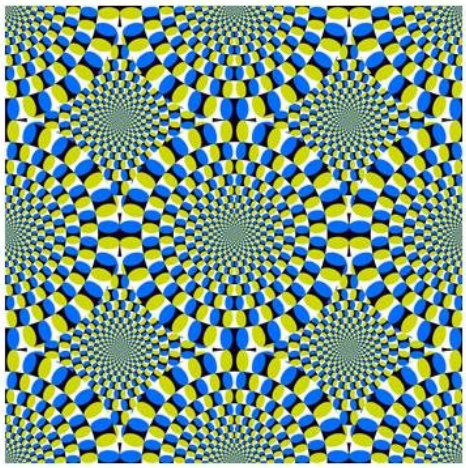
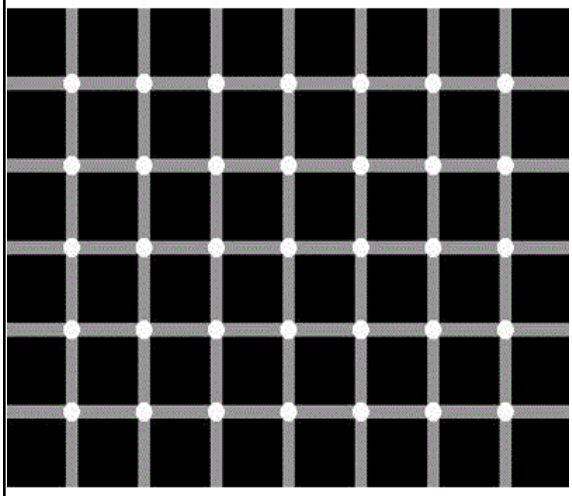
Name: _____ **Date:** _____

Learning Objective: Students will be able to explain why color-blindness occurs based on the structure and function of the human eye by sequencing how sensory input and perception create vision.

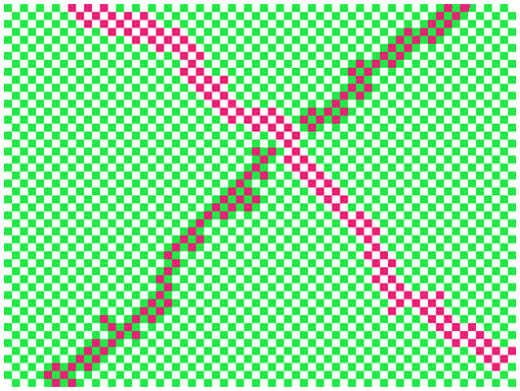
I. Warm-Up:



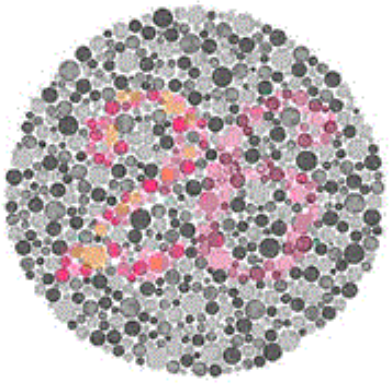
1. **Are the pinwheels moving in this image?**



3. **How many black dots are in this image?**



2. **How many colors are present in this image?**



4. **What number do you see inside the circle?**

II. Turn and Talk

1. Independently respond to the question below and justify your answer using your knowledge of biology.
2. Share your response with your partner and agree/disagree with their response using your knowledge of biology.

Question: Why do you think each of the images from the warm-up produced an optical illusion? **Hint:** Think about the structure and function of our eyes.

III. Vocabulary

Photoreceptors	**Definition:**

Sensation	**Definition:**

Perception	**Definition:**

IV. Think, Ink, Link Protocol

1. Group members each read a different paragraph (Paragraph 1, Paragraph 2, Paragraph 3, or Paragraph 4) of the divided text.
2. **Think & Ink:** Read and annotate your assigned paragraph. Then, answer the discussion question for your assigned paragraph using **specific**, **relevant,** and **sufficient** evidence from the text.
3. **Link:** Discuss your assigned paragraph and response with your classmates. Listen and take notes on your classmates' assigned paragraphs.

1. Genetic Causes of Color Blindness	**1. Why are people assigned male at birth more likely to experience genetic color blindness than people assigned female at birth?** **2. How is genetic color blindness related to sensation and perception in vision?**
2. Retinal Detachment & Loss of Color Vision	**1. How does retinal detachment affect the structure of the eye?** **2. How is retinal detachment related to sensation and perception in vision?**

