Physiology 435 team

COLOR VISION

Objectives:

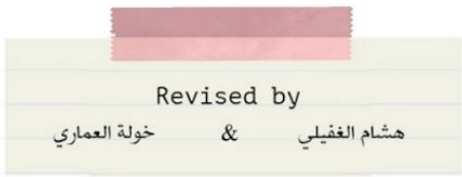
- **Define color vision.**
- **Identify and describe the mechanism of color vision and the three types of cones, including the range of spectral sensitivity and color blindness.**
- **Identify color vision theory.**
- **Describe the items needed for any color perception.**
- **Compare different types of color blindness.**

Done by:

- **Team leaders:** Shahad AlEnezi - Rawaf AlRawaf.
- **Team members:** Afnan almalki - Dalal alhuzaimi - Dania AlHindawi - Farrah Mendoza - Malak Alyahya - Hassan Al-shammasi.

Edited by: Shahad AlEnezi.

Revised by: Rawan Aldhuwayhi - Shahad AlEnezi.



Color index: Important - Further explanation - Doctors Notes - Numbers.

---

*Please check out this link before viewing the file to know if there are any additions or changes.

Introduction:

❖ COLOR VISION Definition::

It the ability to discriminate between different colors.

- There are **3 primary colors** (blue- red- green) sensed by **cones** in fovea & appreciated within photopic vision.
- Sensation of extra spectral colors as **white, yellow, orange, purple,** can be **produced by mixing** properties of the blue **&** red **&** green in different combinations.
- **Black** is the sensation produced by the **absence of light** (**not darkness** because in dark we do not see black only) but it is probably a **positive sensation** because the **blind eye does not "see black"** rather, it "sees nothing." Black color has no waves. Darkness has waves.
- **Colors have three attributes** hue[1] , 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.

ما ذكركم الكلام السابق بحصة الفنية بأولى ابتدائي؟

Color vision theory: (Young- Helmholtz theory)

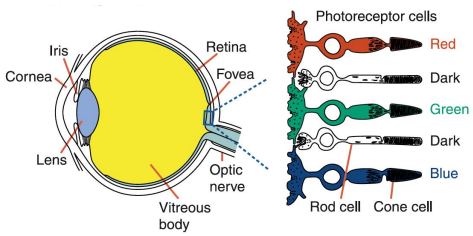
هذه النظرية كغيرها من النظريات لها قواعد تعتمد عليها وهي ملخصة كالتالي:

I. We have 3 kinds of cones each has a specific photopigment (rhodopsin) & is sensitive to one of the 3 primary colors:

	Blue cone system	**Green cone system**	**Red cone system**
Pigment:	Has **S pigment** (blue sensation pigment).	Has **M pigment** (green sensation pigment).	Has **L pigment** (red sensation pigment)
Wavelength it responds to:	**SHORT** wave length (440 nm)	**MIDDLE** wavelength (535 nm).	**LARGE** wavelength (**at** or > 535 nm .
Color it senses:	senses the **blue** color	senses the **green** color & less to **yellow**	senses the **red** & **yellow** color.

[1] It's a color or shade, which is dependent on its dominant wavelength and independent of intensity or lightness.
بالعربي هي درجة اللون أو تعدد الألوان.

	-	Absorbs light at the **green** portion.	Absorbs light at the **red** portion.



في هذه الصورة نرى بأن الـ (cones) ملونة حسب أنواعها ولكن هي بالحقيقة غير ذلك هي بالعين الحقيقة نفس اللون ولكن لكل منها خاصية استقبال لون محدد لذلك وضحت بهذا الشكل.

من المرحلة الابتدائية نعرف ان اللون الأزرق هو صاحب أقل طول موجي "Shortest" ← وعليه صبغته بيرمز لها بالحرف S، واللون الأحمر هو صاحب أعلى طول موجي "longest" ← وعليه صبغته بيرمز لها بالحرف L.

II. Sensation of any color determined by:

A. **Wavelength** 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 wavelength of light.

III. Each cone system respond to its color at a lower threshold than needed to sense other colors.

- **E.g :** (red cones respond to red or yellow color at a lower threshold **than to** green color).

ذكرنا إن عندنا ٣ أنواع من الكونز وكان لكل كونز لون معين يستطيع استشعاره ونجد هنا أن هذه القاعدة تنص على أن كل كونز يستطيع استشعار لونه الخاص عند ثريشولد منخفض على عكس استشعاره الألوان الأخرى التي لا تنتمي له.

IV. Perception of white is due to equal stimulation of blue & red & green cones.

- There is **NO wavelength corresponds to white**, white is a combination of all wavelengths.

اللون الأبيض ينتج عن تحفيز الـ 3 cones بنفس الدرجة.. ليش أشوف لابكوتي أبيض؟ لأن كل الكونز محفزة بنفس الدرجة!

Interpretation of color in the nervous system.

