

CALIFORNIA
ACADEMY OF
SCIENCES

Light in Air and Water

GRADE LEVEL 3rd-8th; Standards for 3rd, 4th and Middle School

SUBJECTS Physical Science

DURATION Prep Time: 10 min; Activity Time: 30-45 minutes

SETTING African Hall, Color of Life, Steinhart Aquarium

OBJECTIVES

In this lesson, students will:

1. observe the physical phenomenon of light bending when traveling through different mediums
2. model the phenomenon of refraction
3. become familiar with animals that have strategies and/or adaptations related to the phenomenon of refraction.

MATERIALS

- Pencil
- Light in Air and Water Scavenger Hunt Worksheet
- Optional: Clipboard

SCIENTIFIC TERMS FOR STUDENTS

- » **adaptation:** a change in the structure or behavior of an organism or any of its parts as a result of the evolutionary mechanism of natural selection
- » **reflection:** light bouncing off of a surface
- » **refraction:** the bending of light due to the change in the speed of light as it crosses the boundary between two different mediums
- » **speed of light:** the speed at which light information travels. Approximately 300,000,000 m/s in a vacuum
- » **medium:** a substance, for example water, air or glass
- » **fast medium:** a substance in which light travels faster than a second substance
- » **slow medium:** a substance in which light travels slower than a second substance
- » **normal:** a line drawn perpendicular to the surface of a substance

BACKGROUND FOR EDUCATORS

Interesting things happen when light travels from one medium to another. And what makes this phenomenon, called **refraction**, even more fascinating is how we, as animals, perceive it visually.

As opposed to **reflection** where light bounces off of an object, refraction is the *bending* of light as it passes from one medium to another. This bending happens because light travels faster in one medium than the other. One analogy to help us think about this phenomenon is a marching band. Imagine a marching band as they march from pavement (a fast medium) into mud (a slow medium). The marchers on the side that runs into the mud first will slow down first. This causes the whole band to pivot slightly toward the normal (makes a smaller angle from the normal). This is evident in Figure 1, if the each dot in the line represented a band member in line.

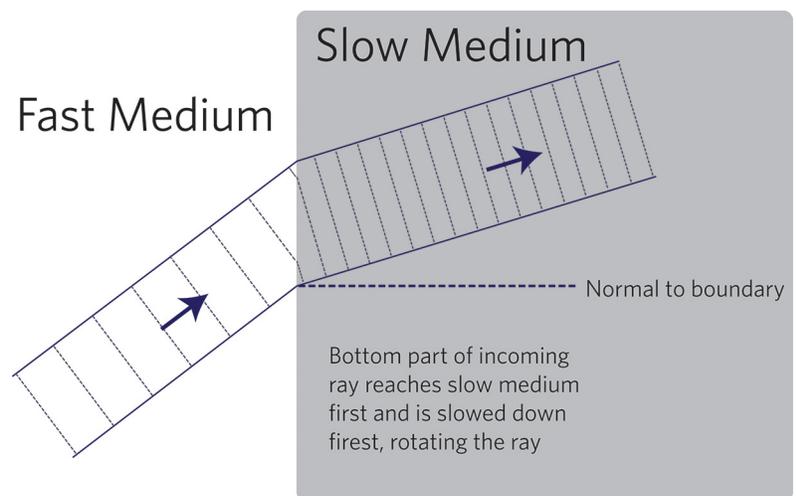


Figure 1

Light in Air and Water

The most common boundary between two mediums in the museum, is air and water. Light travels slower in water.

- » How does this impact what we and other land animals see when we look into the water?
- » How does this impact what aquatic animals see when they look out of the water?

When we see an object, it is because light from a source (the sun, a lamp) is reflecting off of the object and entering our eye, where our brain processes the information. The bending of light described above means that the light bouncing back from objects under the water into our eye appears to be coming from a different location than it actually is!

In the tide pool activity, students will experience a consequence of this. When trying to touch an object under the water by aiming from outside of the water, they will probably miss! This is because they are aiming for where the object appears to be (where the light appears to be coming from) as seen in Figure 2. Rather than where the light is actually reflecting from, before it is bent at the air/water boundary.