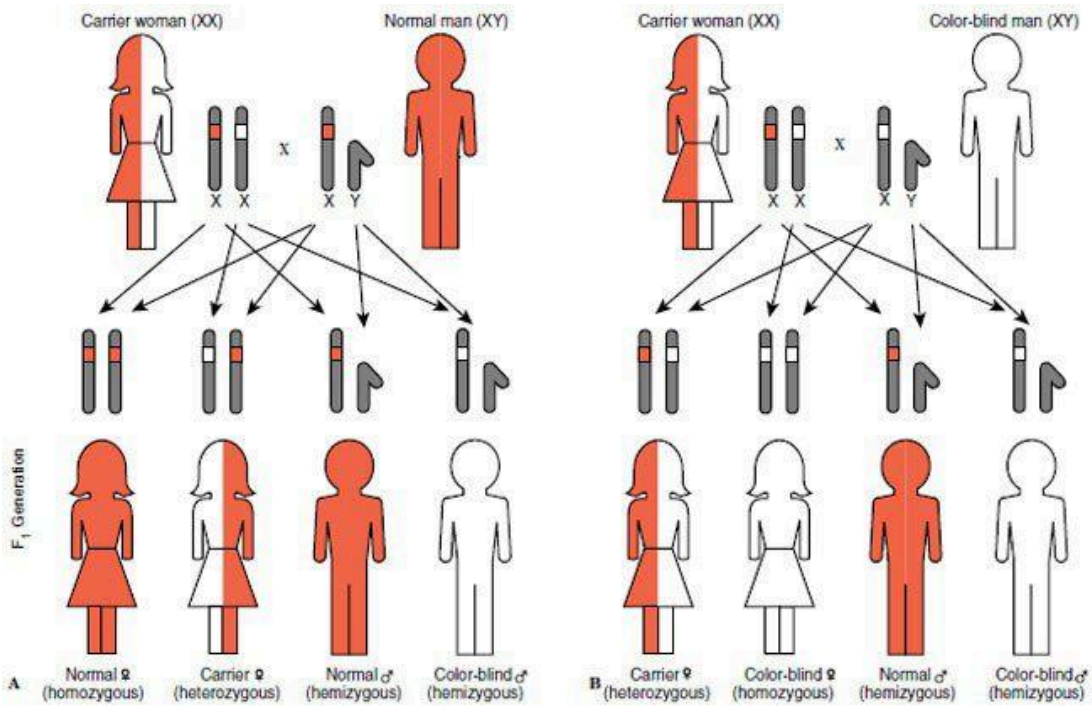
3. Brain Tumors & Loss of Color Vision	**1. How can brain tumors affect the structure of the eye as well as the brain?** **2. How are brain tumors related to sensation and perception in vision?**
4. Cataracts & Loss of Color Vision	**1. How do cataracts affect the structure of the eye?** **2. How are cataracts related to sensation and perception in vision?**
5. Corneal Scarring & Loss of Color Vision	**1. How does corneal scarring affect the structure of the eye?** **2. How is corneal scarring related to sensation and perception in vision?**

Paragraph 1. Genetic Causes of Color Blindness

Color blindness is usually caused by a genetic mutation that affects the genes responsible for the light-sensitive proteins in the cones of the eyes. Cones are photoreceptors concentrated in the center of the retina at the back of our eyes. These mutations can cause cones to not work properly, making people less sensitive to certain colors or unable to see them at all.

The genes for color vision are located on the X chromosome, of which males have one and females have two. This is why color blindness is more common in people assigned male at birth, affecting about 8% of people assigned male at birth and 0.5% of people assigned female at birth. People assigned male at birth only need one X chromosome with the mutated gene to be color blind, while people assigned female at birth need both X chromosomes to have the mutation.

The most common form of color blindness, red-green color blindness, is caused by mutations in the OPN1LW or OPN1MW genes. Blue-yellow color blindness is caused by mutations in the OPN1SW gene.

