Revista Médica del
Hospital General de México

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HISTORY ARTICLE

# Color blindness, a scientific perspective on the world of color

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## Introduction

John Dalton's curiosity about his unique color perception led to the discovery of color blindness, a condition that affects the way we perceive color and challenged our understanding of human vision. His scientific legacy blazed a trail in the study of color perception and remains key to current research.

Fog drifts through stone and houses. Vines climb fences, and lush greenery blankets the land and hills; this is Eaglesfield, England. The tranquility of the village is disturbed by a piece of news: John Dalton, the chemist, mathematician, and naturalist best known for his work on atomic theory and the law of partial pressure, donated his eyes for scientific study after his death. What secrets did these eyes hold that Dalton was unwilling to reveal until after he left this world?

At the age of 28, Dalton realized that he saw the world in a different way. For him, colors were not the vivid explosions of tones that others described, but he experienced them as shades and indefinite contrasts. Far from being a limitation, this situation awakened in him an irresistible curiosity, a thirst for knowledge that would lead him to explore the darkest corners of his vision.

In 1794, John first described the visual defect he suffered from. He had discovered it by accident 2 years earlier when he gave his mother a pair of deep purple stockings. The color was inappropriate for a conservative woman of the time, so she was puzzled and asked her son why he had chosen that color. It was then that the young scientist realized that people perceive color differently than he does[1].

## Dalton's curiosity and the experiments that revealed a new view of color

Following this event, he conducted an experiment in which he observed the color of a geranium flower illuminated by candlelight. In broad daylight, the flower would have appeared blue to him (its color was actually pink), however, under candlelight, he saw it as red. This observation was the beginning of an extensive study of color perception that led him to write "extraordinary facts relating to color vision" (1794), in which he described his experience in detail[2,3].

– "Although I had no doubt that such a change of color would be the same for all, I asked some of my friends to observe the phenomenon; I was surprised to find that they all agreed that the color was not substantially different from what it was in daylight, except in the case of my brother, who perceived the same change of color as I did"[3] (Fig. 1).

To Dalton, his color blindness was a mystery, and to solve it, he discussed it with his friends and students, hoping to find other people who had a vision problem similar to his and his brother's. He met several friends and a family in which all the male children suffered from this condition, which led him to conclude that this was an anomaly found only in males. Thus, he met several friends and a family in which all the male children suffered from this condition, leading him to conclude that it was an anomaly found only in men.

All these observations culminated in the identification of a pathology that would be called color blindness. Since then, the term achromatopsia has been widely used to refer to color blindness.

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Date of reception: 10-12-2024
Date of acceptance: 05-03-2025
DOI: 10.24875/HGMX.24000093

Available online: 30-05-2025
Rev Med Hosp Gen Mex. 2026;89(1):30-33
www.hospitalgeneral.mx

**Figure 1.** Photograph of John Dalton[8]. The geranium in blue as he perceived it (upper right image), the pink geranium in its original color (lower right image).

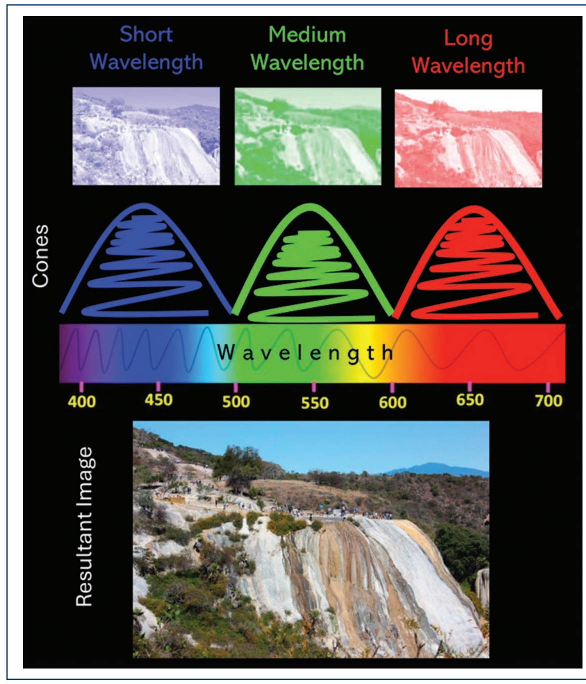


**Figure 2.** Description of the process in which the wavelengths of light are captured by the cones, generating the final perception of the landscape.

