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BRAIN
STEM

Bringing
Neuroscience
to the Classroom

Evolution & Eyes

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Evolution & Eyes

The structure and function of eyes varies greatly amongst species, which determines how each species visualizes and perceives their environment. Students will gain an understanding of how the structure and function of a species' eyes evolves and adapts according to their niche and environmental conditions.

Suggested duration

- 2 x 45 min class period

Essential questions

- What is the relationship between sensation and perception?
- How does an organism's environment affect the structure and function of their eyes?

Objectives

Overall STEM goal: Species evolve and adapt according to their niche within their ecosystem and to changes in their environment.

All students will...

- Understand how sensation provides the input for perception.
- Understand how perception varies according to an organism's neurodevelopment and experiences.
- Analyze how an organism's niche within their ecosystem influences the structure and function of their eyes.
- Design an eye that demonstrates the relationship between the structure of an organism's eyes and their role within their ecosystem.

Materials

- Markers
- Colored pencils
- File Folder
- Smartboard or projector

Supplementary Materials

- Evolution & Eyes Powerpoint
- Evolution & Eyes Student Worksheet
- Evolution & Eyes Supplementary Materials (Accountable Talk Stems, Test-Taking Strategies, Jigsaw Activity Groups)

Based on

The Stavros Niarchos Brain Insight Lecture

- "A Clear Vision: How Animals and Robots See the Physical World"
By Rudy Behnia, Ph. D. and Shuran Song, Ph.D.



Instructional Activities

Class 1:

1. Warm-Up | ⌚ 10min

Use the *Evolution & Eyes Student Worksheet*. Use the *Evolution & Eyes Powerpoint* to project slides 1-3 on the board.

During the first five minutes of class, have the students silently and independently look at the four optical illusions provided under the warm-up section of their worksheets. They should answer the questions below each optical illusion.

After five minutes of independent work time, annotate the learning objective with the students using the following questions:

- What is some of the science vocabulary in the learning objective?
 - Circle the words and have the students work towards a definition of the new vocabulary in black.
- Based on the learning objective, what are we going to do today?
 - Circle the verbs and underline the activities in green.
- Based on the learning objective, what are we going to learn about today?
 - Underline the concepts students will be learning about in blue.

After annotating the learning objective, ask the students how they answered each of the questions for the optical illusions. Here are the correct responses for each optical illusion:

- No, the wheels are not turning. *The moiré effect occurs when two repetitive patterns are superimposed, creating a pattern of light and dark lines.*

- There is only one shade of green and one shade of red.
- There are no black dots. *If you focus directly on each dot, you'll see that all of them are white.*
- The number 26.

2. Turn and Talk | ⌚ 5min

Use the *Evolution & Eyes Supplementary Materials*. Use the *Evolution & Eyes Student Worksheet*. Use the *Evolution & Eyes Powerpoint* to project slide 4 on the board.

During the first two minutes of this activity, have the students silently and independently answer the open-ended question and justify their response in the space provided.

During the next two minutes of this activity, students should turn and talk with their partners about why they think each image from the warm-up produced an optical illusion. Remind students of the turn and talk protocol provided on Slide 4 of the *Evolution & Eyes Powerpoint*. Students can use the accountable talk stems from the *Evolution & Eyes Supplementary Materials* to agree, disagree, or clarify what their group mates stated.

Take one minute to wrap up the activity by providing feedback to the class on what you heard from different pairs that met today's learning objective and provide any necessary clarifications.

3. New Vocabulary | ⌚ 5min

Use the *Evolution & Eyes Student Worksheet*. Use the *Evolution & Eyes Powerpoint* to project slides 5-7 on the board.

Have the students write down the vocabulary words provided on Slide 6, Slide 7, and Slide 8 of the *Evolution & Eyes Powerpoint* in the corresponding spaces on their *Evolution & Eyes Student Worksheets*.