❖ Color vision is coded by:

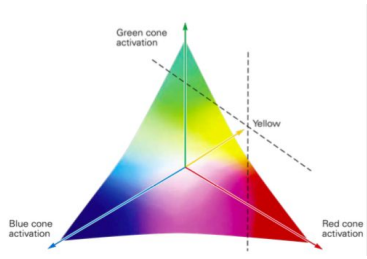
- Different responses in **ganglion cells** that depends upon the **wavelength** of stimulus which determine frequency of impulses in ganglion cells.
- The color perception in the brain depends on the amount of activity in each of the 3 cones systems as mentioned above.

Extra Explanation: Some ganglion cells are stimulated by all three types of cone. Such a ganglion is thought to signal "white" light. Most ganglion cells, however, are stimulated by light of one wavelength and inhibited by another. For example, red light may excite and green may inhibit a particular ganglion cell; this is called "color-opponent mechanism".

❖ 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.

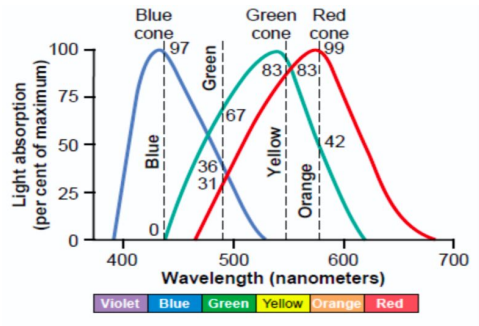
  -As can be seen in this vector diagram white occupies the middle of the vector.



Perception of →	Orange	Yellow	Blue
Red cones	**99%**	**50%**	**0%**
Green cones	**42%**	**50%**	**0%**
Blue cones	**0%**	**0%**	**97%**
Ratio:	**99:42:0**	***50:50:0**	**0:0:97**

***Note: in both Guyton and boys' slide the ratios of 83:83:0 are interpreted by the nervous system as yellow!**

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



This figure show the demonstration of the degree of stimulation of the different color-sensitive cones.

for example, if I want to know the perception of orange is due to stimulation of which cones?

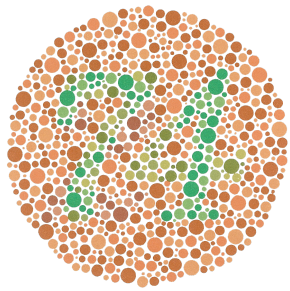
1) mark the wavelength of orange color, then look at the vertical line of this wavelength.

2) mark the color cones that cross this line and at which level (light absorption), which are red (99%) and green(42%) cones, but not blue(0%) cone.

So the ratio is 99:42:0.

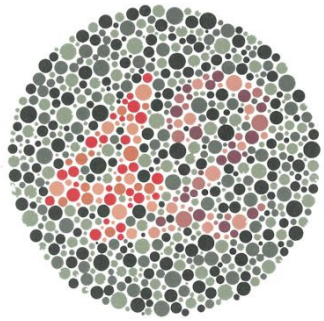
Test for Color Blindness

❖ Ishihara Charts[2] - اختبار إيشيهارا للألوان:



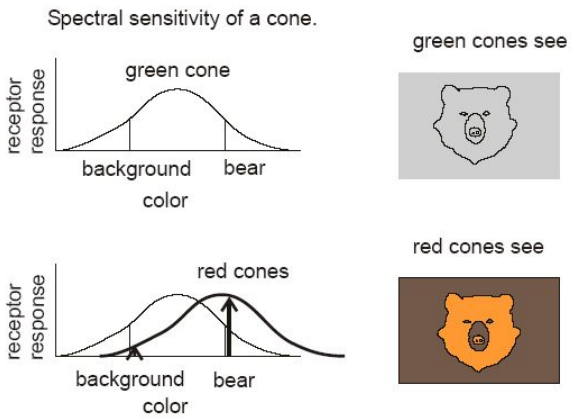
Plates containing figures made up of colored spots on a background of similarly shaped colored spots. The figures are intentionally made up of colors that are *liable to look the same as the background* to an individual who is color blind. Some color blind individuals are **unable to distinguish** certain colors, whereas others have only a **color weakness**.

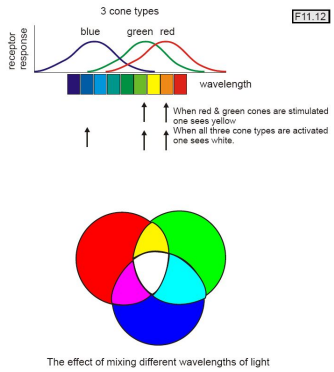
In the "top" chart, the person with normal vision reads "74", whereas the reg-green color-blind person reads "21".



In the "bottom" chart, the person with normal color vision reads "42", whereas the red-blind person reads "2", and the green-blind person reads "4".

- **So, what is the advantage of color vision?** Color is important for distinguishing an object from its background.



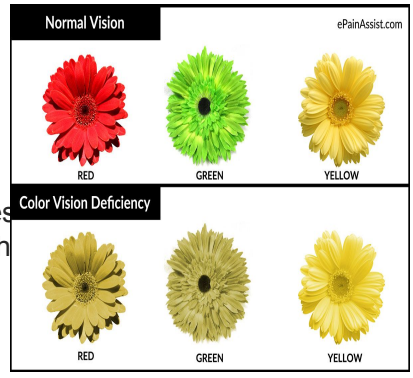


The **red and green** cones are activated, therefore the person with normal vision can see the orange/brown color of the bear.

