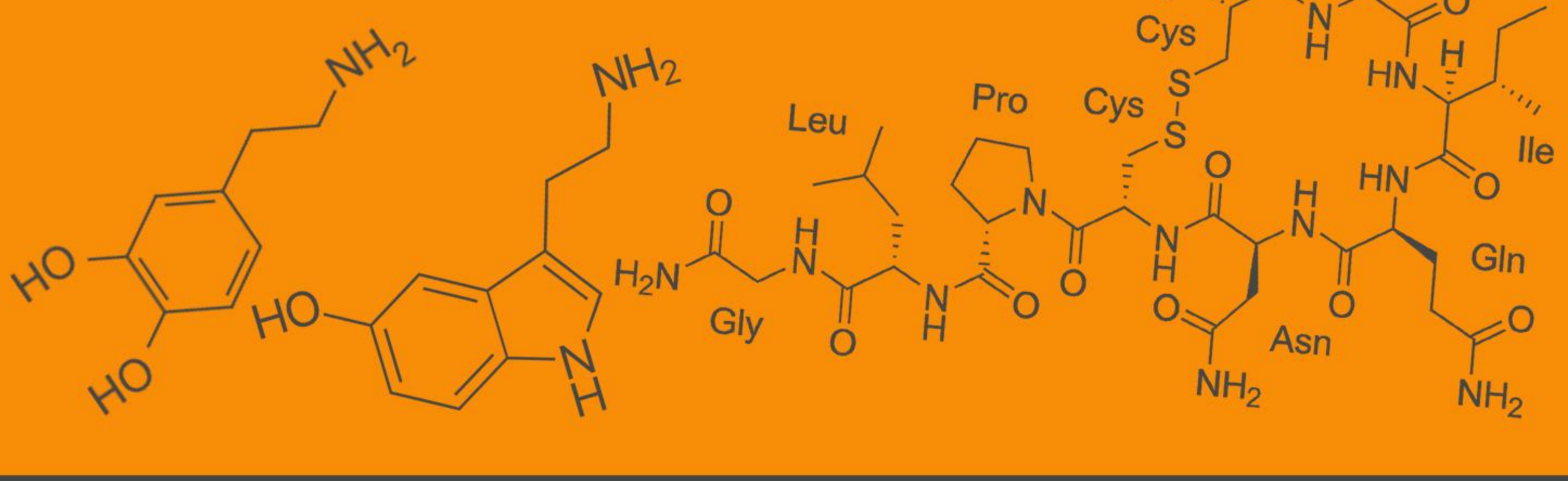

MEDICINE438's CNSPHYSIOLOGY

Lecture XI: Color Vision

IMPORTANT MALE SLIDES EXTRA FEMALE SLIDES LECTURER'S NOTES

1 COLOR VISION

Lecture Eleven

OBJECTIVES

- Identify /describe the mechanism of color vision & the 3 types of “cones”.
- Understand the range of spectral sensitivity .
- Identify /describe color blindness.

Color Vision :

It’s the ability to discriminate /differentiate between different colors.

The colors of color vision :-

- There are 3 primary colors :-
  1-Red 2-Green 3-Blue
  They are sensed by the “Cones” within the Fovea[1], and can be perceived within Photopic vision[2].

- Sensation of extra-spectral color such as White, Yellow, Orange & Purple can be produced by mixing properties of the primary colors in different combinations, but for the case of a White color there is an equal stimulation for each “cone”.

- For each color there is a complementary color that when mixed together form a sensation of a White color, for example : Orange + Blue = White
- Every color has 3 attributes :-
  1- Hue: the classification/name of the color.
  2- Intensity.
  3-Saturation: the purity/intensity of the hue.

