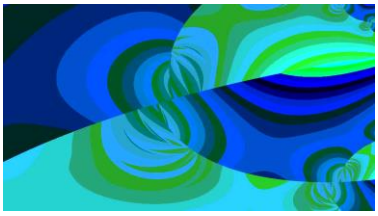
Color Vision

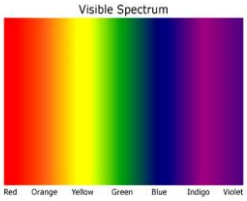


Color Vision Factoids

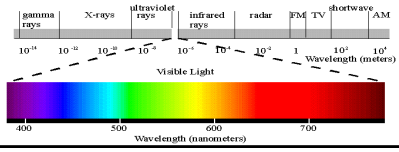
- Color is a *sensory* perception
- Human awareness of color arises out of subjective visual experiences in which given sensations are ascribed names.
- Color names have remarkable consistency throughout diverse cultures.
- There are approx. 7 million colors that the normal individual can *theoretically* see !

Normal Color Vision

- Normal individuals can discriminate approximately **150** different colors in the spectrum.
- There are over 7500 color names in the English language.

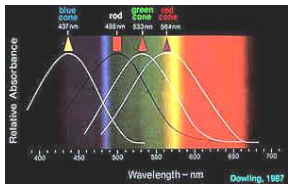


- The electromagnetic spectrum encompasses the full range of photon energy
- Rods and cones absorb photons between 400 – 700 nm

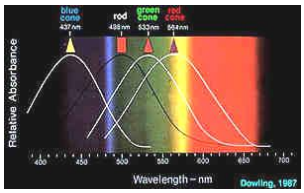


Physiology of Color Vision

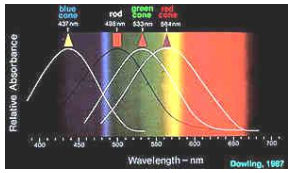
- Three different types of cones:
  - a. **red cones** (long wavelength)
    - contain ***erythrolabe***
    - preferentially absorbs 570 -590 nm light



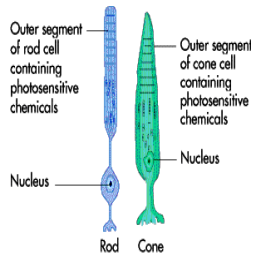
- b. **green cones** (medium wavelength)
  - contain ***chlorolabe***
  - preferentially absorbs 535-550 nm of light



c. **blue cones** (short wavelength):
- contains *cyanolabe*
- preferentially absorbs 440-450 nm light



Cones

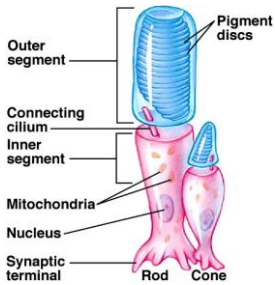


Cones have overlapping spectral sensitivities. Rods cannot distinguish one color from another.

Rods

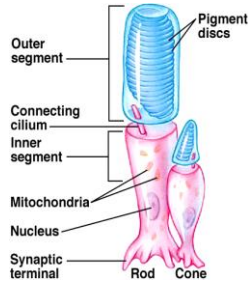
Rods are long and narrow in shape. They have no color ability. They have a chemical called **rhodopsin**.

Their primary action is involved in **scotopic** vision (night vision)

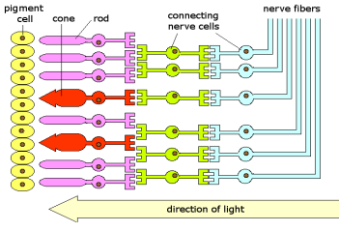


Cones

Cones are short and plump. They are responsible for *color vision*, *fine vision* and photopic vision (day vision). They have (3) chemicals: **cyanolabe**, **erythrolabe** and **chlorolabe**.

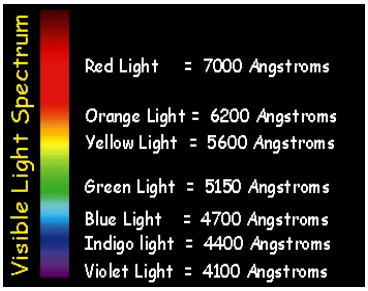


The retina converts *light energy* into *electric energy* by photochemistry.



