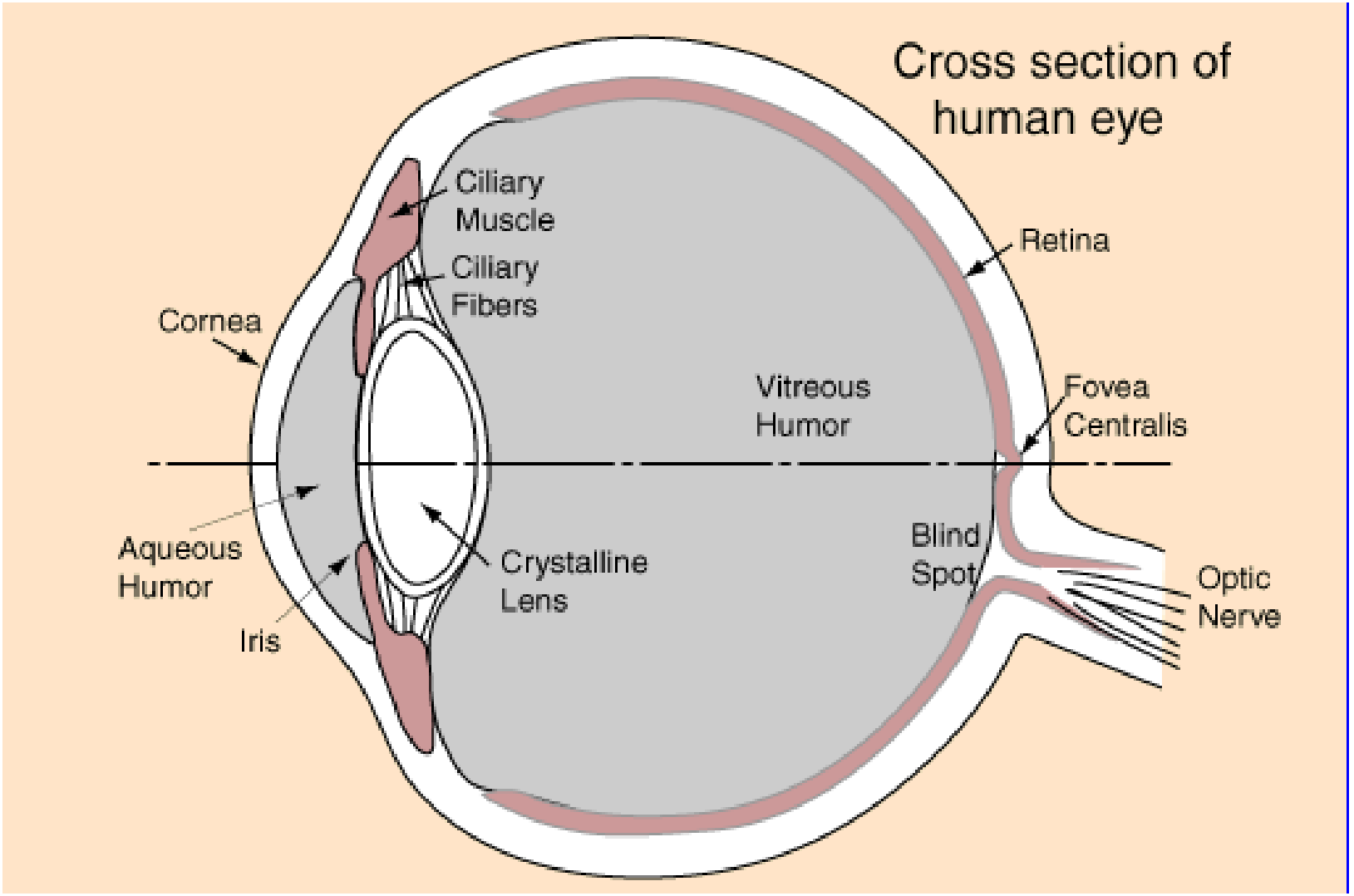
The Eye and Sight

Structure of the Human Eye



Source: Hyperphysics

Functions of Parts of the Eye

- Cornea: thin, tough membrane over eye, does most of refracting of light onto the retina (~80%)
- Aqueous and vitreous humors: nourish eye and maintain its shape
- Iris: the colored part of the eye; a ring of muscles that control size of pupil (aperture) and thus amount of light entering eye
- Crystalline lens: does ~20% of refraction of light onto retina; its *adjustable focal length* allows for far/near **accommodation**

Parts of the Eye (cont.)

- Ciliary muscles and fibers: adjust shape of lens and thus change its focal length
- Retina: light-sensitive layer containing **rod and cone cells** and connections to optic nerve
- Fovea centralis (macula lutea): spot on principal axis of eyeball, location of most acute vision and most color perception
- Optic nerve: carries electric signals to brain for processing (*blind spot* is located where optic nerve leaves for the brain)

Blind Spot: Missing Head Illusion

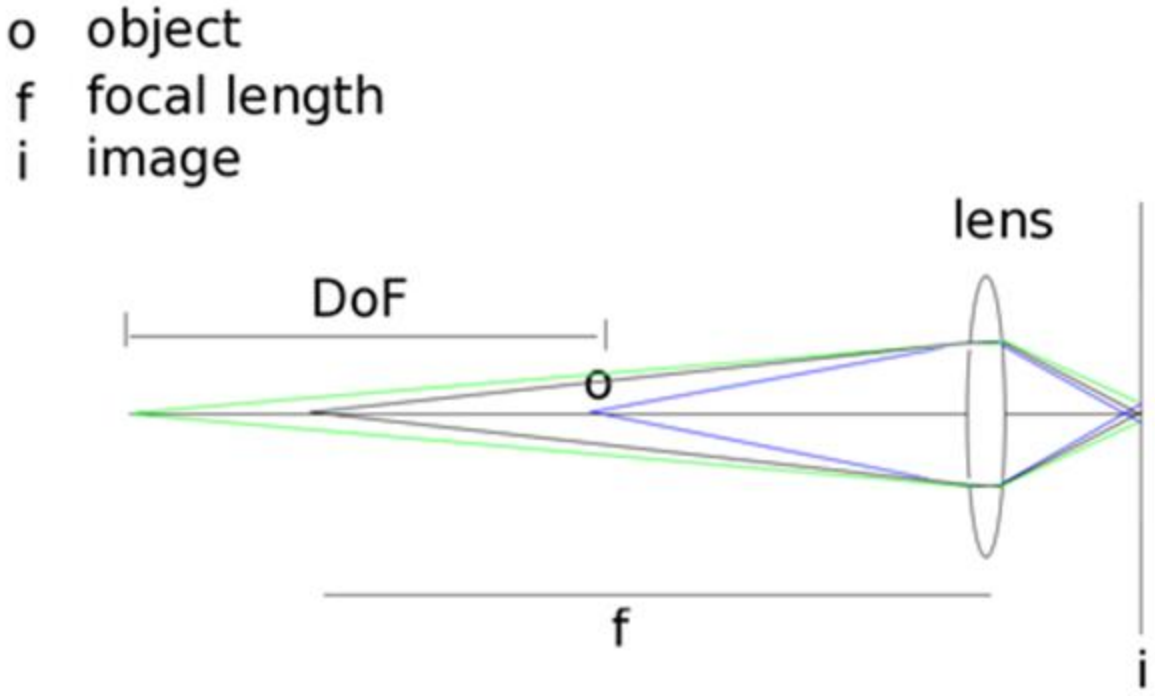
http://www.youtube.com/watch?feature=player_embedded&v=O7jpJ12lBjg

Depth of Vision

- The eye can't focus simultaneously on two objects at two different distances from the eye
- Focusing on an object in mid-range allows objects closer and further than that object to be seen with *sufficient* clarity

Depth of Vision (cont.)

