Skynet Junior Scholars

Skynet Junior Scholars is a partnership between

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

West Virginia University. EXTENSION SERVICE

UW Extension
University of Wisconsin-Extension

THE UNIVERSITY OF CHICAGO

NSF

GREEN BANK OBSERVATORY

ASTRONOMICAL SOCIETY OF THE PACIFIC

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Skynet Junior Scholars
4-H Project Book

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How This Book Works

Are you interested in Astronomy?

There is a whole Universe waiting for you to explore! With the Skynet Junior Scholars (SJS) project you might investigate asteroids in our solar system, dusty clouds of gas forming new stars, or distant swirling galaxies!

As a Skynet Junior Scholar you will have access to **professional robotic telescopes** used by astronomers from around the world for their research. **They are not toys**. It's important for you to gain expertise in using these telescopes, and in analyzing and interpreting the data you receive. Once you have mastered these skills by completing this project, you will earn your Skynet Junior Scholar badge and gain greater access to the telescopes, and to the scientists who use them!

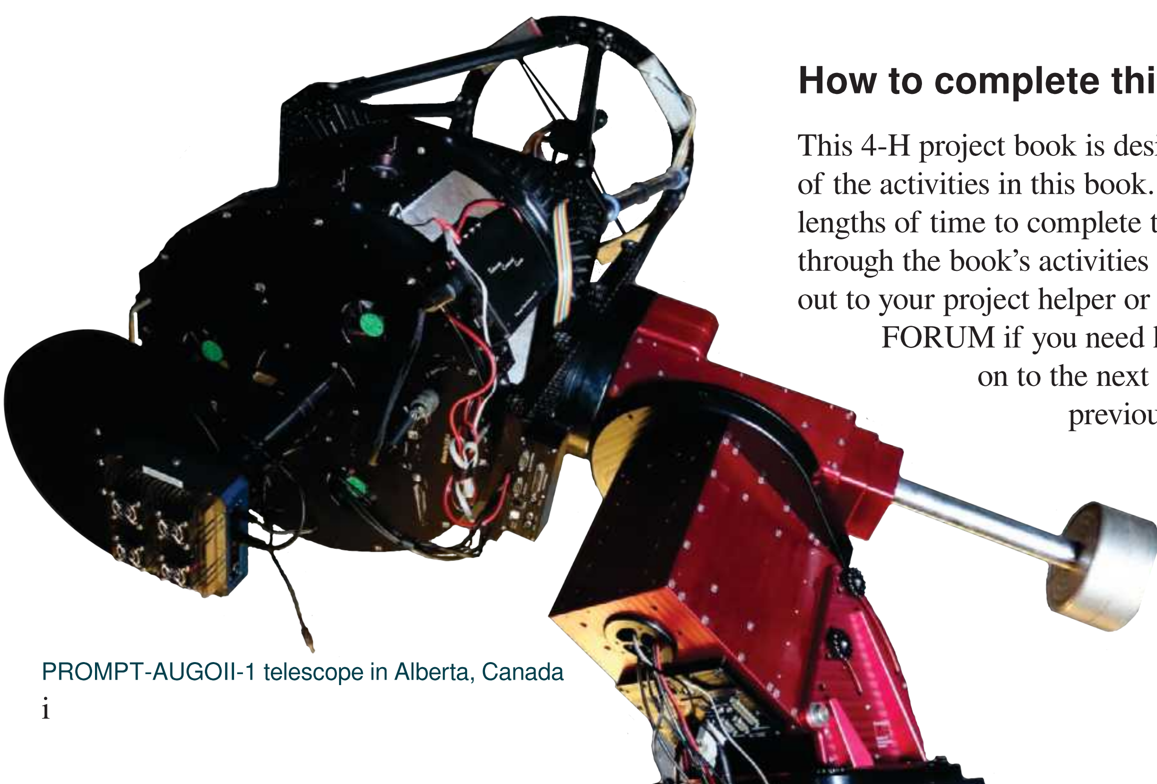
We believe that the best way is to learn by doing! So once you sign up for a Skynet Junior Scholars account, we will award you some telescope time right away so that you can get started.

Why do 4-H members get to use these telescopes?

Skynet Junior Scholars is a great opportunity for students like yourself to access research grade scientific equipment. We hope you're excited to access this technology and will use this opportunity to its fullest potential. The top scientific priority for the Skynet Telescopes is to observe gamma-ray bursts (GRBs). However, when the telescopes are not being used to observe GRBs, Skynet telescopes are used by astronomers, students, and 4-Hers like you to conduct their own research. You can be one of them! Learn more at: https://skynetjuniorscholars.org/telescopes

How to complete this 4-H project book

This 4-H project book is designed for you to complete all of the activities in this book. It will take 4-H'ers different lengths of time to complete this book. Please work through the book's activities at your own pace and reach out to your project helper or other SJS scholars in the FORUM if you need help. If you get stuck, move on to the next activity. Return to the previous activity once you have received help from your project helper or SJS scholar.



PROMPT-AUGOII-1 telescope in Alberta, Canada

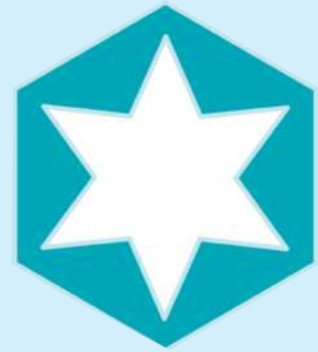
How to Earn Your Skynet Junior Scholar Online Badge*

There are five online Explorations to complete. Do:

1. **First Light!** to command a Skynet Telescope to take your first picture!
2. **Skynet Scavenger Hunt** to learn your way around the Skynet site.
3. **Exposure Time** to determine how exposure duration affects astronomical images.
4. **Investigate Filters** to investigate how scientists use filters to determine the properties of objects in the Universe.
5. **Create it Yourself** to do your own experiment!

There are some awesome hands-on activities too! These would be really fun to do with your friends or 4-H club members.

Once you have...

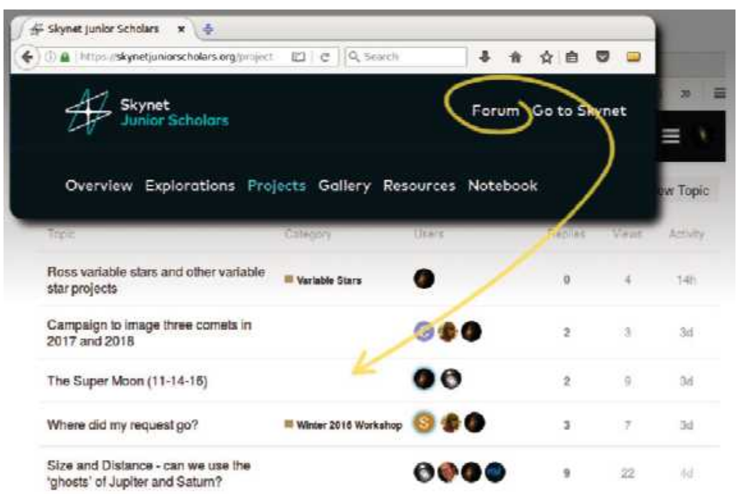


- completed and submitted all five Explorations;
- uploaded two images to the Gallery;
- posted at least one message or question to the Skynet Junior Scholars Forum;

... you will receive the **Skynet Junior Scholar badge**, and more telescope privileges! The SJS team is always available to help you on the Forum. Please ask us questions. Good Luck!

**This is different than completing your 4-H project. See page i about 4-H project requirements.*

Need more help?



Not a problem!

As you will learn in Chapter 1, Skynet is not only a network of telescopes, but also serves as a network of scientists, educators, and other youth like yourself who are all interested in astronomy. Your project helper will probably not have all of the answers, so you may need some additional help. You can log into the SJS FORUM at any time during this project to ask questions and another SJS user will answer. *Just remember to NEVER use your real name in the FORUM or any other online SJS resource.*

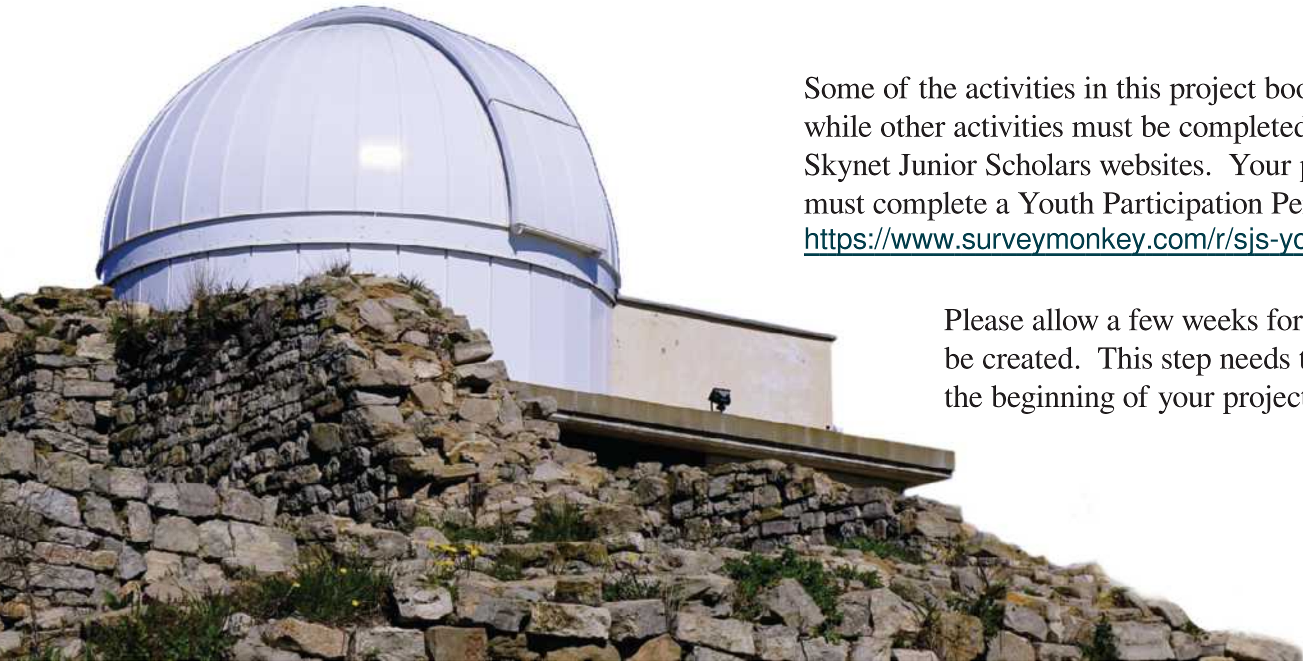
How to find the SJS Forum -

1. If you are not already logged in, go to https://skynetjuniorscholars.org/ and log in with your username and password
2. Look for the **Forum** button at the top of the webpage. Click on this button and the Forum will appear as a new tab.

Online Glossary

Is there a term that you do not understand and would like to learn more about?
Visit the Skynet Junior Scholars Online Glossary of terms at: https://skynetjuniorscholars.org/glossary

How to Request a Skynet Junior Scholars Account



Some of the activities in this project book are hands-on while other activities must be completed using three Skynet Junior Scholars websites. Your parent or guardian must complete a Youth Participation Permission Form at https://www.surveymonkey.com/r/sjs-youth-account .

Please allow a few weeks for your account to be created. This step needs to be a priority at the beginning of your project work.

What To Do While Waiting

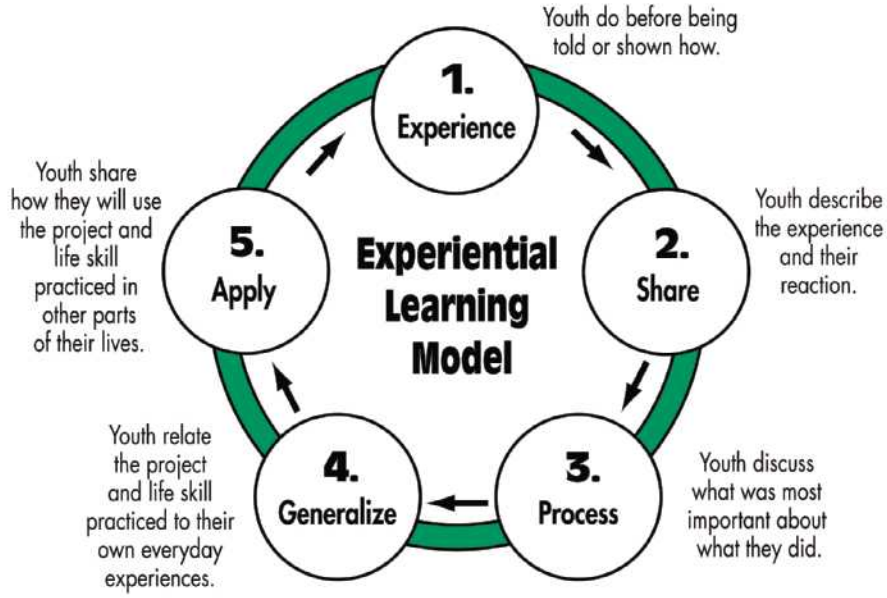
There are many activities in the Skynet book, and while they are listed in a certain order, if you complete the directions step by step in order, you might end up spending a lot of time simply waiting. For instance, let's say that you just programmed some Skynet images to be taken. Your next step, according to the directions, is to compare the images that you get back. It may take a week or two to get the images back. That is a long time to wait before proceeding forward.