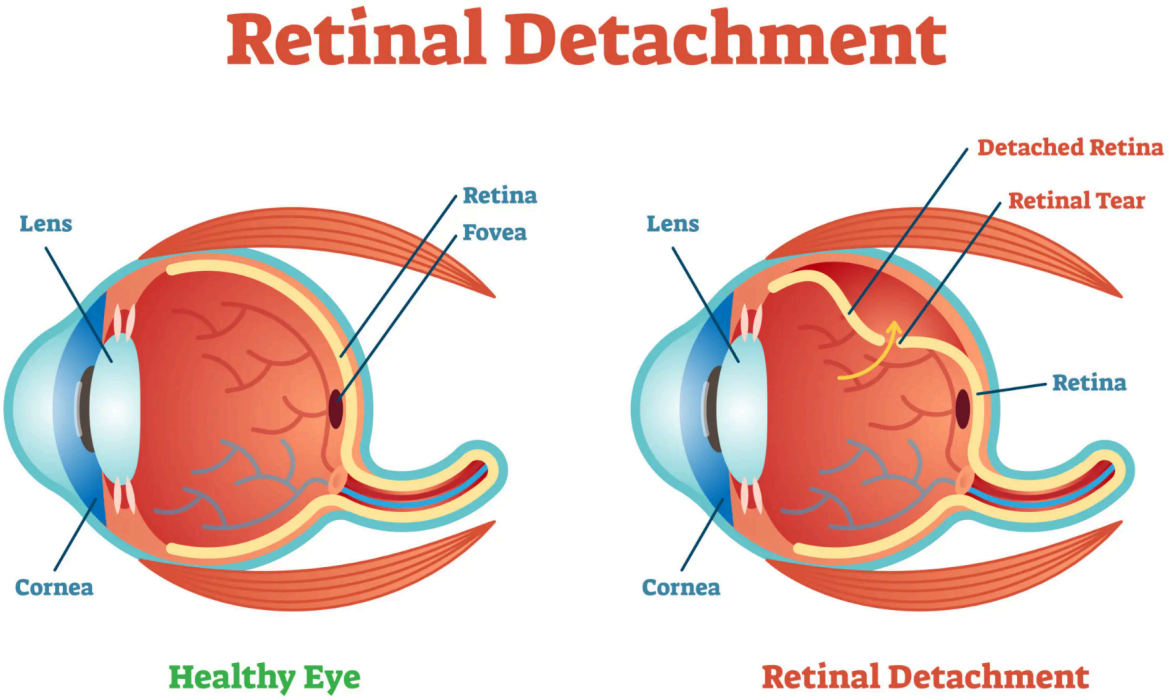


James L. Franklin, *Sex-linked Inheritance of color blindness (Panel on the left demonstrates male Inheritance and on the right female inheritance)*, image, Hektoen International, 2016, accessed August 9, 2024, https://hekint.org/2017/01/22/john-daltons-eyes-a-history-of-the-eye-and-color-vision-part-two/.

Paragraph 2. Retinal Detachment & Loss of Color Vision

Retinal detachment occurs when the retina separates from the retinal pigment epithelium (nourishing tissue) that supports it, causing vision loss. Retinal detachment can be caused by aging, eye injuries, previous eye surgeries, or severe near-sightedness (far away objects are blurry). Symptoms include flashes of light, blurred vision, a dark shadow in the peripheral vision, and sometimes, loss of color vision.

While retinal detachment does not usually cause full color blindness, it can cause some color vision loss, particularly a tritan-like deficit (blue-yellow color vision defects). This is because retinal detachment can selectively damage the S-cones (photoreceptors) in the retina. S-cones, also known as blue cones, are a type of cone cell in the eye that are responsible for detecting blue light. They are one of three types of cone cells, along with M-cones (green) and L-cones (red). S-cones are the least common, making up only 5-10% of the cones in the human retina.



What is Retinal Detachment? Exploring Various Types, Causes and Treatments, image, Iris Vision, accessed August 9, 2024, https://irisvision.com/what-is-retinal-detachment-various-types-causes-and-treatments/.

Paragraph 3. Brain Tumors & Loss of Color Vision

Brain tumors in the occipital lobe, which is the brain's "color center" that processes and interprets visual information from the eye, can cause changes in color vision. Tumors in the occipital lobe can also cause a condition called cerebral achromatopsia, also known as cortical color blindness. This condition occurs when the ventromedial region of the occipital lobe is damaged. People with cerebral achromatopsia lose their ability to perceive color and see the world in shades of gray. As tumors in the occipital lobe grow, they can put pressure on surrounding brain tissue, causing other symptoms like headaches, nausea, and balance problems.

Other tumors that can cause vision issues are orbital tumors, optic nerve gliomas, optic nerve sheath meningioma, pituitary tumors (pituitary adenomas), and craniopharyngiomas. These tumors can all cause loss of color vision or blindness because they place pressure on the optic nerve. The optic nerve is the connection that lets your eyes send signals to your brain describing what they detect. Your brain takes those signals, processes them, and interprets them to construct the picture you see.

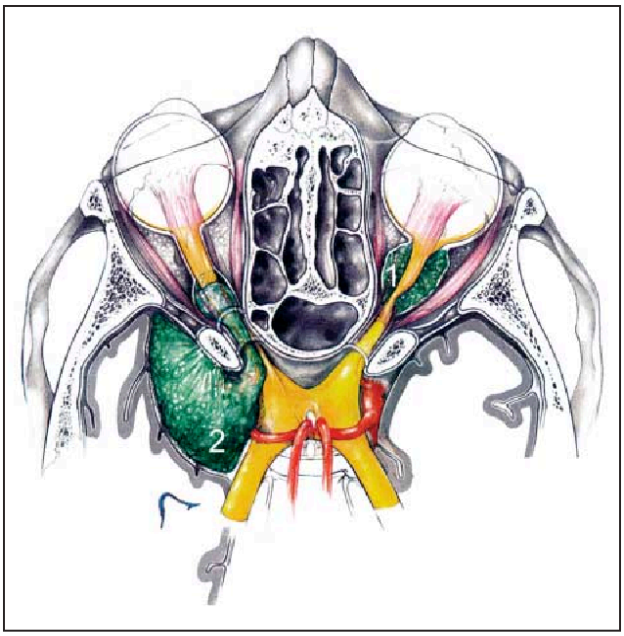
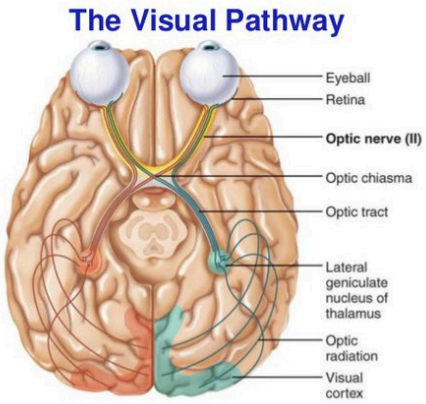
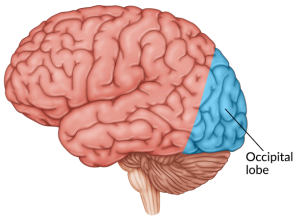