- **Depth of vision**: the range of object distances from the eye within which objects can be seen with acceptable clarity: also called depth of field

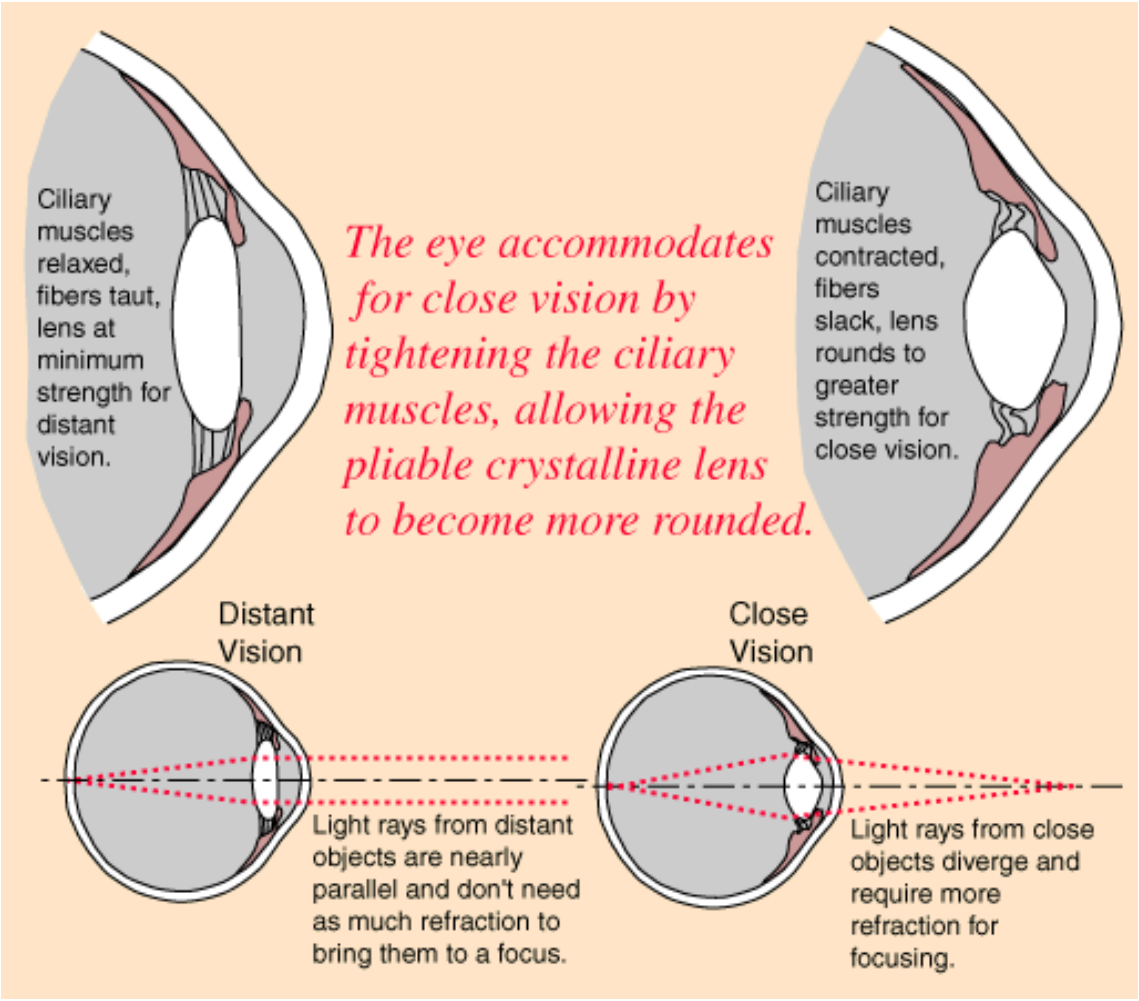


Depth of Vision (cont.)

- Depth of vision depends on distance to the object:
  - The further away the object is from the eye, the larger the depth of vision
  - If the object is placed closer to the eye, the depth of vision is reduced

- Depth of vision depends on brightness of light:
  - In brighter light the iris reduces pupil size and the smaller aperture gives increased depth of vision

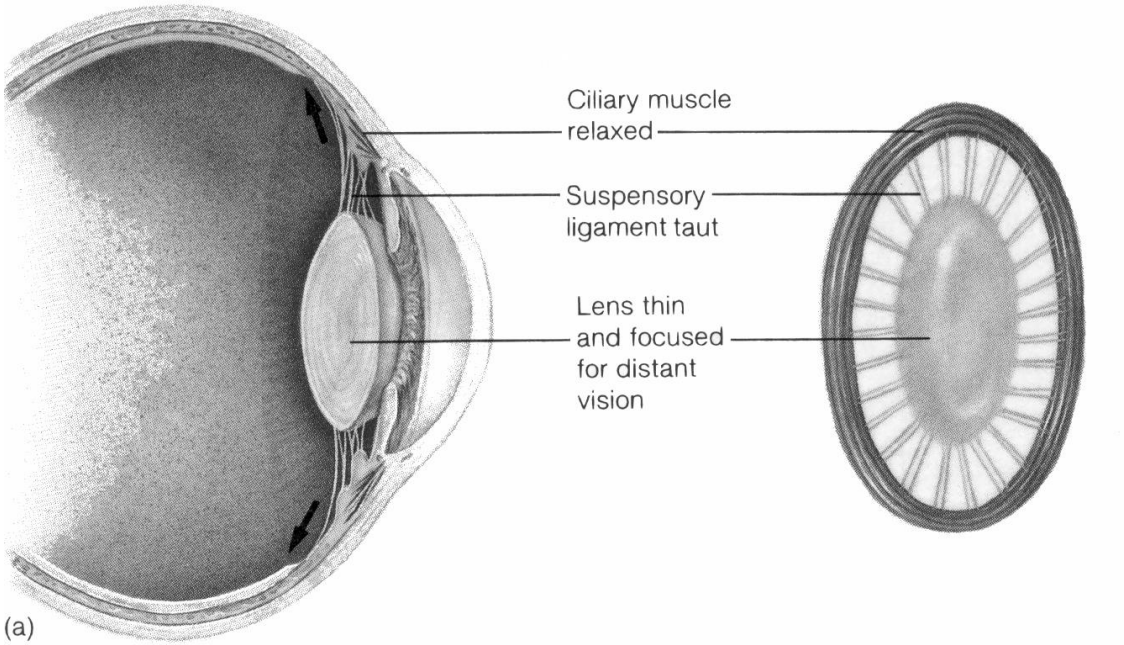
Accommodation

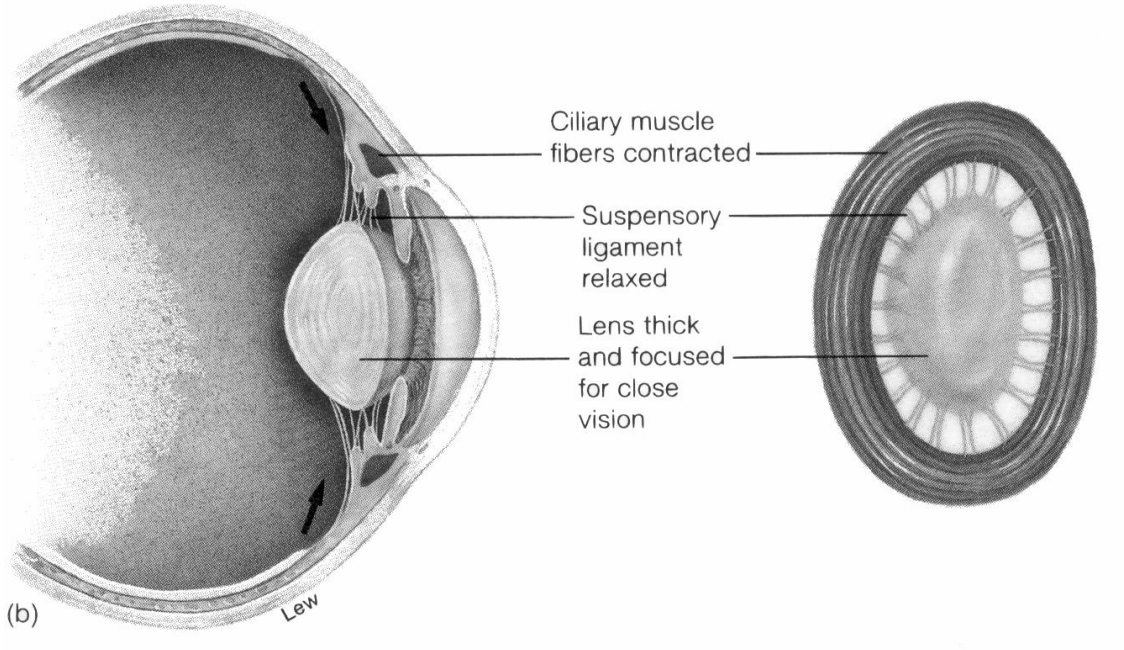


Range over which normal eye can focus

Near point: about 25 cm; ciliary muscles contract, lens relaxes to give more curvature

