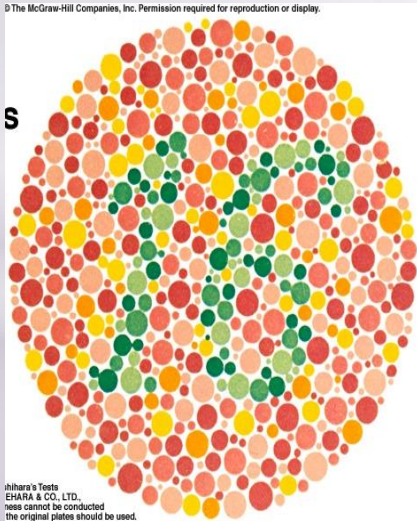


Color Vision

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Objectives

*Define color vision

*Identify and describe the *mechanism of colour vision and the three types of cones, including the range of spectral sensitivity and color blindness

*Identify color vision theory

*Describe the items needed for any color perception

*Compare different types of color blindness



History of color vision

Newton (1704) used a prism to show that sunlight was composed of light with all colors in the rainbow. He defined it as the **spectrum**.



COLOR VISION

- It is the ability to discriminate between different colors.
- 1- there are 3 primary colors (blue- red- green) sensed by cones in fovea & appreciated within photopic vision.
- 2- sensation of extraspectral colors as white, yellow, orange, purple, can be produced by mixing properties of the blue & red & green in different combinations.
- 3- black means absence of light (not darkness because in dark we do not see black only)

-Colors have three attributes hue, intensity, and saturation (degree of freedom from dilution with white).

-For any color there is a complementary color that, when properly mixed with it, produces a sensation of white

-Black is the sensation produced by the absence of light, but it is probably a positive sensation because the blind eye does not “see black;” rather, it “sees nothing.”

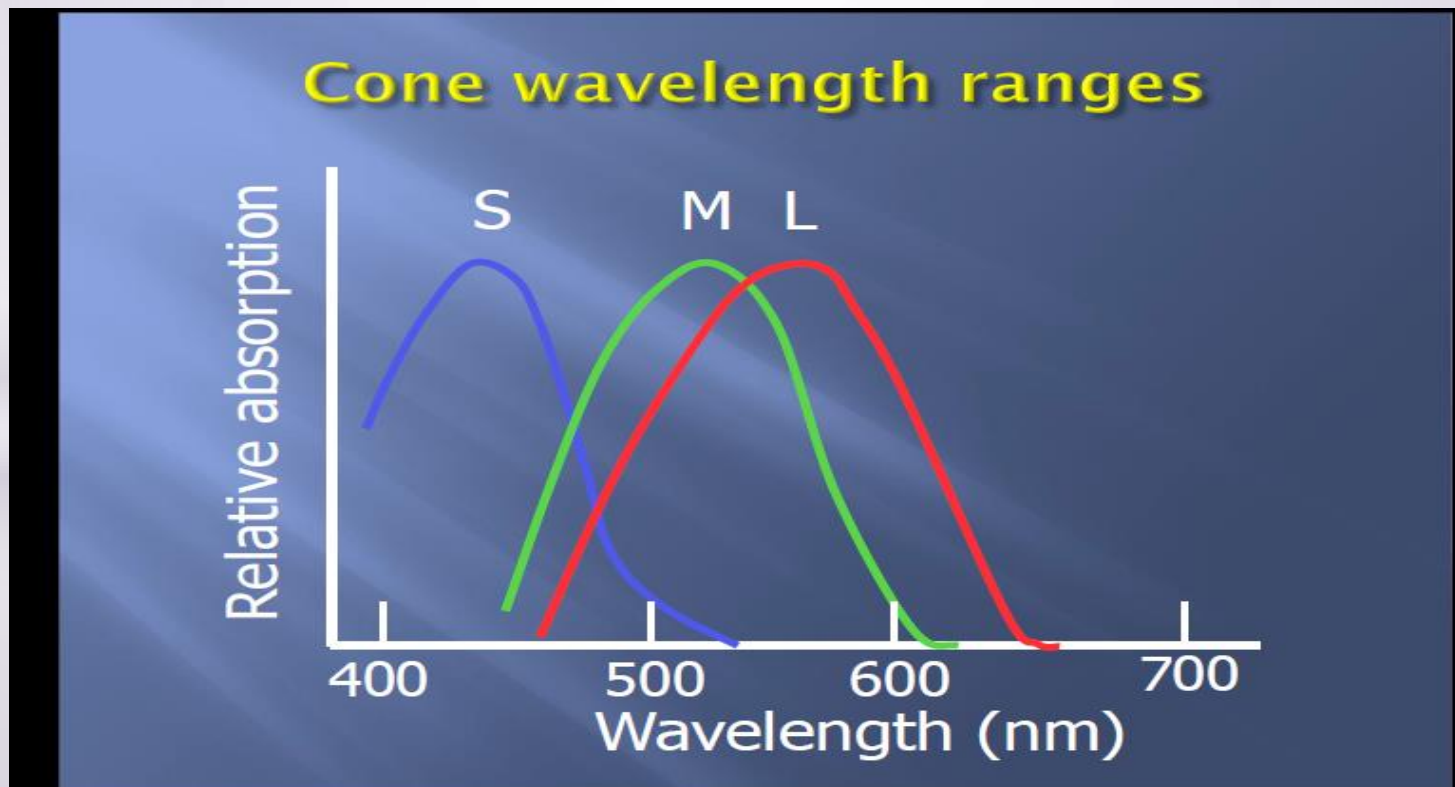
* Color vision theory : (Young- Helmholtz theory)

