SCIENCE·3D

CANOPY CRITTERS

In this packet, sample student answers are provided in red and notes to teachers are in blue.

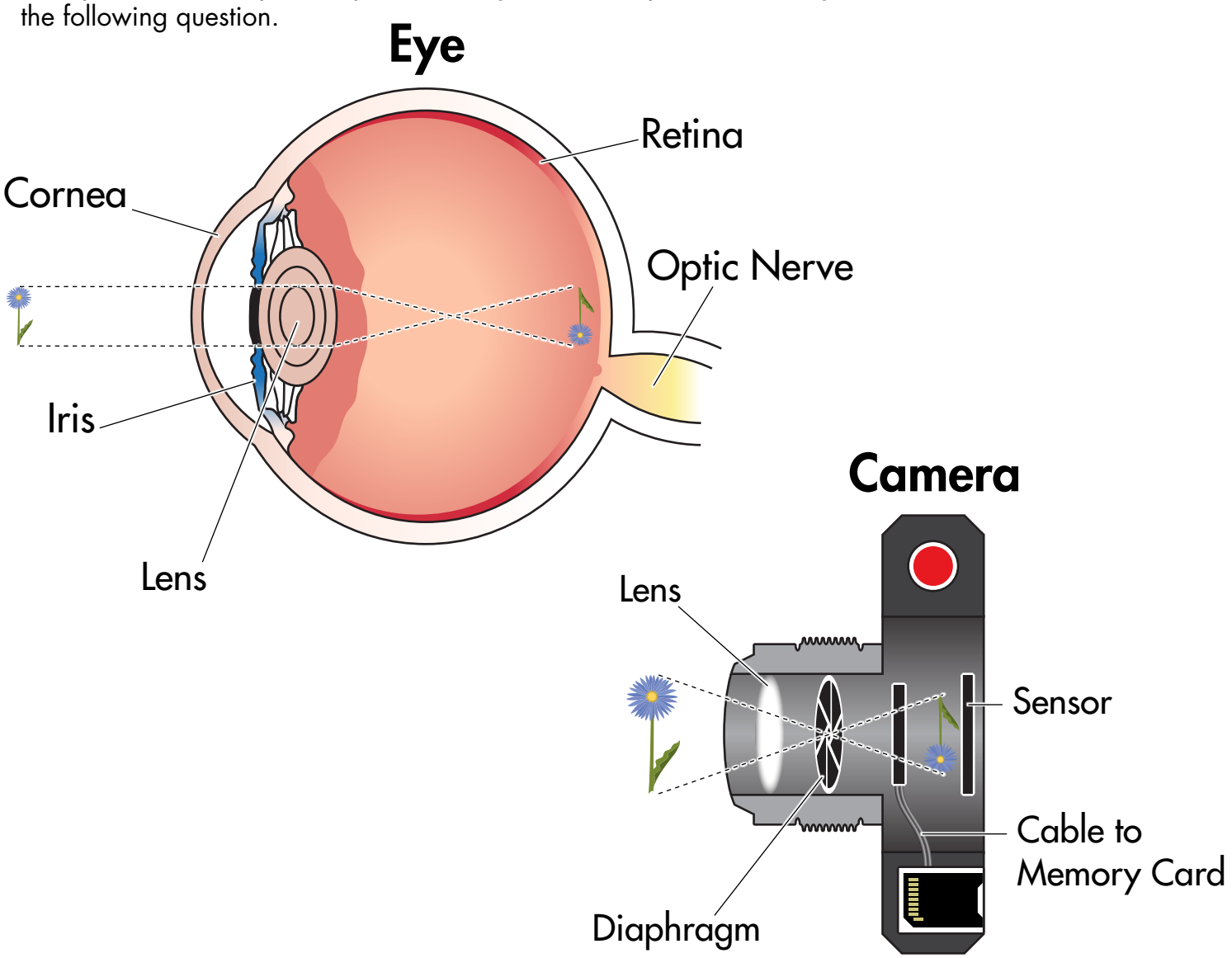
In this **STEM Project**, students will compare and contrast the structure and function of animal eyes and camera systems. They will use what they learn about vision to come up with ideas for new camera systems. Then, they will use inspiration from rainforest plants to come up with ideas on how to build stable structures. Finally, they will devise ways for scientists to work in the canopy.

Plants and animals are adapted to their environments. They have traits that help them solve the problems in their lives. An engineer's job is to design and build solutions to problems. Sometimes engineers try to copy solutions found in nature. Let's explore and design!