There are ways to use your time effectively when waiting for images to return or when the telescopes you wish to use are closed for extended periods of time.   Some activities in the Skynet project book do not require taking images or working with your returned images. They are hands-on activities that add to your knowledge about the Skynet program or the field of astronomy. They are included in the project book, because they help you understand such concepts as how far away objects in the universe are, how the telescopes that you are using work, etc. While they are not necessary activities to complete the image-related assignments, they are considered important to complete.

The hands-on activities that can be done when you are waiting for images to come back are these: "Anatomy of a Telescope"," Field of View", "Sizing Up the Moon"," Pocket Solar System", "Cosmos in Perspective", "Astrophotography", "Fun With Filters", "Address in the Sky", and "Globe at Night-Light Pollution". Take advantage of your "wait" time by using it to complete these activities. Just another hint on how to move forward in a timely way with the Skynet program is to takes lots of images with many telescopes. If you request more images, you will have a better chance at getting back images that will be easy to work with as well as receiving images in a reasonable period of time.

Experiential Learning Model

The 4-H slogan is "Learn By Doing" and that is exactly what the Skynet Junior Scholars (SJS) project wants 4-H members to do! You get to experience the universe through the use of robotic telescopes and hands-on activities. Then you share your observations with other youth, scientists, and researchers through the SJS websites and forum. At the end of each chapter you are asked to reflect on the activities before generalizing and applying what you learned to your daily life. This process is called the **Experiential Learning Model** and it sets 4-H curriculum apart from other programs.



Astronomy is Citizen Science

Baraboo Valley 4-H SJS students at Yerkes Observatory

Did you know that you can help with scientific research? Sometimes people who are interested in science can volunteer to help scientists and researchers. When the public helps with scientific research it is called **Citizen Science**. Citizen scientists can be found collecting data, sharing information, and helping organize programs that help scientists understand the world better. You can be a citizen scientist through Skynet Junior Scholars. There are opportunities to work together with researchers listed under "Projects" on the Skynet Junior Scholars website. Your images and information could help scientists better understand our universe!

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The icon is used to identify online activities

Chapter 1: There Are More Than Just Stars Out There

<1.1> First Light Exploration

24-inch reflector at Yerkes Observatory

The Skynet Robotic Telescope Network is a network of telescopes located around the world. These telescopes are fully automated, meaning that the telescopes are operated by computers. Professional astronomers and students just like you can operate these telescopes from computers thousands of miles away. All you have to do is log into the online Skynet Network and make a request. The First Light Exploration will take you through the process of making your first of many requests.

What do you hope to take images of in our universe using the optical telescopes on Skynet Network?

After completing this activity, you will be able to:

- ✶ Understand how to request and process an image taken with a robotic telescope on the Skynet Network

Before the Activity

- ✶ Participants must have allocated 80 seconds of telescope time to use to complete this activity.

for the Project Helper

Success Indicators:

- Save an image in the Skynet Junior Scholars web gallery

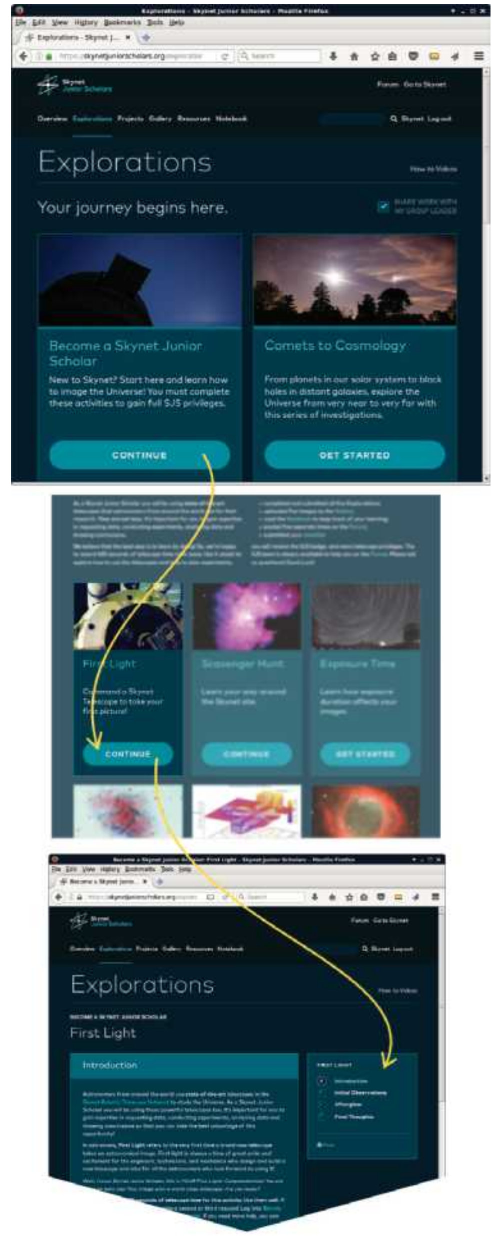
Life Skills:

- Learning to learn, problem solving, critical thinking, goal setting, planning/organizing, keeping records

National Science Standard:

- Science and Engineering Practices
- Planning and carrying out investigations to answer questions

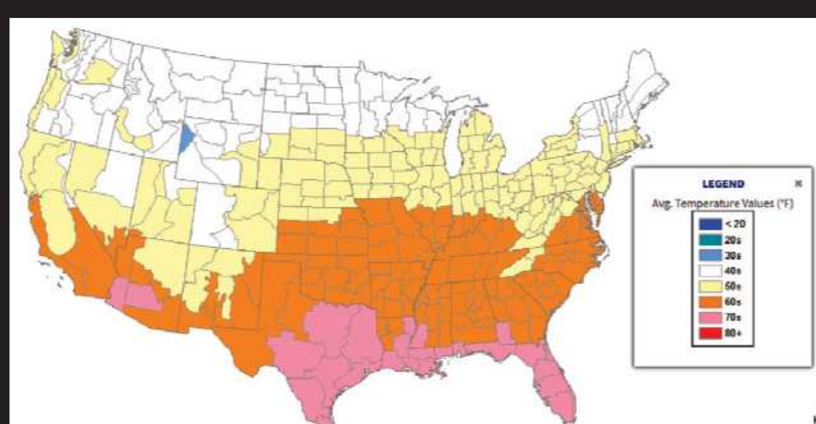
Let's Do It!



1. If you are not already logged in, go to https://skynetjuniorscholars.org/ and log in with your username and password
2. Look for the **Explorations** button at the top of the webpage. Click on this button.
3. Look at the Explorations page. When you scroll down the page, you should see several topics like "Become a Skynet Junior Scholar," "Comets to Cosmology," "Starry Skies," and "Asteroid Research."
4. Find the "Become a Skynet Junior Scholar" box and click on the **Get Started** button (the button will say **Continue** after this).
5. Now you are on a webpage with all of the online Explorations that you will complete to become a Skynet Junior Scholar. When you scroll down, you will see six Explorations.
6. Find the "First Light" box and click on the **Get Started** button (the button will say **Continue** if you have already visited this exploration).
7. Read and follow all of the instructions in all four sections of this online exploration.
   - **A Introduction**
   - **B Initial Observations**
   - **C Analyze Your Image**
   - **D Final Thoughts**
8. Once you have entered your answers into the online exploration, click the **Submit Exploration** button. A SJS leader will approve your completion online and send an email.
9. In the right column, you will find a **Print** icon button. Click this button to open a print dialog box where you can either immediately print your exploration or save it as a PDF file to take to a printer at a later time.
10. Make a copy of this Exploration and your Gallery image and save as part of your project work.

Talk Like an Astronomer!

Congratulations, you have received your first SJS Image! When astronomers take pictures of objects, they refer to them as images. These images are more than just pictures. Underlying each image is an array of numerical data. This data becomes the color in our images, sort of like how temperature becomes color in a weather map.



<1.2> Sizing up the Moon

When you look around, you can see familiar objects. Based on your knowledge about the object and its size, you can estimate how far that object is away from you. For example, if you see your friend across the cafeteria, you could estimate the distance between the two of you. Likewise, if you know how far away an object is, you can estimate the size of that object. In this activity, we're going to have you make a guess about the Moon.

After completing this activity, you will be able to:

- ✶ Understand the relative size and distance between the Earth, Moon, and Sun

Have you ever seen the full moon in the sky?

Could you tell how big it is or how far away?

How does the size of the full moon compare to the size of the sun?

Let's Do It!

1. Open one container of play-doh

Predict the size of the Earth and Moon

2. Divide the play-doh into two pieces to make a scale model of the Earth and the Moon. Mold one piece of play-doh into a model of the Earth. Mold the other piece of play-doh into a model of the moon. You should use all of the play-doh and your two models should represent your predictions about the scale of the size of the Moon to the size of Earth.

Predict the distance between the Earth and Moon

3. Once you have made your two models, place the Earth model on a scrap piece of paper.
4. Then place your Moon model the distance you predict it should be away from the Earth model.

Materials List:

- Scrap paper
- Two 3 oz. containers of play-doh
- A Plastic knife
- Measuring Tape at least 10 feet in length
- String
- Chalk
- **Optional**: Cutting board or sheet of wax paper

How did you choose the sizes for your Earth and Moon models?

How did you choose the distance between your Earth and Moon models?

Create a more accurate model of the Earth and Moon

5. Open the second container of play-doh
6. Divide this play-doh into 50 roughly equal pieces
7. Set one of the "average" pieces of play-doh to the side. How many pieces of play-doh are left?

8. Take the remaining pieces of play-doh and squish them back together into one ball.
9. The small "average" 1/50 piece of play-doh represents the Moon and the large ball represents the Earth.
10. Place the second, more accurate Earth model next to your prediction model of Earth.
11. In the distance between the Earth and the model, you can fit 30 models of Earth or in other words, the Moon is 30 Earth diameters away.
12. With a measuring tape, measure 60" away from the Earth and place your second, accurate Moon model.
13. How did the actual scale size of the Earth and Moon compare to your predicted sizes of the Earth and Moon?
14. How did the actual scale distance between the Earth and Moon compare to your predicted distance between the Earth and Moon?

for the Project Helper

Success Indicators:

- Demonstrate with models the size and distance between the Earth, Moon, and Sun

Life Skills:

- Learning to learn, problem solving, critical thinking

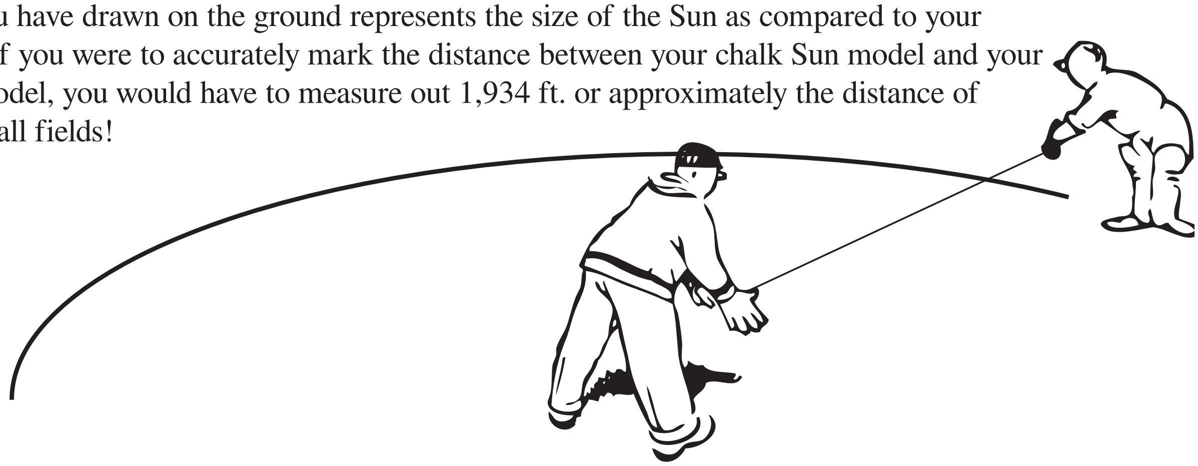
National Science Standard:

- MS-ESS1-1: Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.

Let's compare this to the Sun

15. Keep the second, accurate models of the Earth and Moon. Put away your prediction models.
16. With your measuring tape, cut a piece of string 9' feet in length.
17. Take your piece of string, chalk, and your adult helper outside to a large driveway or parking lot that you can draw on with chalk. Make sure it is a safe location, free from busy traffic.
18. Have your adult helper hold one end of the string.
19. Take the other end of the string and walk away from your helper until the rope is held tight.
20. Bend down to put a mark on the ground with the chalk.
21. Start walking in a circle while your helper stands in place.
22. Mark the ground with the chalk while you walk in the circle to create a large chalk ring.

The circle that you have drawn on the ground represents the size of the Sun as compared to your model of Earth. If you were to accurately mark the distance between your chalk Sun model and your play-doh Earth model, you would have to measure out 1,934 ft. or approximately the distance of 6 and a half football fields!



