How Can Squid Eyes Help Us Understand Light?

Introduction

Light, even though it is all around us all the time, is an active area of research. It might seem odd that we still have so much to learn about something that's everywhere all the time, but light is weirdly complex. It's a form of **electromagnetic radiation,** of course, but it's special—so special we can't even decide on whether it behaves more like a wave or more like a particle because that depends on the situation.

Light behaves like a particle when it does things like excite electrons in a molecule, but we often describe it like a wave when it does something like interact with lenses**.** A **lens** is a transparent object with at least one curved surface. Lenses bend, or **refract** light, because the density of the lens is different than the density of the air or other medium around it.

Most animals have at least two lenses, one in each eye, that bend and focus light enabling the animal to see. Most humans have a lens in each of eye, which works by focusing light onto their retinas. The lens contracts to change how curved it is, allowing us to see things that are closer and farther away. If the light is not focused properly on the retina, a person's vision can appear blurry. We fix this by giving them contacts or eyeglasses that use an additional lens to help refocus the light.

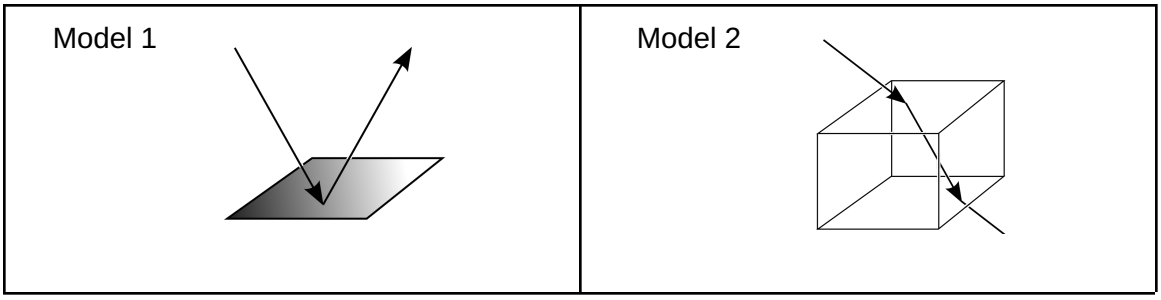
In this lesson, we'll explore light's interactions with lenses and meet a fascinating animal with very special lenses and learn about how scientists are eager to try and replicate their optic success in the lab. Ready to get squiddy with it?

What To Do

Answer the analysis questions below, reading the Bite when instructed

Analysis Questions

1. Look at the two models below.



a. Which model represents refraction? Explain your reasoning.

b. Describe the property represented by the other model.

2. Look closely at this picture of a human eyeball.

a. Describe what happens to light that enters the front of the eye.

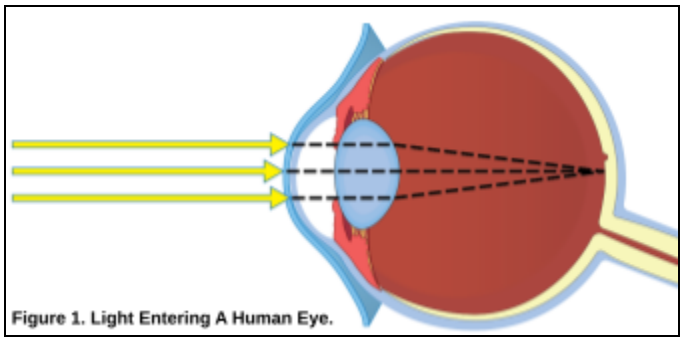


Figure 1. Light Entering A Human Eye.

b. What does this suggest about the density of the human eye vs. the density of the air around the eye?

3. Get a laminated paper with writing, water, and a plastic pipette from your teacher. Place a small drop of water on a piece of the paper with writing.

a. What happens?

b. What do you think is happening to the light waves as they leave the water and enter the air on their way back to your eye? Explain your answer.

4. Red light has a frequency of 4.3×10^{14} Hz. Recall that the equation for the speed of a wave, v, is $v = f \lambda$ and light travels through air at a velocity of 3.0×10^{8} m/s.

a. Calculate the wavelength of red light as it travels through air.

The red light now hits a puddle in the road.

b. The frequency of light does not change through different mediums; however, the density of water is higher than the density of air, so the red light will slow down to 2.25 x 10^8 m/s. Using the equation $v = f \lambda$, calculate the new wavelength of the red light as it travels through water.

c. From your calculations above, what relationship do you see between the density of a medium and light's speed?

d. Based on the equation $v = f \lambda$ and your answer above, what is the relationship between the density of a medium and light's wavelength?

STOP & read Science Bite: Squid Reveal the Secret to "Perfect" Lenses

5. Let's connect the relationship you observed between the density of the medium and light speed to the spherical lens of a squid's eye. Examine **Figure 3** in the Bite.

a. What happens to the density of the eye from the outer to inner layer?

b. Based on your answers above, how would the speed of the red light change as it moves from the outer to inner layers of the eye?

c. How would the wavelength of the red light change as it moves from the outer to the inner layers of the eye?

d. The light also leaves the lens, how would its speed and wavelength change as it moves from the inner to outer layers of the eye?

6. Your friend says, “A spherical lens is nothing special! Human eyes are spherical!” What would you say to help correct their understanding?

7. **Figure 3 i**n the Bite shows the squid eye directing light to a single point, focusing an image. How does a squid’s anatomy support this “perfect” lens?

8. Based on the Bite, what advantage do you think spherical lenses give squid? *Hint!* Think about their environment.

9. What benefits would there be to being able to synthetically produce a perfect lens, like a squid’s eye?

10. **Connect to the Big Question.** What do you think motivates humans to study things they don’t understand? Based on what you read in the Bite, why can that be helpful to humanity?