Activity 1: Animal Vision and Cameras

Animal eyes use electromagnetic radiation to sense the environment. The different parts of the eye make up a system that collects light and transmits signals to the brain. Then the brain processes the information. It forms memories and tells the body how to respond. Canopy animals need to have good vision to get around and avoid becoming a meal.

Eyes collect light that bounces off objects in the environment. The light hits the outer layer of the eye called the cornea. The colored part of the eye is the iris. It controls how much light enters the eye through the lens. The lens focuses light on the retina at the back of the eye. The image that hits the back of the eye is actually flipped upside down as the light bends through the lens. The retina has light receptors that detect the light and the optic nerve sends information to the brain. Cameras are like eyes in some ways. Compare the diagram of the eye with the diagram of the camera to answer the following question.

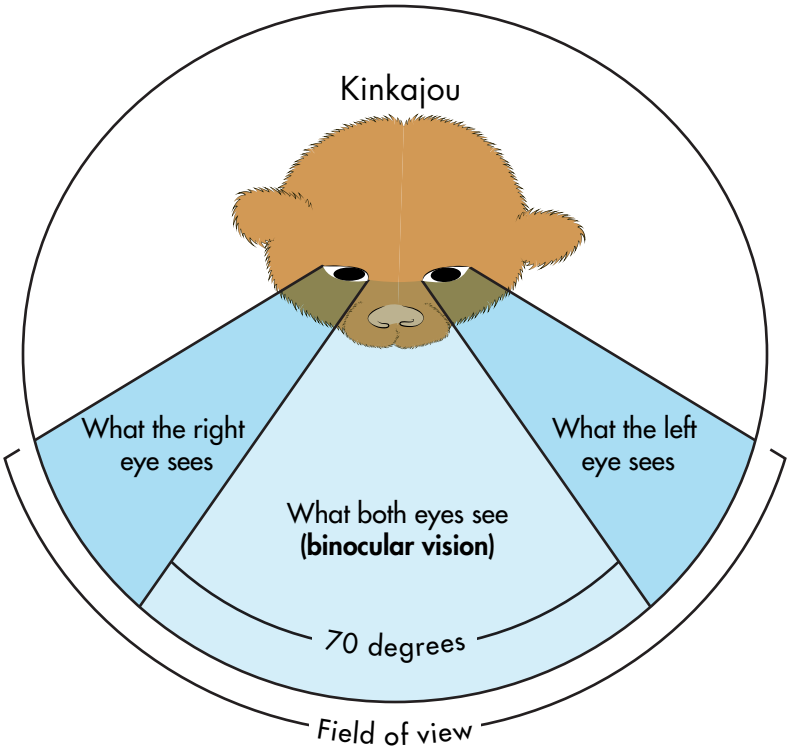


1. **Describe** how the camera functions like an eye. Include a description of the parts of the camera that function like the parts of the eye. Alternative: conduct this question as a class discussion. This should reinforce the functions of the parts of an eye.

Like an eye, the camera detects light and transmits that information. The lens of the camera is like the lens of the eye. They both focus light. The diaphragm is like the iris. It controls how much light comes into the camera. The sensor is like the retina, and the cable is like the optic nerve that transmits the information. The brain is like the memory card that records and stores the images.

Just sensing electromagnetic radiation is not enough. With only one camera (or one eye), it's impossible to tell how far away an object is. It narrows the field of view, or distance, that can be seen on each side. How do animals solve these problems? To determine how far away things are, animals need more than one eye that can see the same thing from slightly different angles. This is called binocular vision. The ability to determine how far away objects are is called depth perception. Depth perception is made possible by binocular vision. Here's how it works.

Binocular Vision



To have binocular vision over a big area, animals need to have their eyes close together. This means that they can't see very far to either side. They have a narrow field of view. Peripheral vision is how far to the side an animal can see when it looks straight ahead.

It turns out that there is a trade-off between peripheral vision and binocular vision. When eyes are close together, the area each eye sees overlaps a lot. This causes the animal to see less to its sides. If an animal has its eyes on the sides of its head, it may be able to see behind itself. But, it won't have good depth perception!

2. **Describe** what kinds of animals might need better binocular vision. Remember, this means better depth perception and a narrower field of view.

Accept any reasonable answer. Best answers include predators needing binocular vision to be able to catch prey. They may also suggest that binocular vision would be very useful in the canopy, where depth perception is needed to reach branches properly.

3. **Describe** what kinds of animals might need better peripheral vision. Remember, this means a bigger field of view and less depth perception.

Accept any reasonable answer. Best answers include animals that are prey. They need to be able to see predators before they sneak up on them.

