OPTICAL ILLUSIONS

LESSON PLAN

Title: Optical Illusions
Setting: In Classroom
Subject: Biology - Neuroscience
Grade Level: 6th-8th Grade
Time Frame: 30 Minutes
Paired Dana Foundation Fact Sheets:
6th-8th Grade How Does the Brain Work?
Next Generation Science Standards:
Meets MS-LS1-1, MS-LS1-3, & MS-LS1-8

STUDENT OBJECTIVES

- Learn about the different components of the eyeball.
- Understand how the objects you see are perceived by your brain.
- Experience and dissect how optical illusions trick your vision.

BACKGROUND

The visual system is the part of the nervous system that allows us to see the world around us. This incredible pathway converts the objects in front of us into images, and the images into electric signals that get conveyed to the visual processing areas of our brains. Without this important sense, our everyday lives would not be nearly as stimulating.

In this lesson, we will learn about the different regions of the eyeball and how they tell our brains what is in front of us. Then we can look at a few optical illusions and discuss how and why our brains like to trick our sight!

MATERIALS

- Printed copies of 6th-8th grade Dana Foundation fact sheet, “How Does the Brain Work?” **Downloadable here: www.dana.org/factsheets**
- Audio and visual capacities for a PowerPoint presentation.

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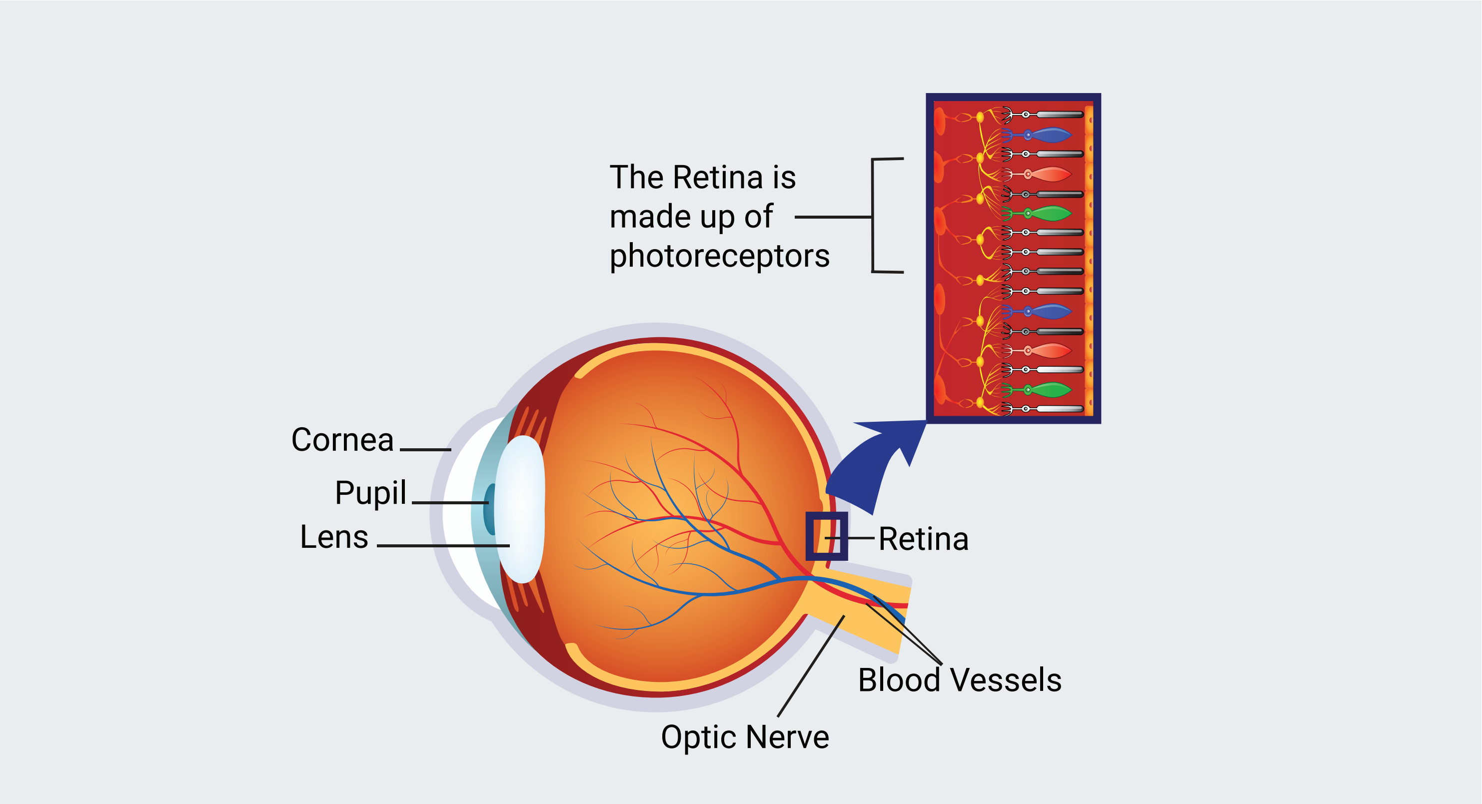
TEACHER BACKGROUND INFO