Figure 1. Illustration of primary (1) and secondary (2) optic nerve sheath meningiomas

Martina M. Bosch et al., "Optic Nerve Sheath Meningiomas in Patients with Neurofibromatosis Type 2," *Arch Opthamol* 124, no. 3 (2006): accessed August 9, 2024, https://doi.org/10.1001/archopht.124.3.379.



Jiawei Zhang, "Secrets of the Brain: An Introduction to the Brain Anatomical Structure and Biological Function," IFM Lab, Information Fusion and Mining Labratory, last modified April 2019, accessed August 9, 2024, https://ar5iv.labs.arxiv.org/html/1906.03314.

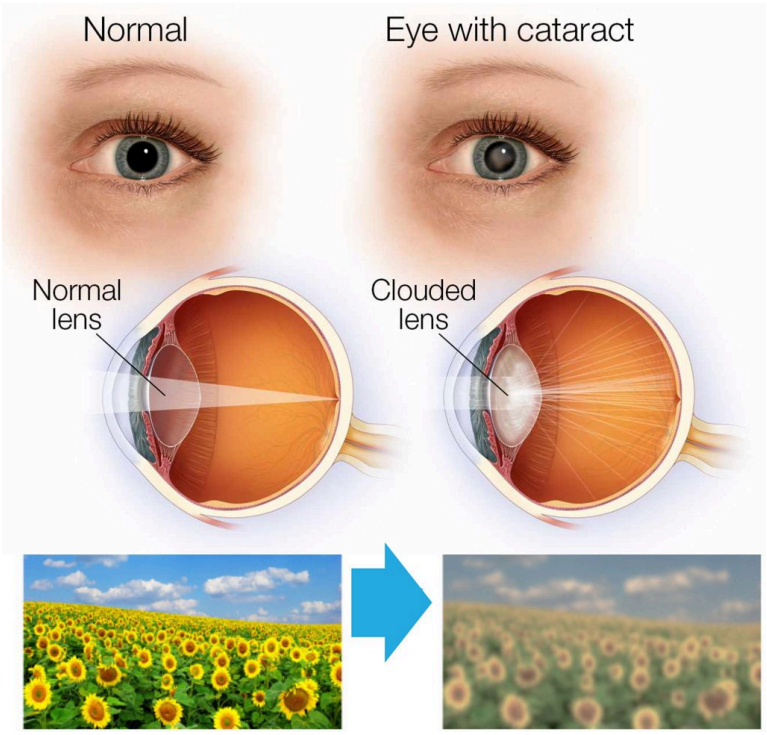


Elizabeth Denslow, "Prefrontal Cortex Damage: Understanding the Effects & Methods for Recovery," *Flint Rehab* (blog), July 7, 2023, accessed August 9, 2024, https://www.flintrehab.com/prefrontal-cortex-damage/.

Paragraph 4. Cataracts & Loss of Color Vision

Cataracts are a clouding of the eye's lens. The eye's lens is usually a transparent, disc-shaped structure that focuses light rays onto the retina, creating clear vision. It works in conjunction with the cornea. The clouding from cataracts prevents light from passing through the lens and focusing on the retina at the back of the eye, affecting vision. Cataracts are caused by a breakdown and clumping of proteins in the lens, usually due to aging. Other causes include eye injuries, medical treatments like steroids, diabetes, and prolonged exposure to ultraviolet radiation without eye protection (sunglasses).

Cataracts can affect color vision by causing yellow or brown tinting on the lens and desaturation. As cataracts develop, the proteins that form them can turn yellow or brown, tinting the light entering the lens and making colors appear faded or washed out. Cataracts can desaturate (reduce) the intensity and vibrancy of colors as well. Together, yellow or brown tinting and desaturation can make it harder to differentiate between colors, especially those with similar hues.