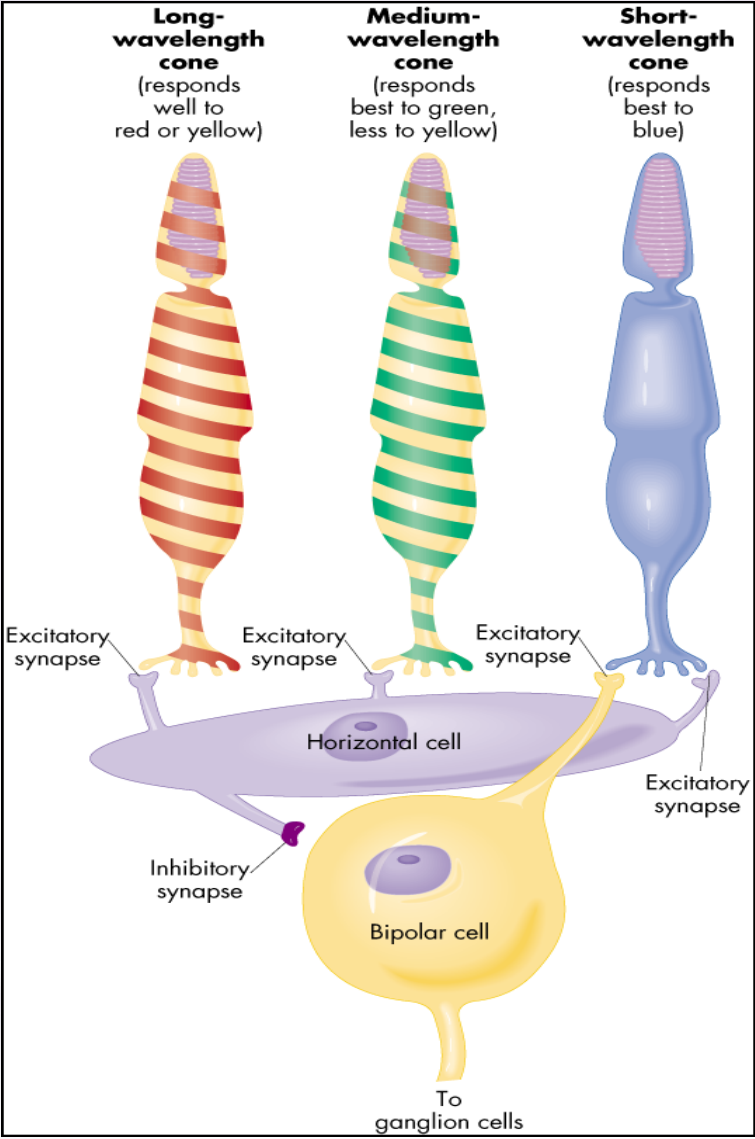
* 1- we have 3 kinds of cones each has a specific photopigment (rhodopsin)& is sensitive to one of the 3 primary colors

* a- Blue cone system:- has S pigment (blue sensation pigment) which respond to short wave length (440 nm senses the blue color)

* b- Green cone system:- has M pigment (green sensation pigment) which respond to middle wave length (535 nm senses the green color & less to yellow) & absorb light at the green portion.

c- **Red cone system**:- has **L** pigment (red sensation pigment) which respond to large wave length at or **> 535 nm** so senses the red & yellow color & absorb light at the red portion.







