Teacher Materials

In their work in the Camera Obscura Program, students have the opportunity to experience many of the properties of lenses and explore two kinds of devices that control light, the camera obscura and the projector.

The follow-up experiences are designed to give students and teachers an opportunity to apply more formal scientific terms and inquiry skills to to the experience provided by the program.

As a follow-up to the Camera Obscura Program, you might:

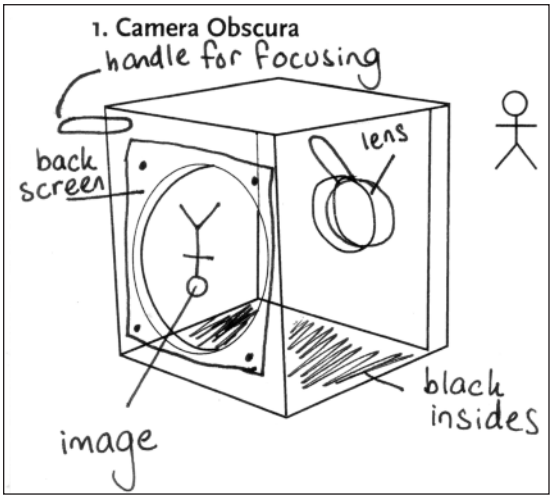
- Have students record what they observe about their cameras and how they work in their science notebooks.
- Have students draw diagrams that show how each device works (Student sheet questions 1 & 2).
- Work with students to represent light rays using arrows to explain how the camera obscura and projector work (Example: page 4, How Does a Camera Obscura Work).
- Have students identify where light is reflected, absorbed, and refracted in the devices (Student sheet question 3).
- Have students apply their understanding of how the projector works to predict improvements that might be successful (Student sheet questions 4 & 5).
- Help students to understand why lenses are so useful by having them compare their camera obscura to a pinhole camera (page 3, Pinhole Camera Investigation)

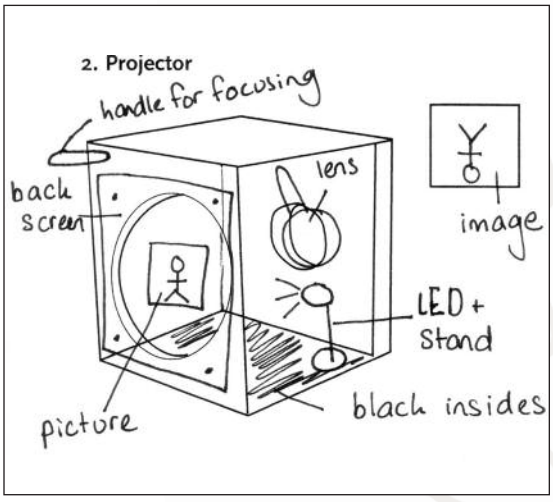
Using the student sheet with your students

Questions 1 and 2: Drawing Diagrams

These questions support students in representing their devices using diagrams, which help others see what the important parts are and how the devices work. Students can be reminded to draw simple representations of each part and to show what they see will look like. Advanced students can be encouraged to add any important parts not listed at the top of the page or to represent light rays using arrows.

Example correct diagrams:





Question 3

Optical devices control where light is light through, reflected, absorbed, and refracted.

Reflected: Light is reflected off the object that you look at when you use a camera obscura. It is reflected off of the picture placed at the back of the camera when you use the projector.

Absorbed: Stray rays of light are absorbed by the black insides of the camera obscura and projector.

Refracted: The lens of the camera obscura and projector refract light.

Question 4

This question challenges students to use what they know about what is happening to light in the projector to make predictions about a proposed improvement. To make accurate predictions, they need to remember that light has to reflect off the picture and then consider the reflective properties of each material.

- *Clear plastic*: The light will go straight through the plastic; no light will be reflected off the picture. This material will not work.

- *Aluminum foil*: Aluminum foil is highly reflective and produces a very bright image. Some students may think that this is too reflective; that all light is bounced off it and no image will show. This is a thoughtful response; challenge students to try it to test their ideas.

- *Thick blue paper*: This paper will absorb most of the light, producing at best a very dark image.

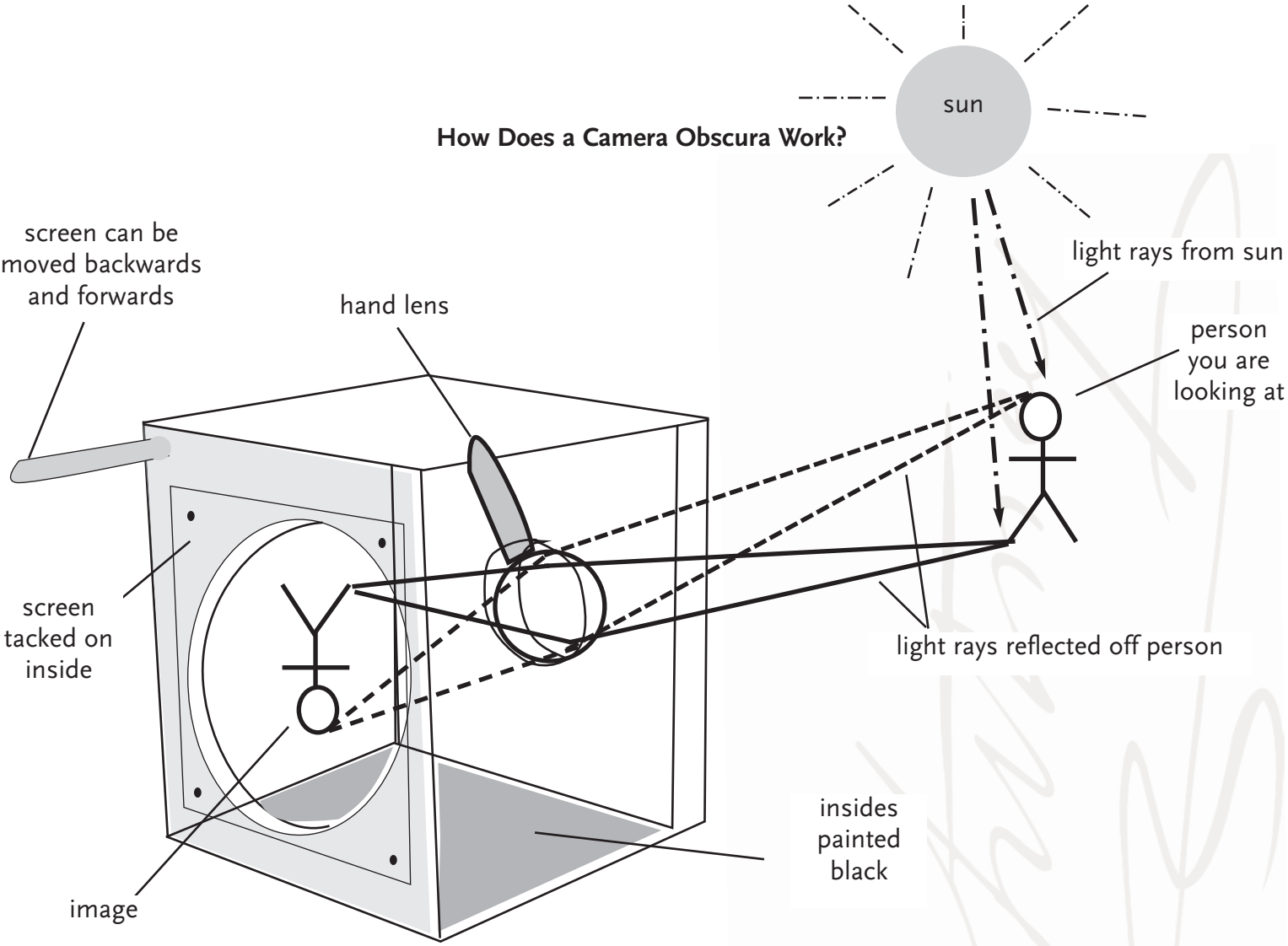
Question 5

Challenge students to focus on what they know about light and how their projector works to think about possible improvements. Students with a higher level of understanding will choose improvements that increase the light reflected off the picture or that block stray light.

Some ideas might include:

- Using the projector in a dark room.
- Drawing a smaller picture so that the entire picture falls in the area on the screen that receives the brightest light.
- Using two or more lights.

How Does a Camera Obscura Work?



A camera obscura captures the image of an object in front of you on a screen at the back of the camera. If you are looking at a person, light rays coming from the sun or overhead lights are reflected off that person. Some of the light rays travel through the lens at the front of the camera. The lens refracts, or bends, the rays of light. This causes the rays of light to travel through the camera toward the back screen. Then the rays of light hit the screen at the back of the camera, which allows you to see an image. When you move the screen to the correct place, the image you see is in focus, or clear. But the image that you see is always upside down and backwards, because of the way that the lens bends the light rays.

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Pinhole Camera Investigation

We have designed the project below to provide an opportunity for students to develop inquiry thinking skills as they use their cameras and further explore concepts of light. We have based our investigation on Curriculum-Embedded Performance Task model. Students have an opportunity to explore a different camera set-up, pose a question that can be answered with methodical research, conduct an investigation, and communicate their findings. Comparing results with the pinhole camera to the camera obscura with lens is especially useful in helping students to think about what lenses do and why they are important.

As with other investigation experiences, we expect that students will need support to structure their exploration, investigation, and writing. We encourage you to adapt the investigation below to fit your classroom routines and students' needs.

Student Investigation

- You can use your camera body to make a pinhole camera – a camera that projects an image without using a lens.
  You will need: squares of aluminum foil, tacks or tape to secure the foil, and a pointed object to make a hole in the foil.
  1. Remove the magnifying glass from your camera
  2. Tape or tack a square of aluminum foil (about 2 x 2 inches) over the open circle in the camera body
  3. Using the tip of a pencil, a tack, or other pointed object, poke a *small* hole in the tinfoil so that it is in the center of the open circle.

- Use your camera and observe how it works.
  Does it project an image?
  How is it similar to and different from the image projected by your camera obscura?

- Talk with other students and compare their cameras and findings to yours. Try to construct an explanation.
  Why do you think that the pinhole camera works the way it does? What do you think is happening to light as it is reflected by objects and passes into the camera?

- Now, think of some of the variables, or things that you can change about your pinhole camera and how you use it. Make a list of the things that you could change.

- Choose one variable, or thing to change, that you can easily do. Design an investigation that will allow you to find out whether this variable is important in how your pinhole camera works.

- Conduct your investigation. Then describe and analyze your findings and construct an explanation. *What did you discover about the way that the pinhole camera works? Why does this make sense given what you know about light?*

Notes for teachers:

A pinhole camera creates an image because light rays enter through a very small hole, meaning that only a small number of the light rays reflected off an object are allowed through the hole. This creates a projection on the screen. Like the camera with a lens, the image is upside down. As you make the hole smaller, the image will become sharper; however, less light will enter, making the image darker and harder to see. Moving the screen closer or farther from the lens will not bring the image into focus; with the size of the hole students will be able to make, the object can never be brought fully into focus. Pointing the camera at more and less bright objects will make a difference. Using the camera in a dark room and pointing it at a brightly illuminated object will project a clearer image.

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