<1.3> Pocket solar system

Did You Know?

The Moon—Earth's eternal companion on its endless trips around the sun, the Moon's familiar face is a sight that only grows more interesting through a telescope. Check out not just the giant craters carved by years of meteor impacts, but also the "rays" of material streaking away, where debris fell back down after being thrown high into the sky. The Moon also contains dark smoother areas called "mare," the Latin word for sea.

Waxing Gibbous Moon - RCOP
by SJSvivian

Materials List:

- 1 meter length strip of paper
- Pencil
- Colored pencils, crayons or stickers

for the Project Helper

Success Indicators:

- Learners will develop a model of the solar system demonstrating appropriate orbit distance.
- Students will develop a theory as to why the planets closest to the sun are closer together than the ones further out.

Life Skills:

- decision-making, teamwork (if more than one student), communication, problem-solving

National Science Standard:

- MS-ESS1.B The Earth and the Solar System
- MS-ESS1.A The Universe and its Stars

Space Montage - public domain image

The Pocket Solar System activity starts with exploring the notion of models. In this activity, you will create a model of the solar system by folding a piece of register tape to illustrate the distances between the orbits of the planets and other objects in our solar system. While images in textbooks often depict the planets squeezed together, this model shows how far apart the planets are, especially beyond Mars.

What is a model? Give some examples.

After completing this activity, you will be able to:

- ✶ Make a decision based on your prior knowledge of where the orbits of the solar system would lie on a length of tape or paper
- ✶ Identify the correct order and relative distance away from the sun of the planets and the asteroid belt

Before the Activity

- ✶ Precut strips of paper
- ✶ Gather other materials

List of Planets

Mercury

Venus

Earth

Mars

Jupiter

Saturn

Uranus

Neptune

Pluto

Let's Do It!

Predict the distances of the planets and asteroid belt

You are going to predict where the planets go. On one side of the register tape, lightly draw two dots, one on each end, right at the edge. Label on one side "Sun" and on the other side "Pluto". Now lightly draw and label the planets in between. Where do you think they go?

Create a more accurate model of the Solar System

1. Turn over the long strip of paper. You now have a clean surface to create a new model.
2. Once again, draw 2 objects on each end of the paper, one large and one small, right at the edge. You can use stickers if you have them. Label the large one Sun and the small one Pluto. Even though Pluto has been reclassified as a dwarf planet, it serves as a useful reference point here. We can use it as the first example of such a dwarf planet ever found.
3. Fold the strip in half, crease it, unfold and lay flat. A planet goes there! You can ask for guesses as to which of the planets might be at this halfway point. Draw and label the planet Uranus.
4. Fold the paper black in half and then in half again. Can you guess what a ½ of a ½ is? There are 4 one fourth sections divided by creases in your strip of paper. Unfold the paper and lay flat. Planets go in each of these creases! Can you guess what planets they are? Draw and label Saturn at the ¼ mark and Neptune at the ¾ mark (Saturn closer to the Sun and Neptune closer to Pluto).
5. No need to fold up the whole strip again. Just fold the Sun edge up to meet Saturn. What planet goes in that crease? Jupiter! Draw and label Jupiter at the 1/8 mark.
6. Fold the Sun out to meet Jupiter to mark the 1/16th spot. A planet does not go here, but you can draw lots of little dots and label them the Asteroid Belt!
7. At this point, things start getting a little crowded and folding is tough to get precise distances, so fold the remaining 1/16th portion in half and crease at the 1/32nd spot. Place a small dot for the Earth just inside this fold (closer to the Sun) and a small dot for Mars just outside the fold (closer to the Asteroid Belt) and label them.
8. Place a small dot for mercury and then Venus, between the Earth and the Sun, pretty much dividing the space into thirds and label them as Mercury (closest to the Sun) and Venus (closest to the earth).
9. Put your name on the model and save it as part of your project work.
10. Look at how empty the outer solar system is. Look at how crowded the inner solar system is (relatively speaking).

Did You Know?

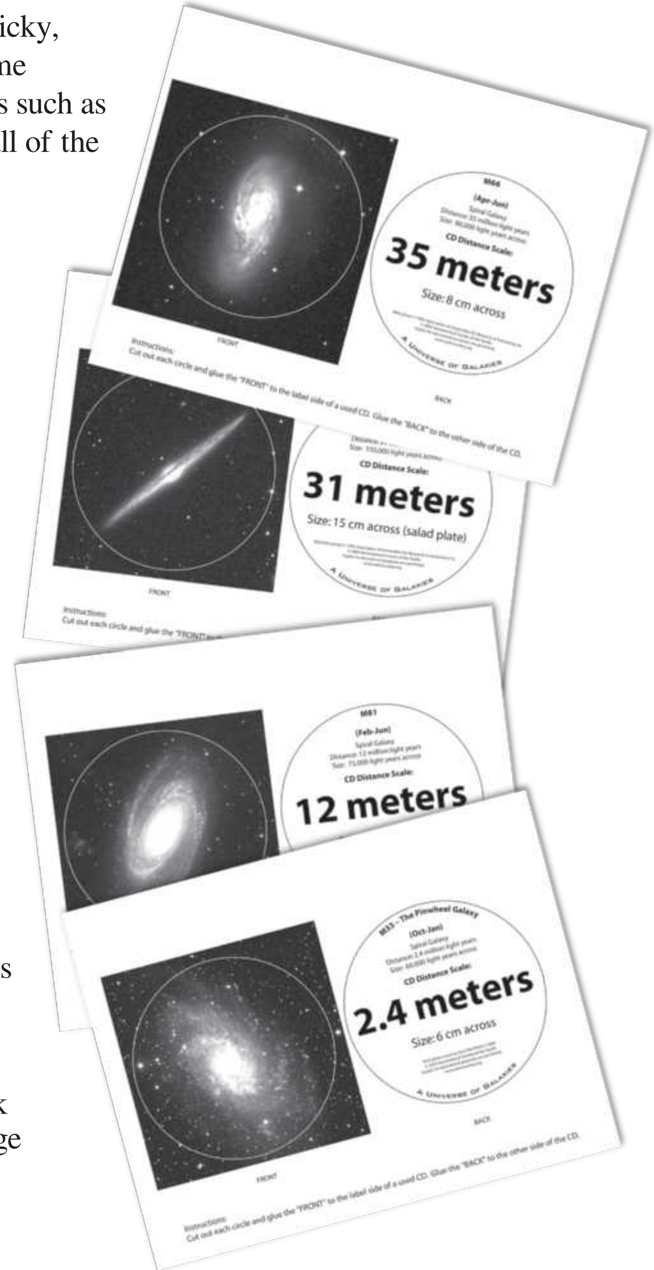
Planets—The planetary members of our solar system are as varied as any family. Jupiter's bands and Saturn's rings make especially nice targets, while smaller planets may be star like in appearance through a telescope. Don't forget to look for moons as well—Jupiter's four Galilean moons are constantly on the move, making the biggest planet a great repeat target.

Daniel Moyer Pdb2
Prompt 1
Combination 2 exposure
Time 0.1 and 1 second

How is this Pocket Solar System a good model for the real solar system and a not so good model?

<1.4> Cosmos in Perspective

Understanding the sizes and distances of celestial objects can be tricky, because in our everyday experience the stars all seem to be the same distance away. Most people's knowledge of dim and distant objects such as nebulae and galaxies comes mainly from images in books, where all of the images are about the same size with no indication of scale.



How big do you think the universe is?

How far apart are galaxies?

After completing this activity, you will be able to:

- ✶ Appreciate the size of the universe and the relative distances between objects

Before the Activity

- ✶ Remove the Cosmic Address page and galaxy CD templates from the back of this book.
- ✶ Cut out the Cosmic Address pictures.
- ✶ Cut out the galaxy CDs and either glue each front and back together or glue them to a used CD or cardboard. Each page contains two sides of the same disk.

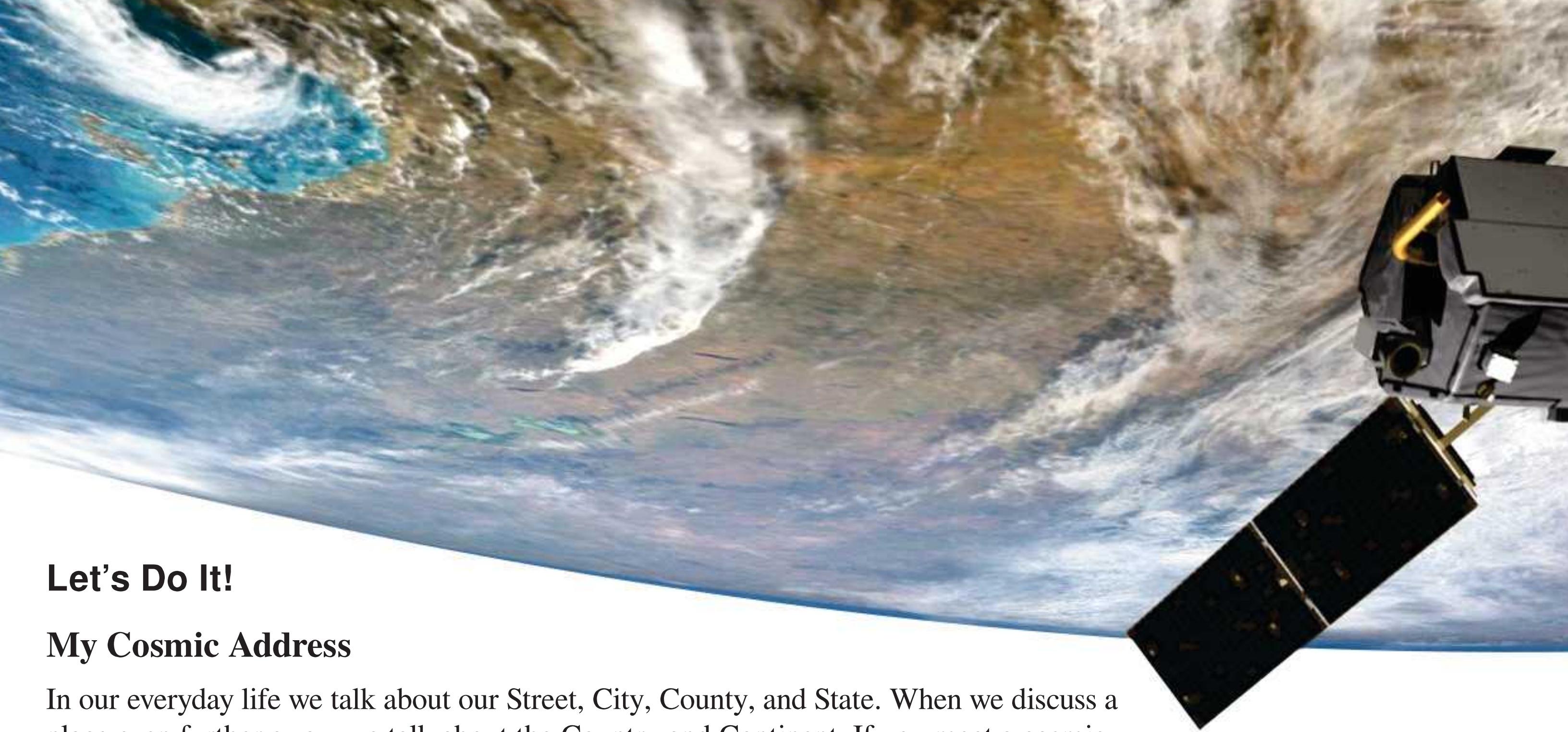
Materials List:

- Cosmic Address pictures (included in appendix)
- CD labels (included in appendix)
- 15+ used CDs (optional)
- Scissors
- Glue stick

Did You Know?

Galaxies—A galaxy is a collection of millions to billions of stars. Galaxies contain stars of many different ages, and as these populations are born and die off over billions of years, the galaxy can change colors and “evolve” almost like a living creature. Big galaxies can also “eat” smaller ones and grow even larger, and evenly matched galaxies tear one another apart and form new galaxies.

M51 (Whirlpool Galaxy) by tmonster



Let’s Do It!

