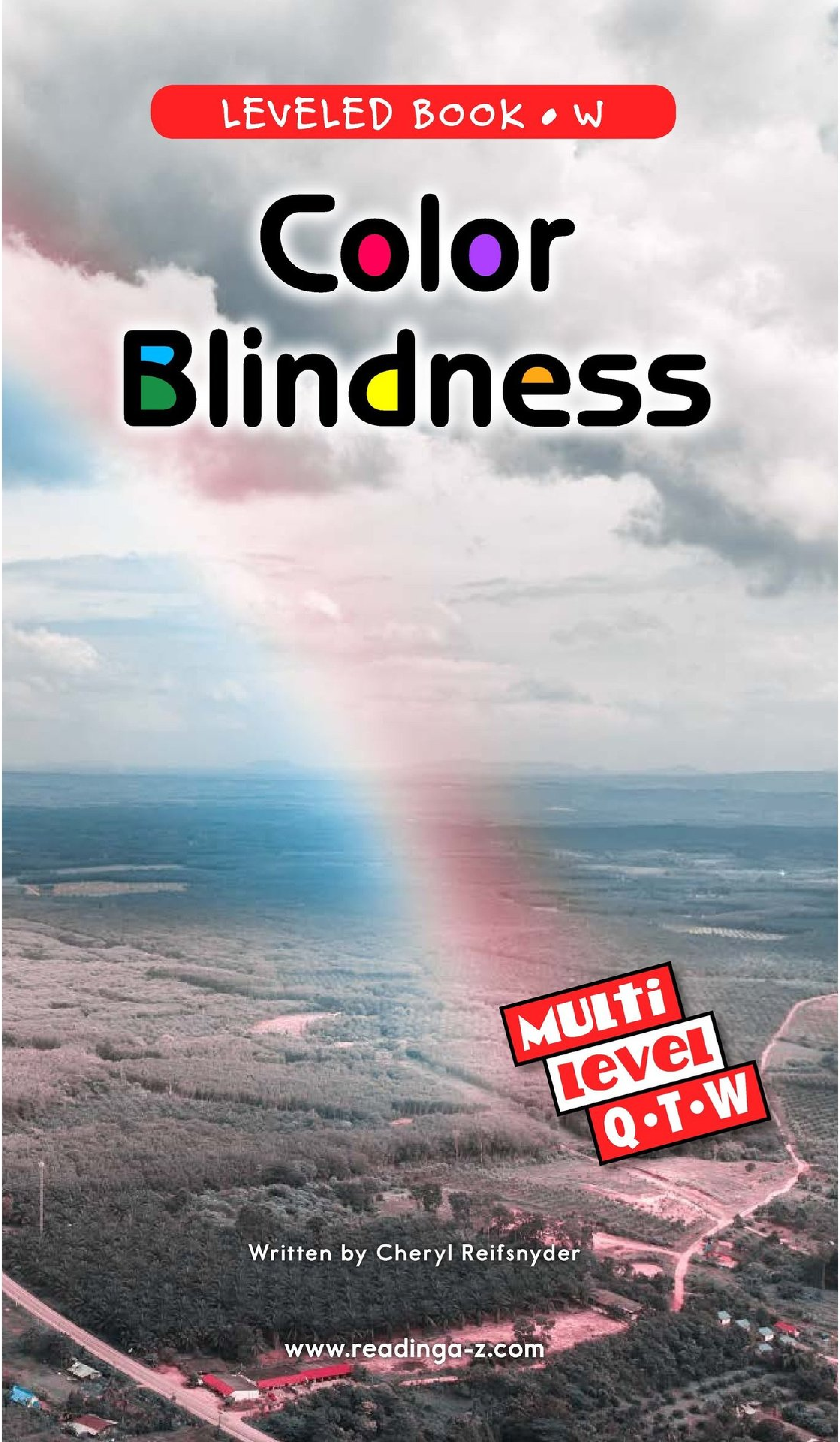
LEVELED BOOK • W

Color Blindness



MULTI LEVEL Q•T•W

Written by Cheryl Reifsnyder

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Focus Question

What causes color blindness, and how can it affect a person's life?

Words to Know

ancestry	molecules
complementary	photopigments
cone cells	prism
defects	retina
genetic disorder	rod cells
hereditary	wavelengths

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Choosing a red crayon is much easier for someone with full-color vision (left) than someone with red-green color blindness (right).

What Colors Do You See?