PRESENT ONLY IN FEMALE SLIDE

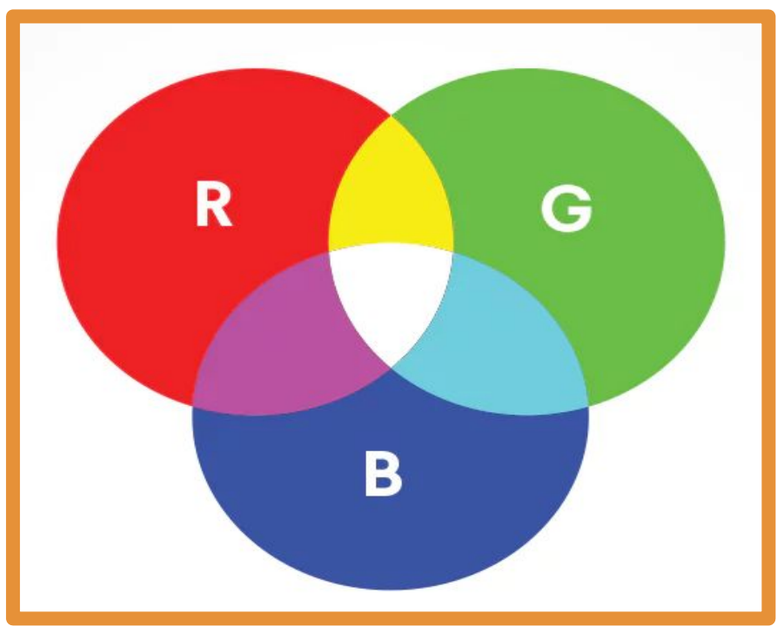

Figure 11-1: the primary colors & the formation of white.

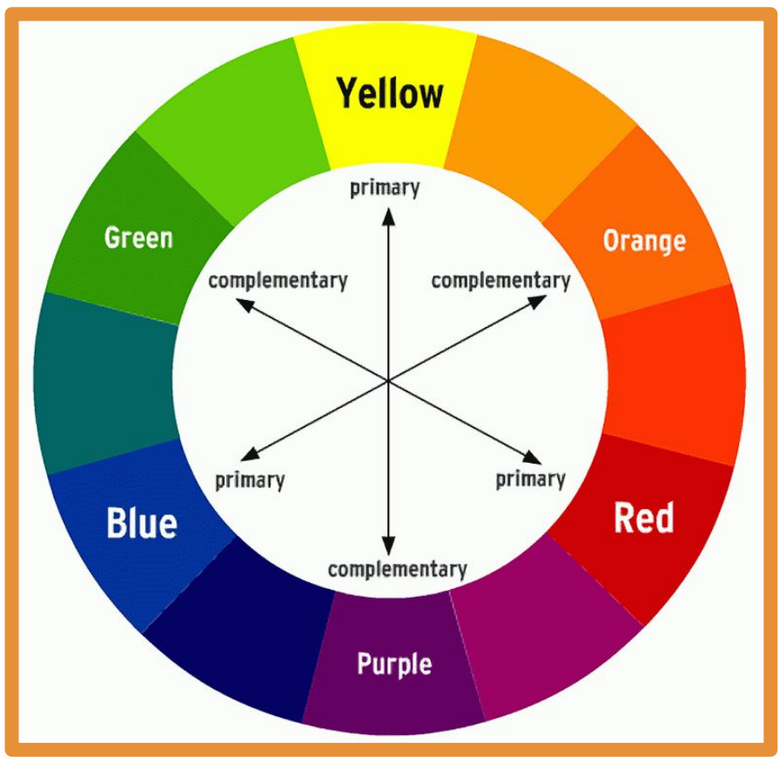

Figure 11-2: more examples for the complementary colors.

Perception of Black:

The perception of a Black color is caused by an absence of light, yet a blind person doesn’t “see” black, he just sees nothing because the visualization of a black color is a positive sensation and not just an absence of light, that’s why darkness doesn’t necessary means a black color.

FOOTNOTES

1. A tiny pit located in the macula of the retina that provides the clearest vision of all.
2. is the vision of the eye under well-lit conditions.