To check for understanding, ask the students the following questions after going through the vocabulary words:

- What do photoreceptors do within the eye?
- How are sensation and perception related?

4. Think, Ink, Link | ⌚ 20 min

Use Evolution & Eyes Supplementary Materials. Use the Evolution & Eyes Student Worksheet. Use the Evolution & Eyes Powerpoint to project slide 8 on the board.

Before the lesson, pre-arrange student desks into groups of five. Place a copy of each of the five paragraphs inside of a file folder and place a folder at each of the groups.

During the first ten minutes of this activity, have the students divide the paragraphs among themselves. Students should silently and independently read and annotate their paragraph. After reading their paragraph, they should answer the corresponding questions on their worksheet. While students are completing their paragraphs, the teacher should be circulating and providing feedback on students' responses.

During the next ten minutes of this activity, each student should share their responses with their group members. Group members who are not sharing out should be taking notes on what they are learning from their classmates in the discussion. Students can use the accountable talk stems from the Evolution & Eyes Supplementary Materials to agree, disagree, or clarify what their group mates stated. Circulate to each group to provide feedback and clarification as needed. By the end of the activity, every student should have responses for every paragraph.

5. Exit Ticket | ⌚ 5 min

Use the Evolution & Eyes Student Worksheet. Use the Evolution & Eyes Powerpoint to project slide 9 on the board.

Using the information students learned during the Think, Ink, Link Protocol, have students silently and independently label the parts of the eyeball and explain their functions in the diagram. Then, answer the short-response question. Collect the worksheet at the end of the period to determine students' understanding of the relationship between sensation, perception, and the structure of the eye in relation to the brain.

6. Reflection | ⌚ 5 min

. Use the Evolution & Eyes Student Worksheet. Use the Evolution & Eyes Powerpoint to project slide 10 on the board.

Have the students check the labels and functions of each part of the eyes. Then, have the students discuss their responses to the open-ended question.



Class 2:

1. Warm-Up | ⌚ 5min

Use the *Evolution & Eyes Student Worksheet*. Use the *Evolution & Eyes Powerpoint* to project slide 11 on the board

During the first five minutes of class, have the students silently and independently look at the six animal eyes provided under the warm-up section of their worksheets. They should guess which animal belongs to which eye. Then, they should explain how they decided what animal matched with each eye.

After five minutes of independent work time, annotate the learning objective with the students using the following questions:

- What is some of the science vocabulary in the learning objective?
 - Circle the words and have the students work towards a definition of the new vocabulary in black.
- Based on the learning objective, what are we going to do today?
 - Circle the verbs and underline the activities in green.
- Based on the learning objective, what are we going to learn about today?
 - Underline the concepts students will be learning about in blue.

After annotating the learning objective, ask the students which animals they thought matched with which eye. Discuss how they decided which eye matched with which animal. Here are the correct responses for each eye:

1. Cuttlefish
2. Lion
3. Goat
4. Domestic Cat
5. Horse
6. Gecko

2. New Vocabulary | ⌚ 5min

Use the *Evolution & Eyes Student Worksheet*. Use the *Evolution & Eyes Powerpoint* to project slides 12-14 on the board

Have the students write down the vocabulary words in the corresponding spaces on their *Evolution & Eyes Student Worksheets*.

To check for understanding, ask the students the following questions:

- What were the environmental conditions that determined the Kirtland Warbler's niche?
- What interactions with other species determined the Kirtland Warbler's niche?
- What is the wolf's niche within their ecosystem? What factors helped you determine the wolf's niche?
- What is the elk's niche within their ecosystem? What factors helped you determine the elk's niche?

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1. Jigsaw Activity | ⌚ 20min

Use the Evolution & Eyes Student Worksheet. Use Evolution & Eyes Supplementary Materials for their Jigsaw groups. Use the Evolution & Eyes Powerpoint to project slide 15 on the board.