2- sensation of any color determined by:

a- wave length of light

b- amount of light absorbed by each type of cones

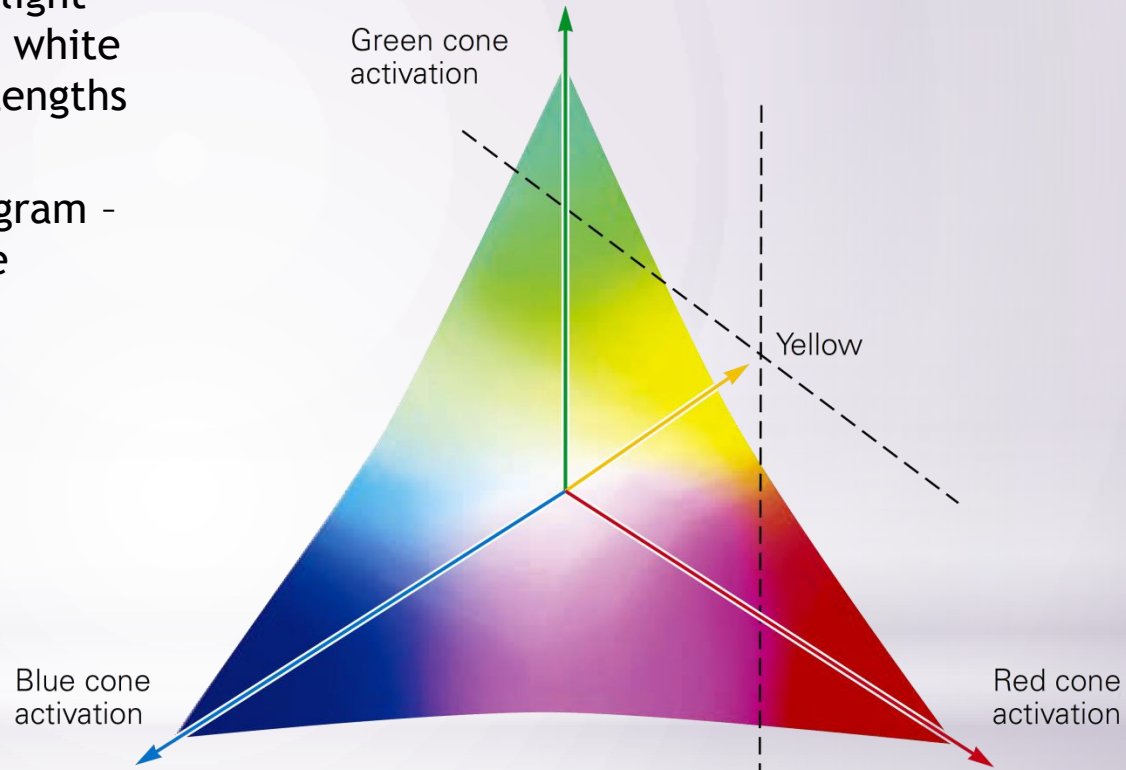
c- frequency of impulses from each cone system to ganglion cells which is determined by wave length of light.