My Cosmic Address

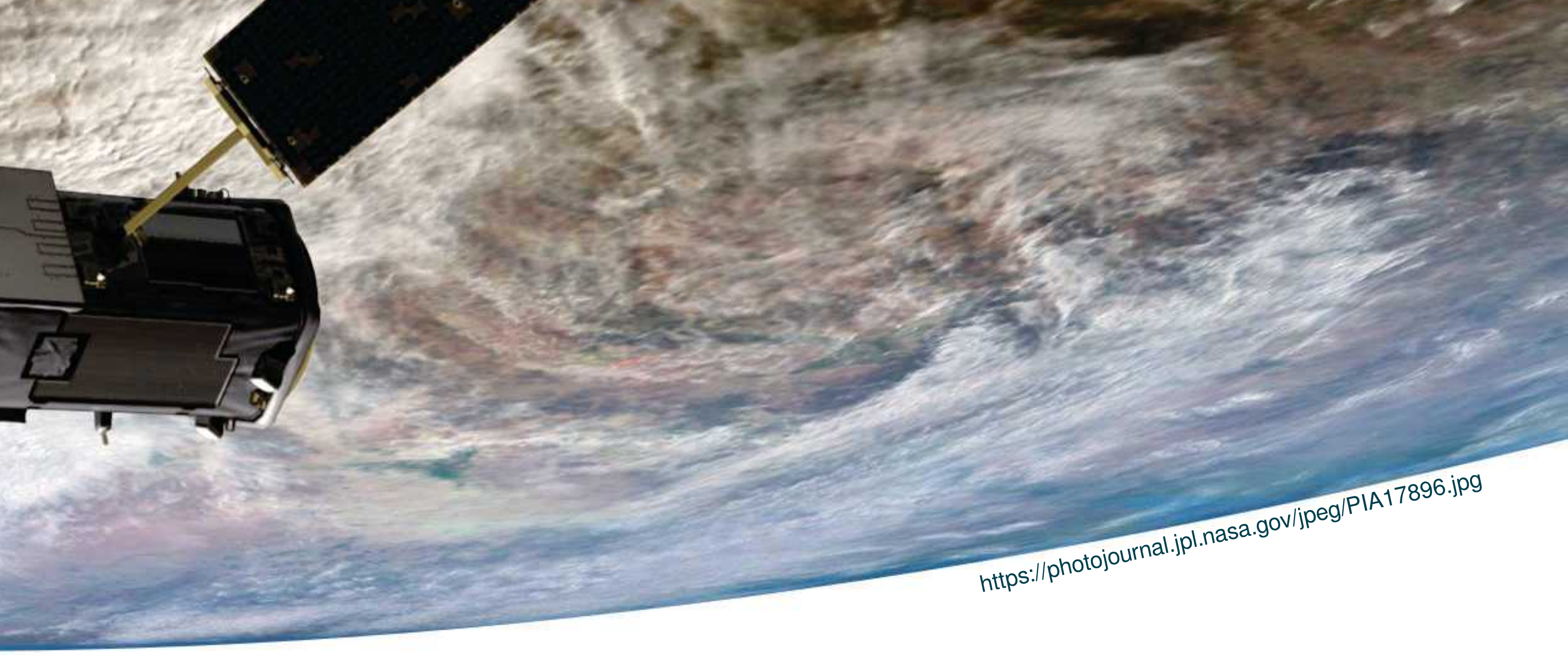
In our everyday life we talk about our Street, City, County, and State. When we discuss a place even further away, we talk about the Country and Continent. If you meet a cosmic visitor, you might tell them about our Planet (Earth), our Solar System, our Galaxy (the Milky Way), our Local Group, and our Universe.

Look at the cosmic address pictures and sort them based on size. Use the pictures to come up with a cosmic address. Paste your cosmic address pictures on a piece of scrap paper and save as part of your project work.

Large Scale Structure of our Universe

Suppose we shrink our Galaxy – the Milky Way Galaxy – down to the size of a CD. How far away do you suppose the rest of the galaxies in our Universe are?

1. Find the CD that represents how our Milky Way Galaxy would look like if we could go far out in space and take a photo of it. The arrow on the CD with “You are here” marks the approximate position of our star, the Sun.
2. Find the other CDs that have galaxies on them. Don't use the Quasar or the Hubble Deep Field CDs yet. If working in a group, hand out one CD to each person. If you are doing this on your own or with just a few friends, you might try hanging some of the CDs on a string, or attaching them to sticks that you can poke in the ground.
3. The person with the Milky Way Galaxy stands in the middle. Have everyone pace off the distance to each of their galaxies, taking one giant step for each meter. The distance needed for travel (in meters) is listed on each CD.
4. When all of the CDs are in position find the galaxies within 3 meters of the Milky Way. These are our Local Group of galaxies – living in the same yard. Which galaxies are within 100 meters? Those are our neighbor galaxies – in the same block.
5. These are just a few of the billions of galaxies in our universe. They are all fairly close to us and we can observe them with the Skynet telescopes. Many galaxies are even further away.
6. Find the CD with Quasar 3C-273. This galaxy is over 2 billion light years away. On your scale model it is 2.5 kilometers away. Would you like to take this one to where it belongs?
7. Now find the Hubble Deep Field CD and look at the image of the galaxies. Some of these galaxies are as far away as our best telescopes can see – over 12 billion light years away! Many of these galaxies are near the limit of the observable universe, which is 13.7 billion light years away. How far away should these galaxies be placed? Turn over the CD and you'll find you would need to place this one about 14 kilometers from the center. Can you name a landmark that is that far away from you?



https://photojournal.jpl.nasa.gov/jpeg/PIA17896.jpg

Are you puzzled go to the Forum and ask an expert! Do you have a question

Wrap-up

At least 200 billion galaxies are within the observable universe. Imagine CDs distributed all around us – out to 13.7 km away in any direction.

Remember that even though the observable universe extends about 13.7 billion light years in any direction, that does not mean that we are at the center of the universe. No matter which galaxy you might happen to live in, you would still only be able to see light coming from galaxies no more distant than about 13.7 billion light years (or 13.7 kilometers on this scale). So there is no “center” to the universe. Every galaxy will appear from its own perspective to be at the “center”.

for the Project Helper

Success Indicators:

- Upon completion of activity students will be able to explain the comparative distances between galaxies and earth's place in the universe.

Life Skills:

- learning to learn, decision-making, problem solving, critical thinking

National Science Standard:

- 5-ESS1-A, The Universe and its Stars. Stars range greatly in their distance from earth.
- Crosscutting concepts: Scale, proportion, and quantity; Systems and system models

background image based on
M51 (Whirlpool Galaxy) by tmonster
inverted and recolored by cliff_n

Go Further

After doing the Galaxy activity, you can try using your CDs to represent other cosmic objects: This web site will help you make new scale models. (A CD is 120 mm in diameter):
http://www.exploratorium.edu/ronh/solarsystem/index.html

What if the Sun were the size of a CD (120 mm)? How would the planets scale in size and distance? Use the Exploratorium website to do some calculations and save as part of your project work. You can check out the answer for Jupiter and Earth at the bottom of this page once you've calculated your own answers. No peeking!

How do you think the distances between the stars compare to distances between the galaxies? The star closest to our sun is 4.22 light-years away. If our Sun were the same size as a CD, you would need to travel 3,200 kilometers to place this nearest star on your scale model. To get a better idea of how far that is, you can experiment on this website:
http://obeattie.github.io/gmaps-radius/

1. Enter your location in the "Search for a place" box and zoom in on the spot where you have your Sun CD.
2. Look in the lower left corner of the page for a toolbox where you can choose the units you are working in (kilometers) and the radius. (3,200)
3. Now click on a spot on the map as close as you can to where your Sun CD would be. If you click in the wrong spot, right-click the circle to erase it and try again.
4. Did your whole screen go blue? Use the + and - buttons to zoom out so you can see the edge of the circle. Follow the edge of the circle and see what cities or towns it goes through. Any one of these will do for your nearest star!

If the Sun were the size of a CD (120 mm), Jupiter would be smaller than a dime and would be 67 meters away! Earth would be just 1 millimeter in diameter and would be 13 meters away!

Chapter 1 Questions

In this chapter, you completed activities that represent the size or distance of our planet, Earth, in relationship to other celestial bodies like our Moon, the solar system and the Universe.

Share

What about these activities surprised you?

Reflect

How did making these models help you better understand Earth and the Universe?

Generalize

How can you use scale models to learn about other topics that interest you?

Apply

How will you use the knowledge gained from this chapter's activities in your Skynet exploration?

Chapter 2: Learning the Tools of the Trade

‹2.1› Skynet Scavenger Hunt

Take some time to find your way around the Skynet Robotic Telescope site. Go on the “hunt” to learn more about cool Skynet Telescope features and how to find objects in the sky from different locations!

Why do you think it is important to learn about the Skynet Robotic Telescope site before you use it for observing the universe?

After completing this activity, you will be able to:

- ✶ Navigate the Skynet Robotic Telescope site
- ✶ Use the SkyViewer to locate celestial objects
- ✶ Understand how to use the Target Visibility Graph
- ✶ Understand information about telescope status and various telescope sites

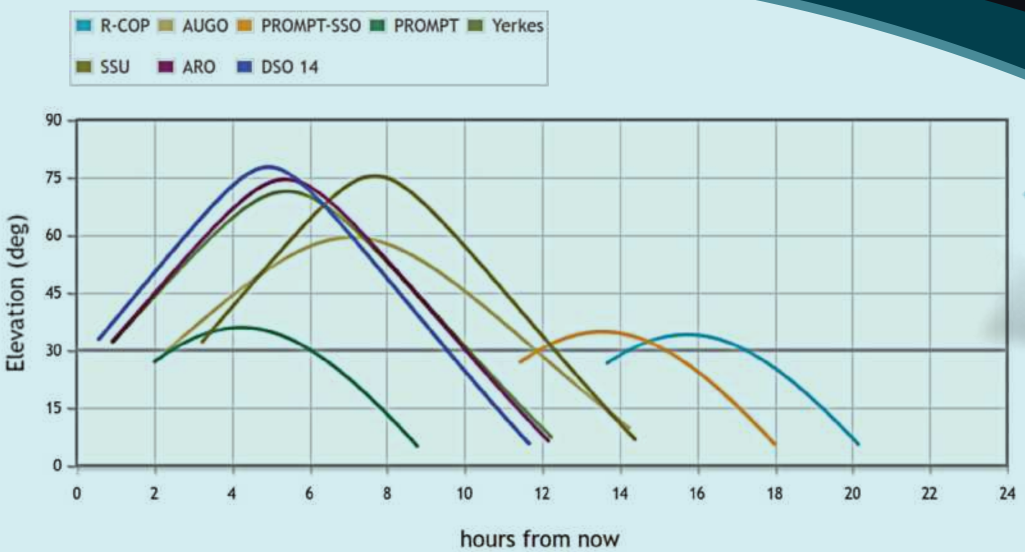
Background information

For this activity, as well as many of the other online explorations, you will need to have both the https://skynetjuniorscholars.org/ and https://skynet.unc.edu/ websites open at the same time on your computer. You will want to arrange these two websites in separate windows, side by side, so you can see them both. You may wish to print out questions or have scrap paper to write down notes as you navigate between the two websites.

Did You Know?

Nebulae—A nebula is a cloud of dust and gas. The different kinds of gases and dust reflect or glow in different colors of light and their complex layers make them beautiful telescope targets. Some nebulae mark where stars have died, either slowly or in brilliant explosions, while others are stellar nurseries.

30 Dorarus by ethanol



Let's Do It!

1. If you are not already logged in, go to https://skynetjuniorscholars.org/ and log in with your username and password.
2. Look for the **Explorations** button at the top of the webpage. Click on this button.
3. Look at the Explorations page. When you scroll down the page, you should see several topics like "Become a Skynet Junior Scholar," "Comets to Cosmology," "Starry Skies," and "Asteroid Research."
4. Find the "Become a Skynet Junior Scholar" box and click on the **Continue** button (the button will say **Get Started** if this is your first visit).
5. Now you are on a webpage with all of the online Explorations that you will complete to become a Skynet Junior Scholar. When you scroll down, you will see six Explorations.
6. Find the "Scavenger Hunt" box and click on the **Get Started** button (the button will say **Continue** if you have already visited this exploration).
7. Read and follow all of the instructions in all three sections of this online exploration.

    A Introduction
    B The SkyViewer
    C The Target Visibility Graph

8. Once you have entered your answers into the online exploration, click the **Submit Exploration** button. A SJS leader will approve your completion online and send an email.
9. In the right column, you will find a **Print** icon button. Click this button to open a print dialog box where you can either immediately print your exploration or save as a PDF file to take to a printer at a later time.
10. Make a copy of this Exploration and save it as part of your project work.

for the Project Helper

Success Indicators:

- Correct completion of the Skynet Scavenger Hunt questions

Life Skills:

- Learning to learn, problem solving, keeping records

National Science Standard:

- 4-ESS2-2. Analyze and interpret data from maps. This standard applies to maps of Earth, but SJS provides an additional application.

Go Further

Discuss your images and your ideas about imaging celestial objects on the SJS Forum with your SJS colleagues. As a good scientist, it's important to get feedback from your peers. Do they agree with your ideas? Do they have a new way of looking at the data that you didn't think of?

Expand your experiments with different objects, filters, and exposure times.

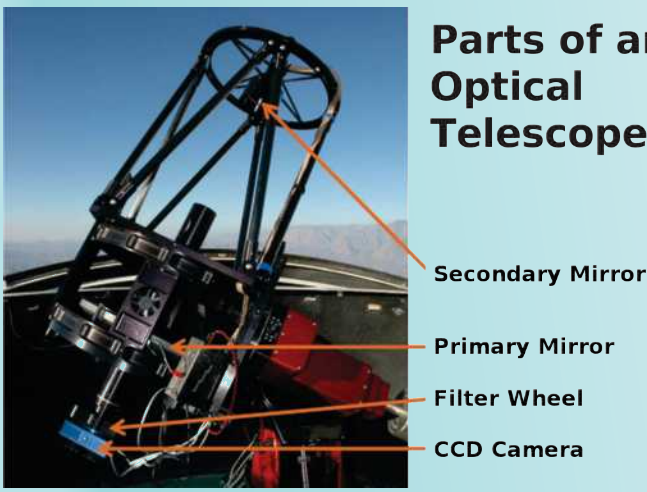
Are you puzzled
go to the
Forum
and ask an
expert!
Do you have a question

‹2.2› Anatomy of a Telescope

Telescopes are like light buckets. Just as a rain bucket collects rain droplets when left outside, a telescope collects packets of light called photons. Because the light is coming from very far distances in space, the photons shine into the telescope in parallel lines. Most telescopes use mirrors or lenses to focus this light. In this activity, we will learn how concave mirrors focus light.