Dalton thought that his color blindness was due to the pigment within his vitreous humor (a clear, gelatinous fluid that fills the space between the inner surface of the retina and the back of the lens inside the eyeball), so he thought it would not be transparent as in a normal eye, but possibly blue and act as a red filter. To test this hypothesis, he would have had to perforate his eye to extract the vitreous, and he definitely did not consider that an option. Therefore, in his will, he directed that his eyes be extracted to test whether the vitreous humor was blue. The person responsible for carrying out this request was Joseph Ransome, his general practitioner[2].

## A scientist's eyes: the autopsy that changed the study of color vision

John Dalton died on July 27, 1844, and as agreed, Ransome performed the autopsy the next day. He removed the vitreous humor from one of John's eyes, placed it over a lens, and described it as transparent. He removed the second eye, drilled a hole in it, and found that neither red nor green was distorted when viewed through it[4].

With this experiment, he rejected the hypothesis that color blindness was caused by a "preretinal filter" and concluded that the defect might be in the optic nerve that connects the retina to the brain.

Fortunately, Ransome had the good idea to preserve the eyes for further study. They were placed in a container with a preservative and remained in the custody of the Manchester Philosophical and Literary Society. They were later given to the Manchester Museum of Science and Industry for safekeeping[4].

In 1994, 150 years after Dalton's death, a group of Cambridge geneticists and physiologists resumed the analysis of the scientist's eyes. The researchers took a small sample of the retina to extract and amplify deoxyribonucleic acid to analyze the genes of the three types of retinal cones involved in color vision[4].

Cones are light-sensitive retinal cells responsible for color detection and perception. There are three types of cones, each sensitive to different wavelengths of light. There are cones sensitive to short wavelengths (blue), cones sensitive to medium wavelengths (green), and cones sensitive to long wavelengths (red). The combination of signals from these three types of cones allows the brain to perceive and distinguish a wide range of colors[5,6] (Fig. 2).

Dalton's genetic analysis revealed he was a deuterope, meaning he lacked sensitivity to medium wavelengths of light, critical for distinguishing greens[2].

John Dalton's eyes are much more than a sensory organ: they are a window into the vast and complex universe of human knowledge. His decision to donate them marked a milestone in scientific history, opening new doors to understanding a condition that had baffled mankind for centuries. Dalton's eyes became a

**Table 1.** Types of color blindness

| Red-green color blindness | Blue-yellow color blindness | Complete color blindness |
|---|---|---|
| Deuteranomaly: the most common type of red-green color blindness. It causes certain shades of green to appear redder. This type is mild and usually does not interfere with normal activities. | Tritanomaly: makes it difficult to distinguish blue from green, yellow from red. | If you have total color blindness, you cannot see colors at all. This is also called monochromatopsia or achromatopsia and is rare. Depending on the type, you may also have trouble seeing clearly and be more sensitive to light. |
| Protanomaly: causes certain shades of red to appear greener and less bright. This type is mild and does not usually interfere with normal activities. | Tritanopia: makes it impossible to distinguish between blue and green, purple (violet) and red, and yellow and pink. It also makes colors seem less light. | |
| Protanopia and deuteranopia: both make you unable to distinguish between red and green. | | |

symbol of his commitment to the advancement of knowledge and his desire to leave a legacy for future generations.

## Color variations: there is no single color blindness

Thanks to Dalton's curiosity and his unique gift, we now know a little more about color blindness. But you may be wondering, what does it mean that Dalton was color blind? isn't there only one type of color blindness, and do all people with this condition perceive colors in the same way?

To answer these questions, we need to know a little more about the cells involved in color perception.

Our eyes have two types of light-sensitive cells in the retina: rods (their function is to allow us to see in the dark) and cones, which require more light and allow us to see in color. As briefly mentioned above, there are three types of cones, and the difference between them is a function of the wavelength of light to which they respond[6].

For example, the short-wavelength (S) cones, known as blue cones, are less numerous than the other two types and are critical for the perception of blue and violet hues.

Mid-wavelength (M) cones, known as green cones, are more numerous than blue cones and play a critical role in the perception of green and yellow tones.

Long wavelength (L) sensitive cones, known as red cones, are the most abundant and are essential for the perception of reds, oranges, and yellows[6].