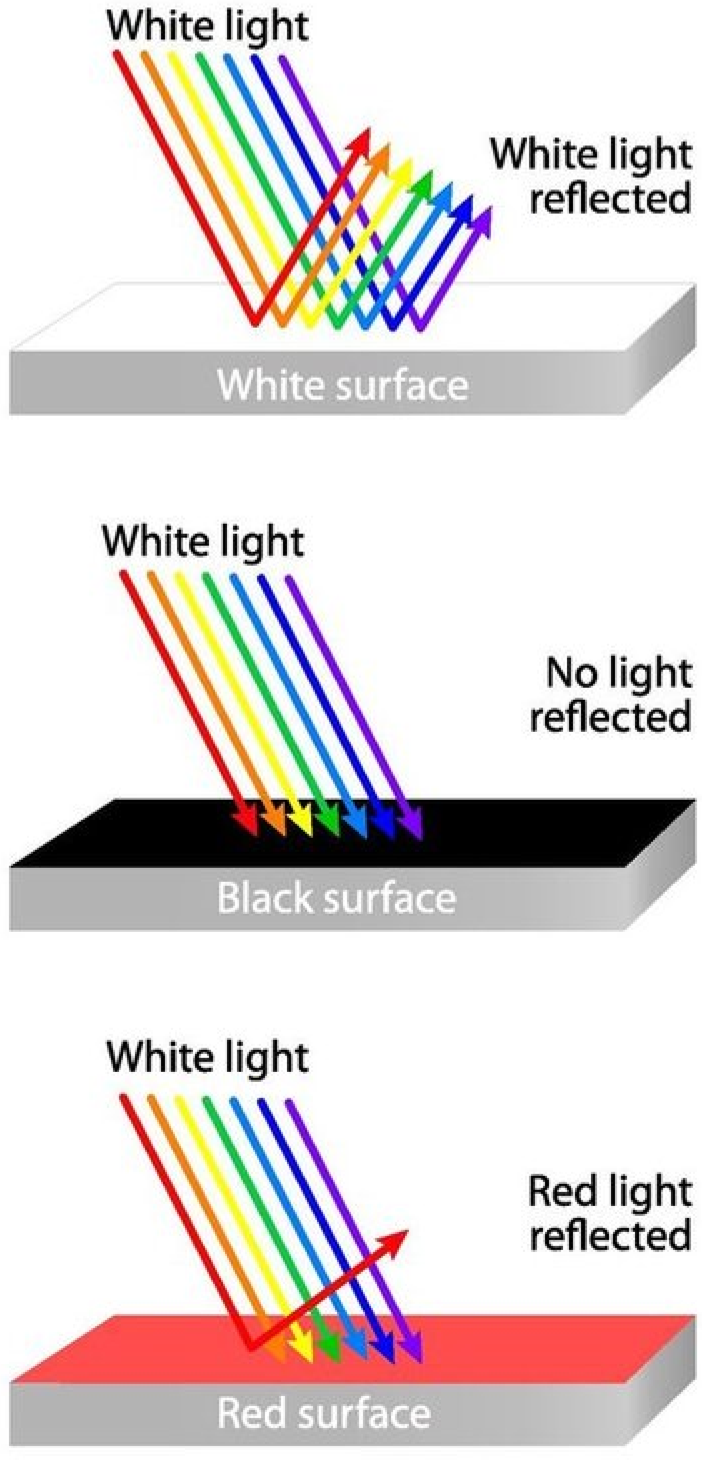
Imagine looking at a box of crayons and seeing only shades of gray, blue, and yellow, or looking at a traffic signal on which the red and green lights look very similar. That's how the world can appear to someone who is color-blind. As you can imagine, this can cause problems!

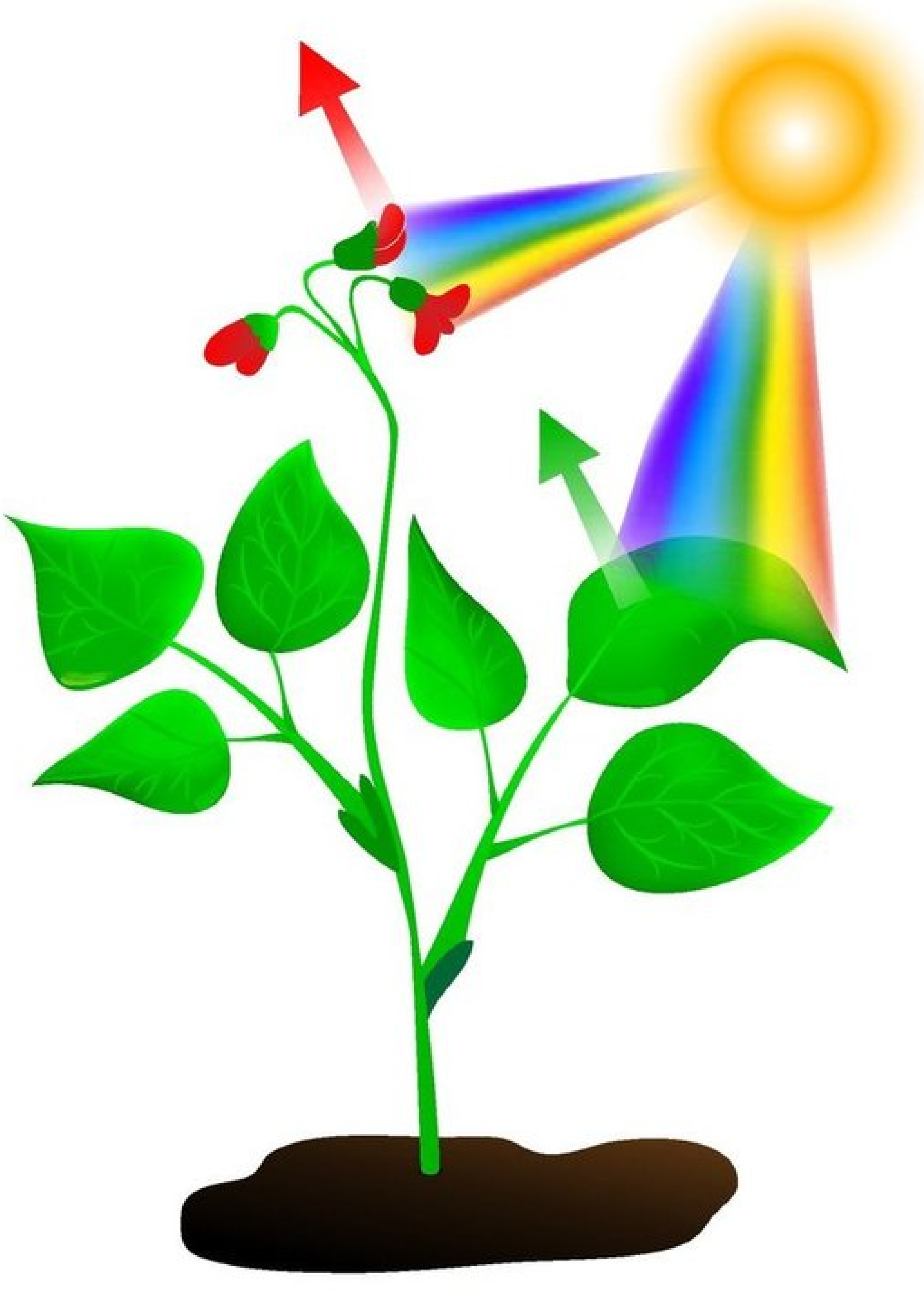
Color blindness is the world's most common **genetic disorder**, affecting more than ten million people in the United States alone. Despite its name, though, color blindness does not cause blindness. Most people affected by color blindness can still see some colors. Color blindness simply means the inability or decreased ability to see certain colors.

