Do You Have Eagle Eyes?
Test your vision against an eagle’s vision.

Overview of Lesson – Students will test their vision in several experiments and compare it an eagle’s vision.

Minnesota Science Standards

5.1.1.2 - Describe how plant and animal structures and their functions provide an advantage for survival in a given natural system. For example: Compare the physical characteristics of plants or animals from widely different environments, such as desert versus tropical, and explore how each has adapted to its environment.

6.2.3.1.3 - Use wave properties of light to explain reflection, refraction and the color spectrum.

Time Needed: approx. 1 hour
Ages: 5th - 8th
Season: Any
Materials: 2 glass bowls, 2 glass jars/cups, pennies, scissors, tape, tape measure, newspaper, pitcher, pencil, worksheets, pitcher, station instruction cards

Outline:

I. Introduction – 10 minutes
II. Vision Experiments – 30 minutes (about 5 minutes per station)
III. Conclusions and clean up – 10 minutes
Background

Have you ever heard someone referred to as having “eagle eyes”? Eagles have incredible vision. Based on studies of other species, and speculation based on the structure of the eagle’s eye, it is estimated that an eagle could see a fish from a mile up, or a rabbit running on the hillside three miles away. Like all raptors, eagles are visual predators. Eagles have other senses, but it is their eyesight that is most keenly developed. An eagle’s hearing is similar to humans’ and their sense of smell is poorly developed. It is their keen eyesight that eagles rely on to hunt and survive.

Eagle eyes are similar to human eyes in that they both contain rods and cones. Rods and cones are the sensory receptors in our eyes that allow us to see. Rods detect light in various shades, and cones detect color. Eagles have both rods and cones and see in full color. Eagles have four types of cones in their eyes, so they can detect more of the color spectrum than humans. In fact, we know that many raptors can even see into the ultraviolet (UV) part of the spectrum.

Eagles are adapted to daytime hunting. Their night vision is not especially well developed. At night, an eagle’s vision is roughly equivalent to a human’s night vision.

In most raptors, the eyes are huge in proportion to the rest of the skull. In fact, an eagle’s eye is about the same size as a human eye, but an eagle’s eyes take up most of the space inside their skull. As a result, humans can do something with their eyes that eagles can’t; we can roll our eyes side to side, or look up and down without moving our head. We can do this because we have tiny muscles attached to the eyeball that allow us to move our eyes within the skull. Since eagle eyes take up so much space within the skull, they lack these muscles and their eyes are fixed within the skull. If an eagle wants to look in another direction (i.e. change their field of view), they have to move their head.

Binocular vs. monocular vision

Eagles have a very large field of vision, in part because they use both binocular and monocular vision. Eagles, and most raptors, have excellent peripheral vision, allowing them to see things in sharp detail even when the object is not directly in front of them. This is because eagles have monocular vision, meaning they can use each eye independently, giving them a wide field of view.

*Compare this to human vision.* Humans can see things that are not directly in front of us, but if we need to see in sharp detail, we generally adjust so that the object is directly in front of our eyes, so that we can focus on the object with both eyes.

When looking at something directly in front of us, humans are using binocular vision, meaning both eyes are focused on the object. Binocular vision allows for fine focus and seeing sharp details. Eagles also have binocular vision, and use this to see close objects or objects directly in front of them.

Eagles can also rotate their head much farther than humans, extending their visual field even more. An eagle can rotate its head about 180° in either direction. Owls can rotate their heads a bit farther, about 270° in either direction. (No, they can’t turn their head all the way around!) Eagles and owls can rotate their heads farther because they have twice as many bones in their neck; they have 14 neck bones while humans have just 7 bones in our necks.

See illustrations of the field of view for an eagle, owl and human at the end of this lesson.
Since they rely on their eyes to survive, an eagle’s eyes are very important and they have some adaptations to protect their eyes and help them to see even better.

The supraorbital ridge is a boney structure above the eye. This acts like a shade or a built in baseball hat to keep the sun out of their eyes. This allows eagles to hunt in bright sunlight without difficulty.