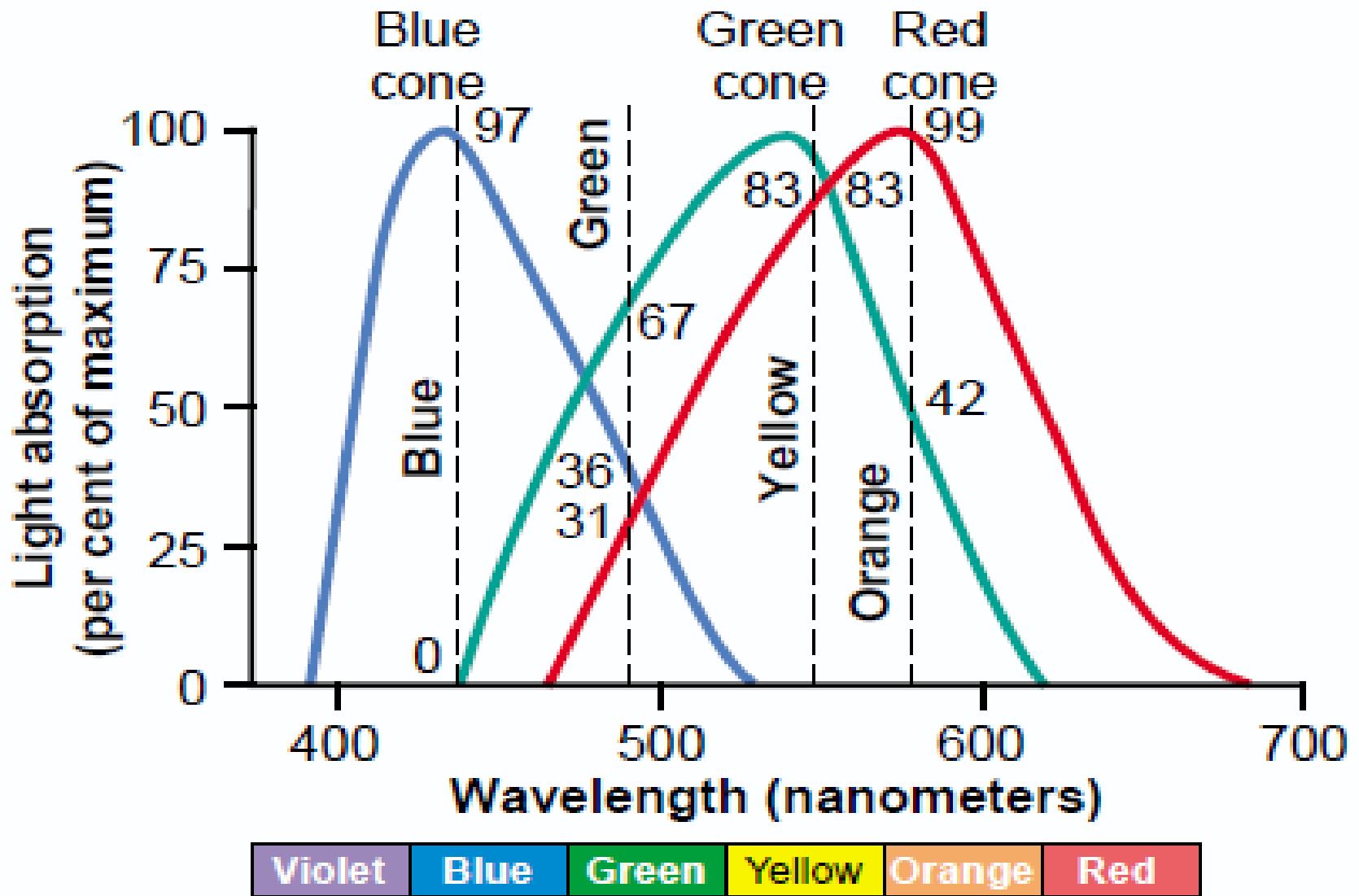
3- each cone system respond to its color at a lower threshold than needed to sense other colors (red cones respond to red or yellow color at a lower threshold than to green color)

5- perception of white is due to equal stimulation of blue & red & green cones. There is no wave length corresponds to white, white is a combination of all wave lengths