WHAT TO KNOW BEFORE YOU TEACH

* Note: This content is primarily for the instructor's reference; the accompanying PowerPoint presentation will be for the students.

How Do We See What We See?

The eyeball: Your eyeball is truly an incredible organ. It takes what you can see and projects that scene to your **retina**, a space at the back of the eye. Light will pass through the **cornea, pupil**, and **lens** as it gets to the retina. The cornea and lens are responsible for focusing light from the objects you see onto specialized cells known as **photoreceptors** in your retina. The lens actually sends an upside down image onto the retina, and the brain will correct for this inversion so that we see the world upright. If a scene is out of our line of sight, we often turn our heads or turn our eyeballs up, down, right, or left. These eyeball movements are actually quite tedious and recruit "extraocular muscles," a set of six bands of muscles that attach to the sclera, the whites of our eyes. These muscles are innervated by 3 different cranial nerves. We only have 12 cranial nerves that all together bring information from sensory organs back to the brain, control muscles (for instance, these eye muscles), or modulate autonomic function of various organs.



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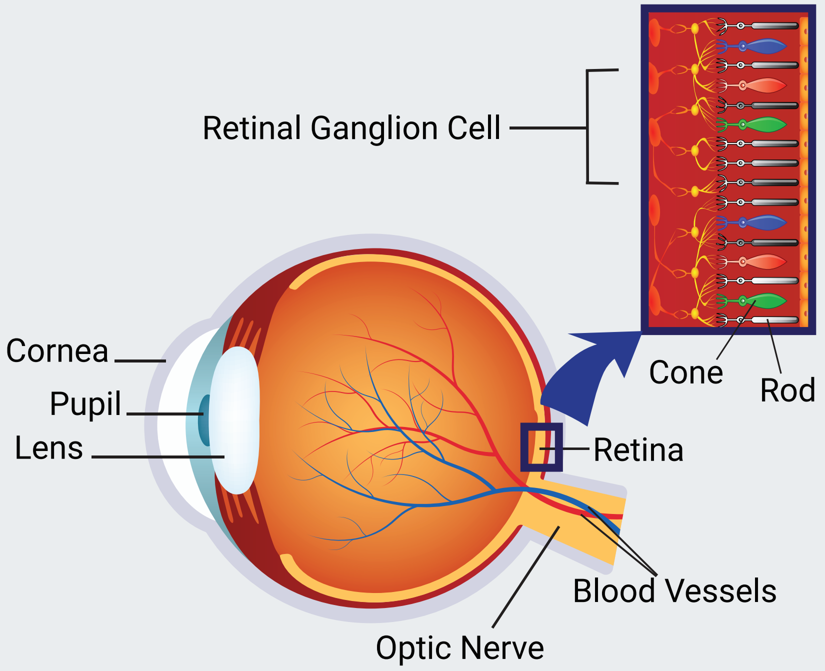
The Retina and Photoreceptors

The retina is a layer of neural tissue located at the back of the eye that contains photoreceptors, or cells that respond to light. There are two types of photoreceptors—**rods** and **cones**—and they are named appropriately for their shapes! The molecules within rods and cones absorb wavelengths of light, and depending on which photoreceptor gets activated, a message will be sent from the retina to the brain.