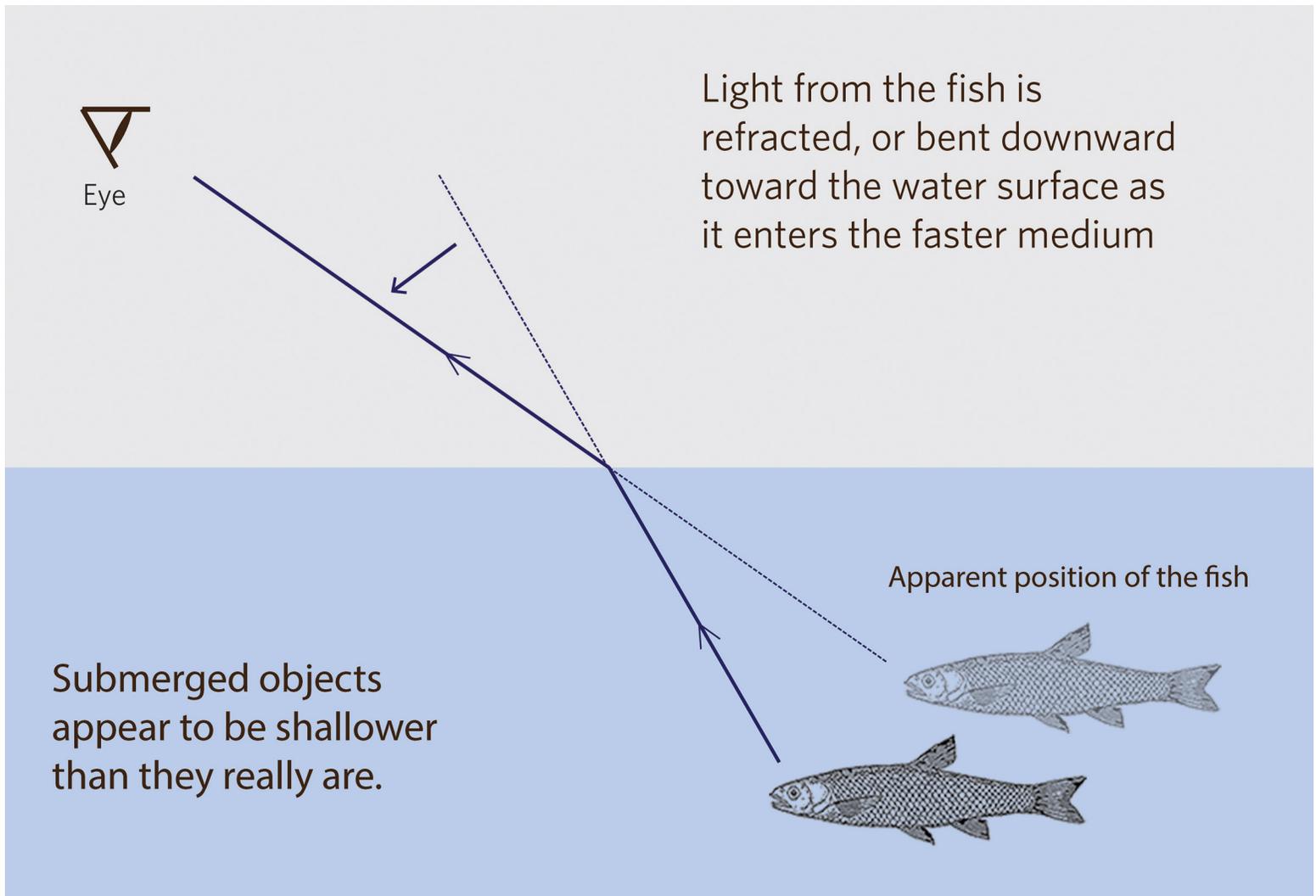


Figure 2

Animals that have adapted to the phenomenon of refraction

In this activity, students have the opportunity to visit 1 to 4 animals that have strategies and/or adaptations related to the phenomenon of refraction. Below is a little bit of information about these three animals, some of which students will also find in the exhibit text. This information can be useful for engaging students in discussion of these animals and how their physical structure and/or behavior is related to refraction (bending of light).

Four-eyed Fish (*Anableps anableps*)

Aquarium location: Amazon Flooded Forest, near the Rainforest exit

Distribution: Trinidad and Venezuela to the Amazon delta in Brazil

Diet: Insects, small fish, other invertebrates, and diatoms

These fish spend most of their time at the surface of the water, where their main food source, insects, is plentiful. Since they live in the water and the food source is in the air, their eyes are specially adapted to see in both air and water. The Four-eyed fish's eyes have adapted to compensate for the refraction that happens as light travels between water and air. Seeing through water requires a thicker lens than seeing through the air, so this fish's "four-eyes" that are actually only two eyes have a lens that is thicker on the lower portion (that stays under the water) and thinner on the upper portion (that stays above the water).

