Where did all the colors go?

Think back to when the hit movie The Good, the Bad and the Ugly first made its debut in 1966. The movie looked as though the film had been saturated in yellow ink. Today, people are so used to seeing movies with excellent color quality and stunning attention to detail that they scoff at the rustic look of the film's tinted color scheme. Of course, filmmakers back then couldn't change the fact that their films were colorless. Older films had poor color quality because movies could be produced only in black and white. The Good, the Bad and the Ugly is a perfect metaphor to describe colorblindness, or color vision deficiency. Despite the common misconception that color blind people only see in black and white, color blindness simply causes a person to see colors in a different hue, or tint, as a person with normal color vision would. Just as some colors are skewed in old sepia films, color blindness causes people to see the world as if they were looking through tinted glass.

History of Color Blindness

Figure 1- John Dalton

The first scientist to identify and give a name to color blindness was John Dalton, born in Eaglesfield, England on September 6, 1766 (see Figure 1). In 1793, Dalton published his first paper on the subject, called Extraordinary Facts Relating to the Vision of Colours. Dalton was able to gain an insider's view to color blindness, as he and his brother were red-green color blind. In his paper, Dalton stated "That part of the image which others call red appears to me little more than a shade or defect of light. After that the orange, yellow and green seem one colour which descends pretty uniformly from an intense to a rare yellow, making what I should call different shades of yellow" (Flück). Dalton believed that differences and defects in color vision were caused by a discoloration of a certain liquid in the eye called *aqueous humor*. His explanation was that when a person was color blind, his or her aqueous humor was tinted blue, and therefore it filtered out all colors that could usually be seen by people with normal color vision. These ideas and observations eventually evolved into the theory of Daltonism, which is a term commonly used for 'color blindness'. John Dalton was so dedicated to his work that, in his will, he wrote that he wanted an autopsy to be performed on his eyes to test the validity of his theory of the cause of color blindness. When the autopsy was performed, however, there was not any *aqueous humor* found in Dalton's eyes. Therefore, Daltonism was proved not to be true. Color blindness is not caused by a deformity in the aqueous humor, but by something else.

The Modern Diagnosis

Since Dalton's day, scientists have discovered the true cause of colorblindness, and it has nothing to do with bluish liquids. There are about six million cone cells present in the human eye, and they are responsible for taking in light waves which are later processed by the brain and identified as colors. The three types of cones in the eye are the red cones, the green cones, and the blue cones (these can also be called the long, medium and short cones, respectively). The red cones make up most of the color perception- about sixty-four percent- while the green cones make up thirty- two percent of color perception. The blue cones make up only two percent of color perception, but they are the most sensitive cones ("Rods and Cones"). Each of the three different types of cones contains certain pigments that are sensitive to either red, green, or blue light waves- or wavelengths. By absorbing in these wavelengths in different combinations of fixed ratios, the human eye is able to take in the entire spectrum of visible light, or the range of colors of light that a can be seen by the naked eye (see Figure 2). When colorblindness plagues an individual, it directly affects the cone cells of the eye. When a person is colorblind, his or her eyes' cone cells are damaged or absent and cannot absorb the wavelengths that they are meant to. Usually, some cones- red cones, for instance- will warp to become more like green cones, causing them to take in different wavelengths than they are meant to. Therefore, when the brain tries to process what kind of color the eyes are taking in, it will send warped signals, causing the person's view of a certain color to be warped as well (see Figure 3). The result is colorblindness.

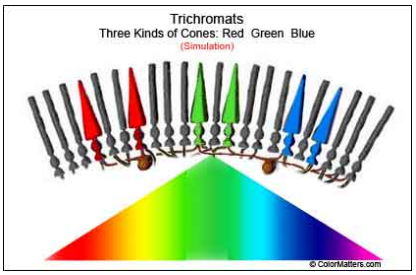

Figure 2- The three types of cones in the eye and the spectrum of visible light that they take in.

Figure 3- A diagram of the American flag as it would been seen by people with different color perceptions.

How does a person become color blind?

