Smithsonian
National Air and Space Museum

Exploring Telescopes Discovery Station

Revised August 2011

Main Concepts

- ★ Larger telescopes collect more light and allow you to see greater detail.
- ★ Telescopes make objects appear larger.
- ★ Larger telescopes allow astronomers to see farther into space.
- ★ The James Webb Space Telescope (Webb) views the universe in infrared light.

Activities

- ★ *Telescope properties*
- ★ *How to make a larger telescope*
- ★ *Collecting light*

Teaching Objects and Artifacts

Right Cabinet

- ★ Astroscan Telescope
- ★ Red laser pointer
- ★ Image of a star taken through a telescope
- ★ Webb Scale Model
- ★ 18 Webb magnet "mirror" pieces (36 total)
- ★ 1 round Hubble "mirror" piece (6 total)
- ★ 75 round disc "photons" or "particles of light"
- ★ Laptop computer w/ Webb deployment video and PowerPoint of infrared images

Storage Location

Explore the Universe Gallery on the far back wall by the Big Bang Mural

Presentation Location

ETU Gallery next to the Infrared Camera Display

ACTIVITY ONE: *Telescope Properties*

Objectives (Not all objectives will be met during each interaction)

Visitors will understand that:

- ★ Larger telescopes collect more light and allow you to see greater detail.
- ★ Telescopes make objects appear larger.

Materials

Right Cabinet

- ★ Astroscan Telescope
- ★ Red laser pointer
- ★ Image of a star taken through a telescope

Hook: *Have you ever looked through a telescope? What do you use a telescope for? What do you think you'll see?*

Using a red laser pointer, point out the orbiter painting on the wall above the backup primary mirror for the Hubble Space Telescope (Hubble).

Ask: *Take a look at the "orbiter" on the wall, and describe in as much detail what you see. What do you notice?*

Explain: Accept all answers from visitors. Guide them to be specific in their descriptions – how large? How much detail?

Ask: *Now let's look at the "orbiter" through the telescope. How do you think it will compare to what you just saw visually?*

Have visitors take turns looking at the "orbiter" through the telescope.

Accept all answers from visitors – they should tell you that the image is larger, in more detail and is upside down.

Great answers, let's find out why. Take a look at the mirror in the telescope.

Have visitors look at the mirror in the telescope.

Explain: The mirror is curved which allows objects to appear larger and show more detail than you can see with your eyes. One of the by-products of having a curved mirror is that objects appear upside down.

Have visitors look at the image of a star.

Ask: *Can anyone tell which way is right-side up on this image?*

Explain: Stars appear as points of light no matter how you look at them so we really don't mind if things are upside down through a telescope.

Ask: *If we had a larger telescope here, which one would you rather look through? Why?*

Explain: If we have a larger telescope, we'll be able to see fainter and farther objects in more detail. If you would like to stick around, we'll discover how to make telescopes larger.

End: Telescopes use mirrors, but also lenses to make objects appear larger and to see objects in greater detail. You'll be able to find examples of both types of telescopes in the gallery.

ACTIVITY TWO: *How to Make a Larger Telescope*

Objectives (Not all objectives will be met during each interaction)

Visitors will understand that:

- ★ Larger telescopes collect more light and allow you to see greater detail.
- ★ Larger telescopes allow astronomers to see farther into space.

Materials

- ★ Astroscan Telescope
- ★ Webb Scale Model
- ★ 18 Webb magnet "mirror" pieces (36 total)
- ★ 1 round Hubble "mirror" piece (6 total)

Hook: *How do you think we can make a bigger telescope?*

Explain: By using a larger mirror, you can see fainter objects farther out in space.

Show visitors the round "mirror" piece.

Ask: *Do mirrors have to be round?*

Explain: Mirrors can have lots of different shapes.

Show visitors one Webb magnet "mirror" piece to compare to the round "mirror' piece.

Ask: *Which mirror would be better for the telescope? Why?*

Explain: A larger telescope mirror allows us to see fainter objects farther into space, so the larger round one is better. The shape doesn't matter just as long as it brings light to a focus.

Show visitors one Webb magnet "mirror" piece.

Ask: *How could we collect more light using this size mirror?*

Explain: Adding extra mirrors is one way to make a larger telescope, thus allowing it to collect more light.

Show visitors five more Webb magnet "mirror" pieces (6 total), and have them construct a larger mirror using them.

Ask: *Which telescope mirror is better now – the round one or the segmented one? Why?*

Explain: A larger mirror allows us to see fainter objects farther into space, because it can collect more light, so the segmented one is better.

Ask: *How could we make the segmented mirror collect even more light?*

Explain: By adding even more mirrors!

Show visitors twelve more Webb magnet "mirror" pieces (18 total), and have them construct a larger mirror using them.