How do astronomers build telescopes so they can collect as much information about the universe as possible?

Parts of an Optical Telescope



After completing this activity, you will be able to:

- ✶ Identify parts of an optical telescope
- ✶ Understand the basic functions of optical telescope parts
- ✶ Understand how light is gathered through optical telescopes
- ✶ Understand how telescopes focus light

How Skynet's Optical Telescopes work:

The optical telescopes on the Skynet Robotic Telescope Network have the following parts in common: a primary mirror that reflects the light to a secondary mirror, which redirects the light through a hole in the bottom of the primary mirror. The light then passes through a filter, before striking the CCD camera. The CCD detects the light and sends the data about the intensity of the light to a computer, where an image is produced.

for the Project Helper

Success Indicators:

- Correct identification of telescope parts
- Demonstration of how telescopes focus light
- Correct Completion of activities

Life Skills:

- Critical thinking, problem solving, communication

National Science Standard:

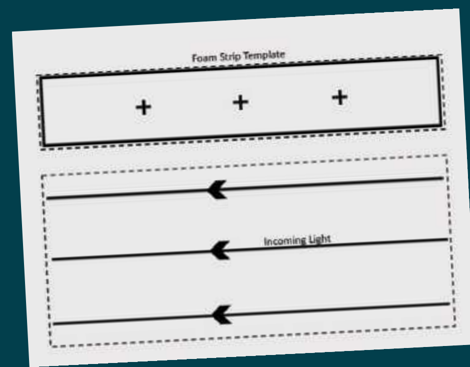
- MS-PS4-2 Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials

Let's Do It!

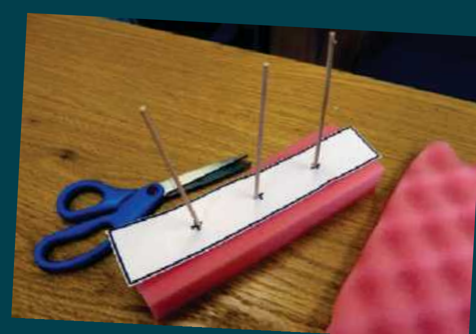
1. Remove the Foam Strip Template from the back of the book.
2. Cut the Foam Mirror Template and Incoming Light diagrams along the dotted lines. Trim about 1/4 inch off the sharp end of each skewer stick.
3. Place the template on the foam strip. Insert the skewer sticks or pencils into the foam strip at the marks – try to make them as vertical and parallel as possible.
4. Remove the template.
5. Loose sticks? If the sticks become loose after several uses, you can either: glue them into the holes by wiping the end of the each stick over a glue stick, or move each stick just to the right or left and make a new hole.
6. Tape the Incoming Light diagram horizontal on a wall at eye level (see image on the next page).

Materials List

- Metal Spoon
- Foam strips. You can use any fairly dense, soft foam (like the material some computers come packed in) or you can order the material at: www.oneoceankayaks.com. The material is "Mini-cell Foam". Order the 5/8'' thickness. You can use a utility knife to cut the foam.
- Template for foam strips found in back of project book



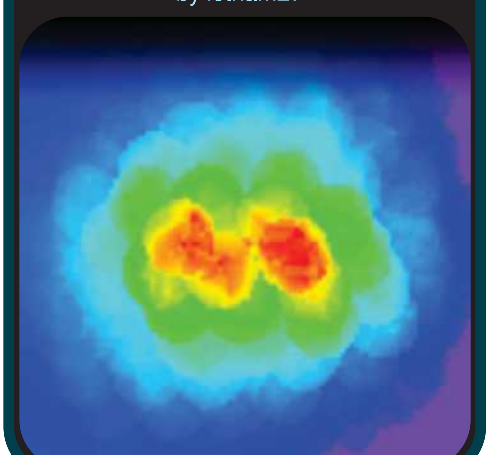
- 3 skewer sticks or sharpened pencils
- Scissors & Tape



Did You Know?

Supernovae—When a star bigger than the sun reaches the end of its life, it may explode in a powerful blast called a supernova. Supernovae are unpredictable. But the universe is a big place, and supernovae are strong beacons. This means that even amateur astronomers sometimes find "new" stars while performing routine observations. And after one has been announced, astronomers have only a short time to observe this "new star" before it disappears to most telescopes' view.

Color Spectrum Radio Crab
by letham27



Are you puzzled go to the Forum and ask an expert! Do you have a question

Because the light coming from objects in space is traveling great distances, the incoming light is always parallel, so we can use the Incoming Light lines for any telescope design. Your foam represents a telescope mirror. You can bend it and twist it to experiment with different mirror designs. The skewers represent the reflected, or outgoing light.

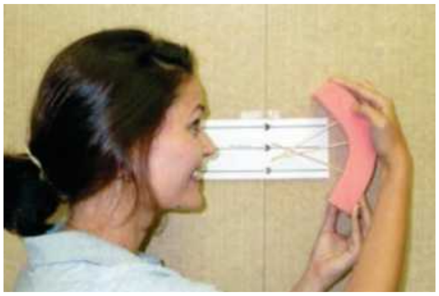
Push the foam so there is a small bump in the curve surface. Notice how this affects the position of the skewers. Why do you think it might be important to design very smooth mirrors?

Let's see how the shape of our telescope mirror (i.e. our foam) affects the pattern of the reflected light!

Pretend that you are using your foam mirror model to "image" your own face.

Stand with your head at the tail end of the Incoming light arrows. Then hold the foam mirror model with skewers facing toward you at the far end of the incoming light arrows.

1. To model a flat mirror, allow the foam model to remain straight. When you look into a flat mirror, the light comes straight back out at you. The top skewer is where your forehead is and the bottom skewer is where your chin is.
2. To model a convex mirror, gently curve the foam strip toward you so the skewers spread out. Now the incoming light from your forehead is reflected higher up above your head, and the incoming light from your chin is reflect lower down toward your neck. Look into the outside part of your metal spoon to see the image this produces.
3. To model a concave mirror, gently curve the foam strip away from you so the skewers bunch up and cross each other. NOW where is the reflected light from your forehead and chin pointing? Look at your reflection from the inside of your metal spoon to see the image a concave mirror produces.

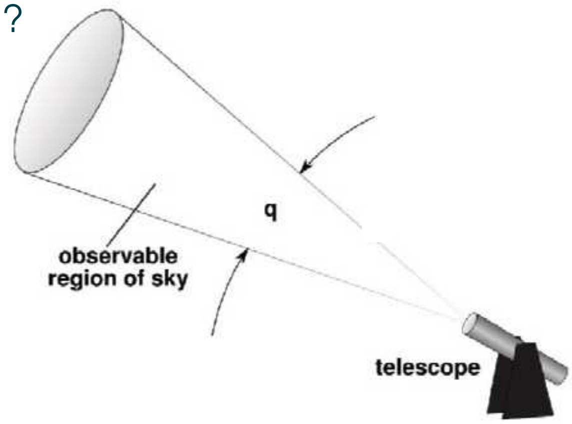


Go Further Learn more about how optical telescopes work by watching this video: http://www.faulkes-telescope.com/files/faulkes-telescope.com/archive/flash/ft_light.swf

8.2-m primary mirror of Yepun, Unit Telescope 4 of ESO's Very Large Telescope

<2.3> Field of View

Why can't we take an Image of a Constellation?



Different telescopes can see different amounts of the sky. These "pieces" of the sky are referred to as the telescope's "field of view." Field of view is measured in degrees, arc minutes, and arc seconds. It is not possible to view a whole constellation through a telescope, because the field of view of any telescope isn't big enough.

After completing this activity, you will be able to:

- ✶ Define the term "Field of View"
- ✶ Explain the difference in fields of view between the human eye and various instruments including the Skynet Telescopes

Materials List:

- "Field of View" template found in back of book
- Paper clip unfolded
- Card Stock
- Printer
- Scissors
- ¼" hole punch
- 16-penny nail
- Small nail or push pin
- Straight pin

Before the Activity

1. Print out a Field of View card on card stock. (Hint: Print 2 copies back to back, then you'll have one card for yourself and one to share.)
2. Punch a hole for the 30 arcmins hole with a regular 1/4" hole punch. Poke a hole for the 15 arcmins hole with a 16-penny nail.
3. Poke a hole for the 5 arcmins hole using a small nail or push pin.
4. Poke a hole for the 3 arcmins hole using a straight pin.
5. For the 60 arcmins hole, you can fold the card at the hole and cut out the circles, but it is recommended just to leave the card with the top circle intact. Drilling can fray or tear the paper.

for the Project Helper

Success Indicators:

- Learner will be able to answer the question "Why can't we take an image of a constellation?"

Life Skills:

- communication, decision-making

National Science Standard:

- MS-ETS1.A: Defining and Delimiting an Engineering Problem
- MS-PS4.B Electromagnetic Radiation

Let's Do It!

1. Hold your index finger at arm's length against the sky. That covers an area of the sky that is about 1 degree in size. A circle has 360 degrees of space. Each degree can be divided further into 60 minutes of arc, called arc minutes (abbreviated "arcmin"). An arcmin is the apparent thickness (width) of an unfolded small paper clip about 8 feet away.
2. Close one eye and hold out an unfolded paper clip. The thickness of the paper clip metal covers about one arcmin. What does one arcmin cover in the area around you?

NGC6992
by epjmm15

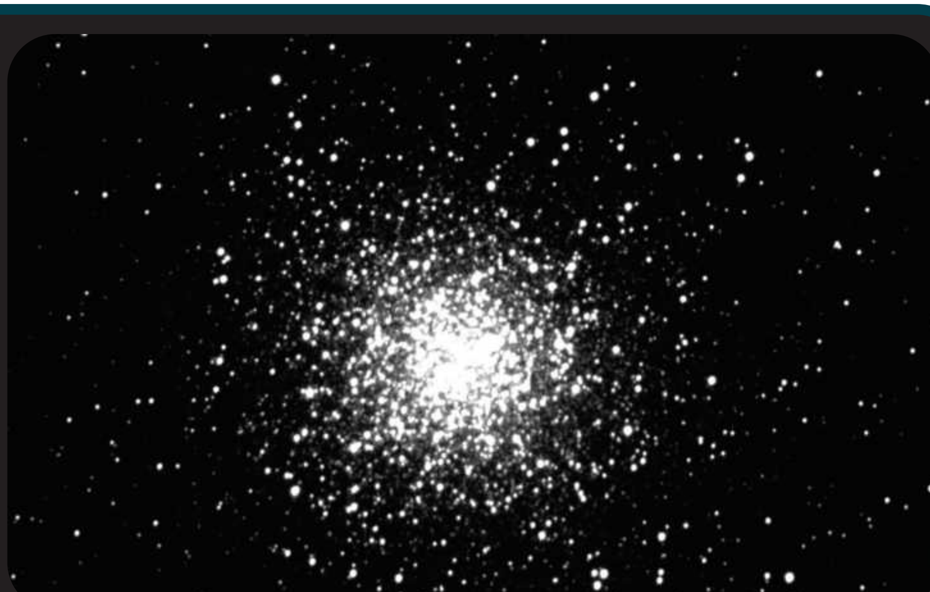
The Field of View of the human eye is nearly 180 degrees. A typical backyard telescope has a Field of View that is about half a degree. That's about the size of the full moon. With a backyard telescope, you can change the magnification by using different eyepieces, which also changes the Field of View. An eyepiece allows you to zoom in on a small piece of the telescope's Field of View, but it can't provide any more detail than what is already there. How much of the sky each Skynet telescope allows us to see varies from telescope to telescope and is determined by the combination of mirrors and lenses in each scope. The Field of View does not change.

3. Hold your Field of View card at arm's length, close one eye, and look at the sky through the 30 arcmins hole. That's how much of the sky you can see in a typical backyard telescope. It's also the apparent size of the Full moon. Look at the same area of sky through the other holes and estimate how much of the sky the different Skynet telescopes would see.

When you see a photo taken with the Hubble or one of the Skynet telescopes, that image is the amount of sky they were looking at when the telescope took the picture. Therefore, if the object under investigation covers more of the sky than the telescope's Field of View, scientists might take a whole series of pictures and put them together in a mosaic to capture the whole object.

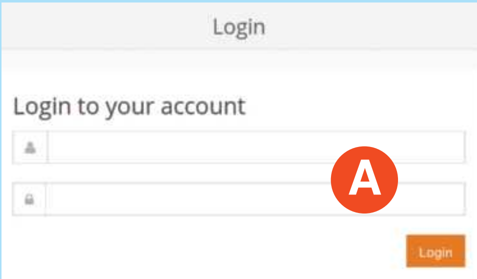
Did You Know?