* PERCEPTION OF WHITE LIGHT

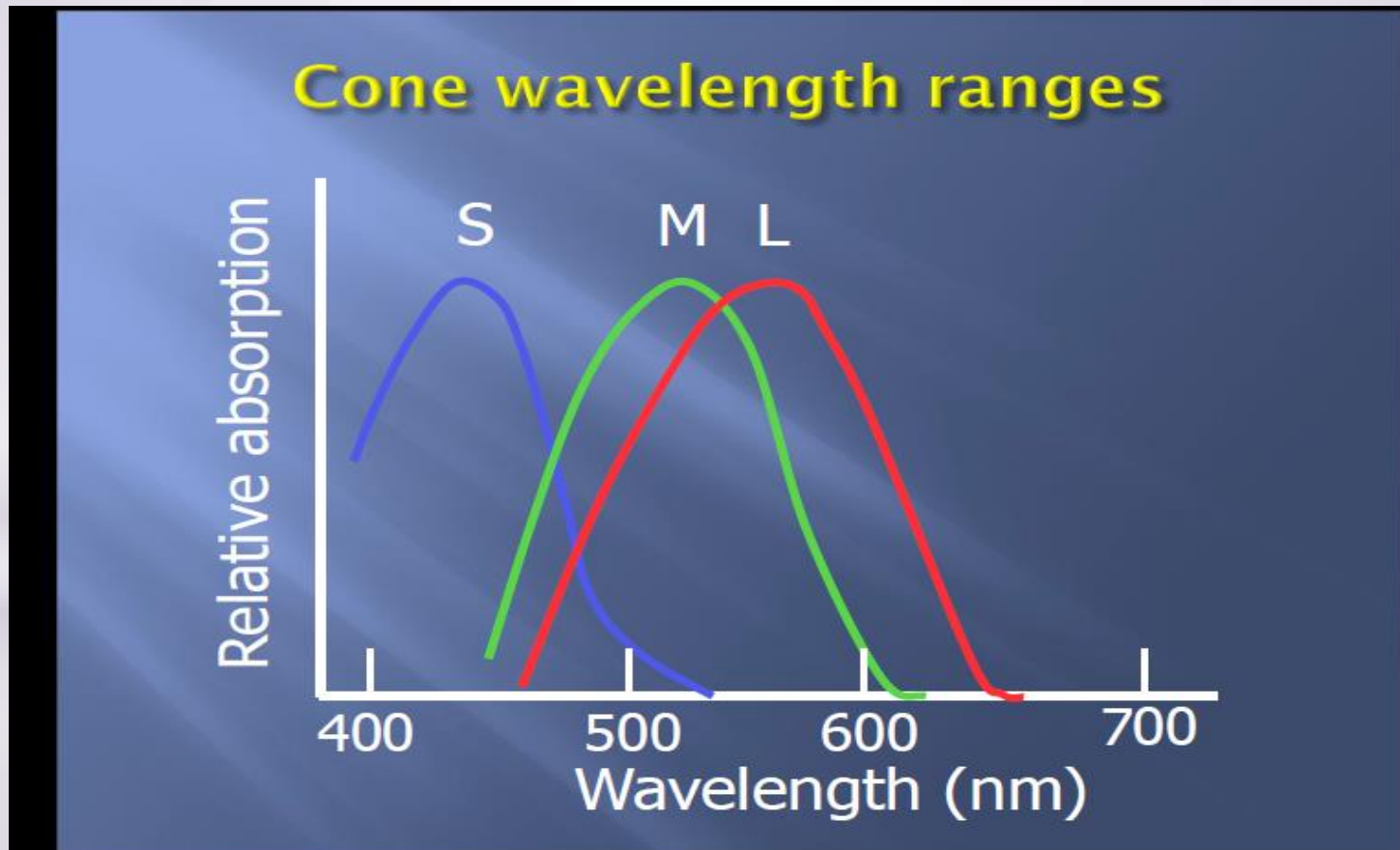
- there is no single wavelength of light corresponding to white; instead, white is a combination of all the wavelengths of the spectrum.
- as can be seen in this vector diagram - white occupies the middle of the vector





Light absorption by the pigments of three color-receptive cones of human retina.

Cone wavelength ranges



Photopic vision (CONES)

Cone pigments: three kinds



- * #- Color vision is coded by :-
- * --different responses in ganglion cells that depends upon the wave length of stimulus which determine frequency of impulses in ganglion cells
- * - the color perception in the brain depends on the amount of activity in each of the 3 cone systems as mentioned above.

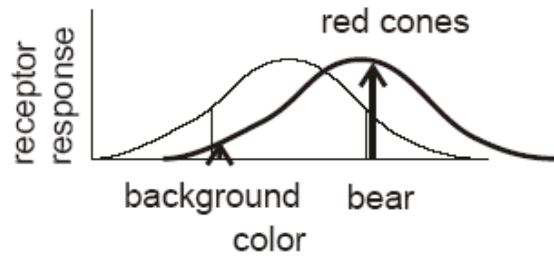
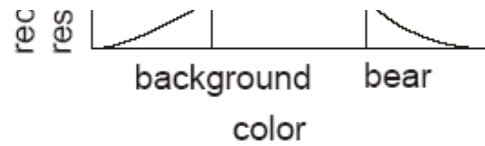
- 6-perception of orange
- is due to stimulation of 99% of red cones & 42% of green cones & 0% of blue cones (so ratio is 99:42: 0)
- 7--perception of yellow
- is due to stimulation of 50% of red cones & 50% of green cones & 0% of blue cones (so ratio is 50:50: 0)
- 8-perception of blue
- is due to stimulation of 0% of red cones & 0% of green cones & 97% of blue cones (so ratio is 0:0: 97)



Spectral sensitivity of a cone.

What is the advantage of colour vision?