Vitamin-A is obtained from food and stored in the liver. Vitamin-A is converted to **retinol** (a light absorbing chemical). This is released into the blood stream and is eventually captured by the retinal pigment epithelium.

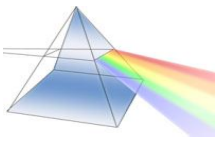
Color Physics



* Lights can be characterized by the sensation *perceived* when they hit the retina...for example...

short wavelength = **blue**
long wavelength = **red**

When light strikes another medium, the speed and the wavelength *decrease*. Shorter wavelengths are slowed (bent) more than the longer ones. This phenomenon explains why a prism breaks up white light into the colors of the spectrum.



Most objects *absorb* light at specific wavelengths of light. **Black** objects *absorb* most light rays. White objects *reflect* most light rays and transmit (or reflect) not just one wavelength, but an assortment of them.

White light is a combination of ALL visible wave lengths.

Normal Color Vision

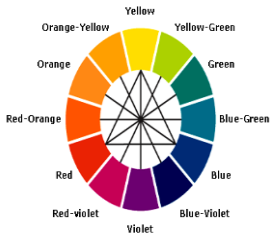
Any color is described by *three* major traits.

* **Hue**: attribute denoted by red, green yellow, etc.
* **Brightness** (*luminance*): quantity of light coming from the color
* **Saturation** (*chroma*): index of the purity (richness) of a hue.

An object will have hue because it reflects and transmits light of a given wavelength. ***The addition of black to a hue produces various shades.***

Color Vision

Primary Colors: red, green and blue



Trichromats: normal color vision
have all (3) cone pigments
Dichromats: have (2) cone pigments
Monochromats: have (1) cone pigment

Color Vision Defects: Congenital Defects

- 7-8% males affected
- 0.4% females affected

Defect is transmitted through female (X chromosome) and is male predominant. Males have re-green defects if they inherit a defective gene from their mother. Affected males can pass the gene *to all their daughters but none of their sons*.

Females who inherit only *one* defective gene are carriers. Females who inherit the gene from both parents are affected .

Tips

- Congenital deutans are most common
- Tritans are most likely *acquired*
- If someone has very poor vision – think of a monochromat
- Retina disease usually causes blue-yellow
- Optic nerve disease usually causes red-green

There are three types of *inherited* color vision defects:

a. **monochromats**: true "color blind" as they cannot see **any** colors (hues). They only see degrees of grays, black and white. Also have poor vision, nystagmus and photophobia. Gene inherited from both parents. One cone pigment.

b. **dichromats**: can tell some hues apart. (2) cone pigments. Divided into:
   a. *protanopia*: red-green defect
   b. *deuteranopia*: red-green defect
   c. *tritanopia:* blue-yellow defect

Red – Green Defect

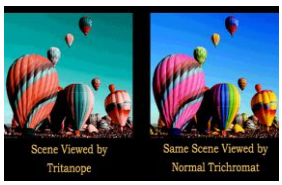
People with red-green defects have difficulty distinguishing between reds, greens and yellows but can discriminate between blue and yellow. Protanopes often can name red and green correctly because green looks lighter than red.

"ope" *think* NOPE !

If someone has an "opia" – they are deficient in a color identification.

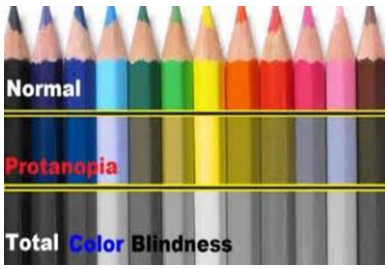
protanopia: **no red**
red-blind at wavelengths > 650 nm
red-green confusion

deuteranope: no green
red-green confusion



tritanopia: no blue
blue-yellow confusion
cannot see the difference between blue-yellows but can see red-green. Rare, occurs equally in males vs. females.

Color "Blind"



Youtube.com

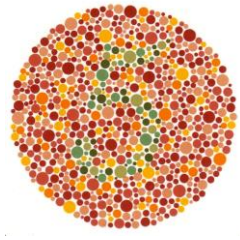
"anomaly" is a decrease in sensitivity

In "anopia", the ability to detect color is absent, an "anomaly" means that they have decrease in sensitivity to determining that particular color.