Far point: infinity; ciliary muscles relax, lens pulled tight and flat

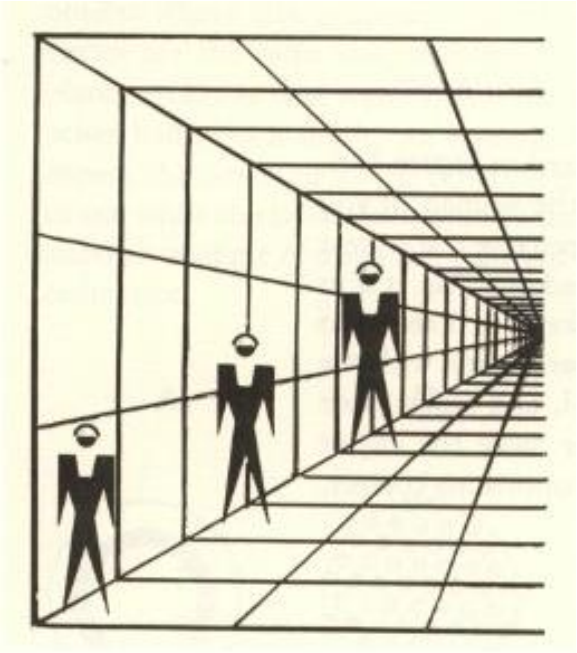

Ciliary muscle
relaxed
Suspensory
ligament taut
Lens thin
and focused
for distant
vision
(a)


Ciliary muscle
fibers contracted
Suspensory
ligament
relaxed
Lens thick
and focused
for close
vision
(b)
Lew

Depth Perception

- Clues from monocular vision:
  - Motion parallax (far off objects appear to move more slowly)
  - Depth from motion (changing size of moving objects)
  - Perspective
  - Relative size of objects

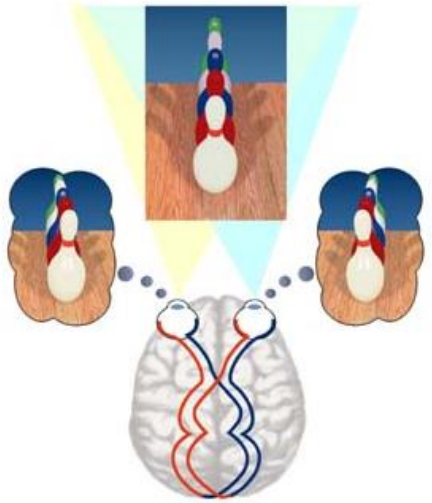
    (closer subtends larger angle)
  - Familiar size
  - Light and shade
  - Aerial perspective



The Trapezoidal (or Ames) Room

Depth Perception (cont.)

- Clues from binocular vision:
  - Stereopsis (two images of same scene from slightly different angles)
  - Convergence/fusion (images from two retinas merge to form a single image)

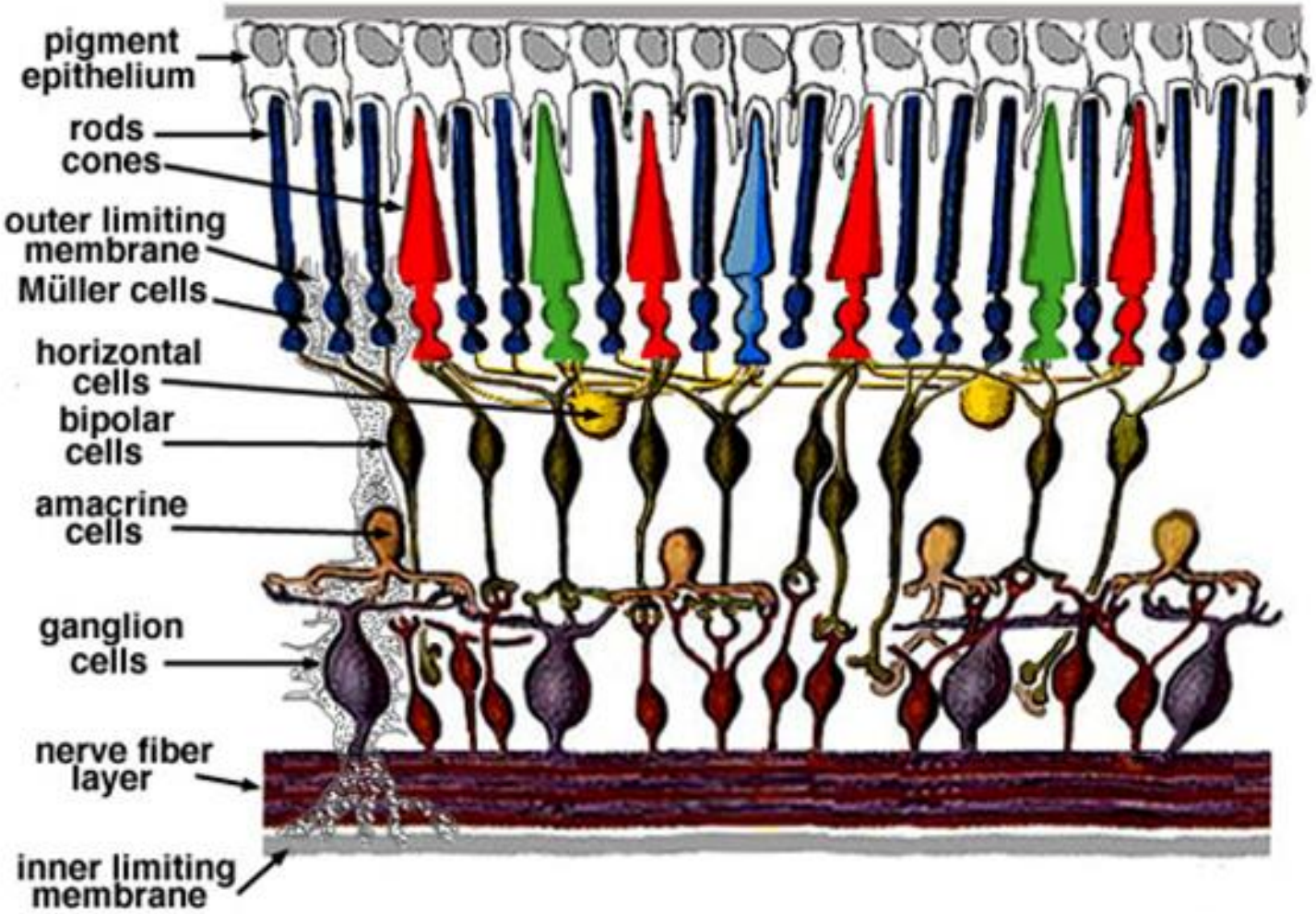


Cyclops: One eye.
Zero depth perception.