In most cases, color blindness is the result of a genetic defect; it is caused by a dysfunctional X-chromosome that women carry. Benjamin Joy Jeffries, a nineteenth- century physician, wrote about color blindness being passed down through the family of Dr. Pliny Earle in his book Color-Blindness: its Dangers and its Detection. He wrote "Of the first he knows nothing as to their color-blindness. Second: of seven brothers and eight sisters, three brothers had the defect. One was Dr. Earle's grandfather. Third generation, -children of the grandfather,- three brothers and four sisters: no one imperfect. Fourth generation,- first family of five brothers and four sisters: two brothers color- blind…" (Jeffries). Color blindness' hereditary nature was proven earlier by Swiss ophthalmologist

J.F. Homer in 1876, when he “demonstrated that a man with red-green color blindness transmitted the trait to his male grandchildren through his unaffected daughter” (Wynbrandt). The gene that causes color blindness was the first gene ever assigned to a specific chromosome.

In other cases, color blindness is caused by the aging process, an eye injury, disease, or problems with the eyes’ optic nerves. Sometimes, a person becomes color blind as the side effect of certain medications. As Jeffries observed, color blindness shows up in more men than women; about 5 to 8 percent of men are born color blind, while only about 0.5 percent of women are (Waggoner). More than often, colorblind people are unaware that they are colorblind until they are diagnosed.

Types of Color Blindness and their Effects

As stated before, the most common misconception about color blindness is that a color blind person sees the world in just black and white. Judging from the prior description of color blindness, it is obvious that this is not the case. There are more kinds of color blindness, and only on very rare occasions will a color blind person see in shades of gray. All of the types of color vision deficiencies can be put into two groups: Dyschromatopsia- a form of colorblindness where a person can only see some colors as a normal person can- and Achromatopsia- a form of colorblindness where a person cannot see any colors as a normal person can.

Dyschromatopsia is the more common form of colorblindness. Five types of Dyschromatopsia are Protanomaly, Protanopia, Deuteranomaly, Deuteranopia, and Tritanopia.

Some people refer to Protanomaly and Protanopia as "red weak” color blind, because people with Protanomaly or Protanopia are not as sensitive to red light as any normal color-viewer. People with Protanomaly or Protanopia have trouble distinguishing between red and green, and between blue and green (see Figure 4). People with red-weak color blindness either have defective red cones, or are missing them altogether. People with Protanomaly have defective red cones, while people with Protanopia are missing their red cones. One percent of all males are Protanomalous, and one percent of all males have Protanopia (Waggoner).

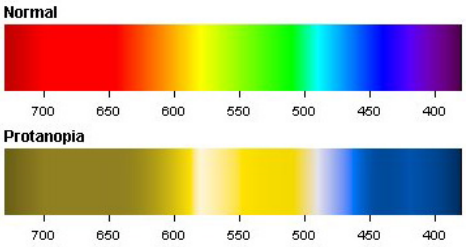

Figure 4- The difference between the spectrum of light as seen by a normal color-viewer and a person with Protanopia.

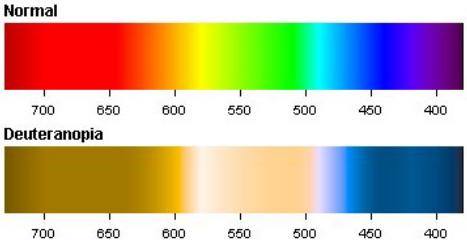

Figure 5- The difference between the spectrum of light as seen by a normal color-viewer and a person with Deuteranopia.

Deuteranomaly and Deuteranopia can both be described as "green weak" color blindness. People with Deuteranomaly or Deuteranopia have trouble telling the difference between red, orange, yellow, and green hues (see

Figure 5). Deuteranomalous individuals are missing the green cones in their eyes, while the cones of a person with Deuteranopia are defective or damaged. Five percent of the male population has Deuteranomaly, while only one percent of the male population has Deuteranopia (Flück).

These four types of color blindness all describe what is commonly known as red- green colorblindness.

When a person has Tritanopia, the blue cones in his or her eyes are either mutated or missing. Tritanopia is also called blue-yellow colorblindness. The .01 percent of people with Tritanopia cannot tell the difference between blue, yellow, green, and violet hues (see Figure 6) (Flück).