Color Vision Theory (Young-Helmholtz Theory)

- **We have 3 types of cones that have a specific photopigment (rhodopsin) each, thus each of them is sensitive to one of the primary colors:**

Cone system	Blue	Green	Red
Pigment Type	**S** pigment	**M** pigment	**L** pigment
Wavelength[1] that the cone responds to	Short wavelength **(440 nm)**	Middle wavelength **(535 nm)**	Large wavelength **(>535 nm) (>565 nm)**

Table 11-1

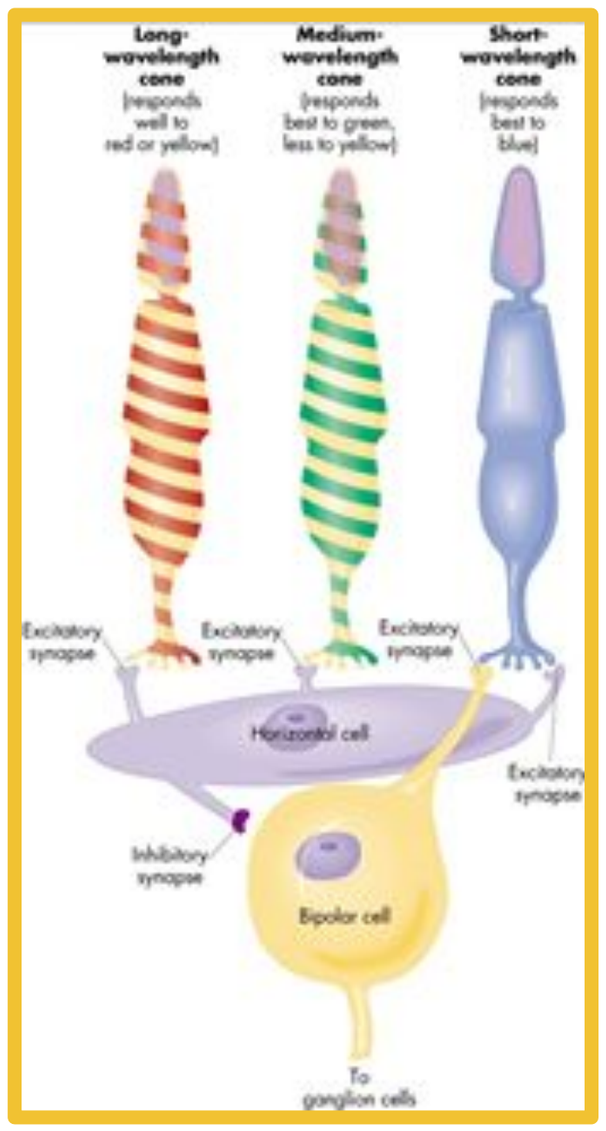

Figure 11-3 The three cone systems..

➽ Sensation of color is determined by :-

1. **Wavelength of light**(which is different for each color).
2. **Amount of light absorbed** (which is different for each cone due to their distinctive colors).
3. **Frequency of impulses by each cone system to ganglion cells**(which is determined by the wavelength of the light received by the cones).

The Threshold Of Color Sensation

Each cone responds to the colors that it's supposed to respond to at a lower threshold, but the threshold is much higher for other colors for example :
Red cones respond to **Red** & **Yellow** at a low threshold ,but for Green ,the **Red** cones have a much higher threshold.

PRESENT ONLY IN FEMALE SLIDES

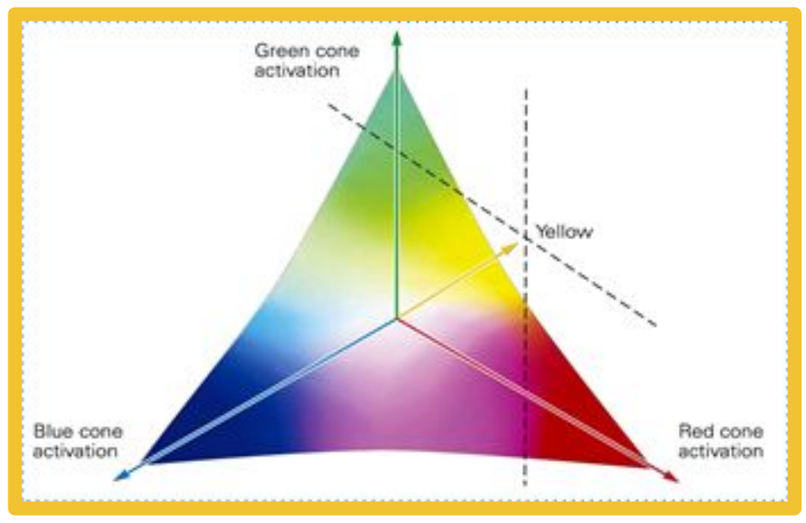

Figure 11-4 A vector diagram showing that the white color is in the middle of the vector.