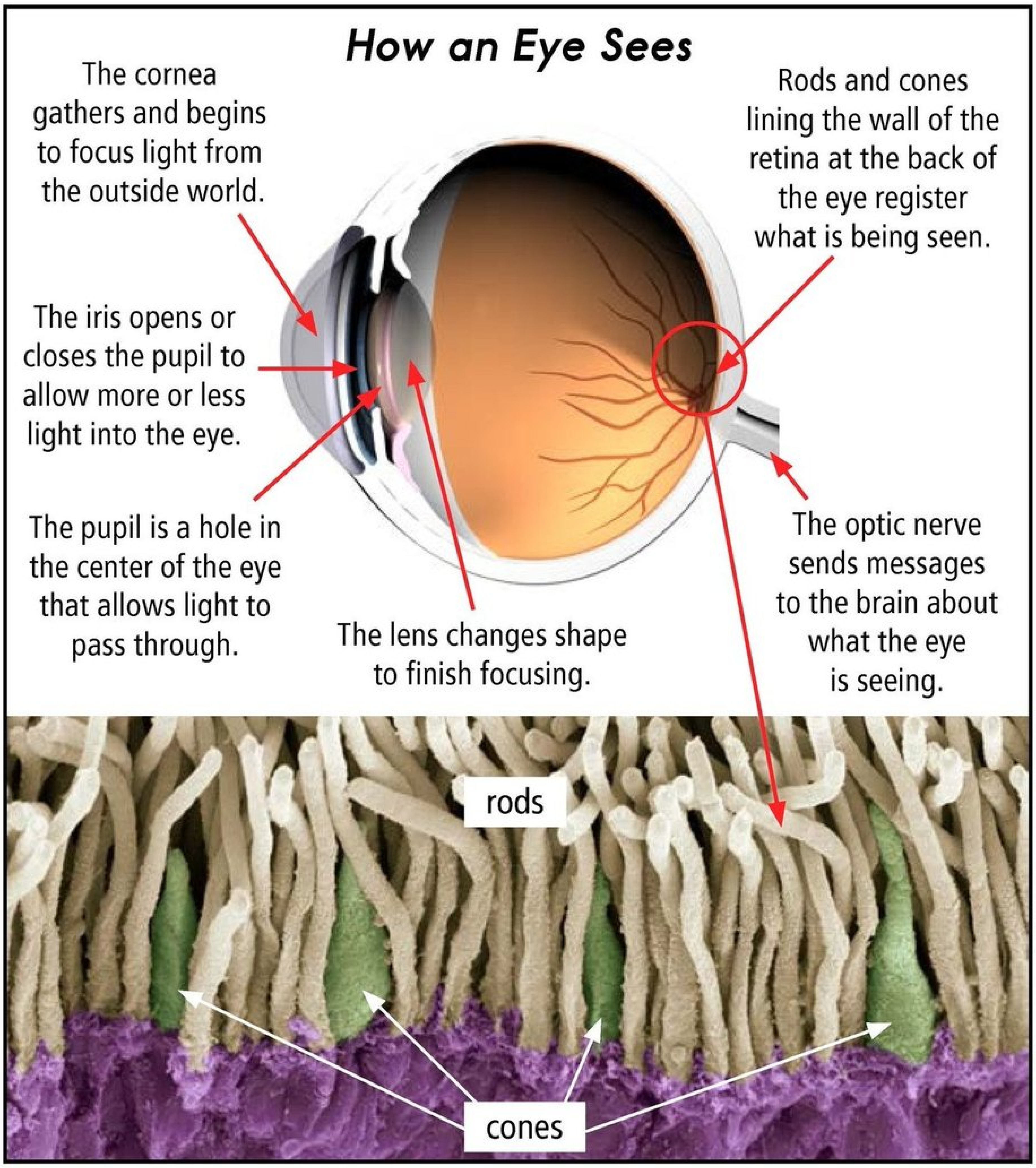
Where Do Colors Come From?

It's easier to understand color blindness when you realize that colors are actually different **wavelengths** of light. If you use a **prism** to separate white light into a rainbow, you're actually separating it into its different wavelengths. The red end of the spectrum contains longer wavelengths of light while shorter wavelengths of light are at the purple end.

Objects appear to be different colors because they absorb and reflect different wavelengths of light. A strawberry looks red because it reflects long (red) wavelengths. If it instead reflected short wavelengths of light, it would look blue!







How Color Vision Works

Humans see colors because light-detecting cells in our eyes respond differently to different wavelengths of light.