Splashing Tetra (*Copella arnoldi*)

Aquarium location: Animal Attractions

Distribution: slow-moving streams in the lower Amazon basin

Diet: worms, insects, and crustaceans

These resourceful fish keep their eggs safe by laying them outside of the water! Both males and female Splashing Tetra leap out of the water together and attach themselves to the underside of a leaf. The female lays 6-8 eggs, then the male quickly fertilizes them. They repeat this process, aiming and jumping onto the same leaf, until 200 eggs have been deposited there! The male will hide near the leaf, but in the water, to defend the eggs and splash water on them periodically to keep them wet until they hatch about 48 hours later. Despite the refraction that occurs between air and water, these fish must be able to aim accurately at an object outside of the water in order to lay their eggs, defend them, and keep them moist before they hatch.

Banded Archerfish (*Toxotes jaculatrix*)

Aquarium location: Water Planet - Feeding

Distribution: Southeast Asia, Australia, Polynesia

Diet: invertebrates, small vertebrates such as lizards

While the Banded Archerfish remain underwater, they hunt by shooting a stream of water from their mouths to hit an insect in the air. Schools of young archerfish practice shooting streams of water.

Not only are they able to accurately aim at an insect from underwater, these fish are also able to move to the place where the struck insect lands in the water within one tenth of a second! Banded Archerfish must account for the bending of light both in knowing where to shoot, and where to retrieve their food.

Burmese Vine Snakes (*Ahaetulla fronticta*)

Aquarium location: Water Planet - Feeding

Distribution: Burma (Myanmar)

Diet: fishes

Burmese Vine Snakes are characterized by thin, elongated bodies, with extremely long tails and a sharply triangular shaped head. They are primarily green in color which helps them camouflage because they spend their lives up in trees and not moving much. Since they live on land to feed they strike at a fish in water while maintaining half of its body wrapped around a branch or twig. It will use a mild venom to render the fish immobile. Also they're rear-fanged. Their fangs aren't at the front of their mouth like in vipers, but at the back of the upper jaw.

TEACHER PREP

Before visiting the museum,

1. Read Background for Educators
2. Print scavenger hunt for each student
3. Print procedures for each chaperone

INTRODUCTION

1. Hand out scavenger hunts and go through each step with students.
2. Remind students to look carefully and sketch what they see!
3. Advise students to check in with an adult before moving on to the location in the scavenger hunt.
4. Assign partners for students to work with.
5. Hand out Chaperone Guides to chaperones willing to help facilitate the scavenger hunt.

PROCEDURE

Activity 1: Sketch a penguin!

1. Start in *African Hall* and visit with the African penguins!

Teacher Tip: Penguin feeding is at 10:30-11am & 3-3:30pm, it can be very crowded from 10 minutes before to 10 minutes after the program.

2. Make sure each student has at least one partner to work with.
3. Have the students sketch what they see including objects above and below the water. Have them try to sketch a floating penguin! (Hint: Look at an object far away from you. Look at an angle.)

WRAP-UP:

1. Gather outside of the Color Visualizer (look out for the giant, light up flower petals) in the *Color of Life* exhibit, at the panel titled "Just Traveling Through"

Teacher Tip: You may want a teacher or chaperone stationed at the Color Visualizer to have this discussion as students come through with their chaperone or move to the Color Visualizer as a group once all students have finished sketching the penguins.

2. Draw students' attention to the photo of the hand and starfish in the touch tank.
3. Ask students guiding questions to discuss what they observed:
 - » How is this similar to what you saw when you were observing the penguins?

- » What do you notice?
 - » Does the part of the penguin above the water looks different than the part below the water?
 - » Do the two parts of the penguin look like they're not connected, or that they are in different places?
 - » Does the penguin looks cut in half - like the fingers in the photo?
4. Read or have students read the large text on the poster. Define this bending of light as refraction.
 5. Ask students:
 - » Why are we able to see the penguins, or the hand, or the starfish at all?

Light from the lamps in the Hall and in the penguins' habitat reflects, or bounces, off of the penguins and into our eyes.

Teacher Tip: If students are having trouble thinking of how we see with light, look to the left at the panel titled "The Path of Light".

Activity 2: Touch pool challenge!