Extend the Lesson: Have students test their hypotheses from their answers in questions 2 and 3. Conduct research online or in magazines and books to explore the eyes and vision of different animals. Before they start, have students think about the characteristics of animals they would want to record, such as where they live or whether they are predators or prey. Have students make a table to record their observations.

4. Based on what you learned about binocular vision and field of view, draw a camera system that might function the way a pair of eyes functions. Label your drawing with descriptions of the function of each part you draw. Label the field of view and any areas with binocular vision.

Designs may vary, but will probably include two or more camera lenses. They may both point forward to mimic binocular vision or be on opposite sides to mimic a broad field of view. Students should label drawings to show the possible fields of view the cameras have or areas where the vision overlaps.

Activity 2: Stand Up Tall!

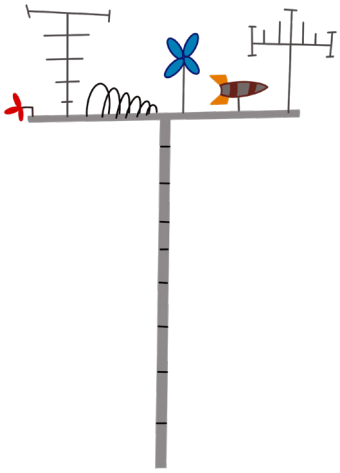
Can you think of any problems the trees in the canopy might have? They need to stay standing up! That is not easy when they grow so tall and have to support the weight of their trunk and branches far above the ground. Even worse, when the wind blows the leaves and branches in the canopy, it puts pressure on the tree to fall over!

Most plants are supported by their trunk or stem, but their roots keep them from falling over. Taller plants usually have roots that grow deep and extend far out to the sides. That helps them hold on to the ground. This doesn't work in the rainforest! Roots can't go deep because there are not enough nutrients down deep. And, with so many other trees, their roots can't go too far to the sides.

Here's how many canopy trees solve this problem!

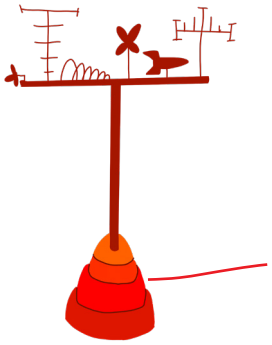
Canopy trees have buttress roots. They provide a wide base for support to keep the tree upright.

Your challenge: You have a tall tower with scientific instruments on top that extend out to the sides. The tower needs to be able to stand up without falling over. The tower looks something like this:



1. **Draw** a solution for how you will get the tower to stand up. Label your diagram to show the function of each part of your design.

   Answers will vary. Expect students might draw a wide base similar to the buttress roots. An example is below.



2. **Describe** where you got your ideas for how to design the system to keep the tower from falling.

   Answers will vary. Best answers will make a connection with the wide buttress roots that keep the canopy trees upright.

3. **Describe** one real-world situation in which engineers had to be sure that a narrow and tall structure was able to remain standing, even when they undergo stresses like winds or earthquakes.

   Accept all reasonable answers. For example, students might describe designing tall buildings, light houses, telephone poles or cell towers.

Extend the Lesson: Bring the problems to life! Have students build tall towers out of narrow blocks. Have them use materials they can find in the classroom or around their homes to get the tower to stand up or withstand being pushed on. You could also make the challenge to stand a pencil up on its eraser. Students may think about building wide bases, creating anchors, or using wires.

Activity 3: Dream Up a Plant!

Canopy animals have no trouble getting into the canopy, moving around, and finding food. But for people, it is very hard to study these animals! Here is your challenge: Learn more about kinkajous and their behavior. Find out about their social lives. Explore what goes on inside the dens where they spend their days. Observe their behavior at night.

In the space below, dream up a way to study the lives of kinkajous. You can write or draw diagrams to describe your plan. Include notes and labels that explain your drawings. You can dream up new technologies that don't even exist! Be sure your plan includes information on how you will get people or technology up into the canopy.

This is all about creativity and dreaming up solutions. Have students think about how they would use existing or develop new technology. It might include cameras on kinkajous, in the trees, on drones, or something else entirely. It could involve night vision cameras. It could include tracking kinkajous, or people spending time in the canopy during the day and night. To extend, have students go through the engineering design process and list criteria and constraints for their project.

Consider having students present their ideas to a small group or the class. Have them talk about or vote on which ones they think are most likely to work! Have students provide feedback and then make improvements to their designs and plans. This will reinforce the iterative nature of the design process and the importance of teamwork.

Extend the Lesson: Have students create a glossary of new terms or terms you identify for them.