When light enters one of your eyes, the lens focuses it on the **retina**, a thin layer of tissue at the back of the eyeball. There it activates light-sensitive cells, called **rod cells** and **cone cells**. Activated cells send electrical signals to the brain, where they are translated into images.

Rods and Cones

Rod cells are the most sensitive cells in your retina. They allow you to see in extremely dim light, but they can't tell different colors apart.

Cone cells are responsible for color vision. Each cell contains one of three different light-absorbing **molecules**, called **photopigments**, which detect blue, green, or red light. Combining these three main colors allows you to see thousands of colors. When one or more photopigments aren't functioning properly, though, color blindness results.

Color Vision in Animals

Most animals can see fewer colors than humans. For instance, dogs can only see shades of blue and yellow, and bulls are completely color-blind! Other animals—including some birds, bees, and butterflies—see more colors than humans do, including wavelengths of light that are invisible to humans.

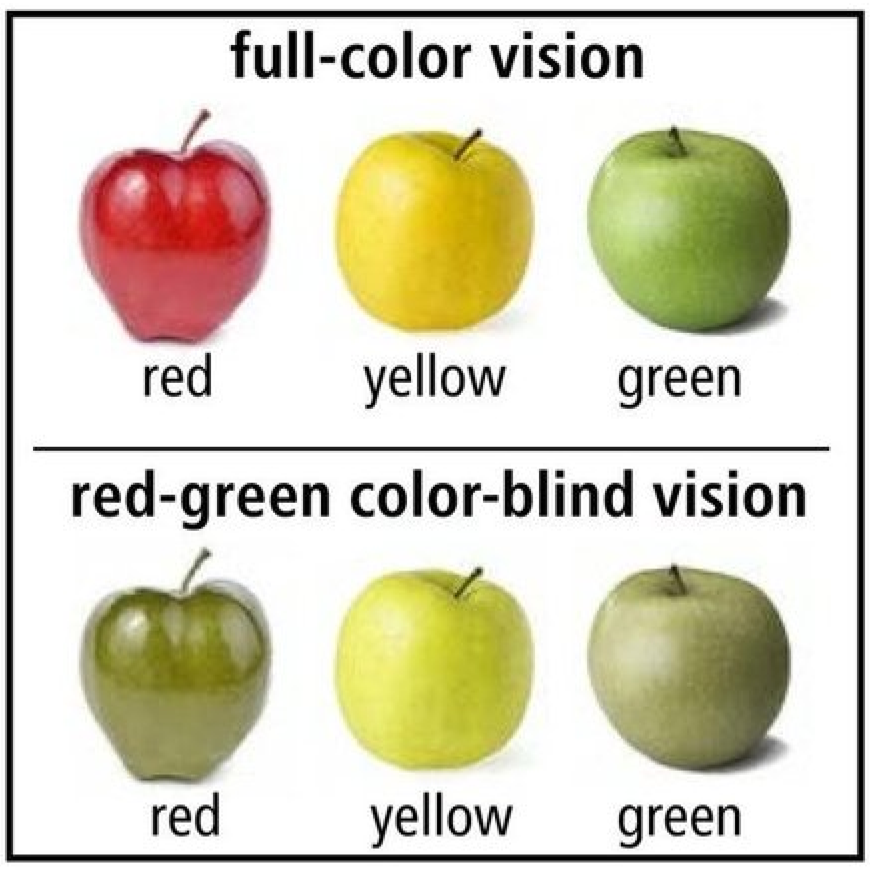
Different Types of Color Blindness

Red-Green Color Blindness

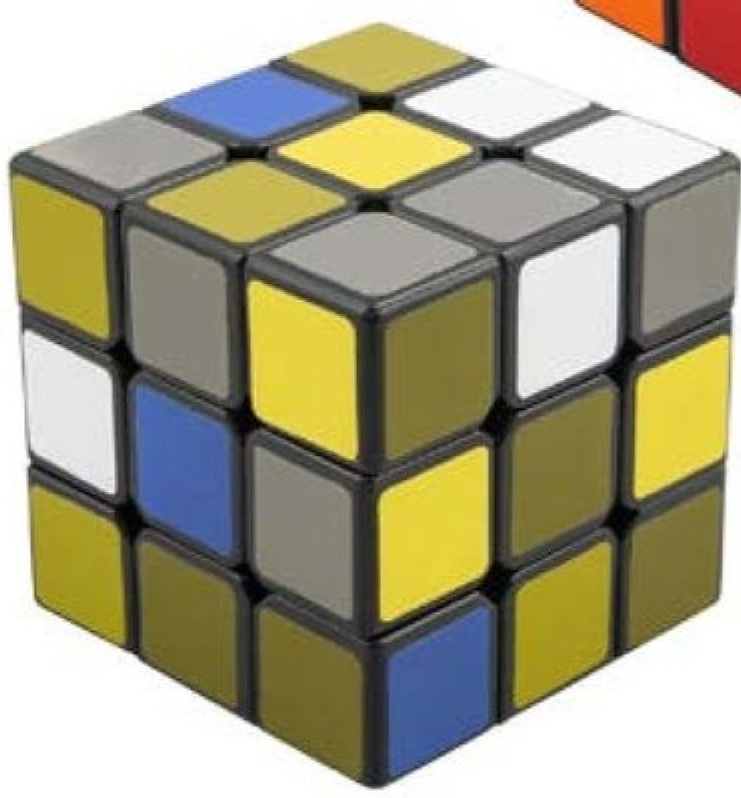
Red-green color blindness, which causes difficulty when it comes to telling the difference between red and green, is the most common type of color vision problem. It's **hereditary**, found most often in people of northern European **ancestry**. It's also more common in men, of which it affects one out of twelve, than in women, of which it affects only one in two hundred.