For the first five minutes, have the students begin the activity in their lettered groups (A, B, C, or D). Each student should first read their text silently and independently and respond to the text's corresponding questions.

For the next five minutes, have students discuss their responses with their lettered group members to deepen their understanding or reconsider their position.

Next, have the students transition to their numbered groups (1, 2, 3, 4, 5, 6, 7, or 8). For the next ten minutes, students should discuss each text with their group members to learn about how the structure and function of each organisms' eyes are adapted to their niche within their ecosystem. As each organism is discussed, students should respond to the questions on their worksheet for that organism.

2. Create your own Eye! | ⌚ 10min

Use the Evolution & Eyes Student Worksheet. Use the Evolution & Eyes Powerpoint to project slide 16 on the board.

Using what they learned in today's lesson, students should independently design their own eye for an organism of their creation that fits their environment. Students should create a name for their organism, describe their organism's environment, name the organism's niche within their ecosystem, name the significant structural characteristics of their organism's eye, and explain how the structure of their organism's eye is best adapted to their environment. They should also draw their organism's eye to visually

depict its unique structures.

Exit Ticket | ⌚ 5min

Use the Evolution & Eyes Powerpoint to project slide 17 on the board. Use Evolution & Eyes Supplementary Materials for the RACES test-taking strategy for multiple-choice questions. Best practice is to have these materials taped to students' desks prior to class for easy reference. Use Evolution & Eyes Student Worksheet.

For the last five minutes of class, students should be completing the exit ticket, which includes two Regents-based multiple choice questions. Remind students to use the RACES test-taking strategy to help them answer the questions correctly. Collect the worksheet at the end of the period to determine students' understanding of the relationship between an organism's niche and their physical development and evolution.



Standards

<p><u>CONTENT SPECIFIC CURRICULUM</u></p>	<p>Living Environment Core Curriculum</p> <ul style="list-style-type: none">• <u>Performance Indicator 1.1a</u>• <u>Performance Indicator 1.1b</u>
<p><u>NEXT GENERATION SCIENCE STANDARDS (NGSS)</u></p>	<p>Life Sciences</p> <ul style="list-style-type: none">▪ LS2.A: Interdependent Relationships in Ecosystems
<p><u>COMMON CORE STANDARDS</u></p>	<ul style="list-style-type: none">• <u>RST.11-12.1</u>• <u>.RST.11-12.9</u>• <u>WHST.9-12.1</u>



Vocabulary

Photoreceptors

The cells in the retina that respond to light. These specialized cells detect light and convert it into signals that are sent to the brain. The human retina contains approximately 132 million photoreceptors.

Sensation

Input about the physical world obtained by our sensory receptors. The physiological basis of perception.

For vision, the input is light and the sensory receptors are photoreceptors.

Perception

Perception is the process by which the brain selects, organizes, and interprets sensations. Perception of the same senses may vary from one person to another because each person's brain interprets sensations differently based on that individual's learning, memory, emotions, and expectations.

Niche

Describes the role a species plays in its community, which encompasses both the physical and environmental conditions the species requires as well as the interactions the species has with other species.

Predator

A biological interaction where one animal, the predator, kills and eats another animal, its prey. Predators are either carnivores (only eat other animals) or omnivores (eat both plants and other animals).

Prey

An animal that is hunted or killed by another animal for food. Prey can be carnivores (only eat other animals), omnivores (eat both plants and other animals), or herbivores (eat only plants).