- Sensation of a White color is caused by EQUAL STIMULATION of each cone ,thus a White color does not have a wavelength because it is a combination of all the wavelengths.

FOOTNOTES

1. Wavelength: the distance between two identical points in a single wave.

Color vision theory (Young. Helmholtz theory) :

- Color vision is coded by:-

1. The different responses in ganglion cells which are determined by the wavelength of the stimuli which determines the frequency of impulses in .

2. The color perception in brain itself is determined by the amount of activity by EACH cone system.

- The perception for each color relays upon the percentage of stimulation for each cone system, especially the extra-spectral colors, some examples include :-

Color	Cone stimulation percentage	Ratio
Orange	99% of red cones 42% of green cones 0% of blue cones	(99:42:0)
Yellow [1]	83% of red cones 83% of green cones 0% of blue cones	(83:83:0)
Blue	0% of red cones 0% of green cones 97% of blue cones	(0:0:97)

Table 11-2

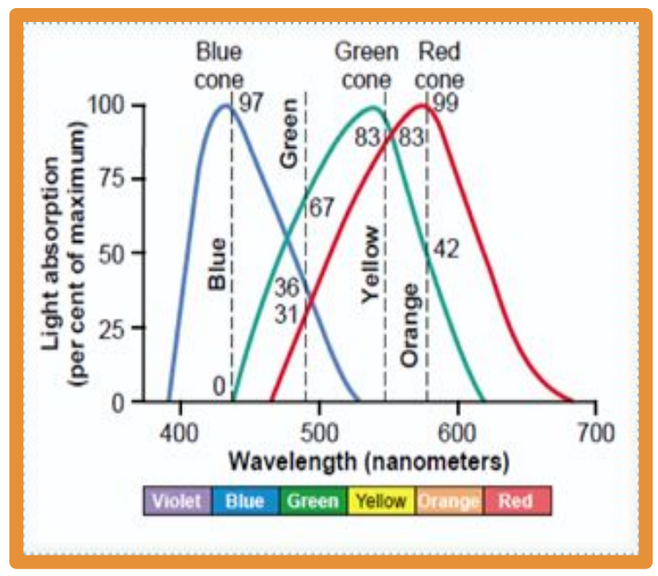

Figure 11-5:a graph showing the percentage of activation in the cones in respect to the wavelength.

The Advantage Of Color Vision

It's important that we distinguish from its background or surroundings, and we do that by sensing color.

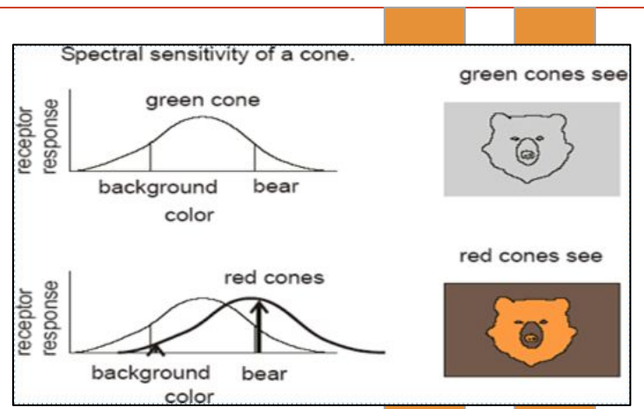

Figure 11-6

The Ishihara Charts

Ishihara charts, which are plates containing figures made 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.

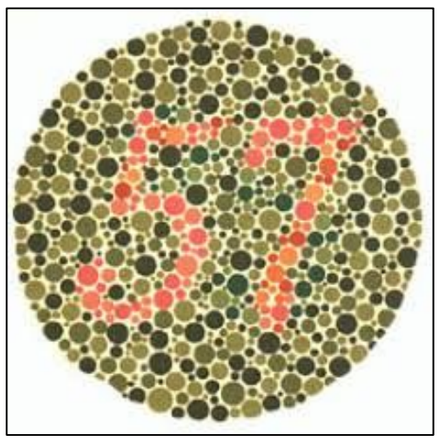

Figure 11-7

FOOTNOTES

1. it's 50:50:0 in female slides, but in male slides and in Guyton and Hall it is consistent with what's in the male slides, note that the ratio is the same but only the percentage of cones activated differs.