Red-green color blindness is usually caused by **defects** in the green photopigment. Without the green photopigment, green and yellow objects appear reddish in color. Defects in the red photopigment also cause red-green color blindness. In this case, red, orange, and yellow objects appear green or black.

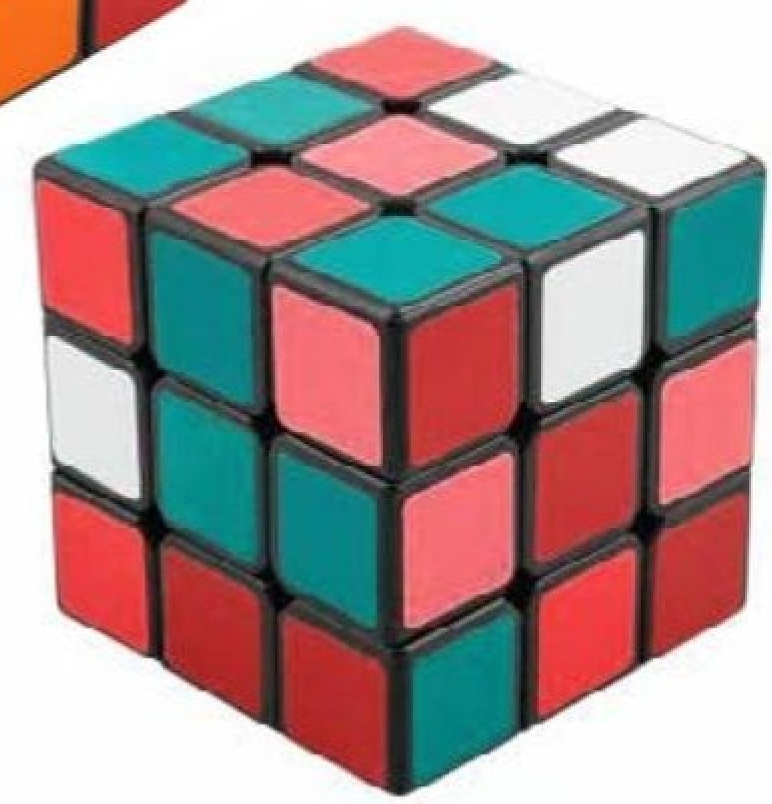
Although people with red-green color blindness have trouble distinguishing colors, they can still see clearly. That's because red and green cones have some overlap in the wavelengths of light they detect. Their eyes can still detect incoming light even if one type of cone is missing or malfunctioning.



full-color vision



red-green color blindness



blue-yellow color blindness

Blue-Yellow Color Blindness

Blue-yellow color blindness occurs when the blue photopigment is defective or missing. It's fairly rare, only occurring in about one out of every ten thousand people worldwide. Unlike red-green color blindness, it's equally common in men and women.

Some people with blue-yellow color blindness have no blue cone cells at all, which causes them to see blue as green and to see yellow as violet or gray. More commonly, people who are blue-yellow color blind have partially functional blue cone cells. As a result, they have a difficult time telling yellow and red from pink.

Complete Color Blindness

Complete color blindness is the most severe form of color blindness. It occurs when there are defects in two or more of the three types of cones.

You might think that a single kind of cone would be enough to enable color vision, but it's not. The brain must compare color information from at least two different types of cone cells to identify colors. That means people who have only blue cone cells, for example, are able to see blue wavelengths of light, but they can't distinguish any colors.

Some traffic lights use shapes as well as colors to convey information to color-blind drivers.

People who are missing two or more types of cones tend to be extra-sensitive to light. They may also have difficulty seeing clearly, especially in bright light. That's because they have to rely on rod cells for most or all of their vision, and rod cells only work in dim lighting conditions.

Only about one out of thirty thousand people worldwide are missing all three types of cones. People who lack any functioning cone cells see the world in shades of black, white, and gray.

Color Blindness Is No Joke

Color blindness can cause serious problems. People who are color-blind have trouble reading color-coded information on maps, graphs, and charts. Children with color blindness may have trouble in school, especially if their color blindness has not been diagnosed. Red-green color blindness makes it difficult to read yellow chalk on a green chalkboard. All types of color blindness make it difficult to choose the correct colors for art and science projects.