Ask: *How many of you have ever heard of the Hubble Space Telescope?*

Explain: Yes, it's a pretty famous telescope and gives us an amazing view of the universe. This round mirror represents the Hubble Space Telescope, or Hubble, mirror. Right over here is the actual backup primary mirror for Hubble that is represented by our round "mirror" piece. Astronomers want to see fainter and farther in space so they need telescopes with larger mirrors. This is the concept behind the James Webb Space Telescope. It uses segmented mirrors like the design you just created.

Show visitors the Webb model.

Ask: *What is different about the mirrors on Webb compared to the mirror you created?*

Explain: The shape is different (Webb uses hexagonal mirrors), and it has a hole in the center. The light is reflected through that hole to the cameras in the back. Let's rearrange your mirror pieces to resemble the mirror of Webb.

Have visitors rearrange the mirror segments to resemble the mirror of Webb.

Ask: *How many Hubble mirrors could you fit inside the Webb mirror?*

Explain: 6.25 Hubble mirrors would fit inside the Webb mirror. This brings us to our last segment which is light gathering power. The real purpose of a telescope is to collect light, and next we'll be doing an activity to see how much light Webb can collect.

End: Be certain to spend some more time at the Hubble mirror. Think about the size comparison you've worked on here and see if you can imagine how large Webb would be compared to the Hubble mirror.

ACTIVITY THREE: *Collecting Light*

Objectives (Not all objectives will be met during each interaction)

Visitors will understand that:

- ★ Larger telescopes allow astronomers to see farther into space.
- ★ Webb views the universe in infrared light.

Materials

- ★ 18 Webb magnet "mirror" pieces (36 total)
- ★ 1 round Hubble "mirror" piece (6 total)
- ★ 50 round disc "photons" or "particles of light"
- ★ Laptop computer w/ Webb deployment video & PowerPoint of infrared images

---

Hook: *How much light can the Webb collect?*

Explain: Telescopes are sometimes called light buckets. Just as a bucket collects water, a telescope mirror collects light. The more light a telescope can collect the fainter and farther it will be able to see.

Show visitors the round Hubble "mirror" piece and the segmented "mirror" Webb pieces. Also bring out the round "photon" discs.

Explain: These small round discs represent units of light, photons.

Ask: *How many photon discs can you fit on the Hubble mirror model? How about on the Webb mirror model?*

Have visitors fill the round Hubble "mirror" piece and the Webb segmented "mirror" pieces with round "photon" discs.

Explain: Notice that the Hubble model can hold about 8 units of light, while the Webb can hold about 50 units of light. So the Webb can collect more light and allow astronomers to see farther into space. Actually, it can collect 6.25x more light than the Hubble.

Ask: *Both Hubble and Webb are space telescopes, they operate outside of Earth's atmosphere. Which do you think would be easier to get into space – Hubble or Webb?*

Explain: The Hubble would be because it's smaller. Getting all of the mirrors of the Webb into space presents some real challenges. Take a moment to watch this short video clip to see how it's accomplished.

Play Webb deployment video on laptop.

Explain: Isn't that amazing? Webb looks just like a Transformer! It must be folded up so that it can travel into space. Slowly, Webb will unfold to its telescope shape to explore the mysteries of our universe.

One big difference between Hubble and Webb is the type of light it "sees". Hubble can view the universe in visible light, what we can see with our eyes; Webb views the universe in "heat" or infrared light.

Ask: *If you could see in infrared or see "heat," what do you think this area would look like? What would be the hottest sources?*

Explain: We would certainly give off a lot of heat and be easy sources to see. One big advantage of seeing in infrared is that you can see objects that you normally can't in visible light. This allows Webb to view the first galaxies and the birthplace of stars in detail that visible light could never give you. This will give you an idea of what things look like in infrared.

Show PowerPoint of infrared images on the computer. These images are of a person holding his hand in a bag, and visual and IR images of a deep-space object taken by Hubble.

End: In this gallery, you'll find an exhibit where you can see what you would look like in infrared light. Try this experiment: put your hand in a plastic bag and see if it's visible in infrared. This is similar to what Webb will be able to see when it is looking through clouds of dust and gas to study the formation of stars and planets.

Enjoy your visit to the museum, and keep looking up!

Hand out Webb outreach materials if visitors express interest.

Connections

Refer visitors to related artifacts in museum and to additional resources:

- ★ Hubble Backup Primary Mirror
- ★ Hubble Test Telescope
- ★ Infrared Light Exhibit

- ★ NASA: James Webb Space Telescope
  http://www.jwst.nasa.gov/

Resources

- ★ Amazing Space: Telescopes from the Ground Up
  http://amazing-space.stsci.edu/resources/explorations/groundup/

- ★ NASA: James Webb Space Telescope
  http://www.jwst.nasa.gov/

- ★ NOAO: Teaching With Telescopes
  http://teachingwithtelescopes.org/

- ★ Webb: Scope It Out! Game.
  http://www.jwst.nasa.gov/scope.html

- ★ Webb: Quick Facts
  http://www.jwst.nasa.gov/facts.html