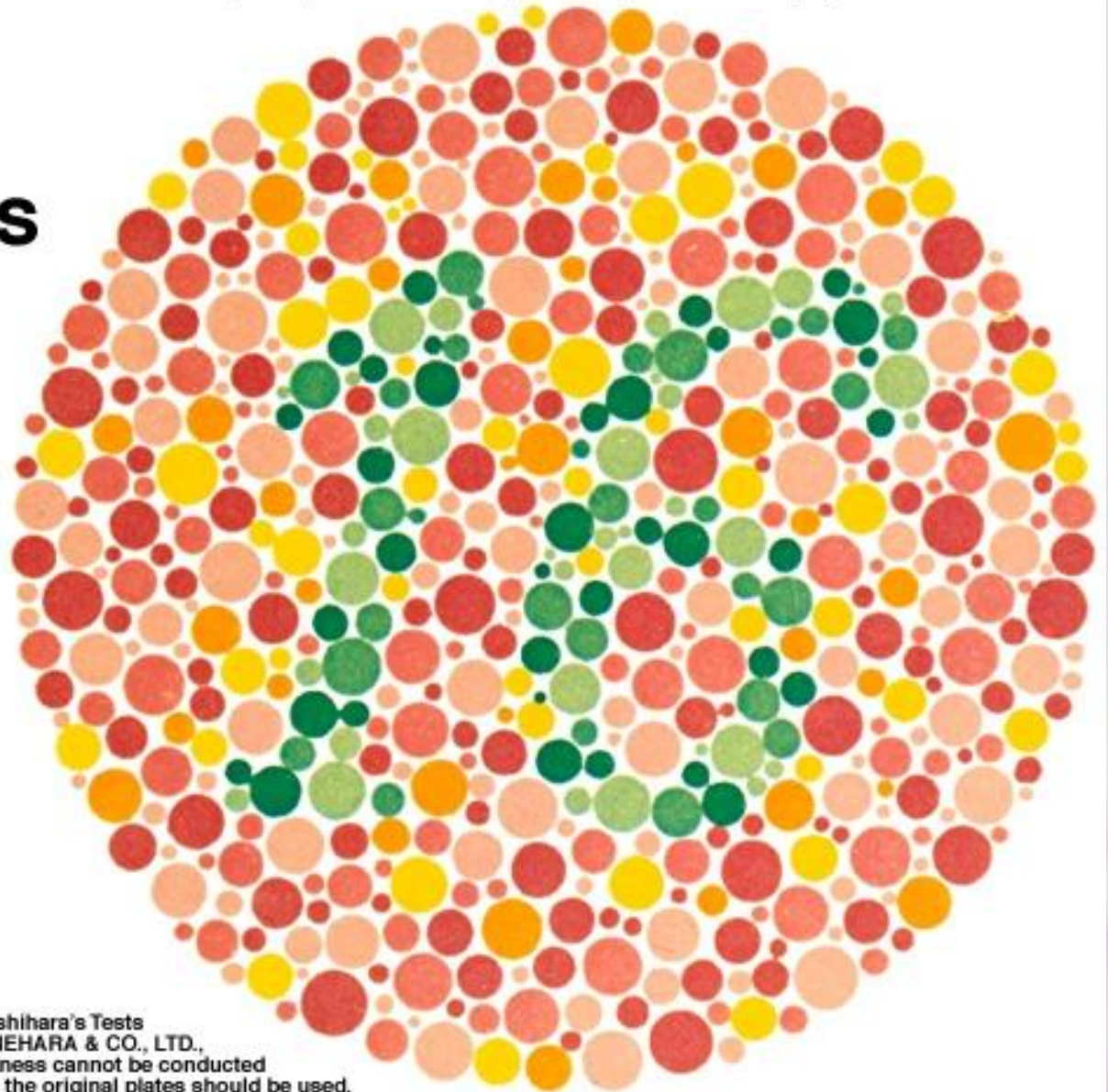
Colour is important for distinguishing an object from its background.



red cones see



Test for Color Blindness

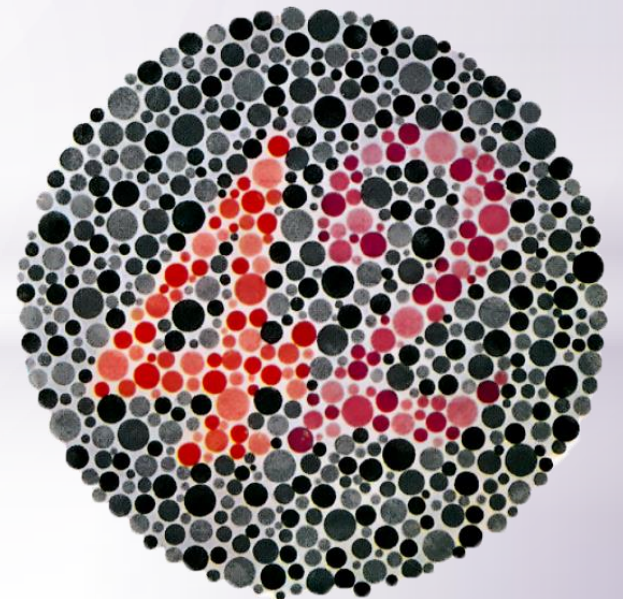
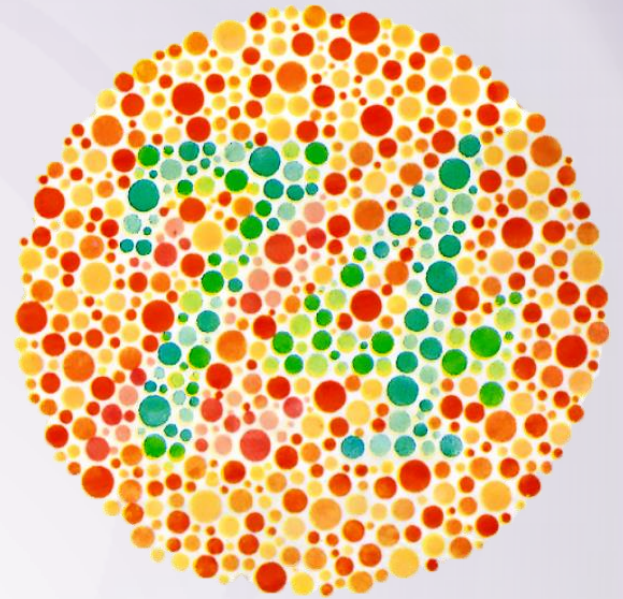