Color Blindness :

The Genes Of The Cone Pigments

- The gene for rhodopsin (Red) ⇒ on Chromosome "3"
- The gene for the S pigment (Blue) ⇒ on Chromosome "7"
- There is gene for the Red & Green sensitive pigments (L & M) ⇒ Chromosome "X"

PRESENT ONLY IN FEMALE SLIDE

Red-Green Blindness :

➔ **Green** & **Red** cones see color between the wavelengths of **525-675 nm**.
If either of these cones are absent, the person won't be able to distinguish between :-
-**Red**.
-**Green**.
-**Yellow**.
-**Orange**.

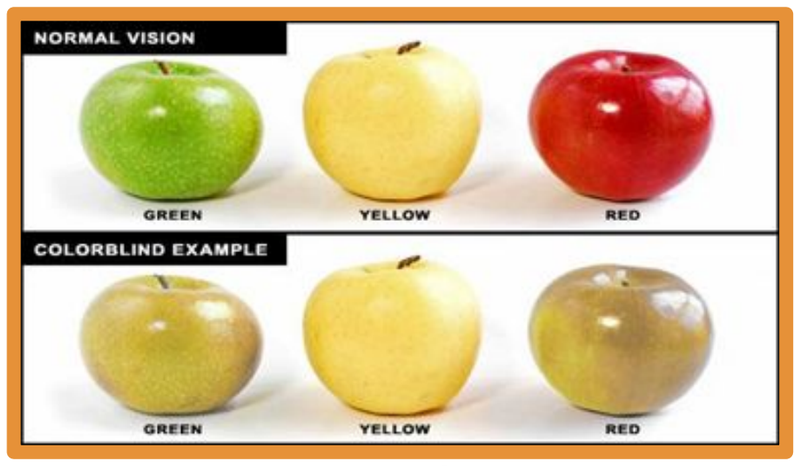

Figure 11-8

Figure 11-9

➔ It's **X-Linked** disease that is transmitted by females to their male children, never occurs in females because they have 2 X Chromosomes, unlike males which they have only 1.
➔ Females show the disease only if both of their X chromosomes lack the gene.
➔ Females from color-blind fathers are only carriers and transmit the disease to half ($^1/_2$) of their children.

Figure 11-10

The types of Color Blindness

Trichromats

Have the 3 cone pigments normal, or have slight weakness in one of them.

Monochromats

Have only one cone system, or loss of all systems, thus the person black & gray, or have no color perception.

Dichromats

Have 2 cone pigments only, so they get the missing color by mixing 2.
It means their missing 1 of the 3 cones, so they are divided into 3 groups:

Protanopia(red-blindness)

No red cone systems so the person has a shortened spectrum wavelength.
If it's only weakness in red , we call it Protanomaly. [1]

Tritanopia (blue-blindness)

No blue cone systems.
If it's only weakness in blue, we call it Tritanomaly.

Deutranopia(green-blindness)

No green cone systems, so the person can only see long & short wavelength.
If it's only weakness we call it Deuteranomaly.

Anopia = Blindness

Anomaly = Weakness

Figure 11-11

Figure 11-12

FOOTNOTES

1- protanomaly, deuteranomaly and tritanomaly considered as trichromatos.

10 COLOR VISION

Lecture Eleven

SUMMARY

-Vision is the ability to discriminate /differentiate between different colors.

-The three primary colors have three cone systems that each correspond to different wavelengths, and they are:
1-Red has L pigment type responds to **>535 nm**.
2-Green has M pigment type responds to **535 nm**.
3-Blue has S pigment type responds to **440 nm**.

-Every color has 3 attributes which are Hue, Intensity and Saturation.

-Sensation of extra spectral color can be produced by mixing properties of the primary colors in different combinations, but for the case of a White color ,theres is an equal stimulation for each "cone" and The perception of a **Black** color is caused by an absence of light.

-For each color there is a complementary color that are when mixed together form a sensation of a White color.