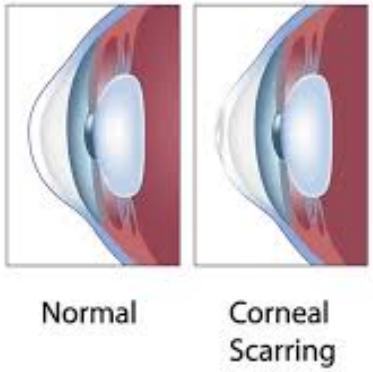


"What Are The Symptoms of Cataracts?," *iCare Family Vision* (blog), December 6, 2022, accessed August 9, 2024, https://www.icarefamilyvision.com/blog/2022/12/4/what-are-the-symptoms-of-cataracts.

Paragraph 5. Corneal Scarring and Loss of Color Vision

The cornea acts as a barrier against dirt, germs, and some ultraviolet rays from the sun. The cornea also bends (refracts) light as it enters the eye, responsible for about 65–75% of the eye's focusing power. This helps focus light onto the retina at the back of the eye, creating clear vision. Corneal scarring occurs when the cornea heals with scar tissue instead of clear tissue. This can be caused by infections, injuries, diseases, or procedures like laser eye surgery.

Corneal scarring can affect color vision by blocking or distorting light as it enters the eye. The cornea's transparency allows light to pass into the eye and its curvature bends light to focus images on the retina. Scarring can cause blurred vision, glare, halos, and difficulty seeing at night. It can also make things appear washed out or gray.



Meredith Marmurek, Corneal Scarring: Causes, Symptoms, Treatment and Healing Time, Allaboutvision.com, All About Vision, last modified April 20, 2022, accessed August 9, 2024, https://www.allaboutvision.com/conditions/cornea/corneal-scar/.

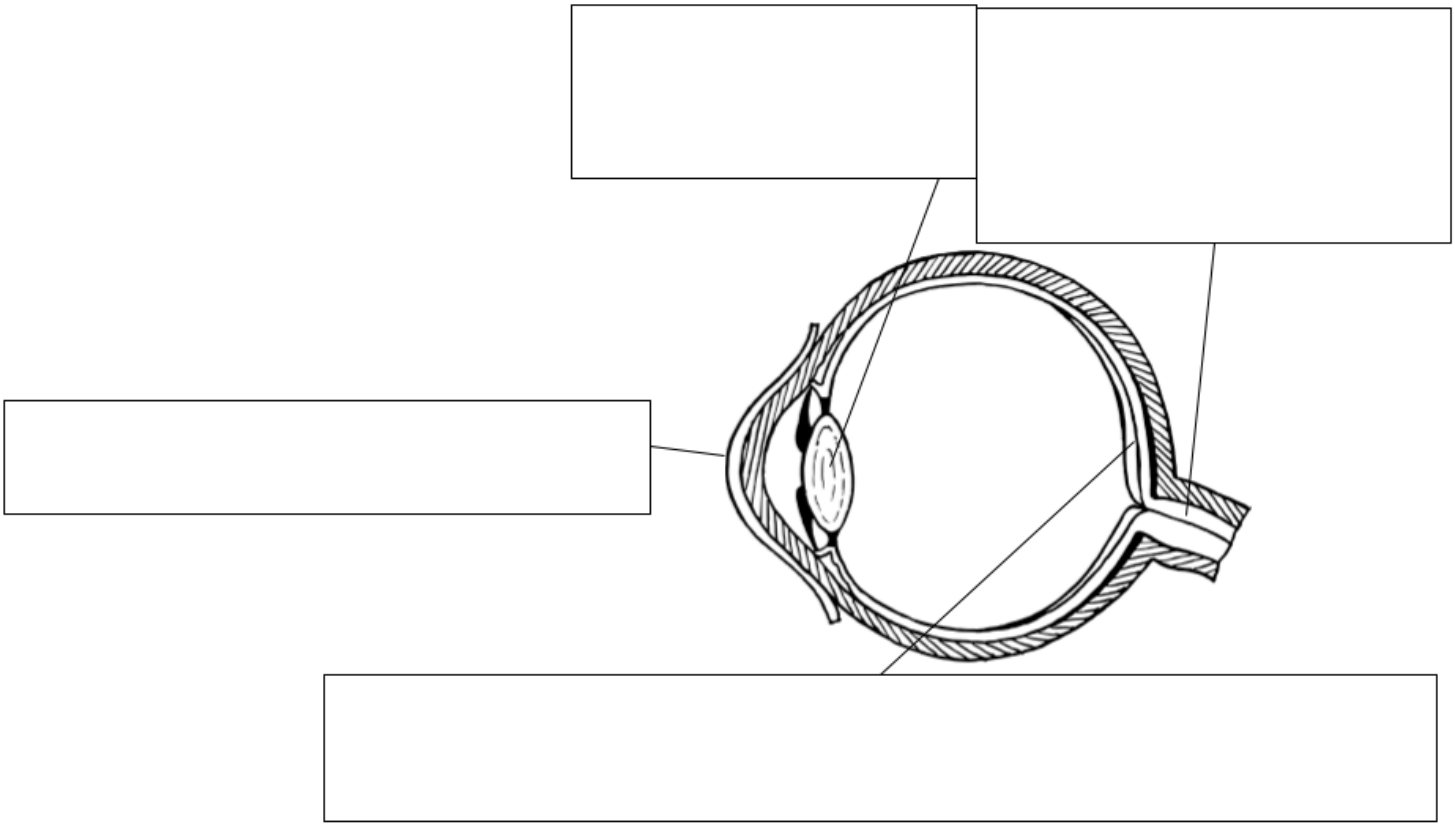
Sonia Kelley, "Corneal Dystrophy: Conditions and Symptoms," Allaboutvision.com, All About Vision, last modified October 20, 2021, accessed August 9, 2024,

https://www.allaboutvision.com/conditions/cornea-conditions/corneal-dystrophy/.