So, what's different about rods and cones?

Broadly, the differences lie in what type of light and how much light you have to see the world around you. In dim lighting or in the dark, we use our rods; rods do not even work in bright daylight! We have a lot more rods than cones, so even the smallest light signal gets amplified by our rods. Cones mediate all of our vision during the daylight. Unlike rods, cones are actually responsive to colors—red, green, or blue—so they allow us to see the world in color!



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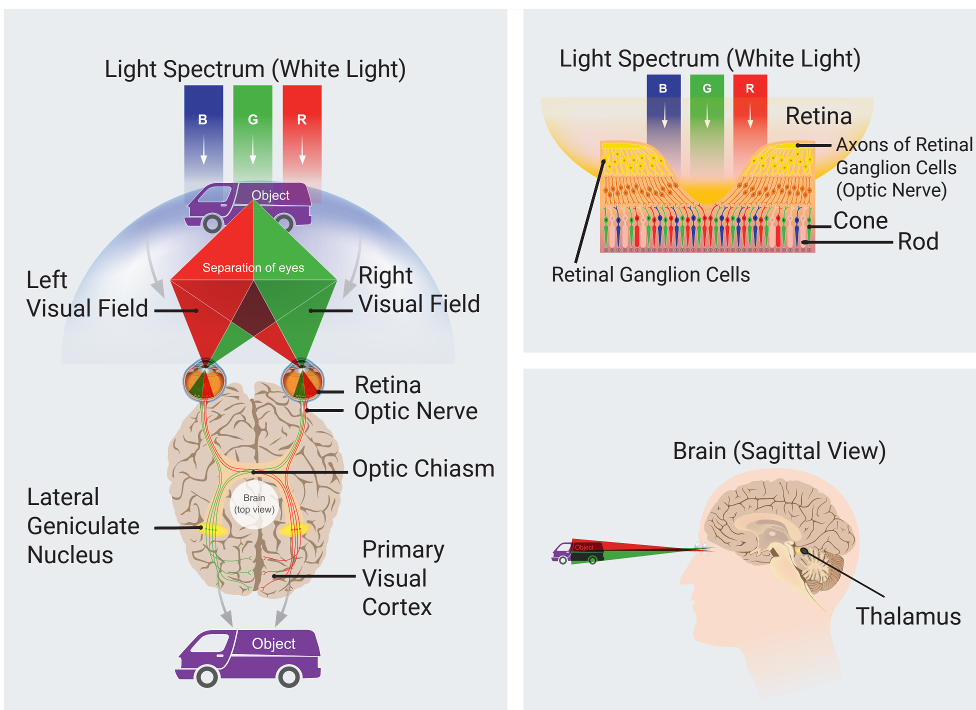
From the Retina to the Brain:

Once rods and cones receive information from light entering our eyeballs, this message is converted into electrical signals and sent to the **retinal ganglion cells,** whose projections (known as **axons**) exit the eyeballs via the **optic nerve.** The optic nerve is a bundle of over a million axons that carry visual signals from the eyes to the brain. Within the optic nerve, a set of axons from each eye (left or right) crosses over to join the opposite optic nerve at the **optic chiasm,** so that each hemisphere of your brain receives visual information from both the left and right eyes. After the axons cross at the optic chiasm, they can go to one of three regions: two possible regions are in the midbrain and one is in the thalamus. The midbrain processes sight on a non-conscious level, and only helps to facilitate pupil reflexes and eye movements.

In the thalamus, retinal ganglion cell axons send information to neurons in the **lateral geniculate nucleus**, which then forwards information to the **primary visual cortex** of the occipital lobe. This region will then communicate with other areas of the brain to process information regarding the motion, shape, and color of what you're seeing!