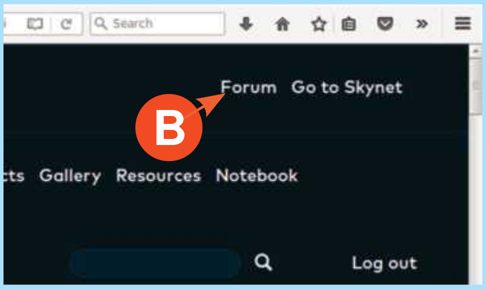
Star Clusters—Just like people in cities, stars are often found in large groups called clusters. These clusters can contain anywhere between a few hundred to a few hundred thousand members. There are globular (tightly packed) and open (more spread out) clusters. By studying how they move and what stars they contain, astronomers learn more about how galaxies form and evolve.

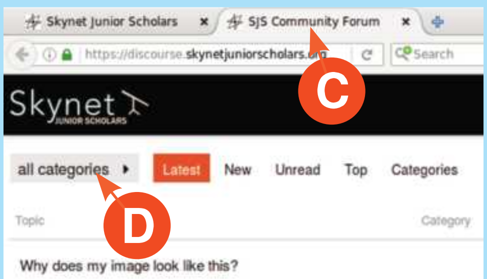


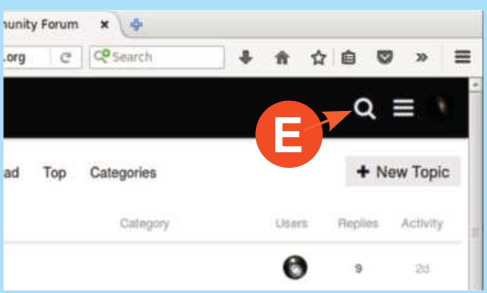
Messier 13 Picture #1
by harkness

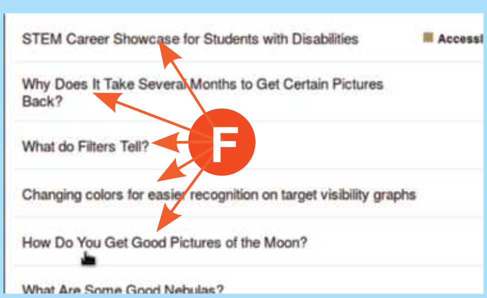
<2.4> Find Me in the Forum

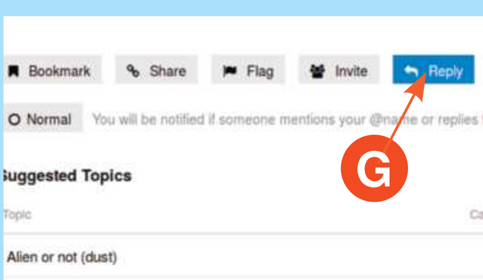












You are on your way to exploring the universe with telescopes on the Skynet network and you may have questions. At the beginning of the project, you identified an adult helper, but that adult may not have all of the answers. Skynet is not only a network of telescopes, but also serves as a network of scientists, educators, and other youth like yourself who are all interested in astronomy. The Forum on the Skynet Junior Scholars website has been designed for you to interact with these individuals to ask questions and discuss what you have learned.

After completing this activity, you will be able to:

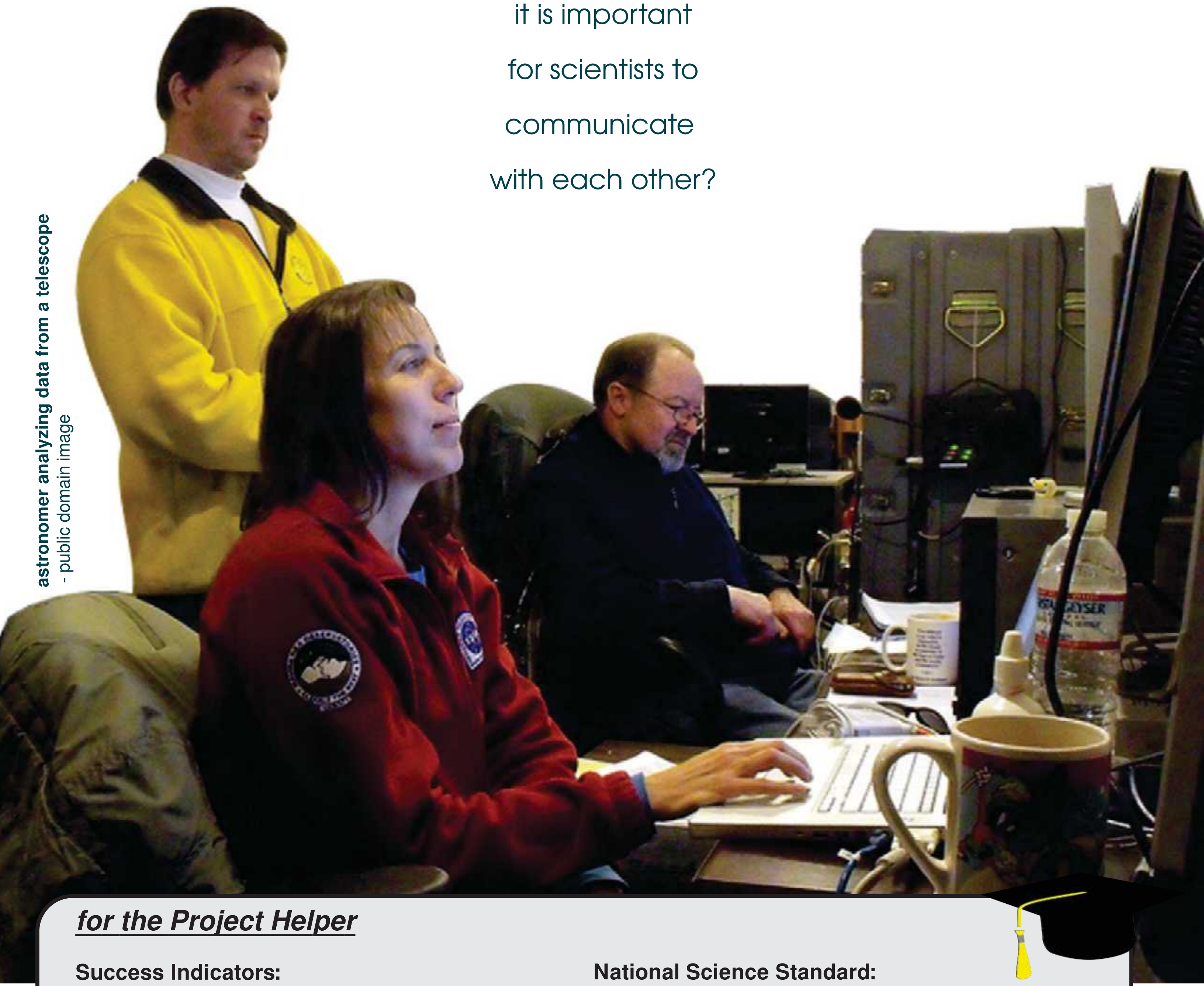
- ✶ Understand how to navigate the Skynet Junior Scholars Forum
- ✶ Use the forum as a tool for asking questions about this project
- ✶ Use the forum to interact with scientists

Let's Do It!

1. If you are not already logged in, go to https://skynetjuniorscholars.org/ and log in A with your username and password.
2. Look for the **Forum** button B at the top of the webpage. Click on this button and the forum will appear as a new tab. C
3. Explore the forum. You can scroll down the page through the list of discussion topics.
4. Try clicking on the **All Categories** dropdown menu D at the top of the forum to find discussion topics about specific categories.
5. Click on the magnifying glass E to search topics that you might be interested in such as Stars, Comets, Planets, Nebula, Constellations, or even search "4-H."
6. Find a discussion that interests you and click on that discussion topic. F You will be able to read the original discussion post followed by any additional discussion by other Skynet participants.
7. If you wish to join the conversation, click on the **Reply** button. G Type your ideas into the textbox and click **Reply** below the textbox.
8. When you are done using the Forum, you can close the Forum tab C or click on the Skynet Junior Scholars tab.

Not sure what discussion topic you want to respond to? Search for "Skynet Junior Scholars 4-H Project Book" and post a reply to this topic.

Why do you think it is important for scientists to communicate with each other?



astronomer analyzing data from a telescope
- public domain image

for the Project Helper

Success Indicators:

- Post a message in the Skynet Junior Scholars Forum

Life Skills:

- Learning to learn, problem solving, critical thinking, communications

National Science Standard:

- MS ETS1.A: Defining and Delimiting Engineering Problems
- MS ETS1.B: Developing Possible Solutions
- MS ETS1.C: Optimizing the Design Solution

Chapter 2 Questions

In this chapter, you completed activities to familiarize yourself with the Skynet Junior Scholars telescopes and how they operate.

Share

What did you learn about telescopes that you found interesting?

Reflect

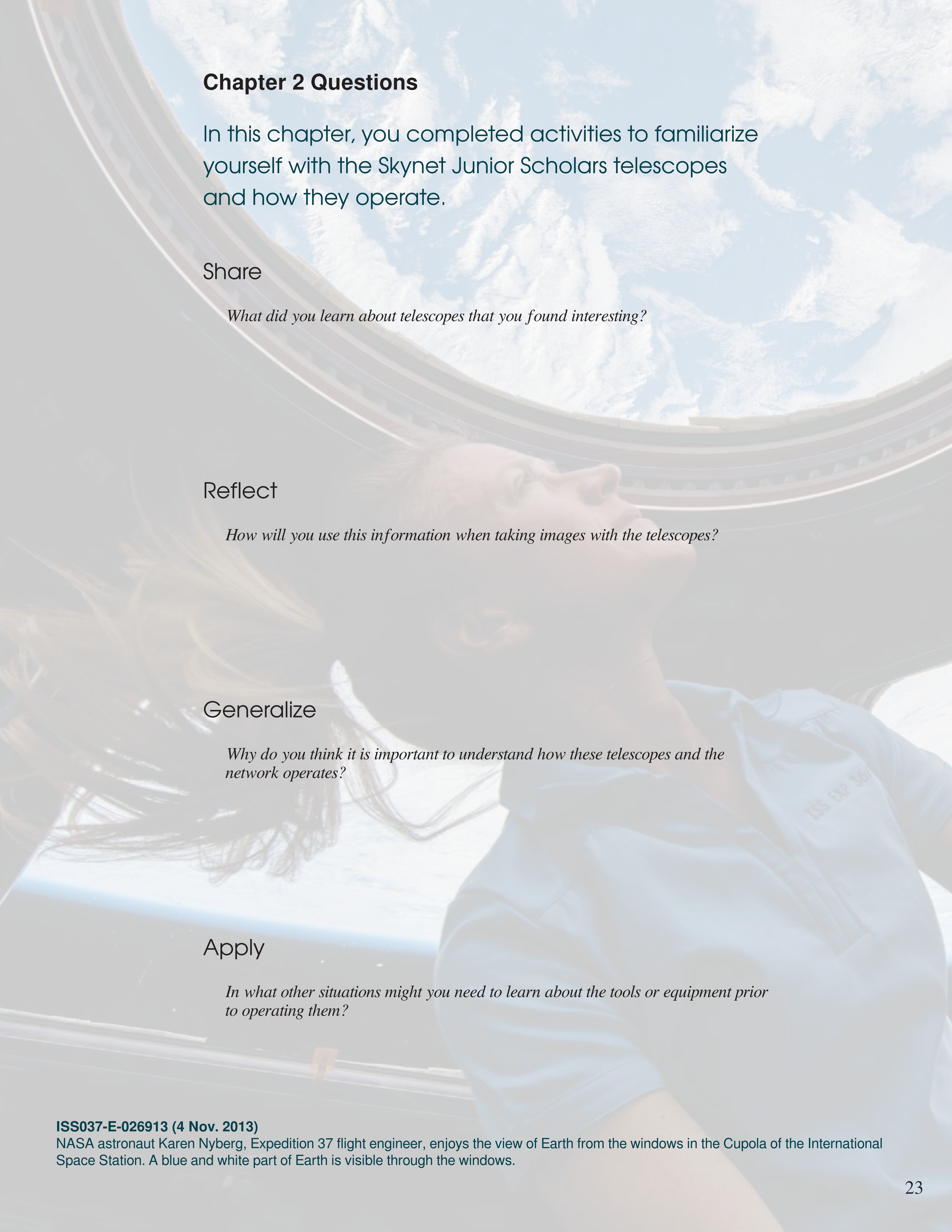
How will you use this information when taking images with the telescopes?

Generalize

Why do you think it is important to understand how these telescopes and the network operates?

Apply

In what other situations might you need to learn about the tools or equipment prior to operating them?



ISS037-E-026913 (4 Nov. 2013)
NASA astronaut Karen Nyberg, Expedition 37 flight engineer, enjoys the view of Earth from the windows in the Cupola of the International Space Station. A blue and white part of Earth is visible through the windows.

Chapter 3: Digital Imagery

<3.1> Astrophotography

In Chapter 2.2, you learned that telescopes are light buckets that collect packets of light called photons and that these photons are focused into images using primary and secondary concave mirrors. Have you ever wondered how the final images are created? In this activity, you will learn how CCD cameras create digital images. You will also use a digital camera to take your own picture of the night sky.