V. Exit Ticket: Parts of the Human Eye

Using the information you learned from the Think, Ink, Link Protocol:

1. Label the parts of the eyeball in the boxes below.
2. Explain the function of each part of the eyeball in your own words in the boxes below.
3. Answer the short-response question below the diagram.



1. How do sensation and perception work together to create vision?

Name: _____ **Date:** _____

Learning Objective: Students will be able to explain how the structure of an organism's eyes reveals the animal's evolutionary niche within an ecosystem by researching the structure and function of eyes and by designing their own organism's eyes.

I. Warm-Up:

Can you guess which eye belongs to what animal?

Nell Greenfieldboyce, *Eye Shapes Of the Animal World Hint at Differences in Our Lifestyles*, image, NPR, August 7, 2015, accessed April 17, 2024, https://www.npr.org/ sections/health-shots/2015/08/07/430149677/eye-shapes-of-the-animal-world-hint-at-differences-in-our-lifestyles.

1.	2.	3.
4.	5.	6.

How did you decide what animal matched with each eye?

New Science Vocabulary Words:

Niche	**Definition:**
Predator	**Definition:**
Prey	**Definition:**

III. Jigsaw Activity

1. Begin the activity in your lettered group (A, B, C, or D). Each person needs to read their text silently and independently and respond to the text's corresponding questions.
2. In your lettered groups, discuss your responses with your group members to deepen your understanding or reconsider your position.
3. Transition to your numbered groups (1, 2, 3, 4, 5, 6, 7, or 8). Discuss each text with your group members to learn about how the structure and function of each organisms' eyes are adapted to their niche within their ecosystem.
4. Answer the questions for each organism's text based on your discussion with your group members.

1. Cuttlefish	**1. What are some of the unique structures in cuttlefish eyes?** **2. How does the structure of cuttlefish eyes help them survive within their environment?**
2. Lion	**1. What are some of the unique structures in lion eyes?** **2. How does the structure of lion eyes help them survive within their environment?**

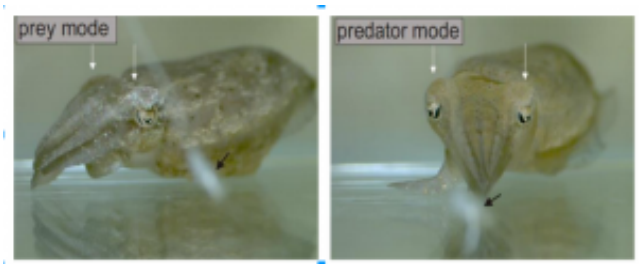
3. Goat	**1. What are some of the unique structures in goat eyes?** **2. How does the structure of lion eyes help them survive within their environment?**
4. Chameleons	**1. What are some of the unique structures in chameleon eyes?** **2. How does the structure of chameleon eyes help them survive within their environment?**

Text #1: Cuttlefish

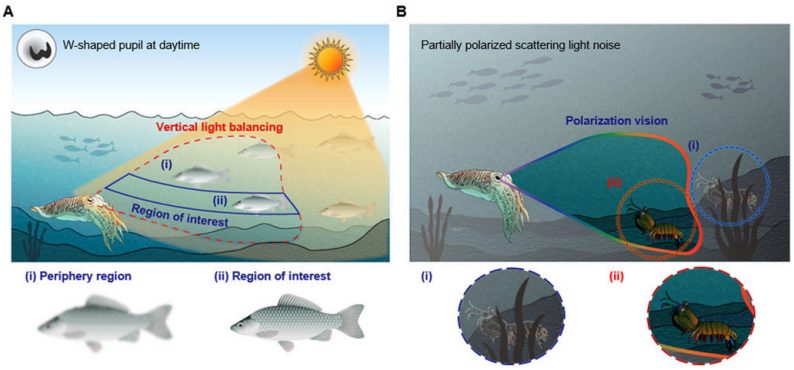
Scientists have long studied the visual systems of cuttlefish to better understand how they see and perceive their environments. Cuttlefish eyes have a W-shaped pupil and W-shaped retina. The W-shaped pupil and W-shaped retina may help control light intensity, reduce distracting lights, balance brightness levels, and detect contrast and movement in low light since cuttlefish live in shallow, murky waters with uneven vertical lighting. Cuttlefish use an ability called stereopsis to perceive depth by comparing the images they see with each eye.