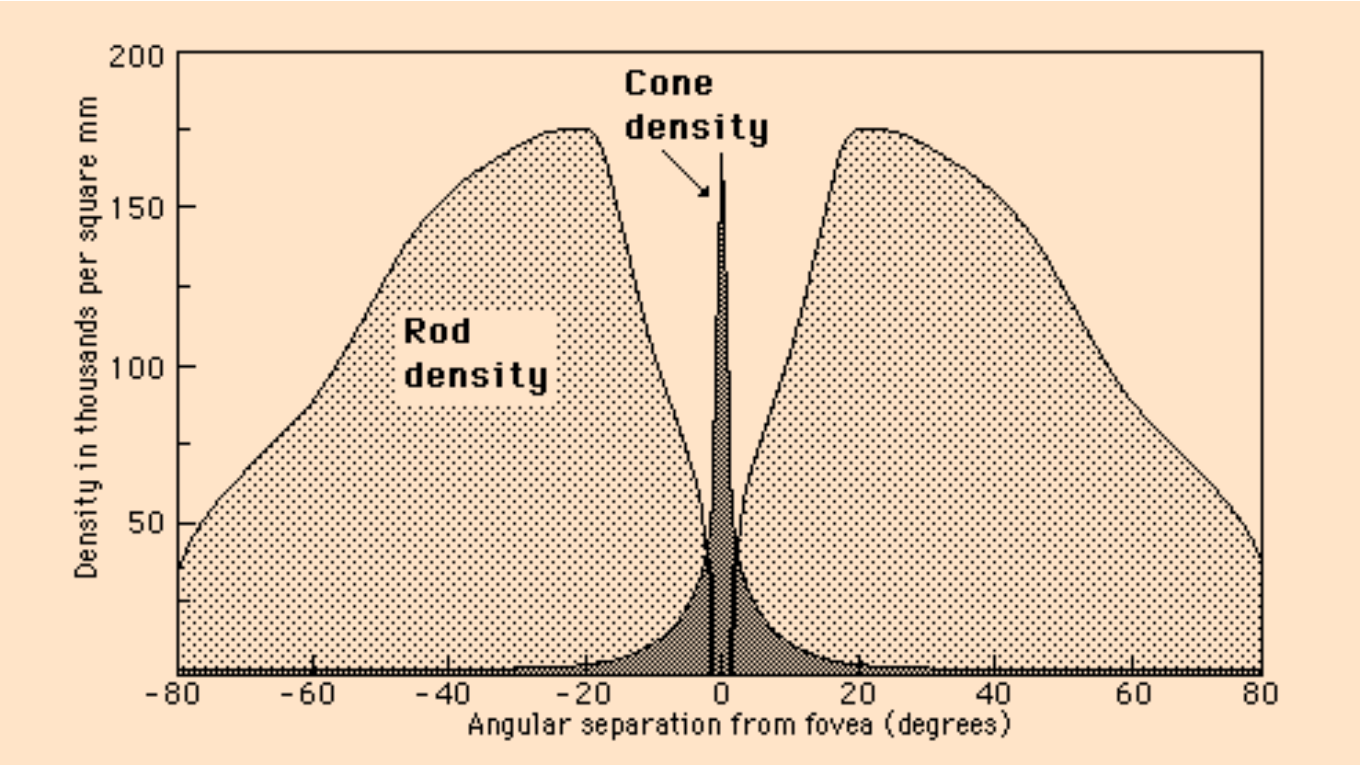
Light Receptor Cells

- Rod cells
  - responsible for scotopic vision (low light intensity)
  - detect motion, responsible for peripheral vision, low-light vision
  - 120 million/eye
- Cone cells
  - responsible for photopic vision (high light intensity)
  - responsible for color vision, visual acuity
  - three types: blue sensitive, red sensitive, green sensitive
  - 6 million/eye

Rod and Cone Cells



Light Receptor Cells Aren't Evenly Distributed

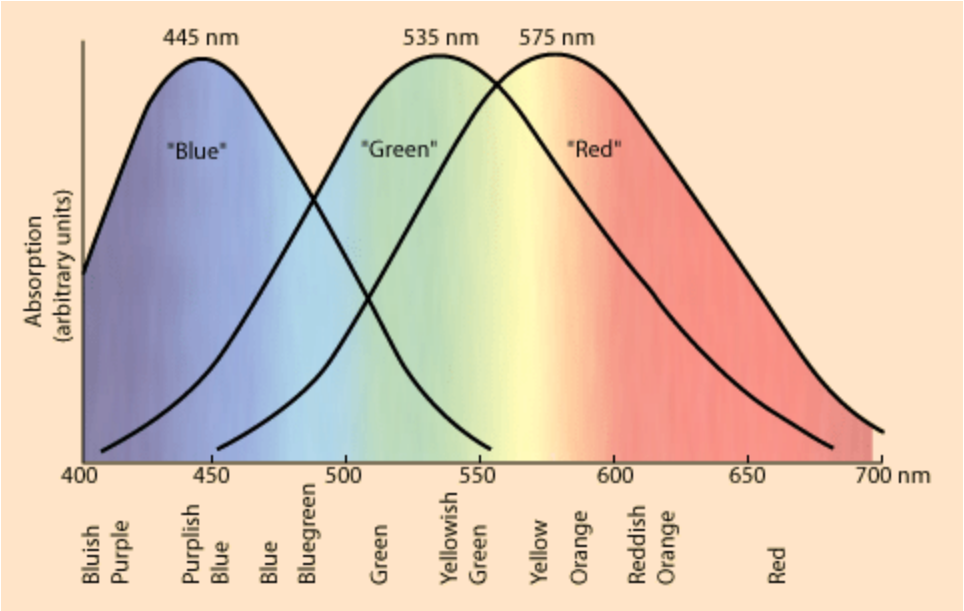


- Rod cells have highest density ~20° from fovea
- Cone cells concentrated around the fovea

Photopic and Scotopic Vision

Photopic Vision	Scotopic Vision
Cones are used	Rods are used
Fewer connected to same nerve fiber	Many connected to same nerve fiber
Used during day and when light intensity is high	Used at night when light intensity is low
Distinguishes shapes and colors	Distinguishes shapes but not colors
Distinguishes detailed images	Distinguishes little detail

Response curves for cone cells

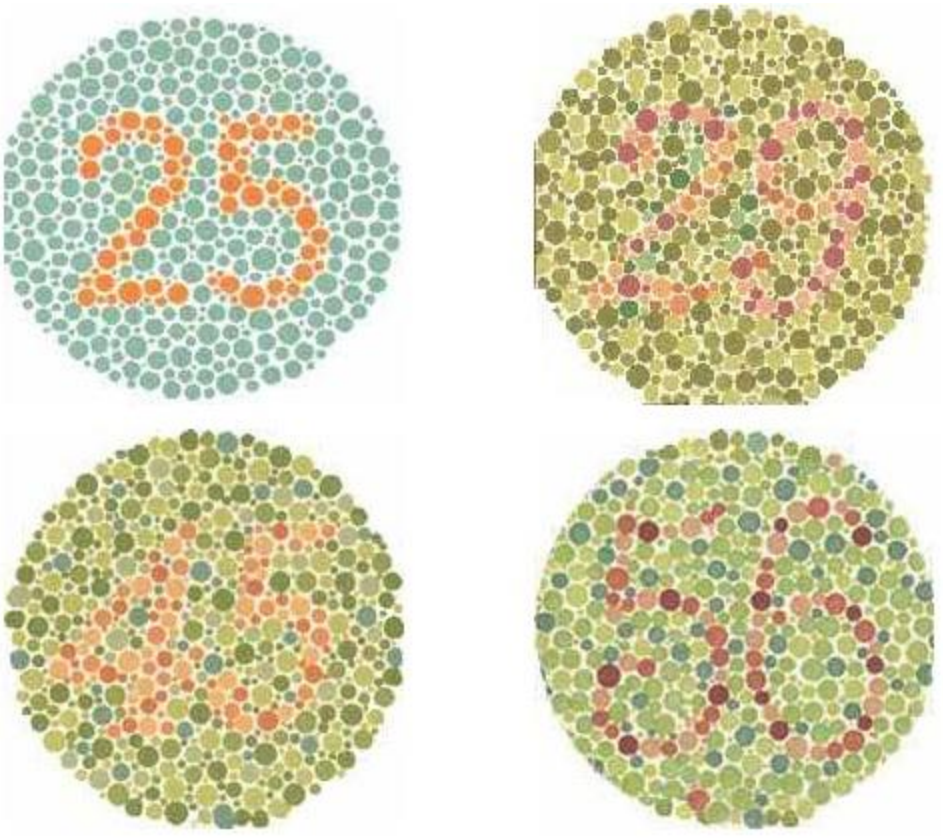


- Number distribution of cone cells: ~2% blue, ~32% green, ~64% red
- Red and green cells both sensitive to yellow
- Blue cells don't respond to yellow or red
- Color blind people have trouble distinguishing between different colors
  - red/green most common, inherited

Color Blindness

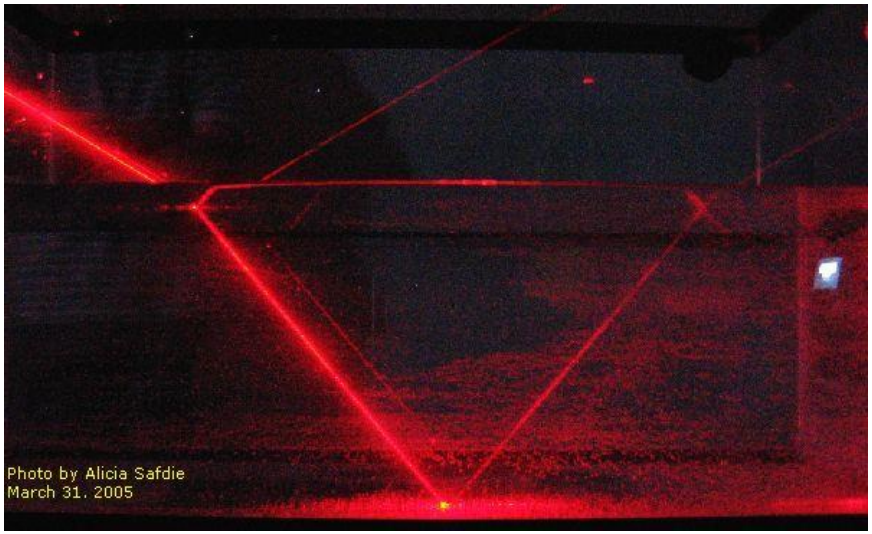
- May be associated with
  - Non-functioning cone cells:
    - If one type non-functioning, colors perceived are those that can be made by combining colors to which the other two are sensitive
    - If two types non-functioning person completely color blind: cannot distinguish between any two colored objects
  - Insufficient numbers of one or more types of cone cells
  - Brain or nerve damage

Typical color blindness test: what numbers do you see?



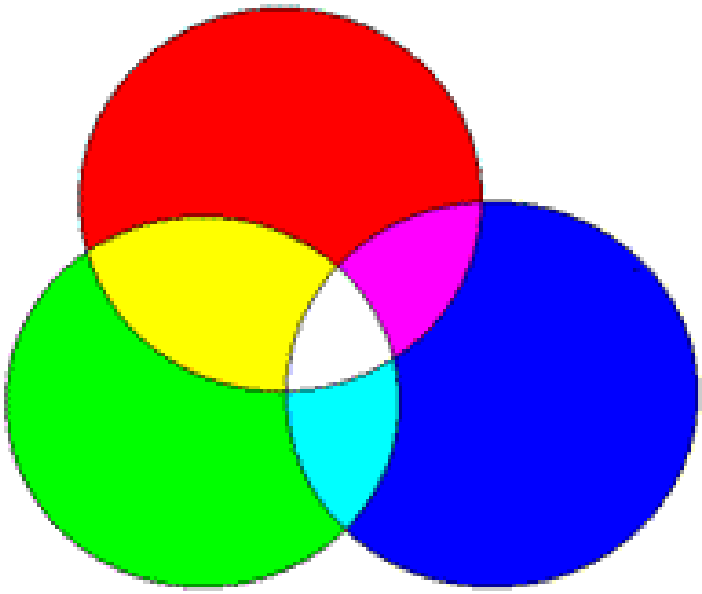
Color Vision and Refraction

- When light refracts, why don't we see different colors of light in the different media?
  - Our perception of light is based on what our brain perceives about the frequency of light
  - Since frequency doesn't change during refraction, even though wave speed and wave length do, we see no difference in color



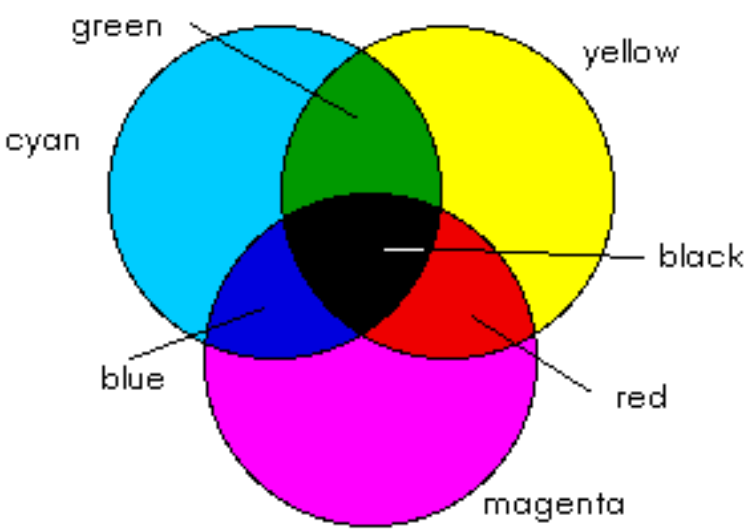
Color by Addition

- Primary colors of light:
  - Red, Green, Blue
- Secondary colors obtained by adding pairs of primary colors:
  - Red + Green = Yellow
  - Red + Blue = Magenta
  - Blue + Green = Cyan
- The primary color added to secondary to give white light is the complementary color of the secondary (e.g., red is complementary color of cyan)



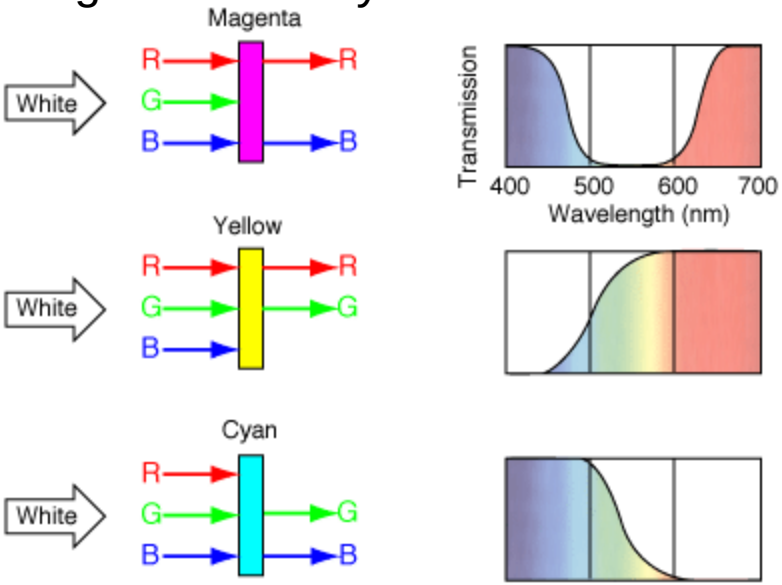
Color by Subtraction

- Filters absorb some wavelengths of light and allow others to pass through
- Colored filters of the subtractive primary colors -- cyan, yellow, and magenta -- allow the additive primary colors -- red, green, and blue -- to pass through where two of the filters overlap
- Where all three filters overlap, no light passes through and the area is black.
- Basis of color printing

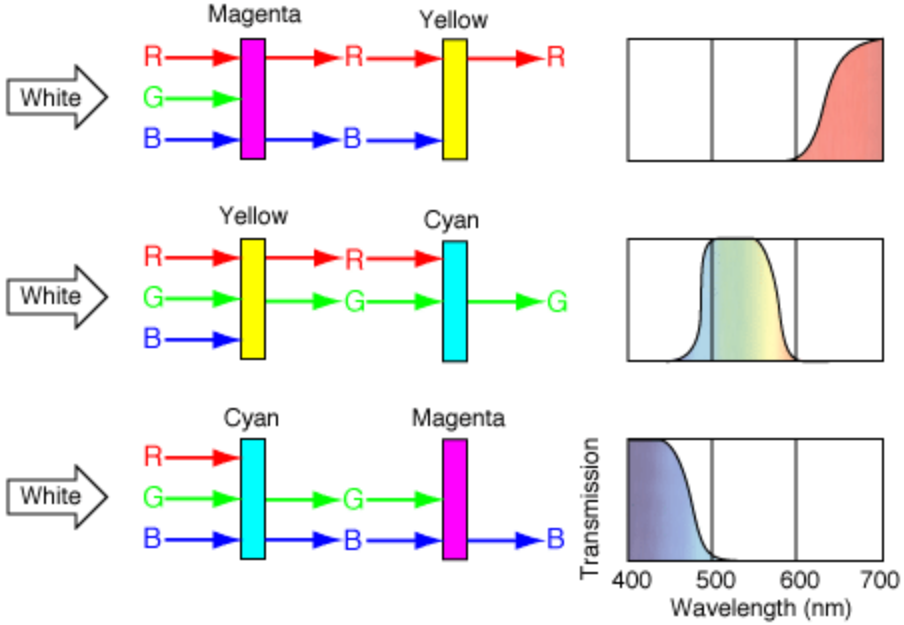


Color Mixing by Subtraction: Filters and Pigments

Single Secondary Color Filters



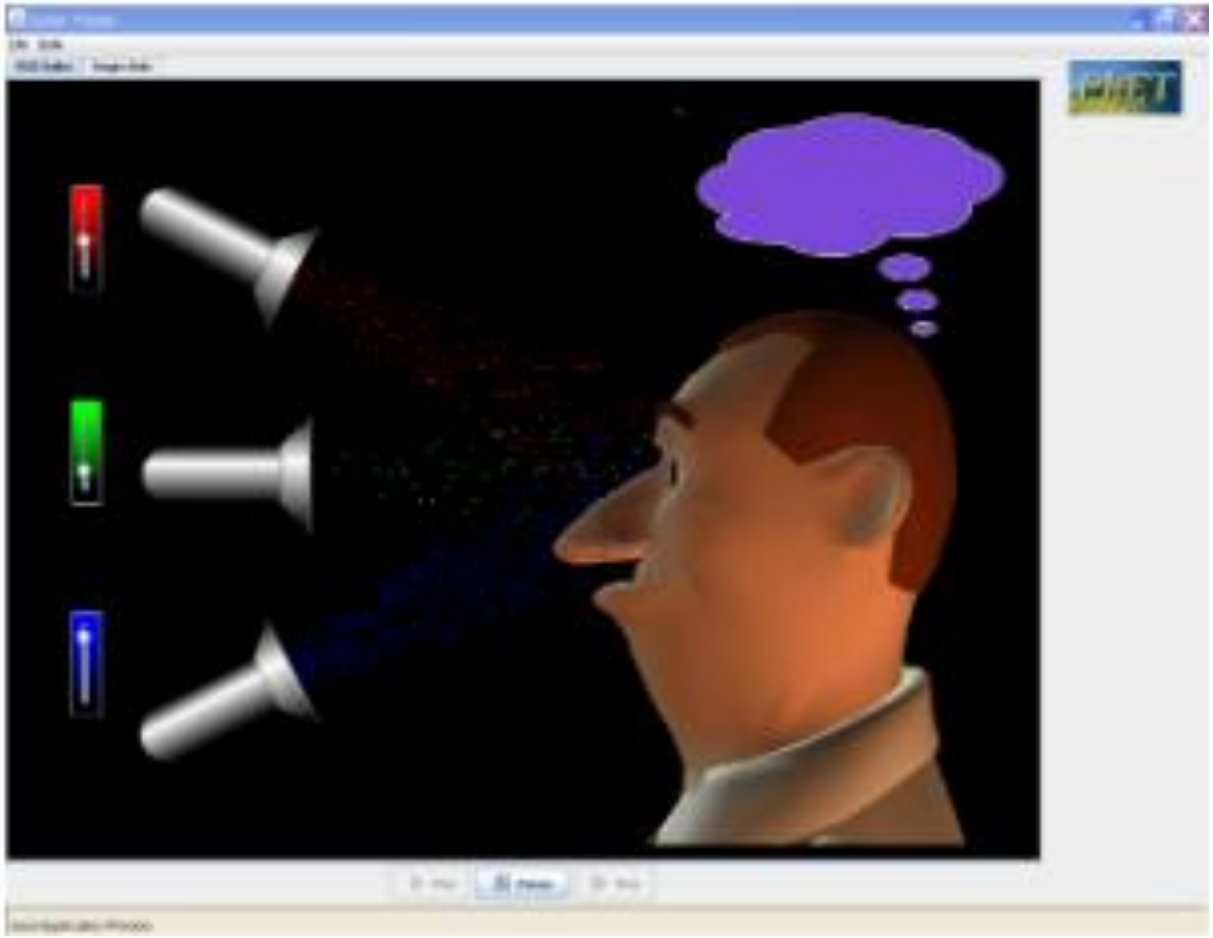
Pairs of Secondary Color Filters



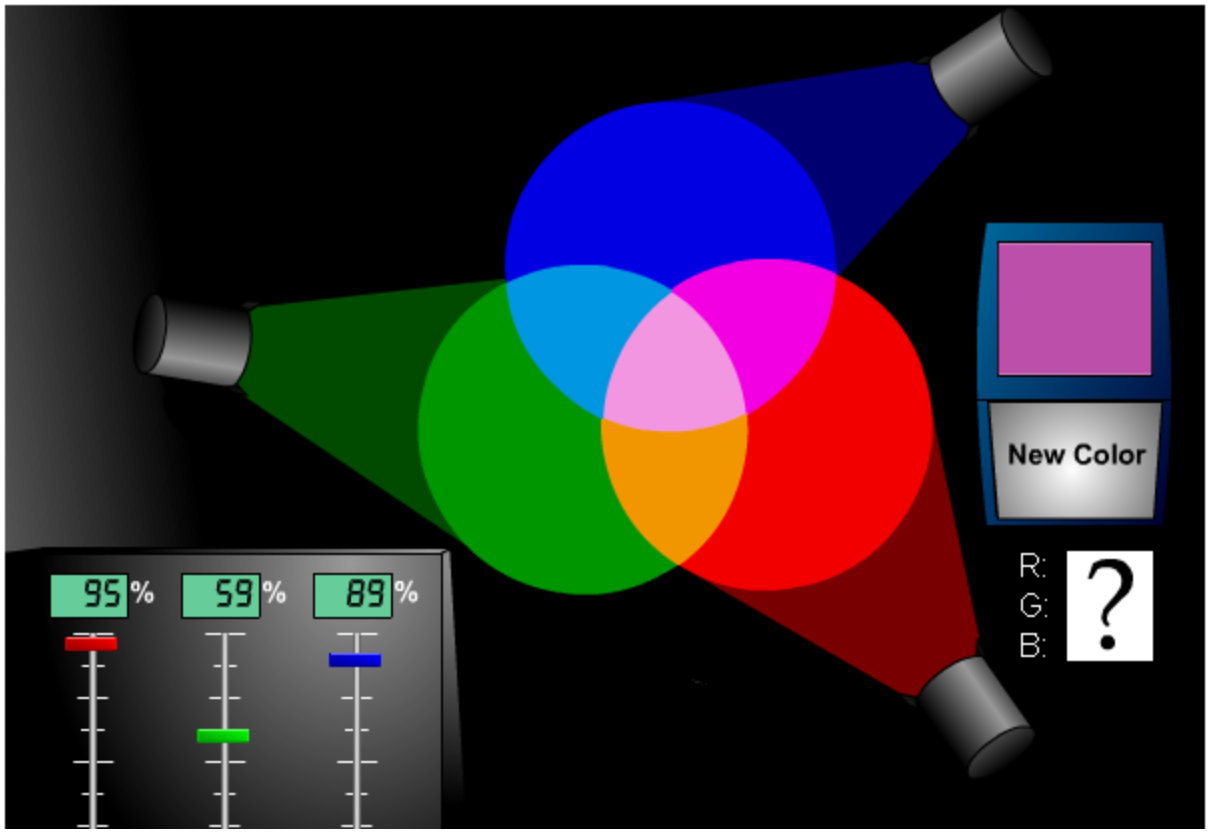
Filters (or pigments) transmit colors that make up the filter color and absorb the others

Filters remove their respective complementary color from white light

Demonstration of color addition and subtraction



Mix to Match



Perception

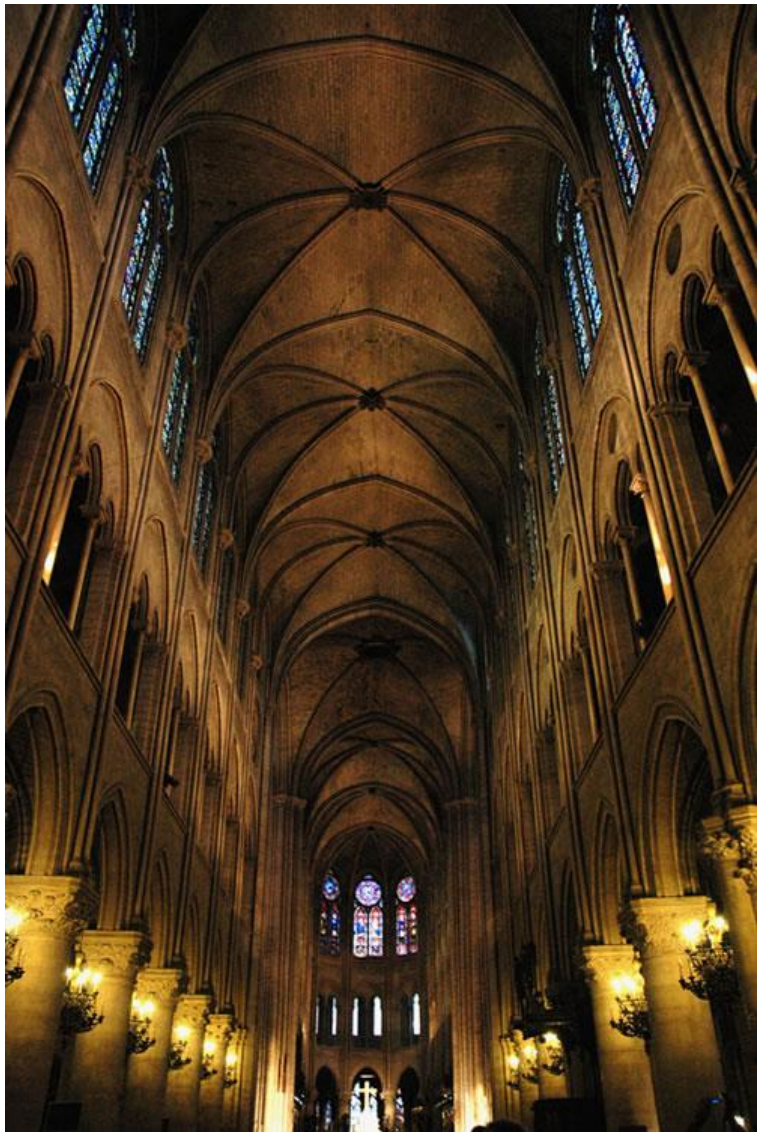
Light, shade and color can be used to influence and even alter our perception of reality

- Deep shadow in painting or building can give impression of massiveness or drama, light shadow of airiness
- Soft, pastel colors give impression of calm, relaxed place
- Blue perceived as cold
- Orange, red give impression of warmth
- Light-colored ceiling appears higher than a dark ceiling
- Room can be made to appear larger by placement of mirrors