Eagles also have special eyelids called nictitating membranes. Eagles have upper and lower eyelids, just like humans. But they also have a third called the nictitating membrane. This clear membrane slides across the eye to clear it of debris, or protect the eye when eagles are flying or hunting. In some ways, the nictitating membrane acts like built in safety goggles!

For an example, go to: http://www.nationaleaglecenter.org/learn/glossary/ and look at Nictitating Membrane. See Photo where membrane is partially covering the eyeball and appears as a cloudy film over the eye.

Vocabulary

Rods – cells of the eye that pick up shades of light.

Cones – cells of the eye that allow us to see shades of color. Humans have three types of cones, eagles have four. We believe they can see more of the color spectrum that humans.

Refraction – The change in direction of a light wave due to changes in the medium the wave is passing through. An example of refraction is light changing direction as it passes through a prism or lens. Light is also refracted when it passes from air into water.

Reflection – light bouncing off of a surface; Light can be reflected by many surfaces including a mirror, or the surface of water. The angle of reflection is equal to the angle of incidence, or the angle at which the light strikes the reflecting surface.

Binocular vision – using both eyes together to focus on an object and create a single visual image; Binocular vision allows for depth perception.

Monocular vision – using one eye independently; In monocular vision, the field of view is increased but depth perception is limited.

Nictitating membrane - also known as “the third eyelid”; closes from the interior edge out to the side; the membrane cleans and protects the eye

Supraorbital ridge - the boney protuberance above the eye socket; This ridge helps shade and protect the eye and gives raptors their fierce look.

These videos show some examples of eagles using their keen vision to hunt.

• Bald eagle catches salmon
  https://www.youtube.com/watch?v=hecXupPpE9o&list=PLu8P_OvWy7pZXQd0-ENY76_QZWjkBxfl0&index=1

• African Fish Eagle hunting flamingos
  https://www.youtube.com/watch?v=2BqV2Adr3hl&list=PL1BF52D1F1200DFF4&index=5
Prior to Teaching:

Gather materials and print out the station directions. Set up the stations around the classroom and provide the directions and necessary materials at each station. Make copies of the worksheet for all students.

Lesson Outline:

I. Introduction
   a. Have you ever watched an eagle catch a fish and wonder just how they were able to do it?
   b. Show a video of the eagle fishing. Eagles are hunting using vision as their primary sense.
   c. Define refraction and reflection and give examples. Going through these stations

II. Vision Experiments
   a. Handout worksheets to students.
   b. Students will rotate through stations to gather data about their own vision and then compare it to an eagle’s. Brief station descriptions are below. The directions for students can be found at the end of the lesson. Some stations require that students work in pairs.

Station A – Distance Vision - An eagle could see a fish from a mile up in the air.
Place a page of newspaper on a wall. Measure out 100 feet and place a piece of tape on the floor. Measure out some shorter distances (50 feet, 30 feet, 10 feet, 5 feet etc.) and mark those with tape on the floor.
NOTE: If there are space concerns, this activity can be done in the hallway or a shorter total distance can be used.

Station B – Refraction
Fill a glass jar with water. Place a pencil in the jar. Prepare a piece of paper with an arrow drawn on it.
As light travels through different mediums (e.g. air and water), the light changes direction making the pencil appear split or bent. The water also makes the arrow appear to change direction. These are examples of refraction.

Station C – Going Fishing
Eagles must learn to deal with the refraction of light to catch fish. In some cases, the fish might appear to be in a slightly different location than it actually is. Eagles that can’t learn to compensate for refraction may not catch fish and not be able to survive.

Tape an image of a fish to the bottom of a glass container and fill the container with water. (See last page for small clip art fish.) Use clear packing tape to ‘laminate’ the paper fish, then tape it to the bottom of the glass. The glass represents the lake.

Provide a pencil for students to ‘catch’ the fish with. They simply need to touch the fish with the pencil tip, which represents the eagle’s talons.
Station D – Rising Fish
Before the lesson, tape a paper fish to the bottom of a glass bowl (empty). Provide another container of water so that students can fill the bowl with water.

When the bowl is empty (light is passing through air), at some point, the viewer can’t see the fish. When the bowl is full of water, the light bends as it passes through the water and the fish can be seen from that same position. This is another example of refraction.