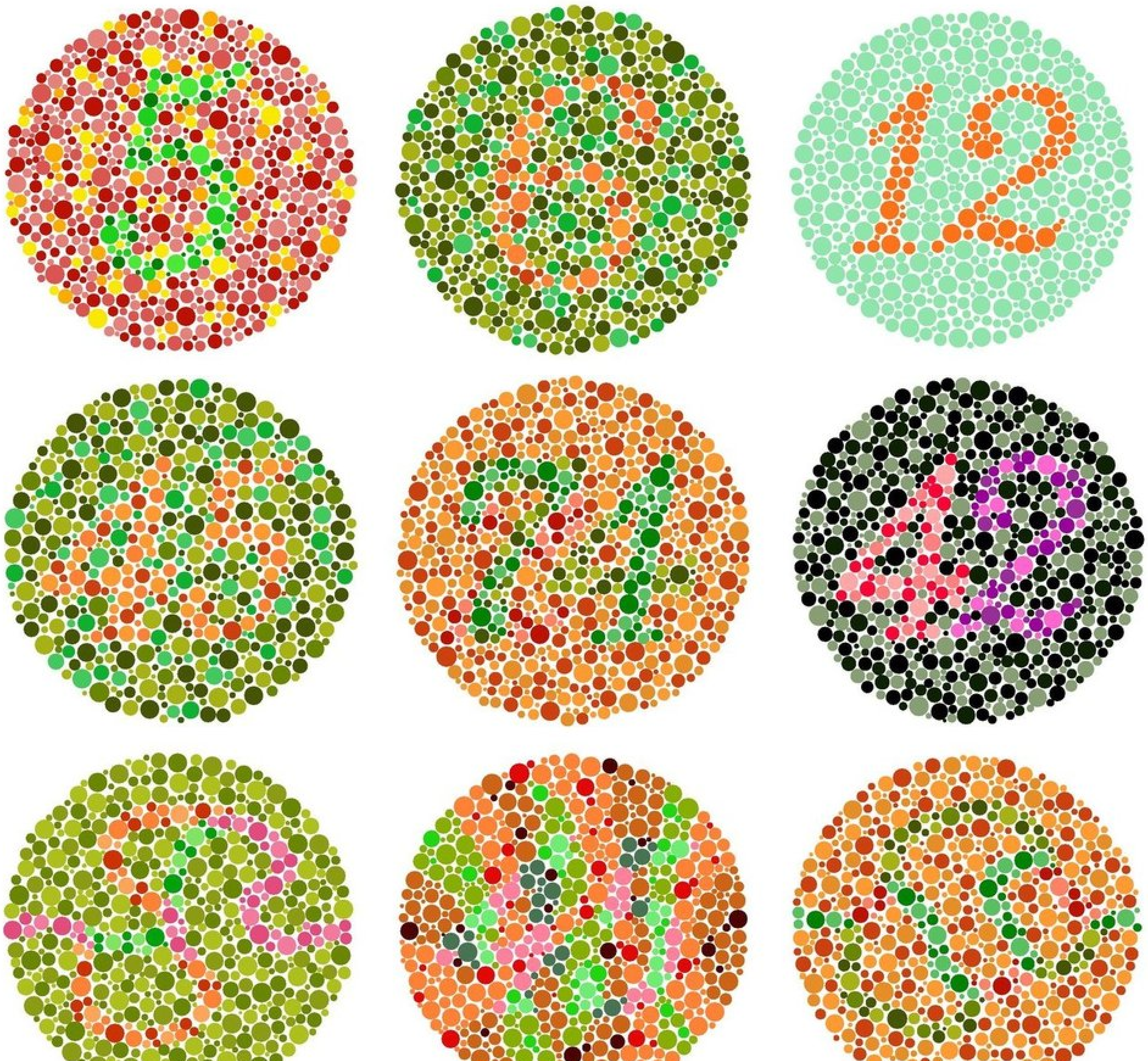
Color blindness can also cause safety issues. Fire hydrants, car warning lights, and emergency equipment are often colored red or yellow to make them more visible. These bright colors may be obvious to those with full-color vision but unnoticeable to those who are color-blind. People may also have difficulty noticing sunburns, rashes, or undercooked meat without color vision.

Color blindness can even limit a person's career options. Some positions, such as geologist or commercial airline pilot, require full-color vision. Other careers, such as interior design, photography, and food inspection, are significantly more difficult with color vision defects.

Testing for Color Blindness

The Ishihara Test is the most common test for red-green color vision problems. It uses images made up of dots that are different sizes and colors. People with full-color vision can see numbers or shapes inside the pictures. People with red-green color blindness find it difficult or impossible to identify the hidden symbols.

Other, similar tests are used to detect yellow-blue color blindness.



Can you see the hidden numbers or shapes in the circles in this Ishihara Test?

These special glasses from EnChroma allow people with red-green color blindness to see a much more colorful world.

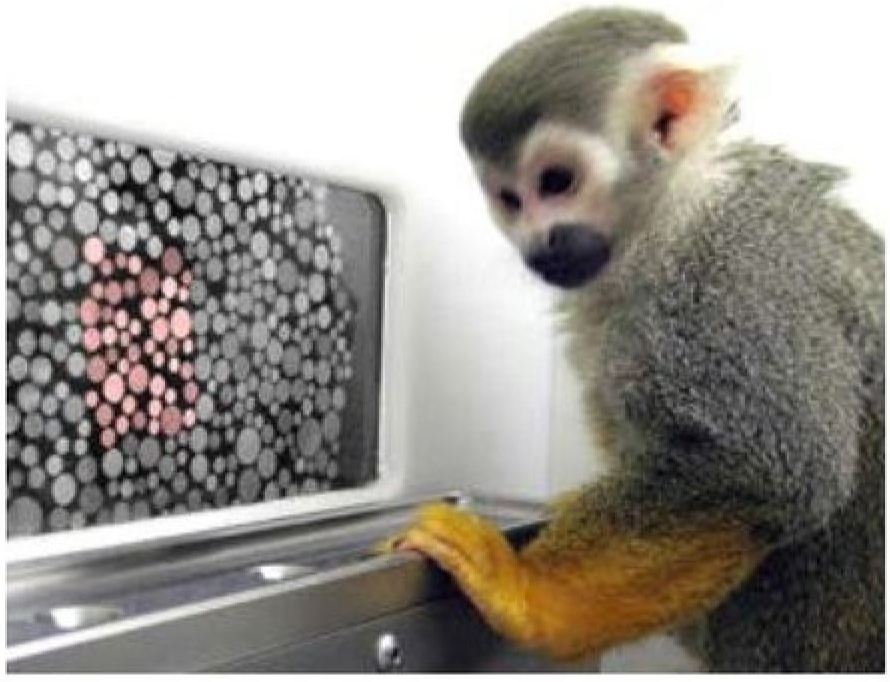
Tools to Help Color-Blind People

Currently, there's no known cure for color blindness. However, modern technology has led to the development of many new tools to help people who are color-blind. Smartphone apps perform tasks such as identifying colors and recommending **complementary** colors. These apps can even help people choose matching clothes or tell which fruits are ripe at the grocery store.