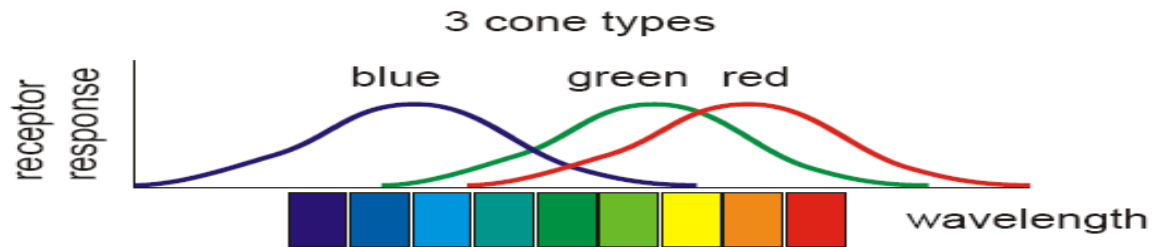
The above has been reproduced from Ishihara's Tests for Colour Blindness published by KANEHARA & CO., LTD., Tokyo, Japan, but tests for colour blindness cannot be conducted with this material. For accurate testing, the original plates should be used.

ISHIHARA CHARTS , WHICH ARE PLATES CONTAINING FIGURES MADE UP OF COLORED SPOTS ON A BACKGROUND OF SIMILARLY SHAPED COLORED SPOTS.

THE FIGURES ARE INTENTIONALLY MADE UP OF COLORS THAT ARE LIABLE TO LOOK THE SAME AS THE BACKGROUND TO AN INDIVIDUAL WHO IS COLOR BLIND.

SOME COLOR-BLIND INDIVIDUALS ARE UNABLE TO DISTINGUISH CERTAIN COLORS, WHEREAS OTHERS HAVE ONLY A COLOR WEAKNESS.

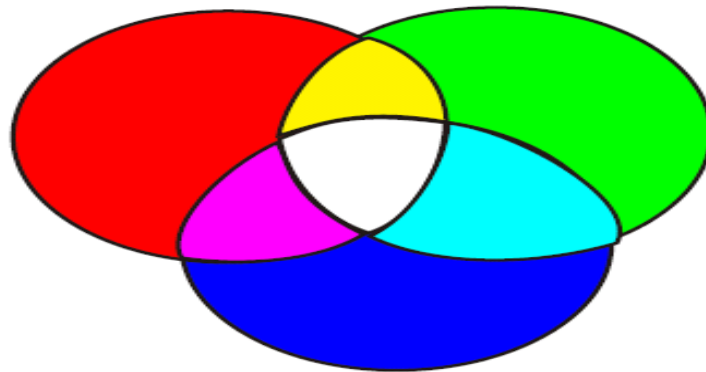




↑

↑ ↑ When red & green cones are stimulated one sees yellow

↑ ↑ When all three cone types are activated one sees white.



The effect of mixing different wavelengths of light

* COLOR BLINDNESS:-

- * - There is gene for **rhodopsin** on chromosome(3)
- * - There is gene for **blue** sensitive **S** cone pigment on chromosome(7)
- * - There is gene for **red & green** sensitive cone pigment on **X** chromosome.

- * - when a single group of color receptive cones is absent (due to absence of there gene) the person can not see or distinguish some colors from others

* - red - green blindness:-

* -Green & red cones see different colors between wave length 525-675 nm & distinguish them.

