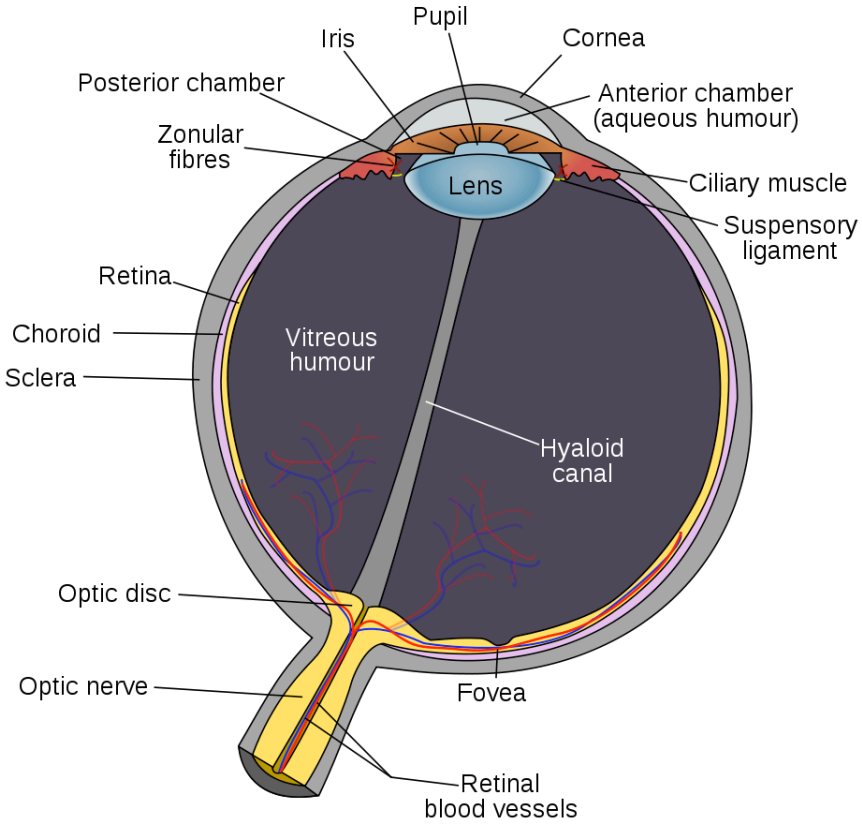
# Vision

# The Eye



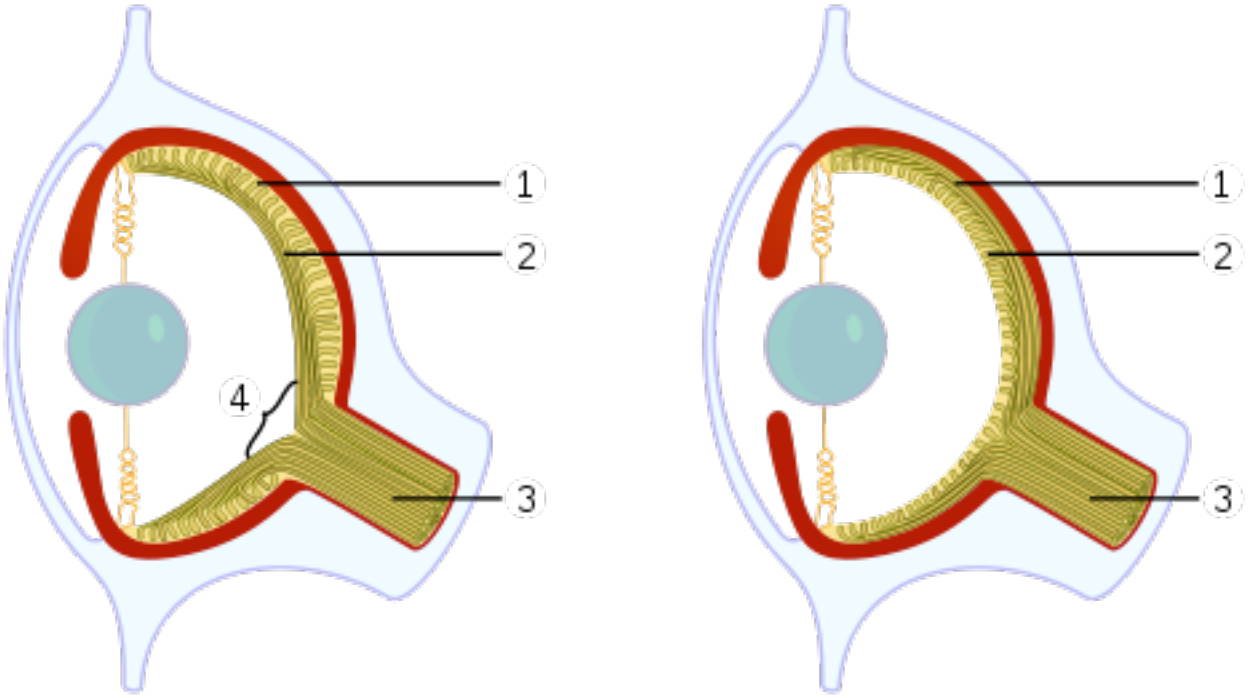

Schematic diagram of the vertebrate eye

Source: Wikimedia commons http://en.wikipedia.org/wiki/Eye

Find blind spot of your right eye

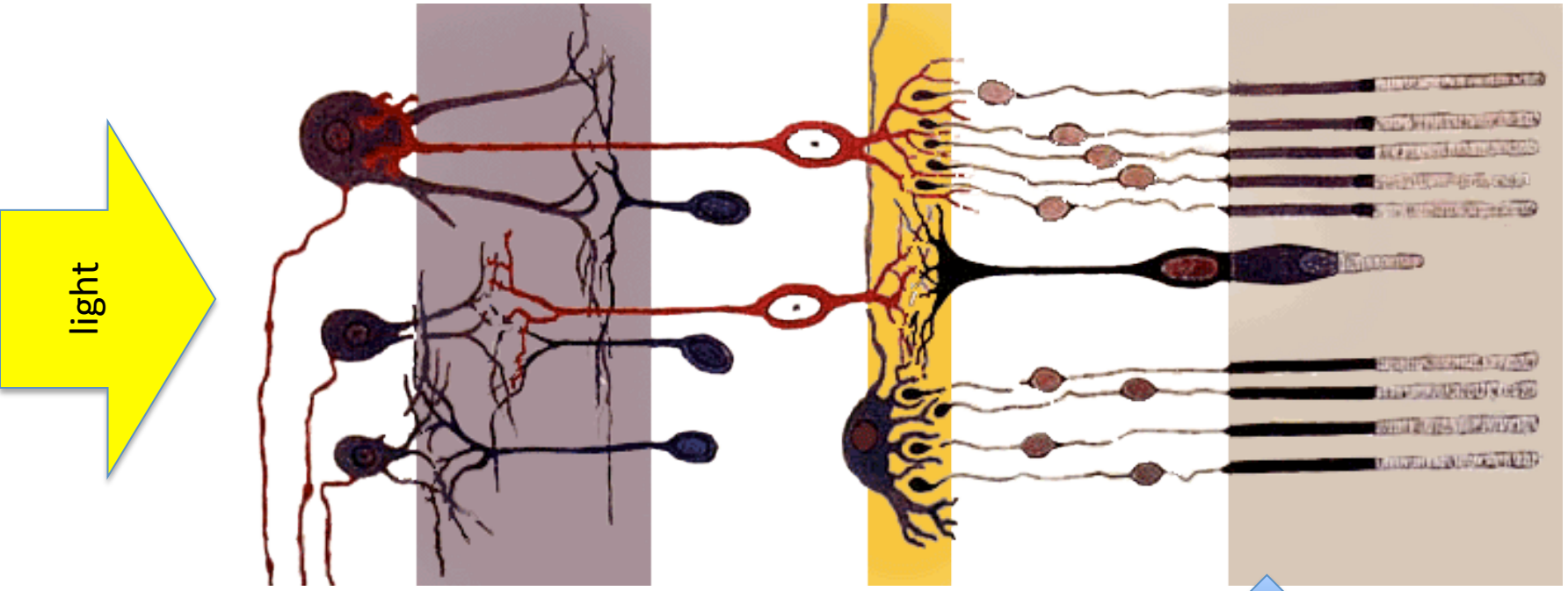
- cover left eye and move cursor around while staring at black circle

# Human vs Octopus




Source: Wikipedia http://en.wikipedia.org/wiki/Blind_spot_(vision)

# Rods, and Cones, and Nerve Cells in the Retina




**Front** (anterior) of the eye.

Rods and Cones

**Back** (posterior) of the eye. Nerve cells are part of central nervous system.

Source: Wikimedia commons http://en.wikipedia.org/wiki/Retina
image url: http://upload.wikimedia.org/wikipedia/commons/2/21/Fig_retine.png