* Protanomaly: red cone deficiency with poor red-green discrimination

* Deuteranomaly: green color deficiency with poor red-green discrimination although red appears brighter
* Tritanomaly: blue cone deficiency with poor blue-yellow discrimination

Color Vision Testing: Ishihara Plates



Number of Plate	Normal Person	Person with Red-Green Deficiencies	Person with Total Colour Blindness and Weakness
1	12	12	12
2	8	3	×
3	6	5	×
4	29	70	×
5	57	35	×
6	5	2	×
7	3	×	×
8	15	17	×
9	74	21	×
10	2	×	×
11	6	×	×
12	97	×	×
13	45	×	×
14	5	×	×
15	7	×	×
16	16	×	×
17	73	×	×
18	×	5	×
19	×	2	×
20	×	45	×
21	×	73	×

Ishihara Plates (pseudoisochromatic plates):

* colored dots of gray and complementary colors arranged in various patterns
* easily seen by trichromats but not by dichromats.
* designed to find red-green deficiencies

ONE EYE AT A TIME WITH CORRECTION!!!

Advantages:

* Easy to perform
* Good screening for congenital deficiencies as well as Type I & II acquired

Disadvantages:

* Cannot distinguish tritans
* Does not allow for protan-deutan proficiencies

All pts. see As 12

Red-green see as "3"

Red-green see as "5"

Red-green see as "70"

Red-green See as "35"

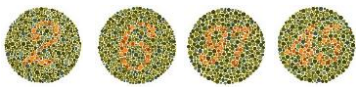
Red-green see as "2"

Red-green see as "5"

Red-green see as "17"

Red-green See as "21"

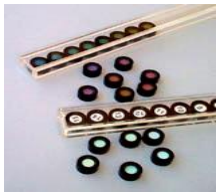
Color vision defect: cannot see all of the following:



Cannot see (all of the following)

Color Vision Testing: Farnsworth D-15 Panel Test

- Subset of the 100 hue test
- (15) caps with a reference number
- Patient arranges the caps according to color of preceding cap

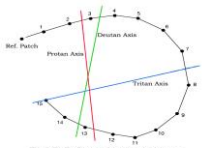


* test records confusion of isochromatic hues (ex: deutans confuse green and red-purples whereas protans confuse blue greens and reds)

- Caps have same saturation and brightness but different hues.
- Red-green test
- Good for *acquired* color defects from retinal disease
- **25 foot candles** of light need (MacBeth lamp)

Advantages:

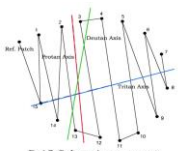
* Fast
* Easy to perform



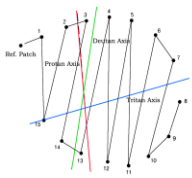
D-15 Colour Arrangement
Normal Trichromat

Disadvantages:

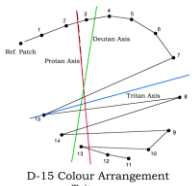
* Does not discriminate between trichromats and dichromats
* INSTRUCTIONS !



D-15 Colour Arrangement
Protanope



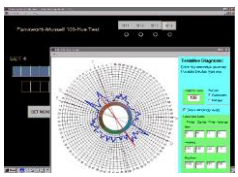
D-15 Colour Arrangement
Deuteranope



D-15 Colour Arrangement
Tritanope

Color Vision Testing: Farnsworth-Munsell 100 Hue Test

- (85) colored caps arranged in (4) groups
- correct ordering produces a circle in the center of the diagram



- Incorrect placement causes points to be plotted further from the center in an axis like distribution

Advantages:

can measure full nature of character and extent

Both Farnsworth are more accurate than Ishihara

Disadvantages:

time consuming

inconvenient

patient must be able to understand directions

Color Vision Testing: Hardy-Rand-Rittler

- Yellow-blue test or red-green test
- Background is neutral gray on which a series of colored circles, crosses and triangles are imposed.

* Can determine mild, medium or severe

Color Vision Testing: Anomaloscope

Patient sees a split image in the viewer. They tries to match yellow on the bottom half with red-green mixture in the upper half. You control the luminance of yellow and mixture of the red-green. Protanomalous uses too red. Deuteranomalous uses too much green.