* -If either of these cones are absent, the person can not distinguish 4 colors (red - green- yellow- orange)& he can not distinguish red from green (primary colors) so called
* (red - green blindness).

-It is x- linked disease transmitted from females to their male sons, never occur in females as they have 2 x chromosomes

- Males have one x & one y chromosome so if this one x chromosome miss the gene for color vision , he will get red-green color blindness(their gene is on x chromosome).

-Females show the disease only if both x chromosomes lack the gene

- Females from color blind fathers are carriers transmit the disease to $\frac{1}{2}$ of their sons.

- * Trichromats :- have 3 cone pigments(normal or have slight weakness in detecting red or green or blue color
- * Dichromats:- have only 2 cone pigments systems only so he is completely blind to red or green or blue (so they may have protanopia, deuteranopia, or tritanopia) they get color by mixing only 2 of the primary colors.

Monochromats :- have only one cone system or loss of all so see only black or grey or have no color perception.

* Nopia = blindness, nomaly =weakness

* 1-Protanopia(red- blindness) :- no red cones system so person has shortened spectrum wave length,

* if only weakness in red color vision is called **protanomaly**.

2-deutanopia (green - blindness) :- no green cones system
-so person see only long & short wave length)

- If only weakness in green color vision is called **deutanomaly**

3-tritanopia (blue - blindness) :- no blue cones system , if
only weakness in blue color vision is called tritanomaly

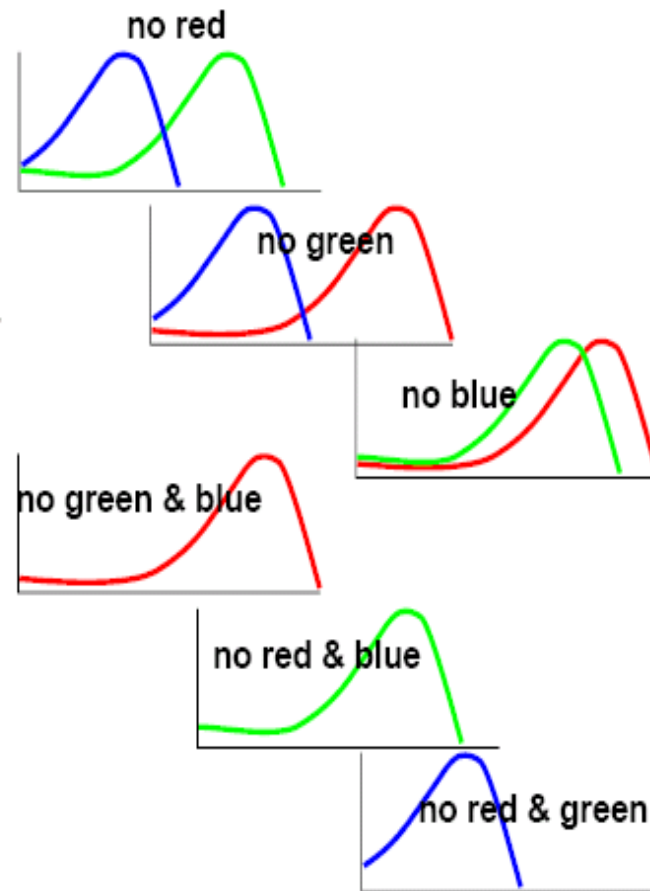
Color Blindness -cont.

- ▣ Anamoly ...weakness
 - ▣ Anopia Total loss
 - ▣ Protanopia
 - ▣ Deuteranopia
 - ▣ Tritanopia
- Dichromats
-
- ```
graph LR; A[Protanopia] --- B[Dichromats]; C[Deuteranopia] --- B; D[Tritanopia] --- B;
```

## Colour blindness.

Each cone type contains a different light sensitive photo pigment. Colour blindness occurs when there is a defect in the genes that produce these photo pigments. Various combinations of defects can occur.

- 1) Missing one cone type
- 2) Missing two cone types
- 3) Missing all three cone types (vision is limited to the rods)
- 4) A cone type is made with a photo pigment different from normal.



How many gradations of colour can the human brain distinguish?

a) 200 hues

The brain transforms the single wavelengths of light seen in rainbow into a colour circle. Hues on opposite sides of the circle are complementary.



b) 20 levels of saturation

Combinations of two more wavelengths. When complementary wavelengths are combine equally one gets white.



c) 500 brightness levels

Any colour on the circle can be made brighter or darker.

Remarkably with only 3 cones types we can see  $500 \times 200 \times 20 = 2,000,000$  gradations of color







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