Within their food web, cuttlefish function as both predator and prey. Cuttlefish are considered predators because they are carnivores that eat small mollusks, crabs, shrimp, octopus worms, squid, and other cuttlefish. While in predator mode, cuttlefish are able to move their eyes to the front of their heads in order to use stereopsis to hunt.

When cuttlefish are in prey mode, their eyes move to the sides of their heads to have a wider field of vision to notice predators. Cuttlefish are preyed on by dolphins, seals, sharks, and other large fish.



Lawrence Liu, "The Amazing Eyesight of Cuttlefish," Sqonline, accessed May 3, 2024, https://sqonline.ucsd.edu/2015/06/the- amazing -eyesight-of-cuttlefish/.



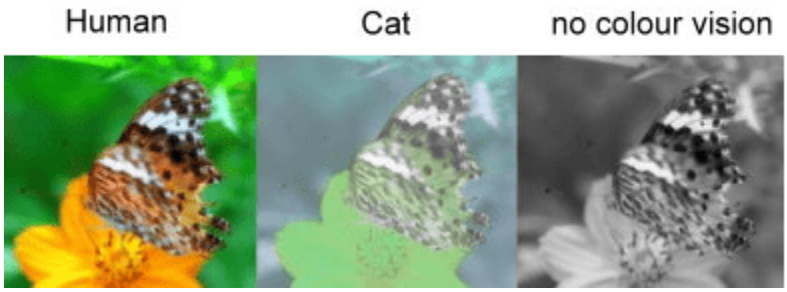
Meeri Kim, "Artificial Vision System Inspired by Cuttlefish Eyes," Optica-opn.org, last modified February 16, 2023, accessed May 3, 2024, https://www.optica-opn.org/home/newsroom/2023/february/artificial_vision_system_inspired_by_cuttlefish_ey/.

Text #2: Lion

Within their ecosystem, lions have very few predators to fear once they are fully grown, which means they are apex (top) predators. As such, their eyes are located at the front of their heads, which gives them binocular vision and depth perception to accurately focus on prey that is far away. Binocular vision is the ability to use both eyes at the same time to see and combine the information from each eye into a single image. This allows lions to see in 3D, judge depth and distance, and coordinate eye movement more accurately.

Lions hunt for prey, such as zebras, wildebeest, water buffalo, and antelope, at dawn and at dusk when there is low lighting. As such, lions' pupils can enlarge much larger than human pupils, which takes in more light and helps them with night vision. They also have a tapetum lucidum, which is a highly reflective tissue layer behind the retina to improve their vision in low light.

Finally, lions have fewer cones (photoreceptors) than humans, so they see less color light. They cannot distinguish red colors. However, lions can see ultraviolet light, which creates images with more contrast and sharpness.



Lions do not see in the red light spectrum. Instead they see the world in blues and greens.

Tim Brown, "Lion's Eyes," *Tim Brown Tours* (blog), accessed August 9, 2024, https://timbrowntours.com/2020/01/31/lions-eyes/.

Text #3: Goat

Goats are herbivores, so they function as only prey within their ecosystem. Goats are often preyed on by wolves, bears, foxes, wild pigs, coyotes, eagles, and bobcats. Based on their niche within their ecosystem, goats have developed several structures in their eyes that help them survive.

Goats have rectangular pupils and rectangular retinas. The rectangular pupils give goats a wider field of view than vertically elongated pupils, allowing them to see almost everything around them, including forward, left, behind, and right. Combined with their rectangular retinas, goats have a panoramic field of vision of 320–340 degrees, with the exception of directly behind them. Having such a wide field of vision helps prevent predators from sneaking up on them. The rectangular pupils and rectangular retinas also improve image quality and sharpness, which helps goats spot predators and flee.

Goats also have side-slanted eyes and rotatable eyes. Most grazing animals (animals that eat grass) have side-slanted eyes (eyes on the sides of their heads) because this location gives them a wider field of vision than if their eyes were located forward on the front of their heads, like humans and other predatory animals. Goats can rotate their eyes more than 50 degrees per eye, which is 10 times the range of human eyes. This allows them to keep their eyes nearly parallel (horizontal) to the ground, even when they bend their heads down to graze, which gives them a better view of potential danger.

Goats' eyes can rotate clockwise or counterclockwise within the eye socket to keep their pupils horizontal.

James Gurney, "Rotating Eyeballs," *Gurney Journey* (blog), July 26, 2010, accessed August 9, 2024, https://gurneyjourney.blogspot.com/2010/07/rotating-eyeballs.html.