Color blindness

❖ Color blindness:

- There is gene for rhodopsin on chromosome 3. "No color if mutated"
- There is gene for blue sensitive S cone pigment on chromosome 7.



[2] a color perception test for red-green color deficiencies, the first in a class of succes pseudo-isochromatic plates ("PIP"). It was named after its designer, Dr. Shinobu Ish University of Tokyo, who first published his tests in 1917.

- There is gene for red and green sensitive cone pigment on X chromosome. "Most common type"!
- When a single group of color receptive cones is absent, (due to absence of their gene), the person cannot see or distinguish some colors from others.

❖ Red-green blindness:

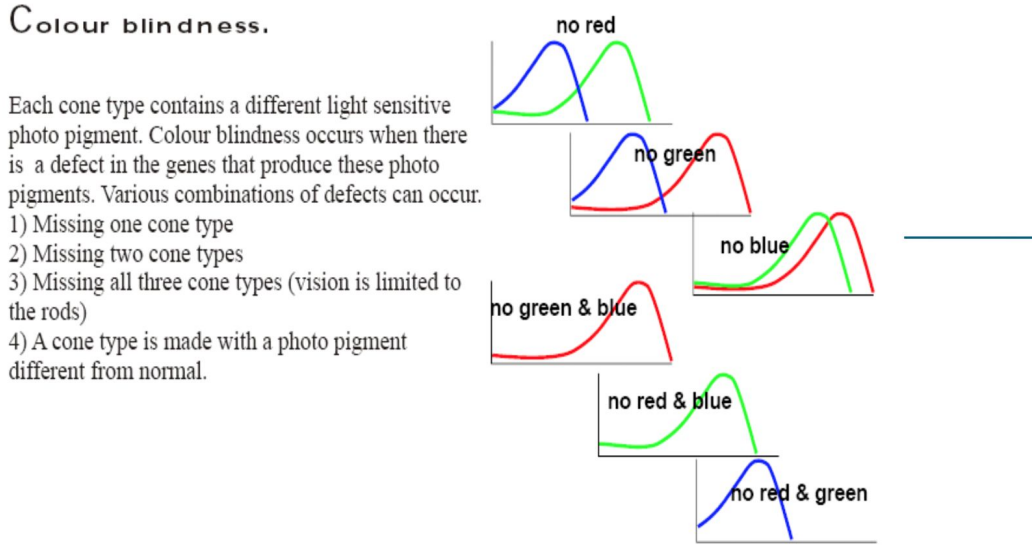
- Green and red cones see different colors between wave length 525-675 nm and distinguish them.
- If either of these cones are absent, the person cannot distinguish 4 colors: red, green, yellow, and orange. Yellow and orange are produced by mixing red and green "go to the third page".
- He cannot distinguish red from green (primary colors) so called red-green blindness.
- It's **X-linked disease** transmitted from females to their male sons, never occur in females as they have 2 X chromosomes.
  - **Male** have one X and one Y chromosome, so if this X chromosome miss the gene color vision, he will get red-green color blindness because their gene is on X chromosome.
  - **Females** show the disease only if both X chromosomes lack the gene.
  - Females from color blind fathers are usually **carriers** that transmit it to the half of their sons.

Trichromats, dichromats, and monochromats.

Trichromats	Dichromats	Monochromats
Have 3 cone pigments. Normal or have slight weakness in detecting red, green, or blue color. تكون الكونز بيجمنتس كلها سليمة، أو فيها ضعف خفيف فقط.	Have only 2 cone pigments systems, so he is completely blind to red, green, or blue. So they may have protanopia, deuteranopia, or tritanopia. They get color by mixing only 2 of the primary colors. يكون واحد من الكونز بيجمنتس فقط غير سليم، أما الاثنين الباقيات تكون سليمة.	Have only one cone system or loss of all, so see only black, grey, or have no color perception. يكون فيه كون بيجمينت واحد فقط سليم، أما الاثنين الباقيات تكون غير سليمة. وممكن يكون كل الكونز بيجمنتس سيستمز غير سليم.
Dichromats "Nopia = blindness. Anomaly = weakness."		

Protanopia (red-blindness):-	**Deutranopia (green-blindness):-**	**Tritanopia (blue-blindness):-**
No red cones system (person has shortened spectrum wave length.) " red has a long wavelength but the person doesn't have the system that receives red → shortened wavelength"	No green cones system (person sees only long and short wave length.)	No blue cones system.
Protanomaly	**Deutranomaly.**	**Tritanomaly**
If only **weakness** in red color vision.	If only **weakness** in green color vision.	If only **weakness** in blue color vision.

Picture from girls' slides:



★ References:

- 435 girls and boys slides and notes.
- Guyton's Physiology, **Chapter 50**.