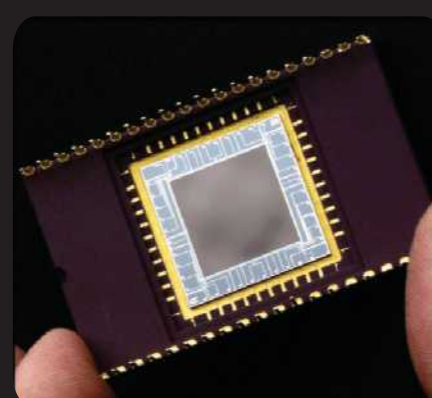
How are images created in modern telescopes?

How does a CCD camera work?

How can you make a digital image of the night sky?

Did You Know?

CCDs—The images produced by Skynet telescopes were created using charge coupled devices, or CCDs. A CCD chip contains pixels that are sensitive to photons of light. When the light from a telescope hits a pixel, it is converted into an electrical charge. This charge is stored on the pixel and can be read by a computer.



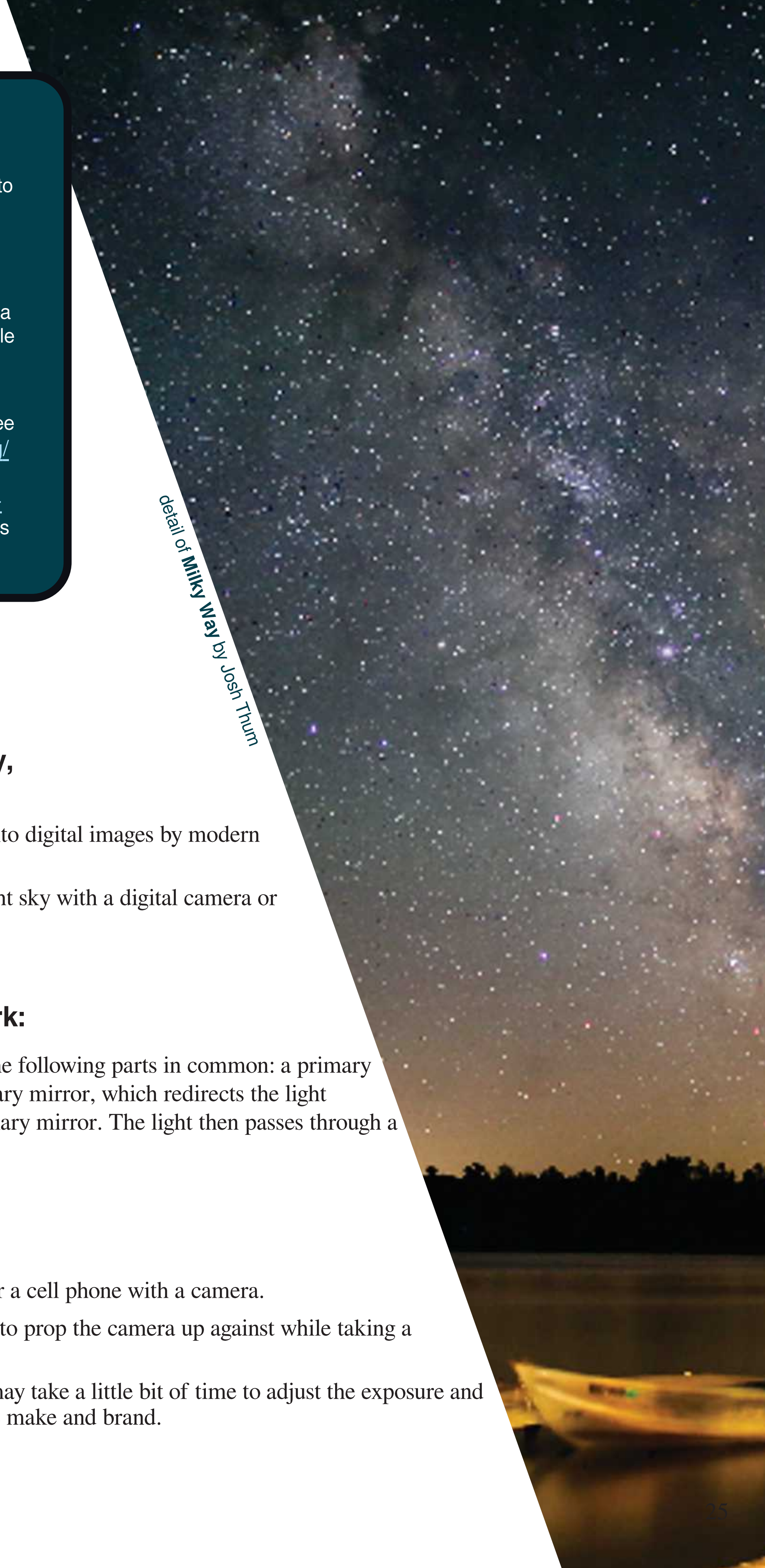
To make an image, many thousands or even millions of pixels are arranged in a grid pattern on the CCD. Much like the scenario discussed in Chapter 2.2, each pixel can be thought of as a small bucket that fills with light, or in this case charge, during the exposure length. Each pixel on the CCD builds up an electric charge that is proportional to the light from the original image. Data about the intensity of light from each pixel is sent to a computer to produce an image. Digital cameras, including cell phone cameras, use very similar technology to create images.

Visit this interactive animation to see how telescope CCD cameras work:
http://support.faulkes-telescope.com/multimedia/ccd/CCD%20Fullscreen.swf

Because CCD cameras only record how much light is detected, they look black and white. However, by using different filters and combining their images in computer programs, astronomers can create color images of the universe.

Materials List:

- Computer with Internet access to view animation
- Digital camera or cell phone camera
- Tripod or something sturdy like a table to prop the camera on while taking the picture
- Optional: an app like NightCap Pro for smartphone camera. See https://www.eyeem.com/blog/heavens-above-5-tips-for-capturing-the-night-sky-with-your-smartphone/ for more tips and suggestions.



detail of **Milky Way** by Josh Thum

After completing this activity, you will be able to:

- ✶ Explain how light is converted into digital images by modern telescopes
- ✶ Create a digital image of the night sky with a digital camera or phone camera

How Skynet Telescopes work:

The optical telescopes on Skynet have the following parts in common: a primary mirror that reflects the light to a secondary mirror, which redirects the light through a hole in the bottom of the primary mirror. The light then passes through a filter, before striking the CCD camera.

Before the Activity

- ✶ You will need a digital camera or a cell phone with a camera.
- ✶ You should also have something to prop the camera up against while taking a picture of the night sky.
- ✶ Every camera is different, so it may take a little bit of time to adjust the exposure and shutter settings depending on the make and brand.

Let's Do It!

1. Watch this interactive animation to see how telescope CCD cameras work:
   http://support.faulkes-telescope.com/multimedia/ccd/CCD%20Fullscreen.swf
2. Take an image of the night sky. Read the tips below about astrophotography.
3. Record data about your image on the next page.

Star Trails by Josh Thum

Astrophotography at Home

Skynet telescopes are great at zooming in on faint, far away objects, but sometimes we need to step back and look at a wider field of view. This helps us get the big picture, so to speak. We don't need a telescope for this kind of picture.

With a digital camera or cell phone camera, you can take a picture of the night sky. However, the night sky is dark! So, a quick "snap" shot won't work. Check your camera setting and try to find one that will allow you to collect light for 10 seconds or more. You will also need a way to keep your camera very still. Use a tripod or prop the camera against something sturdy, and use a voice command or a few seconds of shutter delay to take the photo. Every camera is different, so it may take a little bit of time to adjust the exposure and shutter settings depending on the make and brand.

Try searching the internet for specific directions for your camera. Another option is to use a smartphone camera outfitted with an inexpensive app which will allow you to take more defined pictures of the night sky. On iOS you can use **Slow Shutter Cam** or **Average Camera Pro**. For Android, try **Camera FV-5 Lite** or **Night Camera***. Either way, you will need a little bit of practice and patience before you get the perfect shot. Make sure to keep track of what settings you use in your project book and share it on the forum.

Milky Way with fireball by Josh Thum

**cell phone apps change frequently and the apps listed here may not be available for your particular phone model. You may need to experiment with other apps. Be sure to report good ones in the forum!*

The Big Dipper by cliff_n

Additional tips for taking your picture:

- ✶ When choosing a point of interest, look for a prominent constellation, the moon, or the Milky Way if your night sky is dark enough.
- ✶ Including an object from the horizon in the foreground, like a silhouetted tree or building or a mountainous landscape, will make your photo more appealing.
- ✶ When you are including the landscape in your photo, make sure that horizon is straight.

Orion Constellation over Yerkes Observatory by Vivian Hoette (sjsvivian)

Record the following:

1. Date and Time
2. Location: *Where were you when the image was taken?*
3. Link to the image in the Skynet Junior Scholars gallery.
4. Environmental factors: *Was the moon up? Did you have light pollution to contend with?*
5. List all of the equipment/apps that you used, such as a digital camera, phone, tripod, etc.
6. How did you do it? *Describe your procedure in detail so you and other scholars can follow your advice or learn what things to avoid!*
7. What worked and what didn't? What will you try next?

for the Project Helper

Success Indicators:

- Demonstration of how telescopes and phone cameras use CCDs to covert light into digital images.
- Correct completion of activities.

Life Skills:

- learning to learn, critical thinking, problem solving, planning/organizing, keeping records

National Science Standard:

- MS-ESS1-1, MS-ESS1-2 - Develop and use a model to describe phenomena.

<3.2> Investigate Exposure Time

One of the big decisions you will have to make each time you request an image from Skynet is how long you want the camera's shutter to be open to collect light. That is exposure time. Let's use the Skynet telescopes to investigate! We would like you to use 90 seconds of telescope time to investigate how changing exposure time affects astronomical images. That's plenty of time to take 4 or 5 images.

Materials List:

- Skynet Junior Scholars **Exposure Time** activity listed under **Explorations → Become a Skynet Junior Scholar** on the Skynet Junior Scholars website

What are your initial ideas about the meaning of exposure time?

for the Project Helper

Success Indicators:

- At least three optical observations of the same object with different exposure duration.
- Understanding or the relationship between distance, object brightness, and exposure duration.
- Correct completion of activities.

Life Skills:

- critical thinking, problem solving, communication

National Science Standard:

- 5-ESS1-A, The Universe and its Stars.

After completing this activity, you will be able to:

- ✶ Identify the parts of an optical telescope
- ✶ Understand the basic function of optical telescope parts that control exposure time
- ✶ Understand how light is gathered through optical telescopes
- ✶ Experiment with various exposure durations

How Skynet Telescopes work:

The optical telescopes on Skynet have the following parts in common: a primary mirror that reflects the light to a secondary mirror, which redirects the light through a hole in the bottom of the primary mirror. The light then passes through a filter, before striking the CCD camera. The CCD detects the light and sends the data about the intensity of the light to a computer, where an image is produced.

Before the Activity

- ✶ Participants must have allocated 90 seconds of telescope time to use to complete this activity.

Let's Do It!

1. If you are not already logged in, go to https://skynetjuniorscholars.org/ and log in with your username and password.
2. Look for the **Explorations** button at the top of the webpage. Click on this button.
3. Look at the Explorations page. When you scroll down the page, you should see several topics like "Become a Skynet Junior Scholar," "Comets to Cosmology," "Starry Skies," and "Asteroid Research."
4. Find the "Become a Skynet Junior Scholar" box and click on the **Continue** button (the button will say **Get Started** if this is your first visit).
5. Now you are on a webpage with all of the online Explorations that you will complete to become a Skynet Junior Scholar. When you scroll down, you will see six Explorations.
6. Find the "Exposure Time" box and click on the **Get Started** button (the button will say **Continue** if you have already visited this exploration).
7. Read and follow all of the instructions in all four sections of this online exploration.
   - **A Introduction**
   - **B Design Your Experiment**
   - **C Data Analysis & Results**
   - **D Conclusions**
8. Once you have entered your answers into the online exploration, click the **Submit Exploration** button. A SJS leader will approve your completion online and send an email.
9. In the right column, you will find a **Print** icon button. Click this button to open a print dialog box where you can either immediately print your exploration or save it as a PDF file to take to a printer at a later time.
10. Make a copy of this Exploration and your Gallery images and save them as part of your project work.

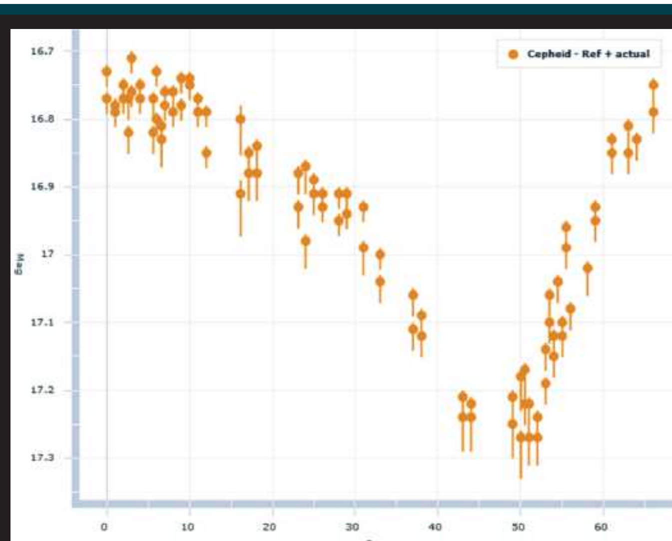
Go Further

Discuss your image and your ideas about exposure time on the SJS Forum with your SJS colleagues. As a good scientist, it's important to get feedback from your peers. Do they agree with your ideas? Do they have a new way of looking at the data that you didn't think of?