-Sensation of color is determined by:
1-Wavelength of light
2-Amount of light absorbed
3-Frequency of impulses by each cone system to ganglion cells

-Each cone responds to the colors that it's supposed to respond to at a lower threshold, but the threshold is much higher for other colors

-Color vision is coded by:
1-The different responses in ganglion cells
2-the amount of activity by each cone system.

-The perception for each color relays upon the percentage of stimulation for each cone system, the ratio for Orange (99:42:0), Yellow (83:83:0) and Blue (0:0:97).

-person with Red-Green Blindness won't be able to distinguish between Red, Green, Yellow and Orange. It's X-Linked disease that is transmitted by females to their male children, never occurs in females because they have 2 X Chromosomes, unlike males which they have only 1.

-The three types of color blindness are Trichromats, Dichromats and Monochromats.

-Dichromats subdivided into Protanopia (red- blindness), deutranopia (green -blindness) and tritanopia (blue - blindness).

- Trichromats could subdivided into protanomaly, deutranomaly and tritanomaly

QUIZ

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1. Perception of yellow color due to stimulation of which cone system?

A) Blue and green
B) Red and blue
C) Red and green
D) Red and white

2. Which wavelength is the blue cone most sensitive to?

A) 440 nm
B) 535 nm
C) >535 nm
D) 525 nm

3. Brain interpretation of orange color perception relies upon which percentage?

A) (99:42:0)
B) (83:83:0)
C) (97:52:0)
D) (31:64:16)

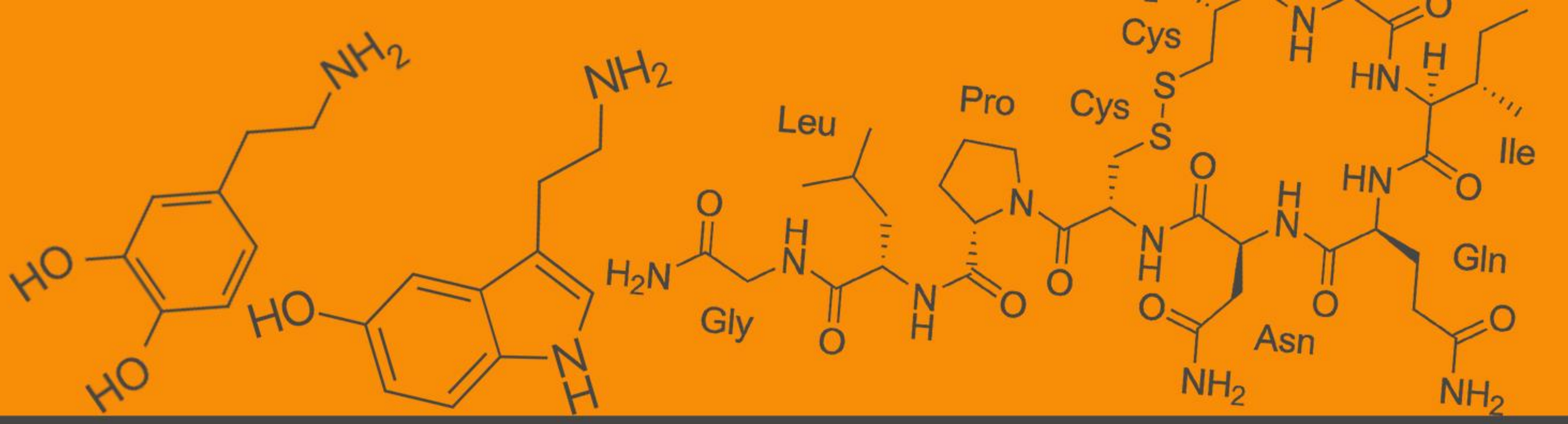
4. Deuteranomaly is:

A) Weakness of red color
B) No red cones system
C) No green cones system
D) Weakness of green color

5. If you were diagnosed with protanopia which of the following cones is most probably affected?

A) Blue
B) Green
C) Red
D) Yellow

ANSWER KEY: C, A, A, D, C



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REFERENCES

- Guyton and Hall Textbook of Medical Physiology
- Ganong's Review of Medical Physiology