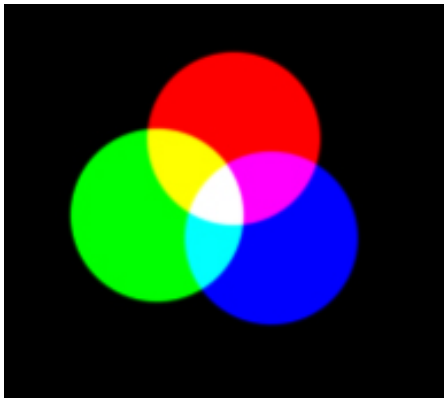
# Additive/Subtractive Color

***We choose 3 primary colors that can be combined to produce all the visible colors:***

Animation: http://dx.sheridan.com/advisor/cmyk_color.html

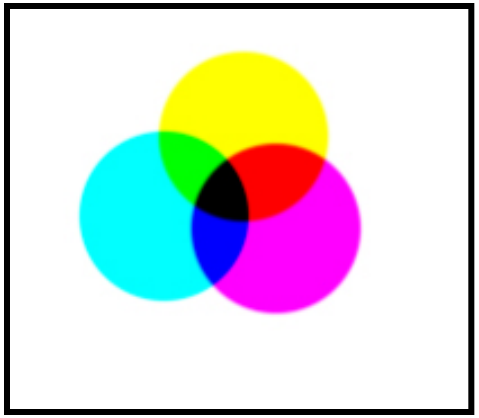
1. **Additive primaries** (Combining light):