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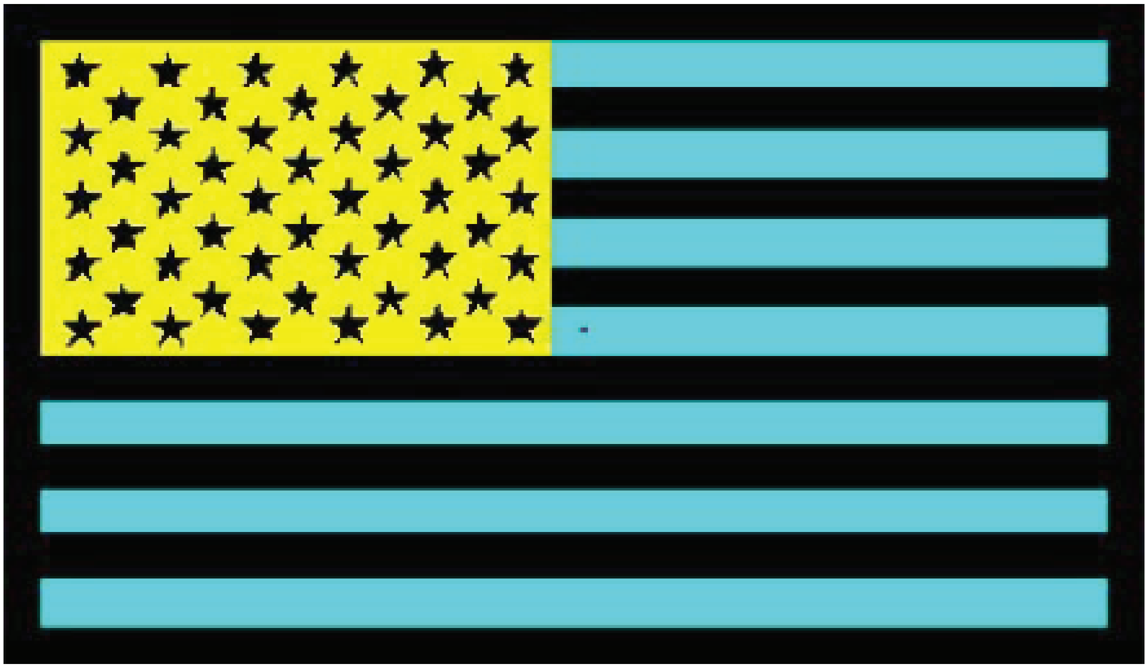
Optical Illusions

Afterimage

Our perception of color depends on how our cone photoreceptors fire together and send signals to our brain. When you stare at colors for 30 seconds or more, your cones detecting those colors get fatigued, and your eyes become saturated and less responsive to that color of light. Therefore, when you finally look away at a white space, you will see an "afterimage" that results from the photoreceptors being imbalanced. This afterimage will be colors that are complementary to the ones you were just staring at. For instance, when you stare at an image with the colors cyan (greenish-blue), black, and yellow, you will see red, white, and blue as the afterimage. Your eyes will adjust and return to their normal chemistry after a few seconds!

Instructions: Stare at the dot in the center of the USA flag for 30 seconds. Now quickly look at a white space—your ceiling, a wall, or a blank piece of paper. What do you see?