1. Make your way down to Discovery Tide Pool in the aquarium.

Teacher Tip: Discovery Tide Pool is open from 10am-4pm

2. In pairs, students pick an object **far back** in the tank to observe (Starfish or Abalone Shell). Instruct them to look at the object or animal and select a spot on the object they will want to touch.
3. The challenge is to try and touch the spot. When touching the object they are going to use **two fingers** and point them straight down. Remind students: Keep fingers straight and try touching the spot when looking from above and below the water line.

WRAP-UP:

Ask students to discuss with a partner:

- » Which view made it easier to touch the spot?
- » Why do you think that view was easier to touch the spot?
- » Where would you need to be to observe NO difference between where your finger hit and your spot?

Activity 3: Do animals experience refraction?

1. Remain in the aquarium. In groups of 2-3 have the students choose an animal on exhibit that has an adaptation and/or strategy related to refraction.
 - » Archer Fish (*Water Planet*)
 - » Burmese Vine Snake (*Water Planet*)
 - » Splashing Tetra (*Animal Attraction*)
 - » Four-eyed Fish (*Amazon Flooded Forest*)

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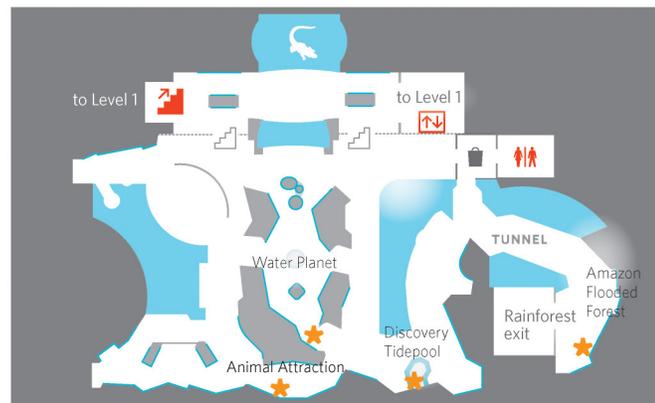
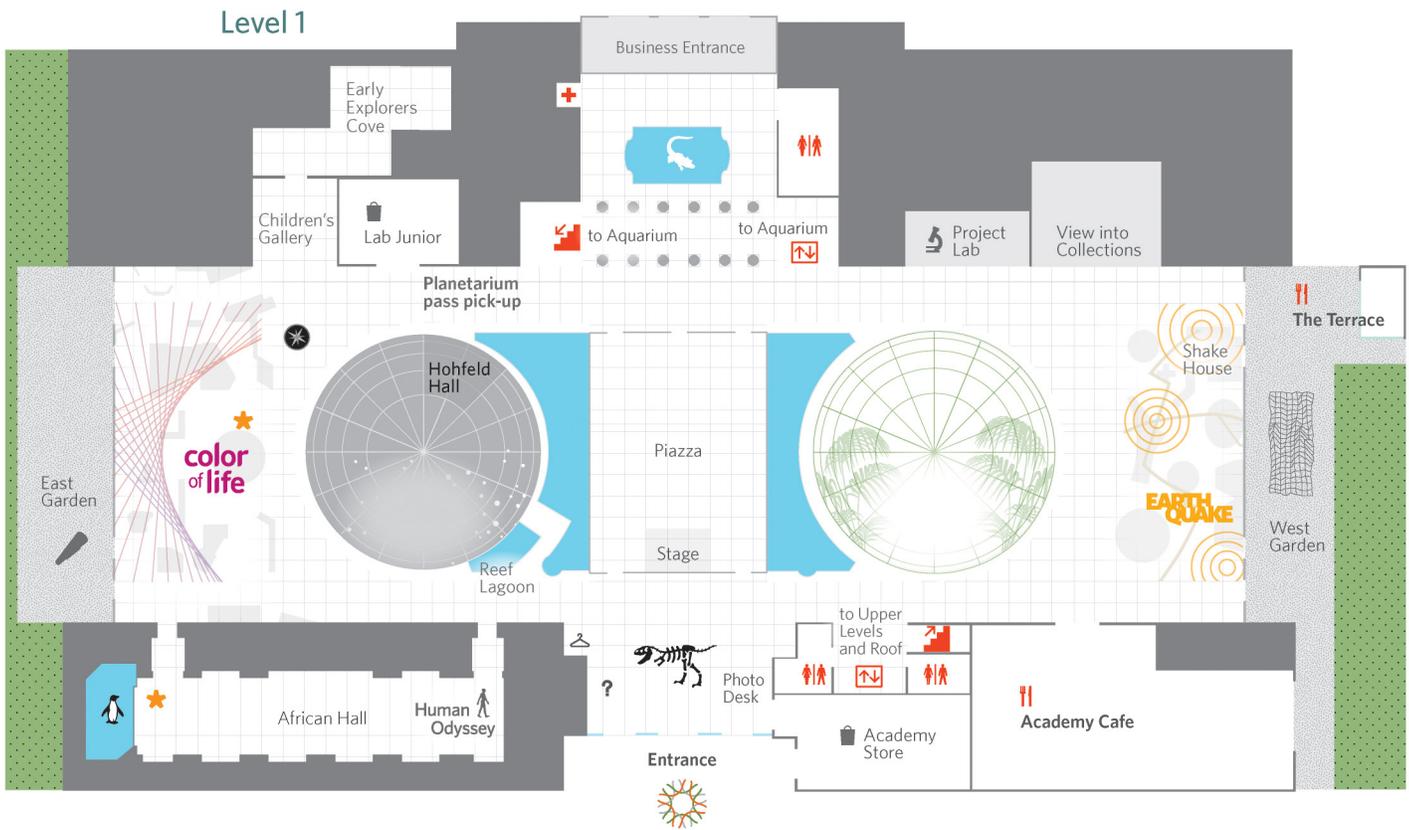
2. Visit the animal. Encourage the students to observe it for **2 minutes**.
3. Give time for students to hypothesize how the animal experiences refraction.
3. If time permits, tell the students to visit the other animals in the aquarium that experience refraction.
4. If time permits, make your way back to Color of Life and the Color Sources area. Read the information panels to discuss refraction more.