Station E – Depth Perception
Eagles and human rely on binocular vision (using both eyes together) to judge how far away things are.
Place a cup in the middle of the table.

Station F – Field of View
Eagles have a large field of view compared to humans. The average human has a field of view of about 114°, while a bald eagle’s field of view is about 180°. (See illustrations). Have two students work together to estimate their field of view. One student should stand behind (but not directly behind) another, and slowly approach. When the first student can see the approaching student, they should estimate the angle, and determine the field of view.

III. Wrap Up / Conclusions
a. Clean up the stations.
b. Students can meet in small groups and share their results. Do they have eagle eyes?

Extensions:

Have the students calculate the class average distance that they could read the newspaper in for station A.

Have students use their science notebook to record/draw observations and answer journal questions. Possible questions include:
How does your vision compare to an eagle’s?

References:

National Eagle Center FAQs: http://www.nationaleaglecenter.org/learn/faq/

National Eagle Center glossary: http://www.nationaleaglecenter.org/learn/glossary/


Student directions for stations

Station A – Distance vision

One person should stand at the tape and try to read the newspaper.

Can you read the title? Headlines? Article? If eagles could read, they would be able to read the articles on the newspaper from 100 feet away!

Each person should slowly walk towards the newspaper until they can successfully read the headlines. Using a tape measure record the distance.

Station B – Refraction

Activity 1:
Look through the side of the glass at the pencil.

Draw your observations.

Activity 2:
Take the piece of paper with an arrow on it and draw the arrow in the first box.

Next, place the arrow behind the glass jar and draw what you see.

Station C – Going Fishing

This activity will test your fishing skills. Pick up the pencil and make one quick plunge to and “catch” the fish. Simply try to touch the fish with the tip of the pencil.

No practicing please!

Repeat until you are able to successful get the fish.

Record your results.
Station D – Rising Fish

Work in pairs.

One person should look at the fish bowl and slowly move their head until the fish just disappears from sight. Stay in that position while your partner fills the bowl with water. Draw your observations.

Empty the bowl into the container, switch roles and repeat the experiment.

Station E – Depth perception

Work in pairs.

Place the cup in the middle of the table. One student (A) should pick up the penny and then close their eyes. Their partner (B) should close one eye and give verbal directions to the student holding the penny. When the penny is over the cup student B should say, “drop it.” Record your observations.

Repeat this experiment while student B has both eyes open. Record your observations.

Switch roles and repeat the experiment.

Station F – Field of View

Work in pairs.

One partner should stand behind and off to the side of the other. The student in front should face straight ahead. The student behind should slowly move forward. When the partner in front can see the approaching partner, estimate the angle.

Draw your observations.

Switch roles and repeat the experiment.
Field of View Illustrations

- Bald eagle
- Owl
- Human

Bald Eagle field of view
Owl field of view

Right Monocular Vision

Left Monocular Vision

Binocular Vision

70°
Human field of view

Visual Limit Left Eye 62°
Visual Limit Right Eye 62°
Word Pattern Recognition
Normal Viewing Filed
Choose the fish that best fits your containers for Station C – Going Fishing and Station D – Rising Fish

- Cut out the fish
- Laminate or seal with clear packing tape
- Tape the fish to the bottom of the glass container
**Eagle Eyes – Worksheet**

Student Name: _______________________

*Station A*

At 100 feet, were you able to read any of the newspaper?

At what distance were you able to read it?

*Station B*

Activity 1 - Pencil

Look at the pencil from several different angles; draw your observations

What happens to the pencil when it is placed in water?

Activity 2 - Arrow

What happened to the arrow when it is viewed behind the jar?
Eagle Eyes – Worksheet  
(page 2) 

Station C 

Did you hit the target the first time? 

How many practices did it take for you to “catch” the fish? 

Did you have a strategy when doing this experiment? 

Station D 

What happens to the fish when water is added to the bowl? 

Why? 

Station E 

Were you successful at getting the penny in the cup with one eye shut? 

Was it easier to complete the task using one eye or both eyes? 

Station F 

Draw your field of view