Some smartphone apps can only identify colors after the user snaps a photo, but others can analyze them in the camera's viewfinder without requiring the user to take a photo first. This lets users identify colors in real time.

Researchers have also created high-tech tinted lenses that filter out specific wavelengths of light. Special sunglasses that use these lenses allow people with red-green color blindness to distinguish between the two colors.

Treating Color Blindness


A squirrel monkey takes a color test.

Although no true treatment for color blindness currently exists, that may soon change. In recent experiments, scientists were able to correct red-green color blindness in squirrel monkeys. The monkeys lacked the red photopigment and, as a result, couldn't tell the difference between red and green. Researchers engineered a specially constructed virus to insert the red photopigment gene into the monkeys' green cone cells. Within about twenty weeks, treated monkeys could distinguish between red and green dots.

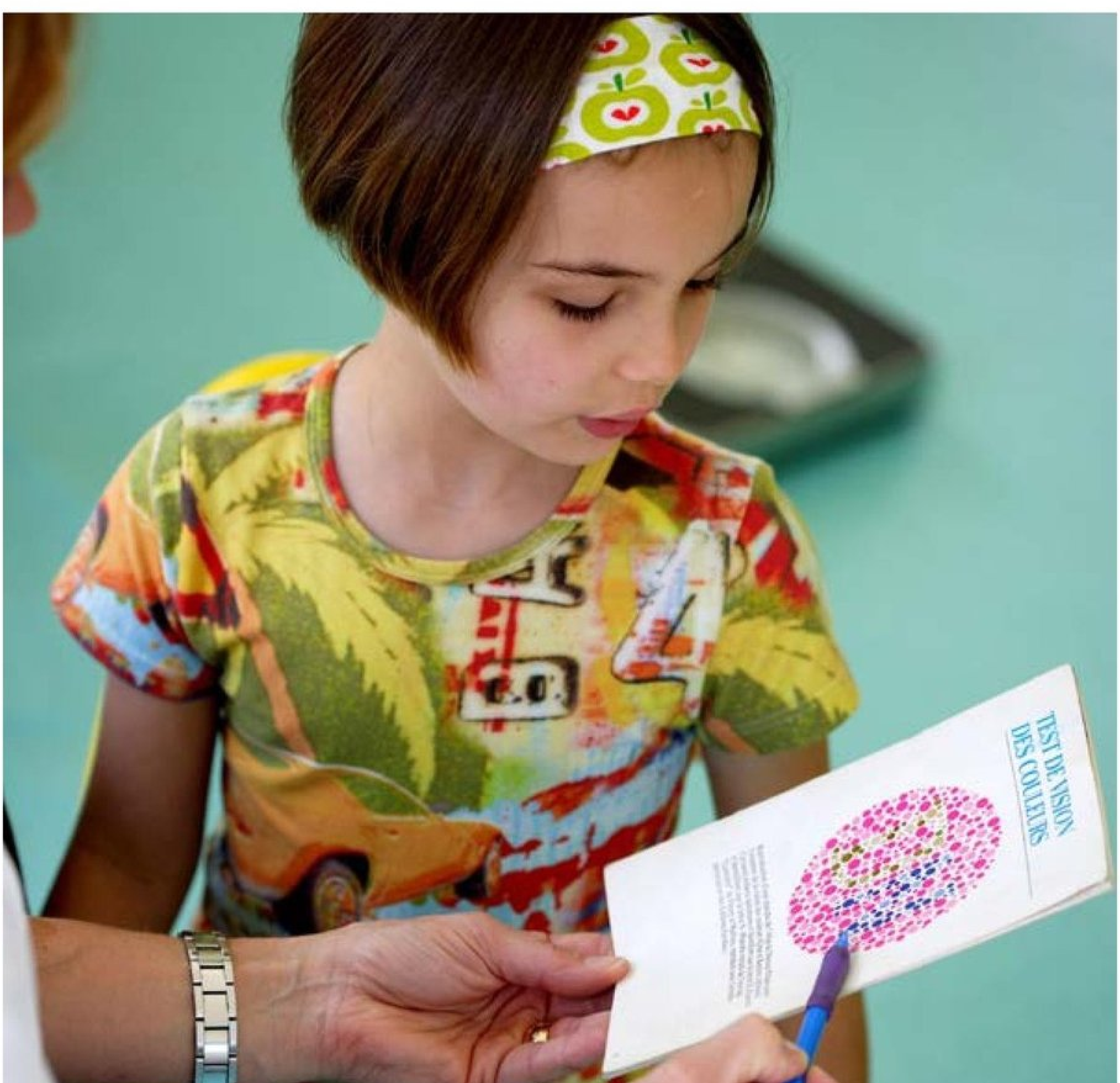
This was exciting news! The monkeys had been color-blind since birth. Many doctors and scientists had predicted that it would be impossible to correct their color blindness because the monkeys' brains would not have developed the connections needed to interpret color information. These connections usually develop when the animals are young.

Now that we know that color blindness can be cured in adult squirrel monkeys, there's hope for a cure in adult humans, too.

Color Vision for All?