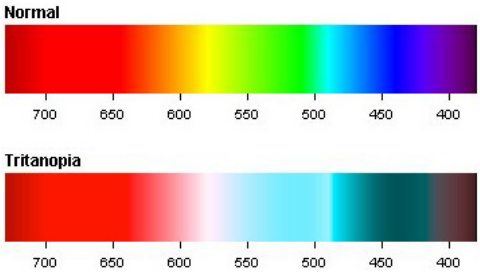

Figure 6- The difference between the spectrum of light as seen by a normal color-viewer and a person with Tritanopia.

In very rare cases, Achromatopsia shows up in an individual. People with Achromatopsia- which is also called Monocromasy- do not see any colors as a person with normal color vision would; they see the world in shades of gray.

How is color blindness diagnosed?

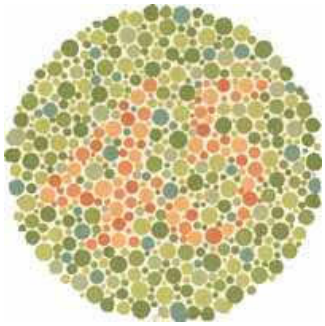

Figure 7- An Ishihara plate used to diagnose red-green colorblindness. A person with red-green color blindness cannot see the red forty-five in the middle of the green dots.

Vision tests called Ishihara plates are available to test the type and severity of color blindness a person may have. These useful medical tests were first invented by Dr. Shinobu Ishihara (1879-1963), a professor at the University of Tokyo. He first published these tests in 1917. Ishihara plates consist of a small circle made up of many more colored circles, where a certain pattern of circles are colored differently to form a number or letter, or some other easily recognizable figure (see Figure 7). A color blind person cannot see the figure if he or she has a certain type of color blindness. For example, if a number made up of red circles is surrounded by many green circles, if that person cannot identify the red number, then he or she would be diagnosed with red- green color blindness.

How does color blindness affect people?

Color blindness can affect people of all ages. For example, children in school could become very confused, because much of children's learning materials and lessons rely heavily on color perception. On the other hand, older people who are colorblind may have difficulty picking out clothes that match. Sometimes, color blind people are not able to obtain a commercial driver’s license because they cannot tell the difference between a green, yellow, or red traffic light.

Color blind people cannot perform certain jobs that require the ability to distinguish between colors: pilot or electrical technician.

How can color blindness be treated?

Color blindness cannot be cured, and it does not go away over the course of one's lifetime. There are, however, certain methods that can be used to help color blind people distinguish between colors. Special tinted lenses, for instance, can be worn to filter out colors so that a color blind person can tell the difference between colors that they usually would not be able to.

Another way to prevent color blindness is genetic counseling. Genetic counseling is defined as "providing an assessment of heritable risk factors and information to patients and their relatives concerning the consequences of a disorder, the probability of developing or transmitting it, and ways in which it can be prevented, treated, and managed" ("Glossary-Medical Genetics"). In other words, with genetic counseling, doctors can identify and assess certain genes in a person's chromosomes. Doctors can then tell if a person is carrying diseases or certain traits, and figure out ways to treat him or her. Color blindness is a trait that can be identified by genetic counselors. Doctors can identify the defective X-chromosome of color blindness, and notify an individual when he or she carries the color blindness gene. Color blindness cannot be cured or prevented with genetic counseling, however.

Just like the black- and- white movies that were produced in the 1960's, color blindness can cause a person to see a color- tinted version of the world as seen by normal color-viewers. The mission to understand color blindness has been underway since the 1700's, and it is still going on today. Innovations such as Ishihara plates and genetic counseling have been created to help detect and understand color blindness, and the future holds many opportunities for more to be made. Who knows what's in store for this wonder of color vision?

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Images

Image 1 found at http://www.aanpa.org/explain-graphics.html

Image 2 found at http://www.colormatters.com/kids/eye.html

Image 3 found at http://www.nationmaster.com/encyclopedia/Color-blindness

Image 4 found at http://www.colblindor.com/2006/11/16/protanopia-red-green-color-blindness/

Image 5 found at http://www.colblindor.com/2007/04/17/deuteranopia-red-green-color-blindness/

Image 6 found at http://www.colblindor.com/2006/05/08/tritanopia-blue-yellow-color-blindness/

Image 7 found at http://www.vischeck.com/daltonize/