Color perception occurs by stimulating and combining these different types of cones in the retina. When light strikes the retina, cones sensitive to different wavelengths respond selectively, sending electrical signals to the brain that are interpreted as different colors. The combination of information from the three types of cones allows the brain to interpret a wide range of colors and distinguish between hues[5,6].

In color blindness, the function of the cones is altered due to genetic abnormalities in the light-sensitive pigments. These abnormalities can affect the sensitivity of the cones to certain wavelengths, resulting in difficulty perceiving and distinguishing certain colors. As a result, there are several types of color blindness, each associated with different cone abnormalities[5-7].

Deuteranopia is associated with difficulty distinguishing shades of green. It was the type of color blindness that John Dalton suffered from. Protanopia corresponds to individuals who have difficulty distinguishing reds. Finally, tritanopia, the least common condition, affects the perception of blue tones[5-7].

These are the main types of color blindness, although there are variations and combinations of these types that can affect color perception differently in each person. It is important to note that color blindness can vary in severity, from mild forms in which the individual can distinguish certain colors but with difficulty, to more severe forms in which color perception is severely affected[5,6] (Table 1).

Another important fact is that color blindness is binocular (it is present in a similar way in both eyes), it affects men more than women, since it is transmitted with recessive character associated with the X chromosome, so it is almost always of genetic origin. It can also be acquired as a result of injury or disease of the retina or optic nerve[5-7].

The study of color vision continues, and it is important to continue to support research that will help us better understand this condition and develop solutions that will allow those who suffer from it to fully enjoy a vibrant and colorful world.

From the scientific curiosity that led Dalton to study his own visual defect to the modern advances in genetics that have allowed us to unravel its many facets, the study of color blindness reminds us that perception is not universal, but a kaleidoscope of individual conditions and experiences. By understanding these differences, we not only advance scientific knowledge but also promote empathy and inclusivity, ensuring diverse perceptions are valued and understood in society.

## Conclusion

John Dalton's personal experience of color blindness marked the beginning of a scientific journey that transformed our understanding of color perception. His observations, followed by post-mortem studies and later genetic analysis, laid the foundation for modern vision and genetics research. The ongoing study of color blindness continues to emphasise the importance of recognising sensory diversity, not only to advance scientific knowledge, but also to promote inclusion and awareness in society.

## Funding

The authors declare that they have not received funding.

## Conflicts of interest

The authors declare no conflicts of interest.

## Ethical considerations

**Protection of human subjects and animals.** The authors declare that no experiments on humans or animals were performed for this research.

**Confidentiality, informed consent, and ethical approval.** The study does not involve patient personal data, medical records, or biological samples, and does not require ethical approval. SAGER guidelines do not apply.

**Declaration on the use of artificial intelligence.** The authors declare that no generative artificial intelligence was used in the writing or creation of the content of this manuscript.

## References

1. Sadurní JM, Dalton J. El Científico que veía el Mundo de Distinto Color. Historia National Geographic. Available from: https://historia.nationalgeographic.com.es/a/john-dalton-cientifico-que-veia-mundo-distinto-color_18278 [Last accessed on 2024 Jan 15].
2. Fishman GA. John Dalton: though in error, he still influenced our understanding of congenital color deficiency. Ophthalmic Genet. 2008;29:162-5.
3. Dalton J. Extraordinary Facts Relating to the Vision of Colours: With Observations. Vol. 5. Manchester: Manchester Literary Philosophical Society; 1798. p. 28-45.
4. Hunt DM, Dulai KS, Bowmaker JK, Mollon JD. The chemistry of John Dalton's color blindness. Science. 1995;267:984-8.
5. Neitz M, Neitz J. Molecular genetics of color vision and color vision defects. Arch Ophthalmol. 2000;118:691-700.
6. Swanson WH, Cohen JM. Color vision. Ophthalmol Clin North Am. 2003;16:179-203.
7. National Eye Institute. Tipos de Daltonismo. Available from: https://www.nei.nih.gov/espanol/aprenda/sobre/la/salud/ocular/enfermedades/y/afecciones-de-los-ojos/daltonismo/tipos-de-daltonismo [Last accessed on 2024 Jan 22].
8. John Dalton RS. Biography, Discoveries, Atomic Model, and Facts. Encyclopedia Britannica; 2024. Available from: https://www.britannica.com/biography/john-dalton [Last accessed on 2024 Jan 22].