   **Red Green Blue**



1. **Subtractive primaries** (combining paint, thus subtracting light): **Cyan**

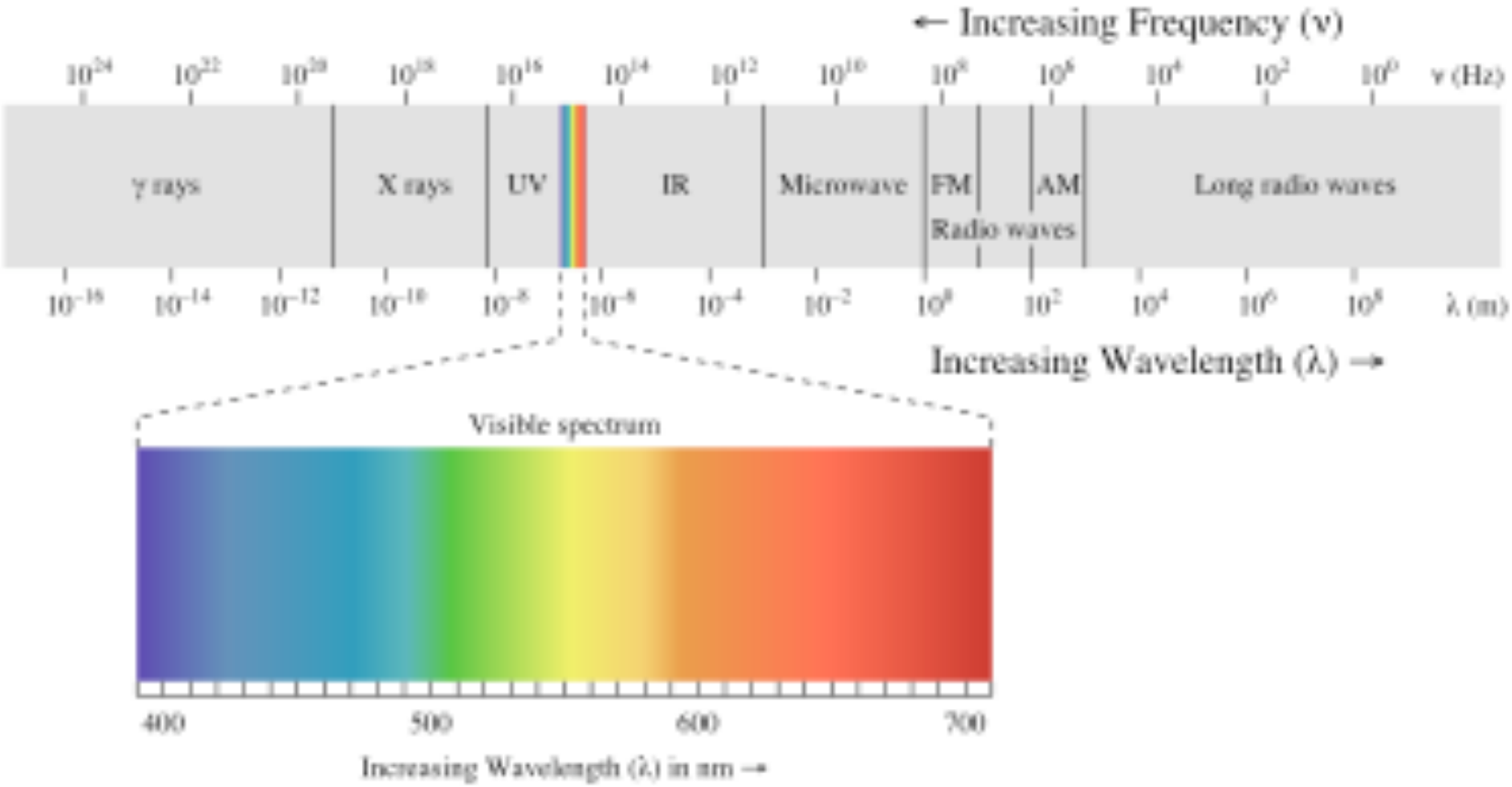
   **Yellow Magenta**



# Rods and Cones

- Rods:
  - Black/white vision
  - Very sensitive to dim light
- Cones:
  - Color vision
  - Need brighter light

# The Spectrum of Visible Light

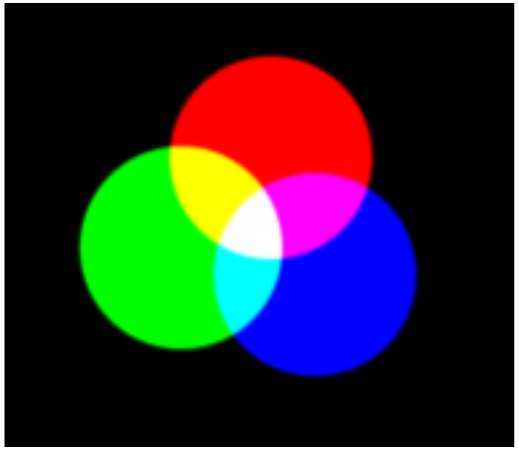


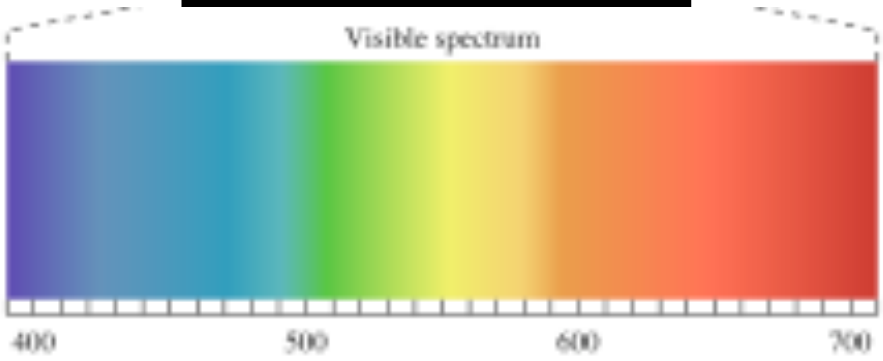

Source: Wikipedia commons http://en.wikipedia.org/wiki/File:EM_spectrum.svg

# Some questions:

- Why three primary colors?
- If the visible spectrum consists of a continuous range of wavelengths, why should just three colors be special? Why not five?
- Why do colors form a circle, when the spectrum does not?