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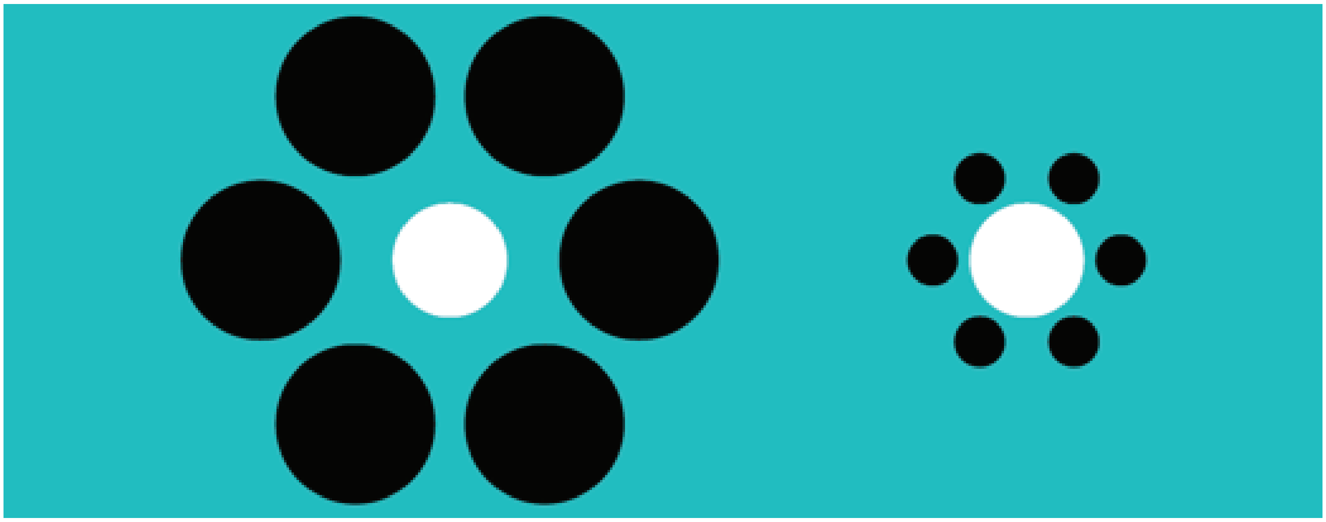
Optical Illusions

Ebbinghaus

This optical illusion relies on our perception of relative size. Two circles of the exact same size are next to each other, but each is surrounded by circles of varying sizes. The circle on the left appears smaller due to the large size of the surrounding circles and their relative distance from the central circle. Our brain's visual perception system will distort the relative size of the inner circles and make us believe the circle on the right is larger when, in fact they are the same size!

Instructions: Stare at the two sets of white circles below. Which of the white circles is larger?



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Optical Illusions

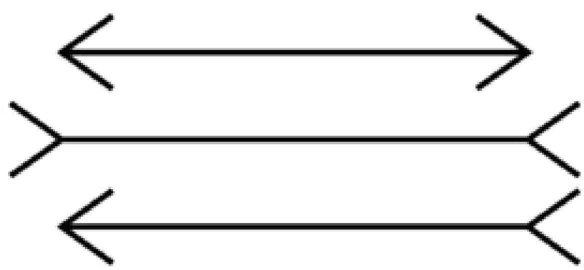
Müller-Lyer

This famous optical illusion makes the viewer think that three lines of the same length appear to be different lengths. Out of the three lines below, which one appears to be the longest? Most people would agree that it's the middle line, however, all three lines are exactly the same length! Look again!

There are a few theories as to why our brain falls for this optical illusion. One is called "depth cue explanation," and it posits that our brains perceive the lengths of the lines based upon depth cues. When the arrows are pointing out and away from the line, we perceive it as sloping away like the corner of a building. This allows us to think that the line is further away and therefore shorter.

When the arrows are turned around and pointing in and towards the line, it looks like the corner of a room sloping towards you; this depth cue makes us believe that this line is closer and longer.

Instructions: Look at these lines. Which one is the longest, and which one is the shortest?



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PROCEDURE

[1] Each student reads 6th-8th grade Dana Foundation fact sheet, "How Does the Brain Work?" **(5 minutes).**

[2] Briefly introduce the exercise and give a short PowerPoint presentation on the visual system **(10 minutes).**

[3] The last slides of the PowerPoint will contain a few optical illusions. As you present each, describe the proposed mechanisms of how they work to trick our brains **(15 minutes).**

ADDITIONAL RESOURCES

- A collection of neuroscience puzzles and fact sheets for kids in grades K-12 that are available for download (PDF): **www.dana.org/educators**

* The "Optical Illusions" activity was originally developed by Eric H. Chudler, Ph.D., University of Washington, and was adapted by Elizabeth Weaver, M.S. and Linda Qi Beach, Ph.D. for the Dana Foundation.