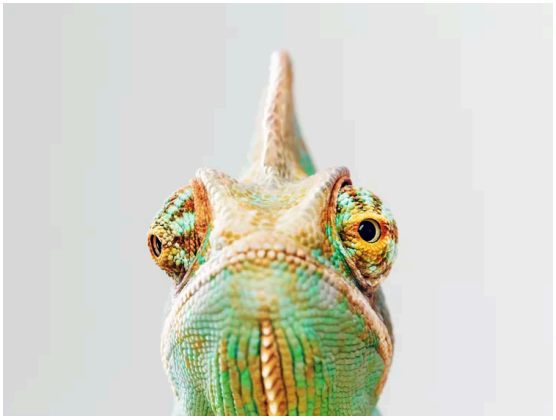
Text #4: Chameleons

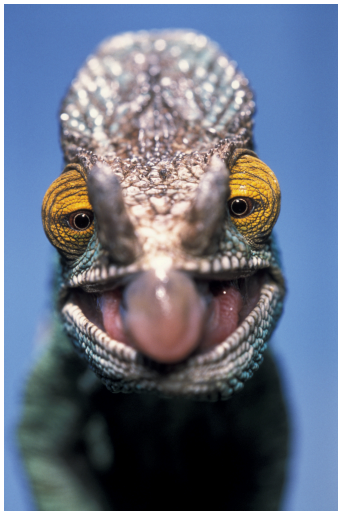
Chameleons are tree-dwelling omnivores that eat mostly flies, worms, crickets, slugs, snails, caterpillars, and sometimes leafy greens. When chameleons are fully grown, they are usually hunted by birds and snakes. Invertebrates (animals without spines), especially ants, threaten chameleons' eggs and their young. As such, chameleons' eyes and vision developed to aid in both prey capture and predator avoidance.

Chameleons have four types of photoreceptors in their eyes, which gives them better color perception than humans who only have three types of photoreceptors in their eyes. Chameleons' retinas also contain multicolored oil droplets and opsin proteins (proteins that bind to light-reactive chemicals) that help them see color and ultraviolet light. Being able to see ultraviolet light allows chameleons to see images with more contrast and sharpness, which helps them spot predators and prey more easily.

Chameleons also use monocular focusing to judge distance. This focusing method allows each eye to focus and move independently, which is made possible by the chameleon's unique eye anatomy. Chameleons' eyes have two separate bundles of nerves that control their eye muscles, which allows them to move their eyes separately. When chameleons use monocular focusing, they also send two separate images to the brain, which allows their brains to process two separate locations in their surroundings to have a better opportunity to search for prey and avoid predators.

Chameleons can also transition between monocular and binocular focusing. Binocular vision allows the chameleon to focus both eyes on a single object or location. When a chameleon spots prey, its eye movements synchronize, a process called "coupling", and both eyes lock onto the target. The brain processes the visual input from both eyes into a single coherent image, which allows the chameleon to have better aim when attacking its prey.





Mary Jo DiLonardo, "7 Colorful Facts You Might Not Know About Chameleons," Treehugger.com, Treehugger, last modified January 15, 2021, accessed August 9, 2024, https://www.treehugger.com/chameleon -facts-5074869.	Ingo Arndt, *Standing Out*, October 28, 2022, photograph, accessed August 9, 2024, https://atmos.earth/chameleons- camouflage-imposter-syndrome/.

IV. Create Your Own Eyeball!

Directions: Using what you have learned in yesterday's lesson and today's lesson, independently design your own eyeball for an organism of your creation to fit their environment.

Name of Organism:	**Draw Your Organism's Eyeball Below:**
Environment:	
Niche:	
Significant Structural Characteristics of Your Organism's Eyes: *Hint: pupil (size and shape), photoreceptors (amount and color-sensitivity), location on body*	
How is the structure of your organism's eyes best adapted to their environment?	

V. Exit Ticket: Regents-Based Question

Directions:

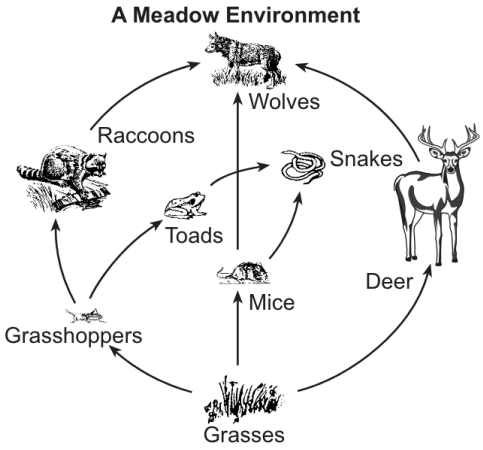
1. Independently answer the Regents-based multiple choice question below and justify your answer using evidence from yesterday's lesson and today's lesson in the space provided.

2 In a stable ecosystem, each niche is usually occupied by only one species. The species occupying a particular niche is able to continue to remain there as a direct result of

(1) ecological succession
(2) favorable adaptations
(3) a new mutation
(4) selective breeding

Justify your response:

27 The diagram below represents a food web.



Two carnivores represented in this food web are

(1) deer and mice
(2) grasses and grasshoppers
(3) deer and wolves
(4) toads and snakes

Justify your response: