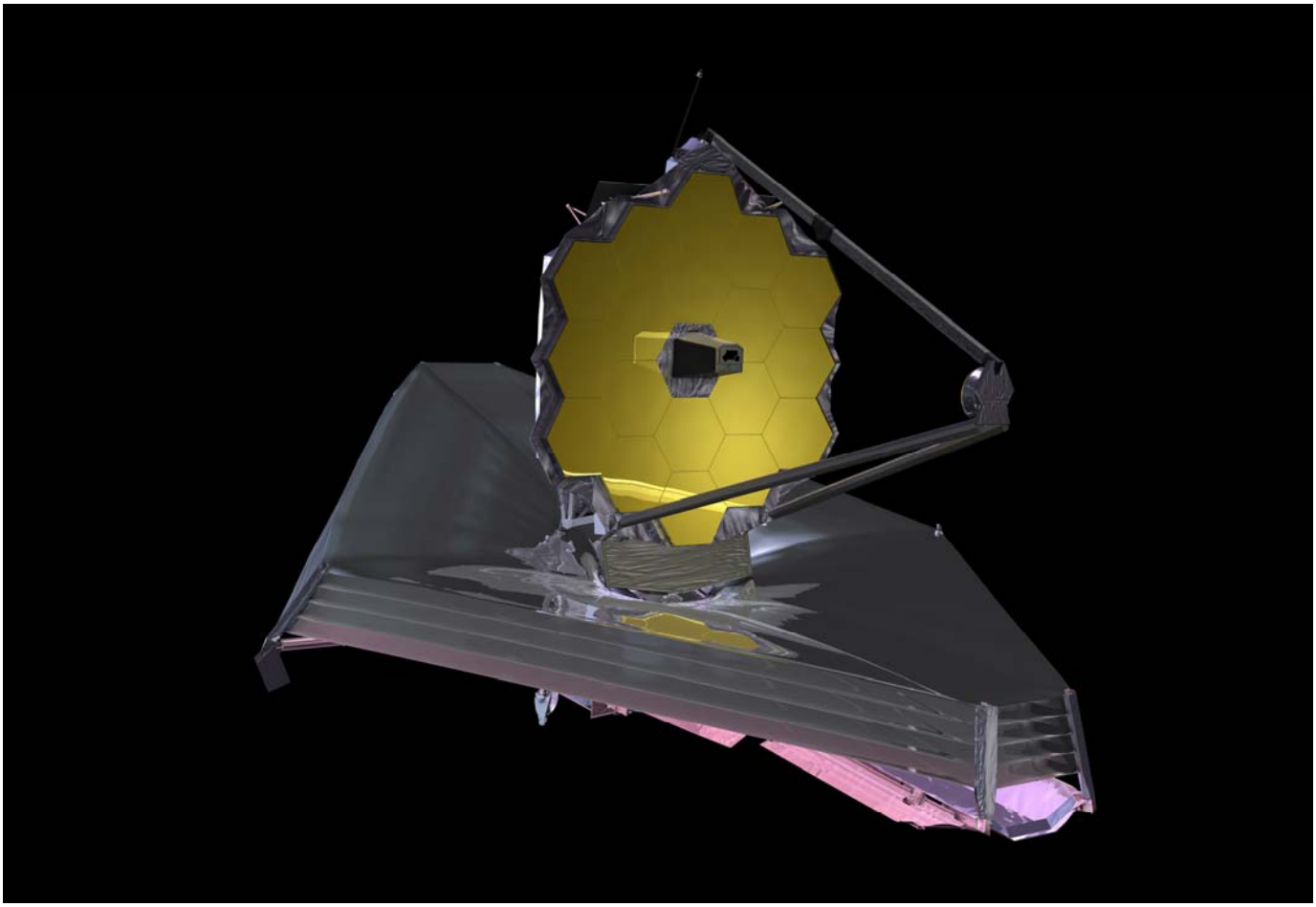
TAKING A CLOSER LOOK

Examining Light and Telescopes



Northrop Grumman Aerospace Systems

Taking a Closer Look

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OVERVIEW

Brief Description of the Activity

In *Taking a Closer Look*, students will explore how lenses gather and focus light by examining images using magnifying glasses and telescopes.

Appropriate Ages

Taking a Closer Look is appropriate for students in grades 3 to 9.

Time

Taking a Closer Look can be presented in approximately 1 hour.

Preparation Prior to Presentation

Assemble the telescopes students will be using during the activity. Tape a straw along the top of the telescopes to use as a sighter, being careful to only tape the straw to one of the two tube parts.

Practice with the telescopes to get a feel for how they operate and where the focus is. Draw a line on the telescope tube at the focus position.

Read and become familiar with the background information presented in this activity. Be able to explain how magnifying glasses and mirrors bend light to create a virtual image, and how refracting telescopes gather and bend light to create a magnified image of a distant object.

Student Outcomes

Students should be able to explain that:
1) Mediums such as water, glass and plastic focus, or refract, light.
2) Surfaces such as mirrors bounce, or reflect, light. We see most things around us because of the light reflected off them.
3) Telescopes work by gathering light with either a lens or a mirror and creating a magnified image.

During the presentation of *Taking a Closer Look*, review the above concepts often with the students. The Northrop Grumman handouts can be used to reward correct answers or insights about the primary ideas.

SUPPLIES

Materials for Each Student

Telescope Worksheet
One set of colored pencils, 4 to 8 pencils per set
One assembled telescope

Materials for Each Student Group

1 clear drinking glass
1 brightly colored straw
1 Chandra poster
1 JWST poster
1 locker mirror

Materials for the Presenter

33 telescopes, one disassembled and displayed in a box
8 magnifying glasses
1 plastic bucket
8 clear plastic drinking glass
1 bottle of water
40 brightly colored straws
2 small *How Does a Telescope Work*? display cards
1 large *How Does a Telescope Work?* display card
2 MOM cards for display, positioned between 5 and 10 yards from the where the students will be standing
1 large poster of the current project for display (e.g. large JWST poster)
30 Northrop Grumman handouts to present to students

Telescope Purchasing Information

The following telescope kits are available from www.starlab.com
PS-04B: Refracting Telescopes (set of 10 bulk) - $50.00
PS-04B/Single: 1 Complete Telescope Kit - $9.00

The 10-Telescope Kit includes (10 of each unless noted):

- foam holders, cardboard spacers and washers for the eyepiece lenses
- red plastic caps, cardboard spacers for the objective lenses
- plastic lenses (43mm diameter, objective, 400mm focal length)
- plastic lenses (17.5mm diameter, 25mm focal length)
- inner and outer tubes
- 1 set of instructions & activities

STANDARDS MATRIX

This activity aligns with the California science content standards.

Kindergarten
Investigation and Experimentation 4 a,b,c,e
Grade 1
Investigation and Experimentation 4 a,b
Grade 2
Investigation and Experimentation 4 a,g
Grade 3
Investigation and Experimentation 4 g
Grade 4
Physical Sciences 2 b,d
Investigation and Experimentations 5 g
Grade 7
Physical Sciences 6 b,c,d,f,g
Grades 9-12
Investigation and Experimentation 1 d

This activity supports the following national science content standards.

Grades K-4
Content Standard A: Science as Inquiry
Content Standard B: Physical Science
Content Standard E: Science and Technology
Grades 5-8
Content Standard A: Science as Inquiry
Content Standard E: Science and Technology
Grades 9-12
Content Standard A: Science as Inquiry

SCIENCE CONTENT

History of Telescopes

The invention of the telescope is often attributed to Hans Lippershey, an optician who, in 1608, aligned two lenses of different curvatures and focal lengths. It is not known how Galileo Galilei heard of the process, but there is evidence that Galileo quickly bought or ground his own lenses and made a simple telescope that he demonstrated in 1610 to the Senate in Venice. Galileo is credited with discovering four of Jupiter's moons, crater walls on Earth's moon, Venus' phases, sunspots, and Saturn's rings. The telescope that Galileo designed over 400 years ago is very similar to the ones students will be using in this activity.

Regardless of type and complexity, all telescopes operate in basically the same way. Telescopes capture light and provide a detailed image to the viewer. Our eyes are telescopes, as are cameras, satellite dishes and radio telescopes.

How Do Telescopes Work?

Telescopes have two main parts: the first lens and the second lens. The first lens is called the objective lens and the second lens is called the eyepiece. Telescopes that use only lenses are called refracting telescopes, or refractors. The telescopes used in this activity are refractors. Some telescopes use a mirror, called the primary mirror, in place of the first lens. These are called reflecting telescopes, or reflectors. Most professional telescopes are reflectors.

The objective lens (or primary mirror in reflectors) collects light from a distant object and brings it to a point or focus. The image is bent, or focused, on a small surface called the focal plane. The eyepiece is a magnifying glass. It focuses the light from the image at the focal plane so the observer sees a larger, magnified image.

A typical refractor

Image from http://www.ulo.ucl.ac.uk/public/telescope-guide/

Refractor

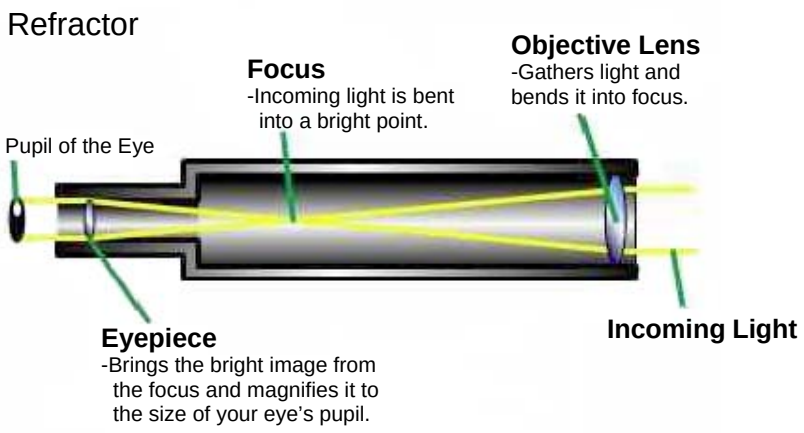
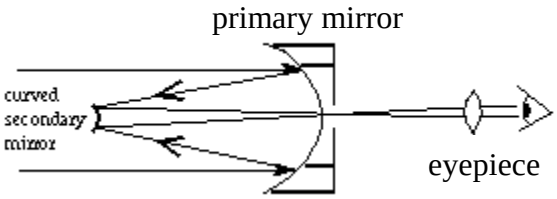


Image from http://www.science.howstuffworks.com/telescope1.thm

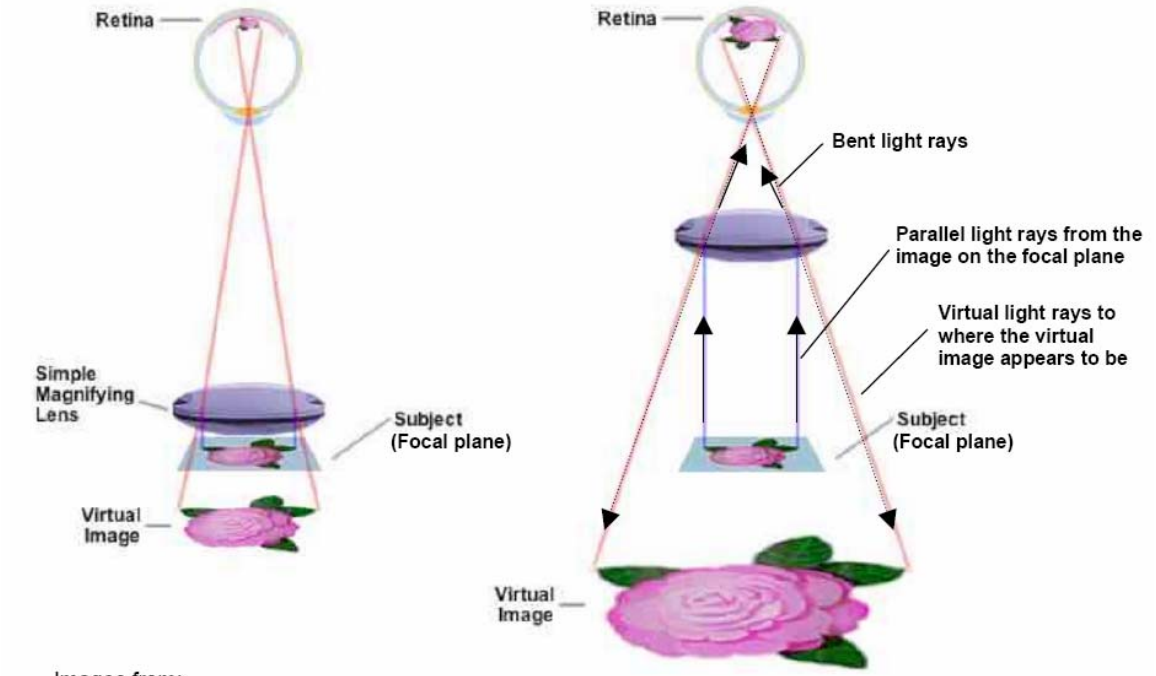
Most professional telescopes are reflectors. The main advantage of reflectors is that they can be made very large because the back of the mirror can be supported. Another advantage of reflectors is that there is no chromatic aberration, a feature of refractors where the different wavelengths of light pass through the lens at different speeds and produce a rainbow-like halo around the image. A third advantage of reflectors is that only one side of the objective (the reflecting side of the primary mirror) needs to be the right shape and smoothness to reflect the light. Because light passes through a lens, however, it needs to be perfectly shaped on both sides.

Reflector



How Does a Magnifying Glass Work?

Magnifying glasses work by focusing light to create a virtual image in a location other than it would appear if the light were not focused. Just like you can see a “virtual you” who appears to stand back in the depths of a mirror, an observer sees a larger, virtual image cast by the light bent through a magnifying glass. The real image is cast on the observer’s retina, not out beyond the focal plane. To the observer, however, the image appears to be some distance beyond the surface of the magnifying glass. Magicians often take advantage of virtual images to make objects seem to appear in a seemingly empty box, or to look like they are hovering in mid air.



Images from:
http://micro.magnet.fsu.edu/primer/java/scienceopticsu/microscopy/simplemagnification/index.ht

Professional Telescopes

Astronomers use telescopes (mostly reflectors) that observe across all wavelengths of light, from low-energy radio and microwave light to high-energy gamma rays and x-rays. The image below is of the complete light spectrum.

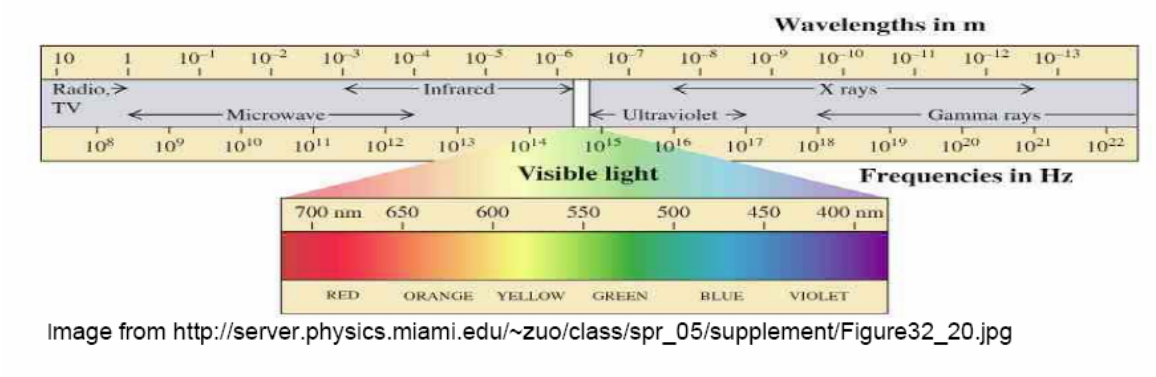
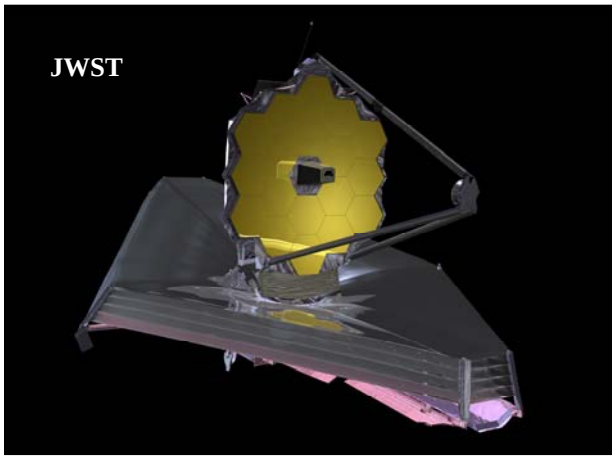


Image from http://server.physics.miami.edu/~zuo/class/spr_05/supplement/Figure32_20.jpg

There are posters of two telescopes included in this activity, the Chandra X-ray observatory and the James Webb Space Telescope (JWST). Northrop Grumman Space Technology (NGST) is the primary manufacturer of both Chandra and JWST. The Chandra X-ray observatory observes x-ray light and the James Webb Space Telescope will observe primarily in infrared light.



The James Webb Space Telescope. Notice the large golden primary mirror. JWST is a reflector and will observe mostly infrared light.

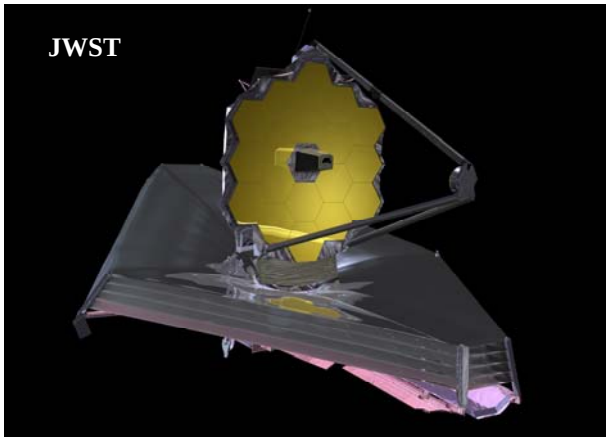
The Chandra X-ray Observatory. Notice the tube extending perpendicular to the solar panels. Chandra is a refractor and observes X-ray light.

More information on telescopes and optics can be found in the content section of the *Bringing It Closer* module at www.science-fest.org.

TELESCOPE DESCRIPTIONS

James Webb Space Telescope

The James Webb Space Telescope is a large space telescope scheduled for launch in 2013. JWST is designed to study the earliest galaxies and some of the first stars formed after the Big Bang. JWST's instruments will be designed to work primarily in the infrared range of the electromagnetic spectrum, with some capability in the visible range. JWST will have a large mirror, 6.5 meters (20 feet) in diameter and a sunshield the size of a tennis court. Both the mirror and sunshade won't fit onto the rocket fully open, so both will fold up and open only once JWST is in outer space.



The James Webb Space Telescope. Notice the large golden primary mirror. JWST is a reflector and will observe mostly infrared light.

The Chandra X-ray Observatory

NASA's Chandra X-ray Observatory was launched and deployed by Space Shuttle Columbia on July 23, 1999. Chandra detects and images X-ray sources that are billions of light years away. The images Chandra makes are twenty-five times sharper than the best previous X-ray telescope. This focusing power is equivalent to the ability to read a newspaper at a distance of half a mile. Chandra is used to study black holes, supernovas, exploded stars, and dark matter. Chandra will increase our understanding of the origin, evolution, and destiny of the universe.

The Chandra X-ray Observatory. Notice the tube extending perpendicular to the solar panels. Chandra is a refractor and observes X-ray light.

ACTIVITY #1 – What Does a Telescope Do?

The intent of this activity is for students to enact the processes used by a telescope to gather light and create a magnified image.

Directions for the Presenter

1. Hold up an assembled telescope and explain to the students that today we're going to learn about how telescopes work.
2. Take out the objective lens and hold it up. State: "First we have the objective lens. It catches and focuses light." At the same time making a catching motion with your hands, then crossing your arms to show light focusing.
3. Ask students to repeat back to you what comes first.
4. Take out the eyepiece lens and hold it up. State: "Then we have the eyepiece. It magnifies the image." At the same time spread your arms to show magnification.
5. Ask students to repeat back to you what comes second.
6. Repeat the motions with the class several times.
7. Ask the students what comes first and second throughout the presentation to remind students how a telescope works.
8. Distribute the worksheets and colored pencils to the students. Ask students to complete question #1 on the worksheet, tracing the light path for a refractor.
9. Explain that there are two types of telescopes: Reflectors and Refractors. Refractors use lenses to catch the light and focus, or refract it. Reflectors use mirrors to catch and bounce, or reflect, it.
10. Hold up the telescope and explain that this is a refractor because it uses a lens.
11. Hold up a picture of JWST and point to the mirror, stating that it is a mirror. Ask a student if JWST is a reflector or a refractor.
12. Repeat the motions used earlier, this time replacing "objective lens" with "primary mirror" and "focus" with "bounces." Cross and bounce your arms to show light bouncing off the mirror.
13. Repeat the motions for both reflectors and refractors with the class several times.

ACTIVITY #2 – Bouncing Light

The intent of this activity is for students to observe how mirrors reflect light.

Directions for the Presenter

1. Hold up a mirror at arm's length and face it, standing sideways to the class so they can see your face and part of the reflection.
2. Ask students to describe to you what you will see in the mirror. Ask them to describe which side your right eye will appear on when viewed in the mirror.
3. Explain that the light around you is bouncing off your face. Some of the light hits the mirror. Because the mirror is very reflective, most of that light bounces back and goes into your eye, so you see your reflection. Demonstrate how the light is moving by tracing your finger along the light path from your face to the mirror to your eyes.
4. Explain that another word for bouncing is reflecting. Ask students to repeat "reflecting."
5. Ask a student to explain back to you why you can see your reflection in the mirror. Ask a student to come up and point out where the light is going as it bounces off your face, off the mirror, and into your eye.
6. Ask students to complete question #2 on the worksheet, tracing the light path from the mirror.
7. Distribute the mirrors to the student groups.
8. Ask the students to examine the mirrors and describe what they see. Pose the questions "Which side of the mirror is your right/left eye on?" to help guide their description.
9. Ask a student to explain why her partner can see herself in the mirror, showing the light as it bounces off her face and the mirror.
10. Repeat with several other students.
11. Ask students to complete question #3 on the worksheet, Draw an oval around the smiley face that the observer sees using the lens. Draw a rectangle around the smiley face the observer sees using the mirror.

ACTIVITY #3 – Focusing Light

The intent of this activity is for students to observe how water and lenses focus light.

Directions for the Presenter

1. Distribute the colored straws to the student groups.
2. Ask the students to examine the straws and describe what they look like to the other students in their group. Pose the question, “Are the straws straight or bent?” to help guide their description.
3. Direct students to put their straws in their glasses and look at them again. Direct students to describe the straws to the other students in their group, again thinking about whether the straw appears straight or bent.
4. Pour water into the glasses and ask students to examine the straws again. Ask students to write a description of the straws in their worksheet, thinking about whether the straw appears straight or bent.
5. Ask the students: “What just happened?” Allow students to explore if the straw is in fact bent, or if it just appears that way.
6. Explain that water focuses, or refracts, light as it passes through the water. The focusing of the light is what makes it look like the straw is bent. This is also what makes images appear larger through a magnifying glass.
7. Ask students to students to complete question #4 on the worksheet and draw the straw in water on their worksheet.
8. (Optional) Display the card with a triple sunset on it (Card 1 on page 18). Other items such as seeds, leaves, and rocks can also be used.
    8.1. Ask students what will happen when they look at the card through a magnifying glass. Expected response: the picture will look bigger.
    8.2. Explain that magnifying glasses focus light, just like water. This is called refraction.
    8.3. Let the students hold the magnifying glass over the picture or display items and examine the magnified image.

ACTIVITY #4 – Using Telescopes

The intent of this activity is for students to use telescopes to observe how lenses focus light. Students will record and critically evaluate their observations.

Directions for the Presenter

1. Hold up the plastic bucket and ask students what buckets do. [Expected responses: collect water, hold stuff.]
2. Ask students if they would like to look through a light bucket. Hold up the plastic bucket and the telescope and explain that first lens in a telescope acts just like a bucket: it collects light. Just like a bucket with a bigger opening will collect more water than a bucket with a smaller opening, a telescope with a bigger diameter miirror or lens with collect more light than a telescope with a smaller diameter mirror or lens.
3. Point to the dissasembled telescope in the display box and explain that the first lens gathers the light from a distant object, then the second lens is a magnifying glass that magnifys the image gathered by the first lens.
4. Ask students to read the “MOM” card (Card 2 on page 18) displayed 5 to 10 yards from where they are seated. Ask students to to complete #5 on their worksheet, taking care to put the colors in the order they appear on the card.
5. Ask students to predict what will happen when they look at the card using a telescope. [Expected answers: “It will look bigger, it will be upside down.”]
6. Hand students the telescopes and ask them to look at the “MOM” card and describe what they see. [Expected response: “It says WOW!, The colors are flipped.”] Younger students may have trouble controlling the telescope and may require assistance from presenters. Volunteers can guide students’ movements by telling them which direction to move the telescope so it’s pointing towards the “MOM” card. Students can look through the straw on top of the telescope to help locate the card, then look through the eyepiece.
7. Ask students to draw what they see through the telescope in box #6 on the worksheet.

MOM card viewed by eye

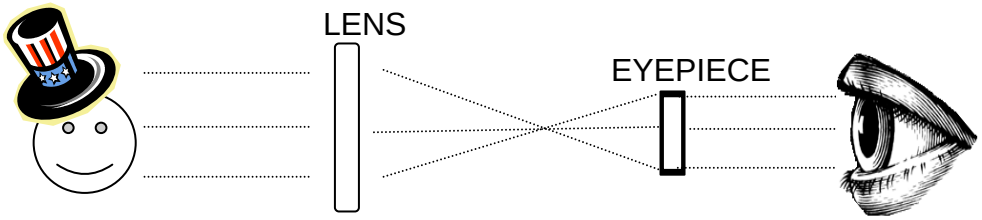
MOM card viewed with telescope

Name: _____

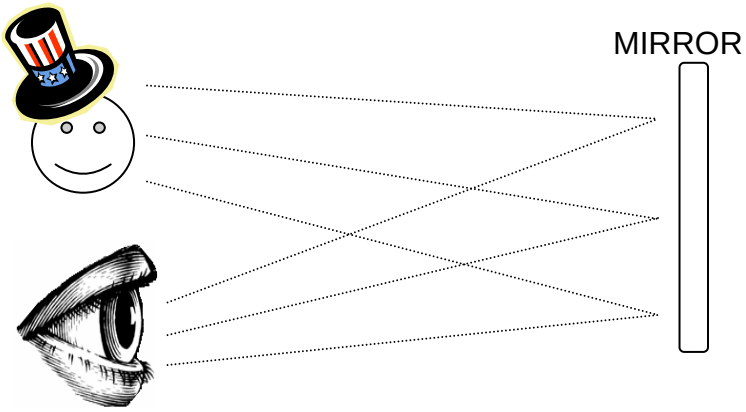
Telescopes!

Trace over the lines showing the light path from the smiley face to the observer's eye. Use a different color for each line.

1) Trace the light path for the refractor.



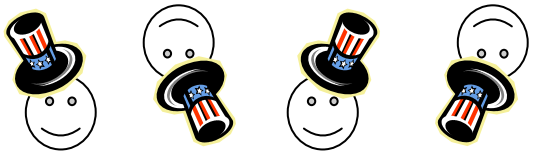
2) Trace the light path for the mirror.



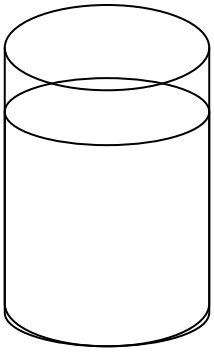
3) What does the observer see?

Draw an *oval* around the smiley face that the observer sees using the *lens*.

Draw a *rectangle* around the smiley face the observer sees using the *mirror*.



4) Draw a straw inside the glass filled with water.



5) Write the word you see with your eyes. Make sure to use the correct colors and correct order!

6) Write the word you see through the telescope. Make sure to use the correct colors and correct order!

7) Use these words to fill in the blanks in the paragraph:

larger light eyepiece refraction telescopes bent magnifying

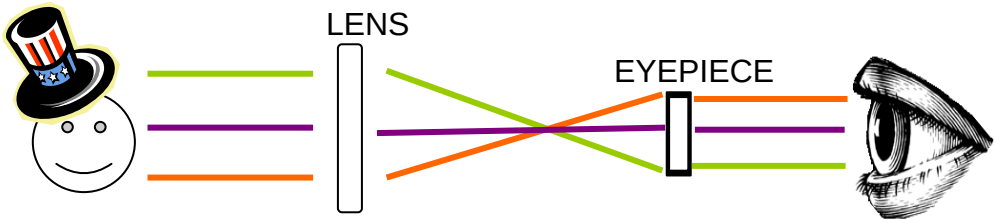
A straw in a glass of water looks like it is _____ because water focuses light. This is called _____. Lenses also focus light. A _____ glass is a type of lens. A magnifying glass works by focusing light from an object so it appears _____ than it is. _____ use two lenses, one in front of the other. The first lens gathers _____ from a far-away object and focuses it to a small point. A second lens called the _____ focuses the light from the small point made by the first lens to make a larger image.

Name: Sample answers

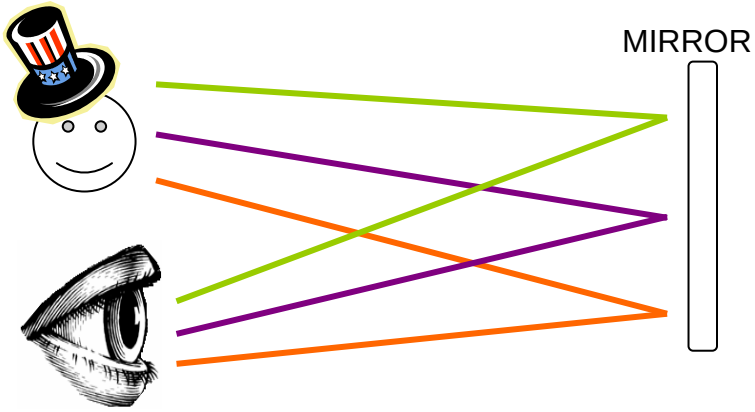
Telescopes!

Trace over the lines showing the light path from the smiley face to the observer's eye. Use a different color for each line.

1) Trace the light path for the refractor.



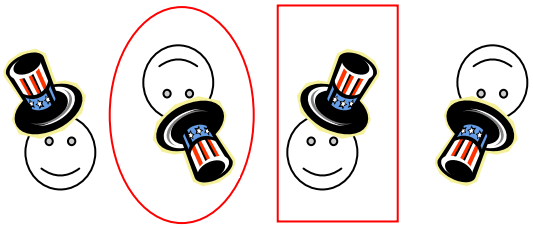
2) Trace the light path for the mirror.



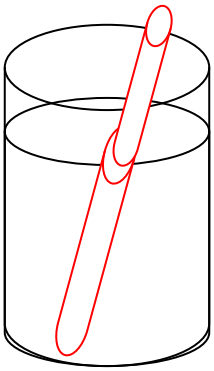
3) What does the observer see?

Draw an *oval* around the smiley face that the observer sees using the *lens*.

Draw a *rectangle* around the smiley face the observer sees using the *mirror*.



4) **Draw a straw inside the glass filled with water.**



5) Write the word you see with your eyes. Make sure to use the correct colors and correct order!

MOM

6) Write the word you see through the telescope. Make sure to use the correct colors and correct order!

WOW

7) Use these words to fill in the blanks in the paragraph:

larger light eyepiece refraction telescopes bent magnifying

A straw in a glass of water looks like it is __bent__ because water focuses light. This is called __refraction__. Lenses also focus light. A __magnifying__ glass is a type of lens. A magnifying glass works by focusing light from an object so it appears __larger__ than it is. __Telescopes__ use two lenses, one in front of the other. The first lens gathers __light__ from a far-away object and focuses it to a small point. A second lens called the __eyepiece__ focuses the light from the small point made by the first lens to make a larger image.

DISPLAY CARDS

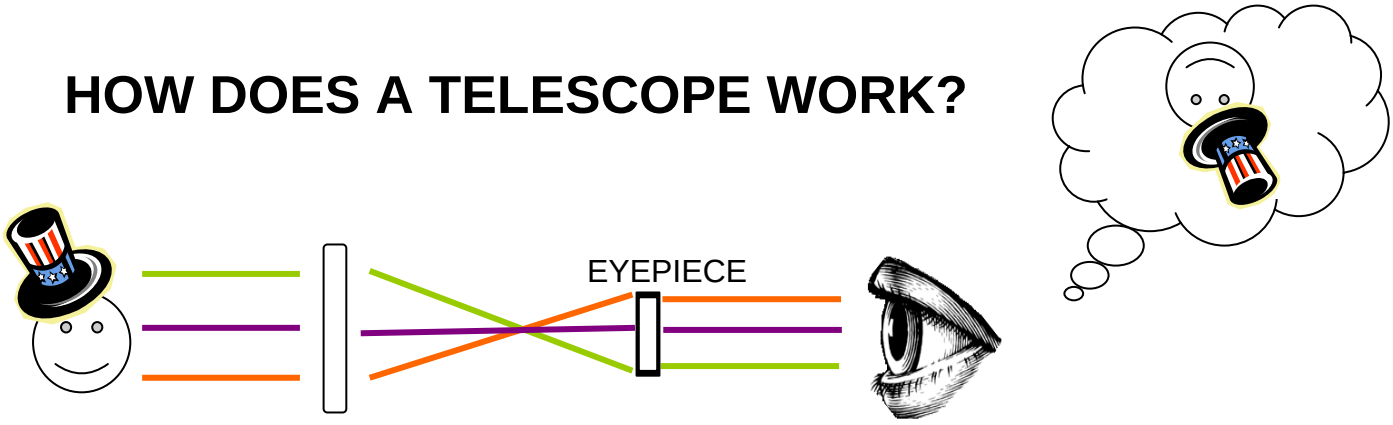
Card 1: An artist's idea of view from a moon orbiting a planet in a triple star system. For use with magnifying glass

MOM

Card 2: For use with telescopes

HOW DOES A TELESCOPE WORK? POSTER

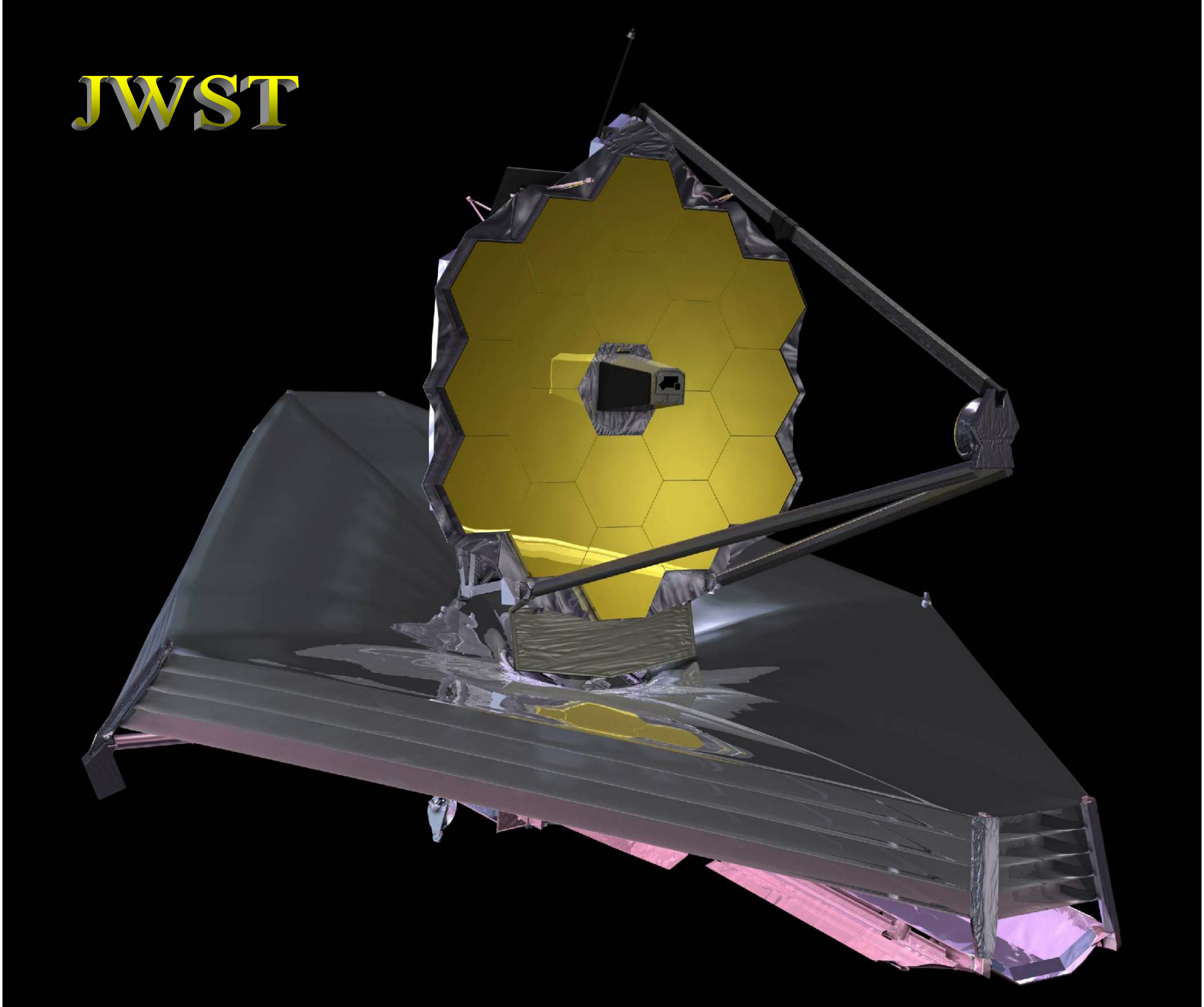
HOW DOES A TELESCOPE WORK?



The first lens gathers light and focuses it to a point.

The eyepiece magnifies the light by focusing it.

The observer sees an image that is rotated compared to the original object.


JWST

CHANDRA