WRAP-UP:

1. Read or have the students read the information, next to the exhibit, about the animal to answer the questions on their scavenger hunt worksheet.
2. Ask the students: How has this animal adapted to use refraction?

Extension: In pairs, students continue on to the cylindrical Mangrove Tank, near the Reef Lagoon (on the first floor) to observe and sketch the Chocolate chip sea stars from above and below the water.

California Academy of Sciences Map



Lower Level | Aquarium

NEXT GENERATION SCIENCE STANDARDS

| Science and Engineering Practices | Disciplinary Core Ideas |
|--|---|
| <p>Asking Question & Constructing Explanations</p> <p>3-5: Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.</p> <p>6-8: Ask questions that arise from careful observations of phenomena, models, or unexpected results to clarify and/or seek additional information.</p> <p>Developing and Using Models</p> <p>3-5: Develop and/or use models to describe and/or predict phenomena.</p> <p>6-8: Develop and/or use models to describe and/or predict phenomena.</p> | <p>4-PS4.b</p> <ul style="list-style-type: none"> An object can be seen when light reflected from its surface enters the eyes. <p>Middle-PS4.b</p> <ul style="list-style-type: none"> The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends |

RELATED PERFORMANCE EXPECTATIONS

Remember, performance expectations are not a set of instructional or assessment tasks. They are statements of what students should be able to do after instruction. This activity is just one of many that could help prepare your students to perform the following hypothetical tasks that demonstrate their understanding:

4-PS4-2 Develop a model to describe that light reflecting from objects and entering the eyes allows objects to be seen.

[*Assessment Boundary:* Assessment does not include knowledge of specific colors reflected and seen, the cellular mechanisms of vision or how the retina works.]

CALIFORNIA SCIENCE CONTENT STANDARDS

Grade Three

Physical Science

2. Light has a source and travels in a direction. As a basis for understanding this concept: (c) Students know the color of light striking an object affects the way the object is seen. (d) Students know an object is seen when light traveling from the object enters the eye.

Grade Seven

Physical Principles in Living Systems

6. Physical principles underlie biological structures and functions. As a basis for understanding this

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concept: (b)Students know that for an object to be seen, light emitted by or scattered from it must be detected by the eye. (c)Students know light travels in straight lines if the medium it travels through does not change. (f)Students know light can be reflected, refracted, transmitted, and absorbed by matter.

COMMON CORE STANDARDS

Grade Four - Five **ELA** RI.4, RI.9, SL.1

Grade Six - Eight **ELA** RI.4, SL.1, SL.4

REFERENCES

FACTS & FIGURES

Figure 1 & Figure 2 are based off images from Hyper Physics

Hyper Physics. (2012). *Refraction of Light*. Retrieved June 19, 2015, from <http://hyperphysics.phy-astr.gsu.edu/hbase/geoopt/refr.html#c1>

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