Sources

- Arndt, Ingo. Standing Out. October 28, 2022. Photograph. Accessed August 9, 2024. <https://atmos.earth/chameleons-camouflage-imposter-syndrome/>.
- Barden, Anna. Photoreceptors and Their Function in the Eye. Image. All About. Accessed August 9, 2024. <https://www.allaboutvision.com/eye-care/eye-anatomy/photoreceptors/>.
- Bosch, Martina M., Werner W. Wichmann, Eugen Boltshauser, and Klara Landau. "Optic Nerve Sheath Meningiomas in Patients with Neurofibromatosis Type 2." *Arch Ophthalmol* 124, no. 3 (2006). Accessed August 9, 2024. <https://doi.org/10.1001/archopht.124.3.379>.
- Brown, Tim. "Lion's Eyes." Tim Brown Tours (blog). Accessed August 9, 2024. <https://timbrowntours.com/2020/01/31/lions-eyes/>.
- Deng, Wei, Ruofei Jia, Xiujuan Zhang, Liming Huang, Jiangsheng Jie, and Xiaohang Zhang. Schematic Illustration of the Human Visual-Perception Process. Image. *Nature*, December 13, 2019. Accessed August 9, 2024. <https://www.nature.com/articles/s41427-019-0182-2>.
- Denslow, Elizabeth. "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/>.
- DiLonardo, Mary Jo. "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>.
- Franklin, James L. 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/>.
- Gray Wolf. Photograph. Accessed August 9, 2024. <https://www.nwf.org/Educational-Resources/Wildlife-Guide/Mammals/Gray-Wolf>.
- Greenfieldboyce, Nell. 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>.
- Grosset, Arthur. Cattle Egret *Bubulcus Ibis*. Photograph. Arthur Grosset. Accessed April 17, 2024. <http://www.arthurgrosset.com/ozbirds/cattleegret.html>.
- Gurney, James. "Rotating Eyeballs." Gurney Journey (blog), July 26, 2010. Accessed August 9, 2024. <https://gurneyjourney.blogspot.com/2010/07/rotating-eyeballs.html>.



Sources

- Hu, Charlotte. "Cuttlefish Have Amazing Eyes, so Robot-Makers Are Copying Them." Popsci.com. Last modified February 15, 2023. Accessed May 3, 2024. <https://www.popsci.com/technology/cuttlefish-eye-imaging-system/>.
- Kelley, Sonia. "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/>.
- Kim, Meeri. "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/.
- Kubiak, Ireneusz. Special Computer Fonts in Electromagnetic Safety of Digital Graphic Standards. Image. Research Gate, May 2020. Accessed August 9, 2024. https://www.researchgate.net/publication/341190106_Special_computer_fonts_in_electromagnetic_safety_of_digital_graphic_standards_Optical_TEMPEST.
- Liu, Lawrence. "The Amazing Eyesight of Cuttlefish." Sqonline. Accessed May 3, 2024. <https://sqonline.ucsd.edu/2015/06/the-amazing-eyesight-of-cuttlefish/>.
- A Male American Elk (Cervus Elaphus Canadensis) in Yellowstone National Park, Wyoming, U.S. June 23, 2024. Photograph. Accessed August 9, 2024. <https://www.britannica.com/animal/elk-mammal>.
- Marmurek, Meredith. 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/>.
- P7R7. A Bumblebee Visits a Flower. Photograph. National Geographic. Accessed April 17, 2024. <https://www.nationalgeographic.com/science/article/bees-can-sense-the-electric-fields-of-flowers>.
- Rzepka, Jeff. Kirtland's Warbler. Photograph. National Geographic. Accessed April 17, 2024. <https://education.nationalgeographic.org/resource/niche/>.
- Tick-Borne Parasite Found in Scottish Sheep in UK First. Photograph. BBC. November 20, 2019. Accessed April 17, 2024. <https://www.bbc.com/news/uk-scotland-50491068>.
- Vidakovic, Dino. Is eyeballing still viable in modern UX design? Image. PushYourPixels.com, October 26, 2023. Accessed August 9, 2024. <https://pushyourpixels.com/articles/is-eyeballing-still-viable-in-modern-ux-design>.



Sources

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



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Created by:	With input from:	Michael Becker
Madalyn McDaniel	Aaron Licari	Ramona Fittipaldi
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	Mariya Barreras	
	Melissa Braxton	