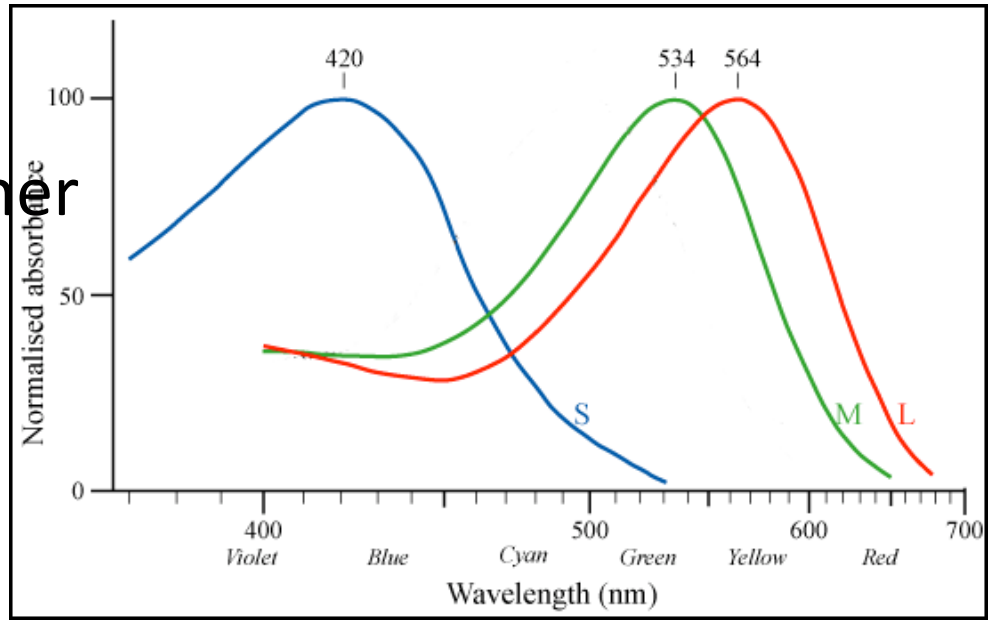
?





# Trichromacy

- Three kinds of cone cells: **L, M and S**
- peak sensitivities in **the long, medium and short** wavelength parts of the spectrum respectively
- Other animals have more or fewer types of cones
  - Monochromats: Dogs
  - Dichromats: Horses
  - Trichromats: Humans, other primates, but also many birds, and other animals, even some invertebrates!
  - Tetrachromats: zebrafish turtles, most birds, and insects
  - Pentachromats: Some birds and some insects, eg pigeons, butterflies

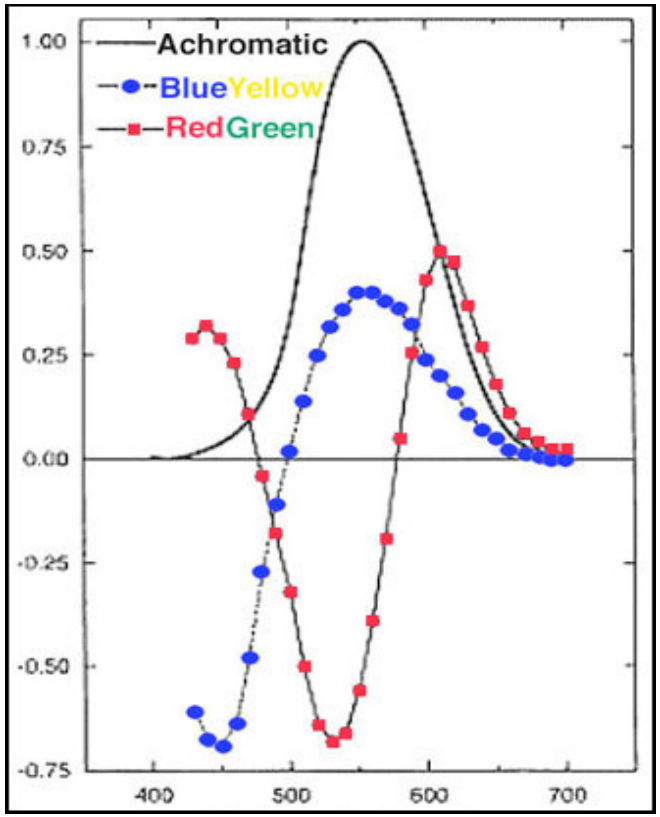


# Opponent Model of Vision

- In late 19th century Ewald Hering proposed a controversial theory to explain complementary colors – the ***opponent model of vision***

- The opponent model was subsequently quantified by Hurvich and Jameson (1957) and later researchers who confirmed it using new physiological understanding of the eye

- Current view is that subsequent processing of the inputs from the three cone types (adding/ subtracting) creates three signals:
  - brightness,
  - redness vs greenness (r/g), and
  - yellowness vs blueness (y/b).
- The 360o range of possible combinations of positive and negative r/g and y/b values creates the circular range of hue of the familiar colour wheel (Figure 3.2, 3.3).




Source: David Briggs "The Dimensions of Color" website http://www.huevaluechroma.com/032.php

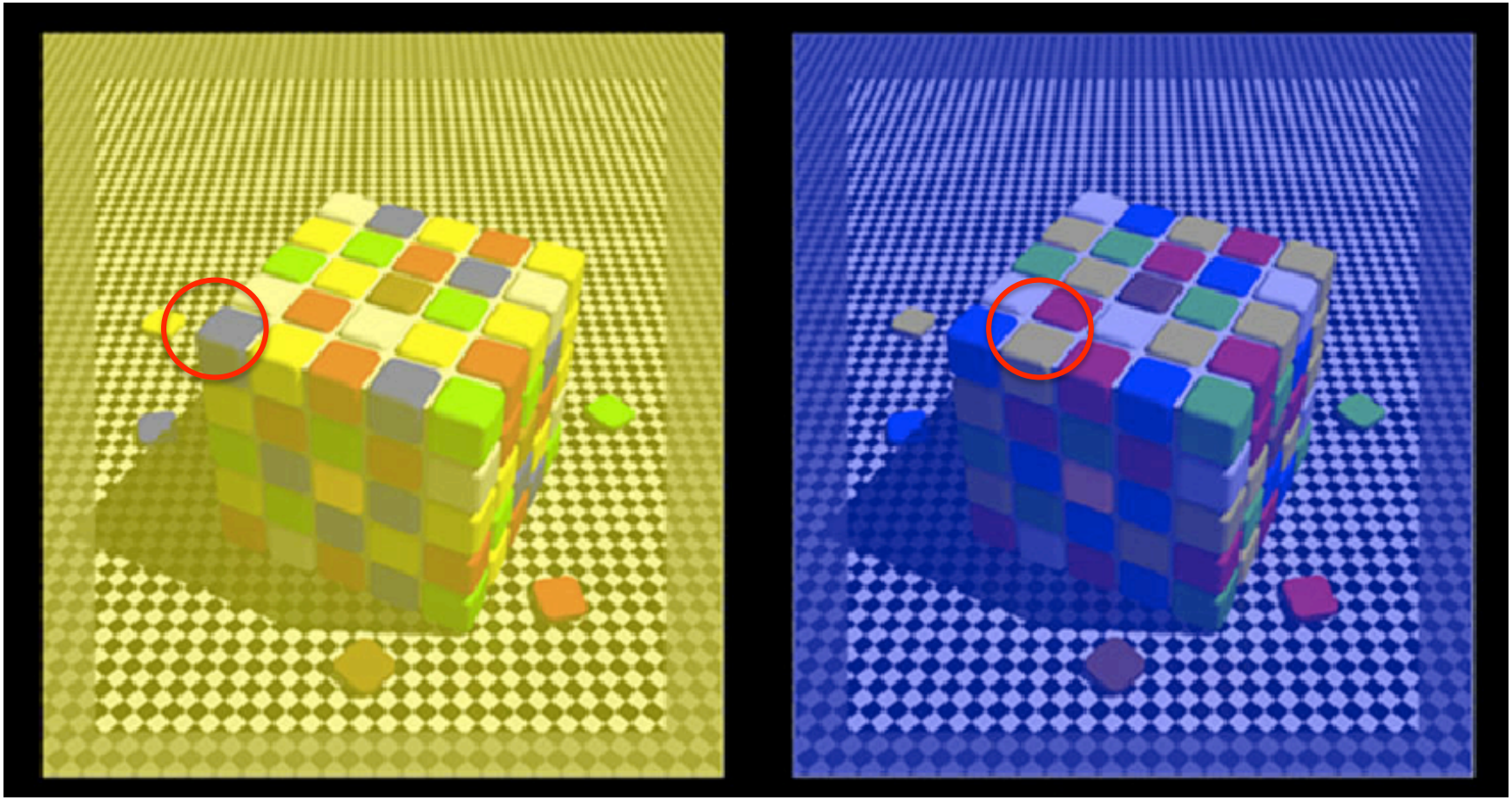
# Early evidence for Opponent Model

- Afterimages

- Hering illusion

we will create some of these in class

# Color is ***Very*** Relative!



Source: http://www.echalk.co.uk/amusements/OpticalIllusions/illusions.aspx

# Further reading

- David Hubel, "Eye, Brain, Vision" available online at http://hubel.med.harvard.edu/index.html
- -- online book - a good source of information about the eye and seeing from a clinical perspective

- David Briggs, "The dimensions of color" webpages http://www.huevaluechroma.com/
- - a set of webpages that give a great overview of color as it is perceived, from the artist's perspective

- eChalk optical illusions http://www.echalk.co.uk/amusements/OpticalIllusions/illusions.aspx