Perception of Light and Dark

http://www.youtube.com/brusspup

Use of Shadow

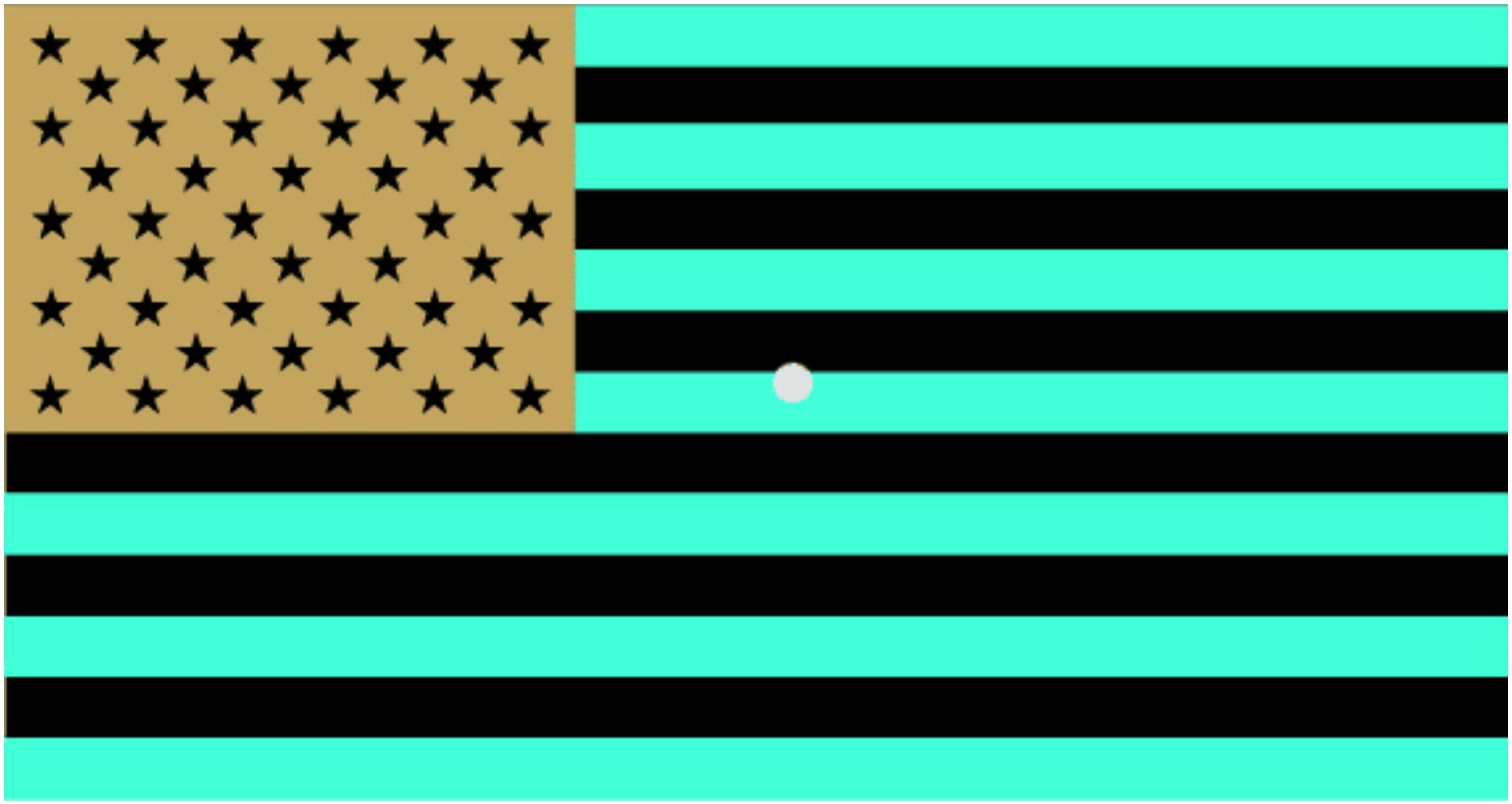


Hot Colors

Cool Colors

Mirrors and Light-Colored Ceilings

Afterimage due to Color Fatigue

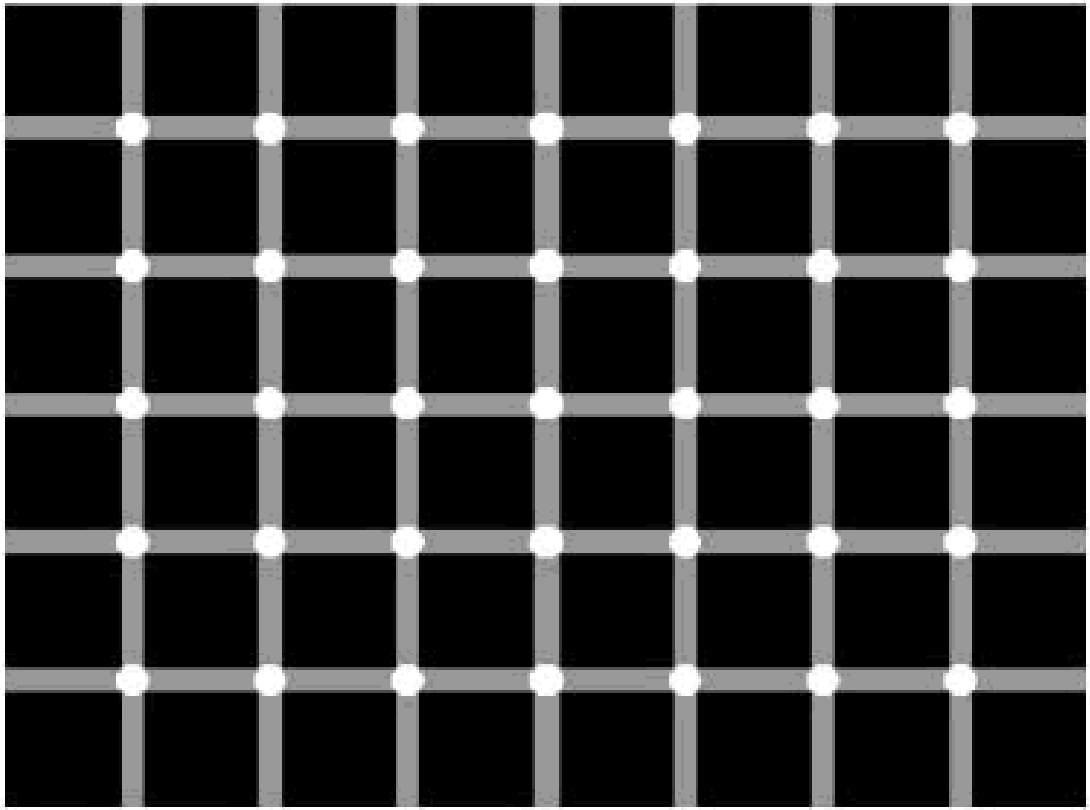


Stare at white dot for a minute, then look at whiteboard

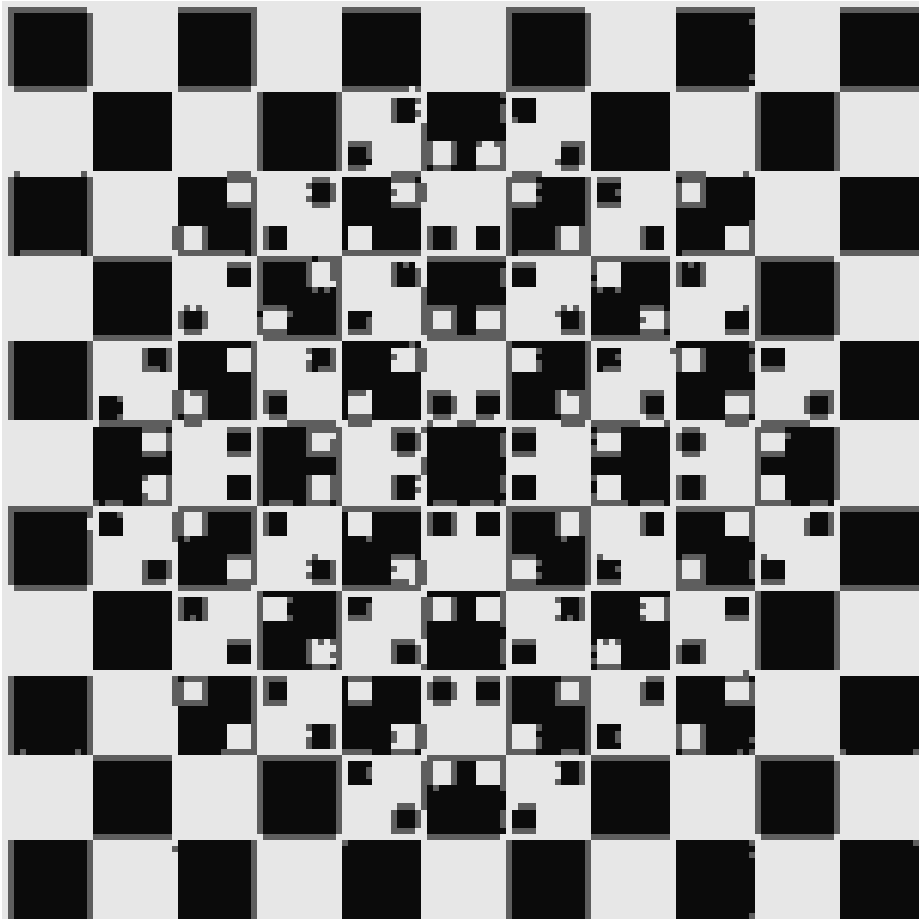
Another afterimage example

Optical Illusions

How many black dots do you see? There are none...



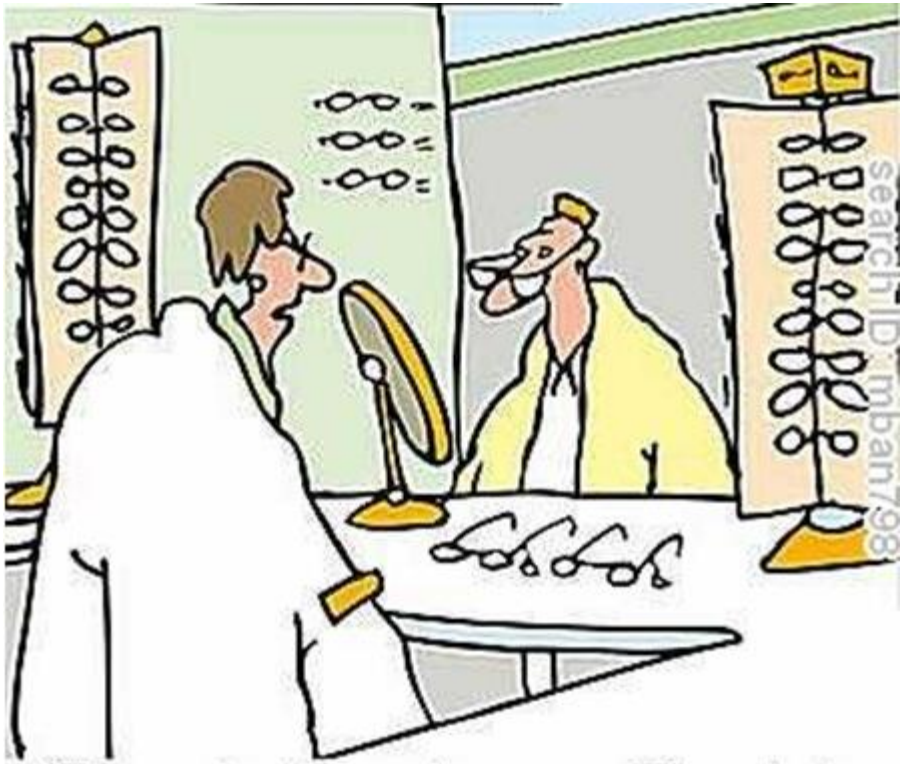
Do the lines “bulge”?



Links

- http://health.howstuffworks.com/eye-channel.htm
- http://webvision.med.utah.edu/KallDepth.html
- http://www.vision3d.com/
- http://www.eyetricks.com/3dstereo.htm
- http://hyperphysics.phy-astr.gsu.edu/hbase/hph.html

A Perception Parting Shot



"Those look good on you. They help make your nose look smaller."