Every year, researchers gain a better understanding of color blindness and its causes. New tools help color-blind people choose ripe fruit and pick out matching clothes. People with red-green color blindness can use special glasses to allow them to tell the difference between shades of red and green.

Best of all, a treatment for color blindness may be available in the near future. Maybe someday soon, color blindness will become a thing of the past!



Glossary

ancestry *(n.)* family members and relations from past times (p. 8)

complementary *(adj.)* serving to complete, balance, or improve something else (p. 13)

cone cells *(n.)* cells in the eye's retina that are color sensitive and work best in bright light (p. 6)

defects *(n.)* weaknesses, imperfections, or failures (p. 8)

genetic disorder *(n.)* an inherited physical condition that is caused by a problem in one or more genes (p. 4)

hereditary *(adj.)* of or relating to genetic traits passed from parents to offspring (p. 8)

molecules *(n.)* the smallest parts of substances that can exist by themselves, made of one or more atoms (p. 7)

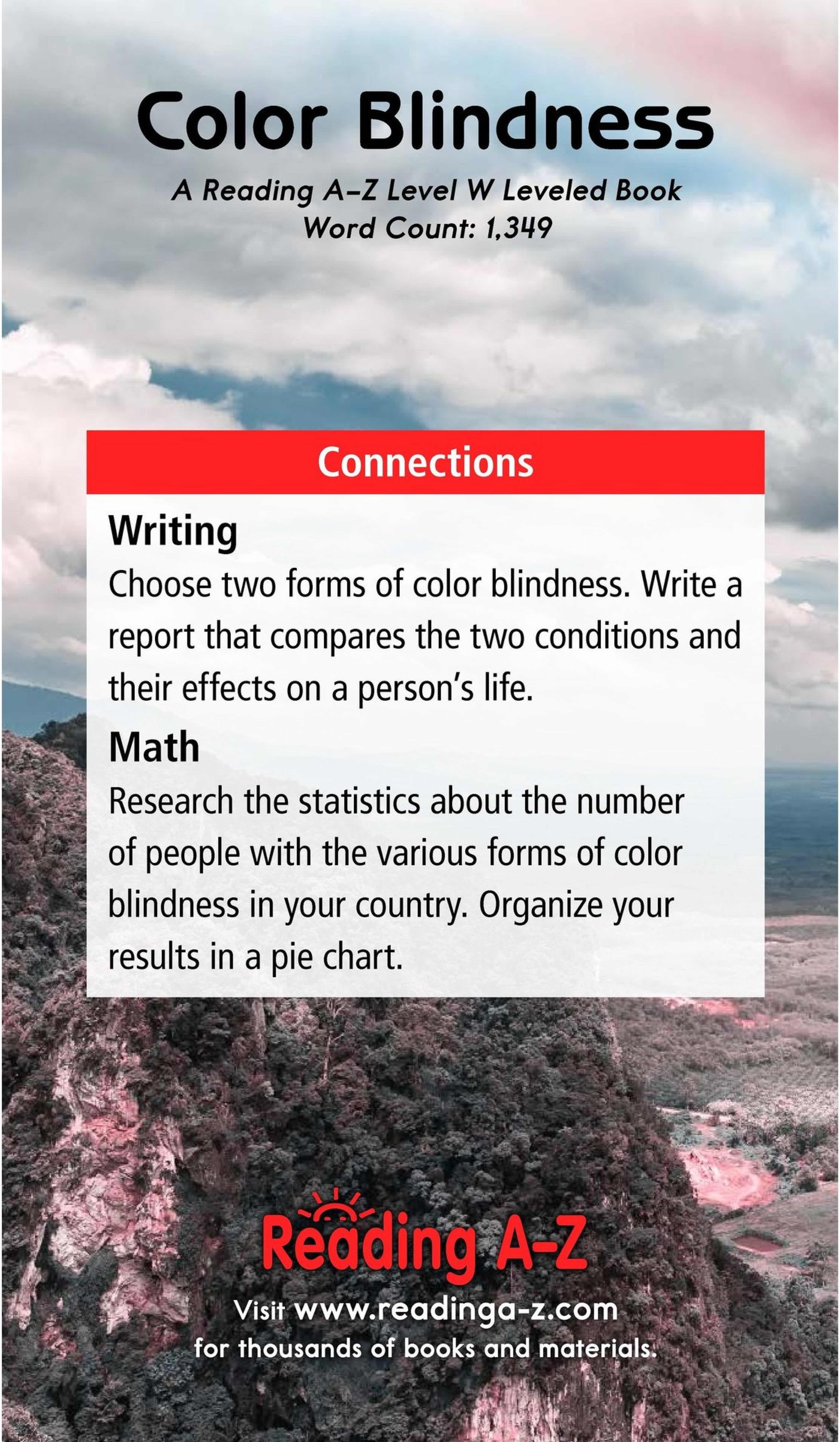
photopigments *(n.)* natural compounds that undergo chemical changes when they absorb light (p. 7)

prism *(n.)* a clear object that bends light so that it separates into a rainbow of colors (p. 5)

retina *(n.)* tissue at the back of the eye that receives images and transmits them to the brain (p. 6)

rod cells *(n.)* cells in the eye's retina that are light sensitive and work best in dim light (p. 6)

wavelengths *(n.)* the distances between the consecutive high or low points of a wave (p. 5)



Color Blindness

A Reading A–Z Level W Leveled Book
Word Count: 1,349

Connections

Writing

Choose two forms of color blindness. Write a report that compares the two conditions and their effects on a person's life.

Math

Research the statistics about the number of people with the various forms of color blindness in your country. Organize your results in a pie chart.