Expand your experiment with different objects or different exposure times.

Did You Know?

Variable Stars—Most stars shine with steady light, changing brightness by only a tiny percent over many years. But some kinds of variable stars change their brightness by enough and on short enough timescales (hours to months) to make them interesting to watch. Some erupt unpredictably, while others keep time like clockwork.



Light curve for Cepheid variable in NGC 6822
by kathryn
Going through the UNC labs. This is fun! I measured the period to be 67.43 days and calculated the distance to be 518 kpc.

<3.3> Fun with Filters

Astronomers often look at objects in space through filters of different colors. Although this changes how the objects look, it helps them sort out details in the structure and composition of the objects they are looking at. This activity gives participants some experience with colored filters and how astronomers use them to understand astronomical objects.

What is a filter? Can you find things in your home or classroom that are filters? How are these filters helpful? What kind of filter might you use in a factory with loud machinery? Or to prevent sunburn? Or to prepare a meal? Or prevent an allergy attack?

After completing this activity, you will be able to:

- ✶ Understand that white light is composed of different colors
- ✶ Understand how to use filters to isolate color(s) of interest

for the Project Helper

Success Indicators:

- Students will be able to demonstrate how a diffraction grating sheet can be used to split white light into colors of the spectrum.
- Students will learn to identify filters of all types in their world.
- Students will learn how color filters are used to visualize data.

Life Skills:

- learning to learn, problem solving, critical thinking

National Science Standard:

- MS-PS4-B: Electromagnetic Radiation
- MS-PS4-A: Wave Properties.

Part One: Visible light is made up of the colors of the rainbow

Materials List:

- One pair of "Rainbow Glasses" or "Rainbow Peepholes" for each student. These may be purchased from science surplus stores, museum gift shops or ordered online.

- Flashlight

Before the Activity

- ✶ Set up a bright flashlight in a dark room so it shines at you
- ✶ Describe what you see

Let's Do It!

Look through your rainbow glasses. What do you notice when you look at the light? Come up with an explanation for what you see.

The Rainbow Peepholes are called diffraction gratings. Diffraction gratings act like a prism and bend the waves of light. (It is useful to think of light as being electromagnetic waves.) The waves that make up purple light are bent the most. The waves that make up blue light are bent more than the waves that make up green light. Red light waves are bent the least. In this way, the diffraction gratings separate the white light out into its different wavelengths or colors! Is the light from the flashlight made up of all of these different colors mixed together? Yes!

Part Two: Alien Eyes

Before the Activity

Assemble a cosmic visor:

1. Cut the blue, green and red theatrical gel sheets into strips that are about 1.25 inches wide and 8 inches long. One color strip is needed to make one mask, and you need at least one mask of each color. (Save the left over bits of gel sheets -- you can cover your flashlight with them in the follow up activity.)
2. Cut manila folders at their fold. Cut them in half again. Cut a 1" x 7" window in each of these pieces. This can easily be accomplished by folding the face mask in half and making the cuts. Cover the window by taping a colored gel strip over it on one side. Place tape along all 4 sides to hold it securely in place. [see figure 1]
3. You can make straps for your visors by using string, ribbons, or rubber bands. You can also make straps by cutting extra manila folders (whole, but folded) into eight strips. You will need two strips per visor. Tape one strip to each side of each visor at the top (tape heavily and on both sides to make sure strips are secure and durable). They should be fastened in the back by paper clips to keep them over people's eyes and on their heads [see figure 2]. Your Cosmic Visors are now complete.

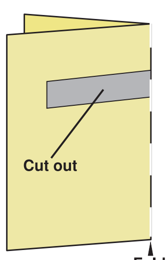


Figure 1

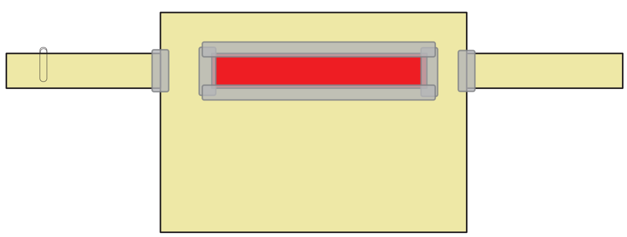


Figure 2

Download the Fun with Filters Presentation:

4. If you are not already logged in, go to https://skynetjuniorscholars.org/ and log in with your username and password.
5. Look for the **Resources** button at the top of the webpage. Click on this button.
6. Use the "Filter by Topics" dropdown menu to locate 'Investigate Filters."
7. Locate the **Fun with Filters PDF for use by youth working on their own** and click on that title.
8. The direct link is: https://skynetjuniorscholars.org/supplements/106/file
9. Make sure the filters presentation is queued and ready on the computer, and be ready to advance the slides when necessary.

Materials List:

- Theatrical gel sheets (blue, red, and green). These filters can be purchased from stage lighting companies but often music stores that sell lighting equipment will have them as well. If you can't find any, be creative! Any colored transparent item will do. For example, some cheese is wrapped in a transparent red plastic sheet. You could even add color dye to unflavored gelatin mix and make a batch of color filters!
- Manila folders, or other face masks.
- Paper clips for securing cosmic visors.
- A computer to show the Alien Eyes presentation. A projector is helpful when working with larger groups.

Please Note!

For best results download the Alien Eyes presentation as a PDF from

https://skynetjuniorscholars.org/↩
supplements/106/file

After downloading, open the file and allow full-screen mode if prompted. Use the arrow keys on your keyboard to go through the slides.

The slide show presentation effects do not work in web browsers!

Did You Know?

Comets—Comets are balls of ice and rock that spend most of their lives near the solar system's far edges. But it takes only a tiny gravitational nudge, probably from one of the outer planets, to send one streaking toward the sun. As it draws close, the sun's radiation and "solar wind" of energetic particles heat up the comet until it produces a cloud of gas and stripped-off material. It grows a long tail of these materials that can extend behind it hundreds of times the size of the comet itself—its nucleus.

Comet Ison before it was destroyed by the Sun
by sjs-admin
Taken with the Yerkes 41 inch
October 2013

Let's Do It!

Put on your cosmic visor. If you don't have a cosmic visor, select a filter to look through. Adjust visors so that you can easily see through the filters, but it is impossible or difficult to see anything else. When your visor is properly adjusted, take a look around.

Note how different everything now looks through the visors.

This may be how an alien from another planet might see the world! Now pretend you are an alien sent to visit other planets to report what you see to your commander.

Your computer screen will show messages and pictures from another world. Listen to your commanders instructions and make a note of what you see for your report.

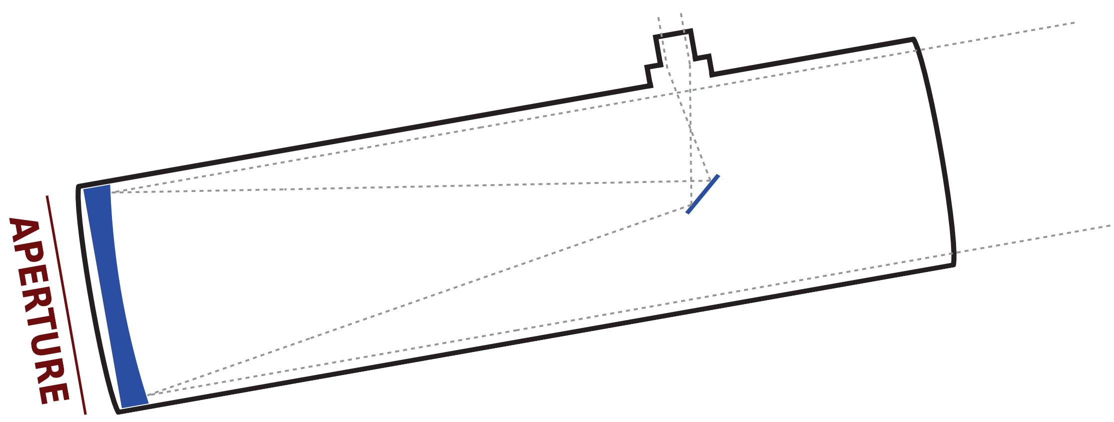
Follow Up:

Revisit Part One of this activity, but now, cover the flashlight with pieces of the colored filters and look at the light with the Rainbow Peepholes.

Green Bank 20 meter
by cliff_n

Talk Like an Astronomer!

Aperture—With Skynet, you have access to many different kinds of telescopes. One of the most basic questions astronomers want to know about a telescope is its aperture. This is a fancy way of talking about the size of its main mirror. (Telescopes usually have two or three mirrors to focus the light and aim it toward the camera or your eye, but the main one is the most important.)



Aperture is key because it is the deciding factor in how much light the telescope can collect. The bigger the mirror, the more light you get. So, more aperture lets you see smaller and dimmer objects that are farther away, because you're collecting more light from them.

Go Further

Make your own Filters!

SJS Project Director Vivian Hoette had a brainstorm one day and created red, green and blue filters with Jell-O®! Here's a picture of University of Chicago astronomer Al Harper viewing a "star cluster" (made of colored bottle tops) through a red Jell-O® filter. What would LEGOs® look like using Jell-O® filters? What other kinds of filters can you find or make?

Tactile Filters.

White light is a mixture of all the colors in the rainbow. Each color represents a different wavelength, where blue light is a shorter wavelength than green or yellow, and red light is longest of all.

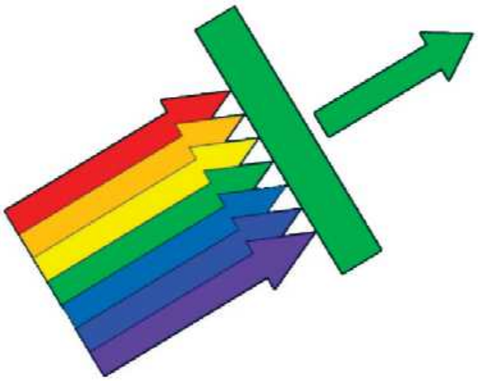
You can represent these different wavelengths of light with a nice bird seed mix! Sunflower seeds can represent red light, corn can represent yellow light and tiny millet seeds can be blue. Can you find a "blue filter" that only lets the "blue light" through?

Reinforce the EM Spectrum by playing electromagnetic war!

The Space Public Outreach Team at Montana State created a fun card game that uses EM spectrum cards! The activity may be downloaded from https://skynetjuniorscholars.org/supplements/35/file. Print on card stock front and back, then cut out to have playing cards. Students can play "Electromagnetic War" to learn about the differences between different types of light. The game can be modified so that highest energy wins, or longest wavelength, or highest frequency. It's played exactly like the card game War.

<3.4> Investigate Filters

Astronomers routinely use filters in front of their cameras when taking images of the Universe. As a Skynet Junior Scholar, you'll have the chance to choose filters each time you request an image. In this exercise, you will learn what a filter is and how Skynet filters will impact your images.



What do you think of when you hear the word "filters?"

After completing this activity, you will be able to:

- ✶ Explain what a light filter is
- ✶ Explain how colored filters affect images
- ✶ Describe the different Skynet filters
- ✶ Compare the brightness of features on images taken with different filters
- ✶ Demonstrate how to use the Skynet Afterglow alignment feature

Visible light is a spectrum of colors. You see the colors that make up visible light when sunlight passes through droplets of water in the sky and creates a rainbow.

Before the Activity

Participants must have allocated 120 seconds of telescope time to use to complete this activity.

Materials List:

- Computer with internet access to Skynet Junior Scholars **Investigate Filters** activity listed under the Explorations tab on Skynet Junior Scholars website
- Handout on Skynet Telescope Filters (included in appendix)

Let's Do It!

1. If you are not already logged in, go to https://skynetjuniorscholars.org/ and log in with your username and password.
2. Look for the **Explorations** button at the top of the webpage. Click on this button.
3. Look at the Explorations page. When you scroll down the page, you should see several topics like "Become a Skynet Junior Scholar," "Comets to Cosmology," "Starry Skies," and "Asteroid Research."
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6. Find the "Investigate Filters" box and click on the **Get Started** button (the button will say **Continue** if you have already visited this exploration).
7. Read and follow all of the instructions in all four sections of this online exploration.

   A Introduction
   B Design Your Experiment
   C Data Analysis & Results
   D Conclusions
8. Once you have entered your answers into the online exploration, click the **Submit Exploration** button. A SJS leader will approve your completion online and send an email.
9. In the right column, you will find a **Print** icon button. Click this button to open a print dialog box where you can either immediately print your exploration or save it as a PDF file to take to a printer at a later time.
10. Make a copy of this Exploration and your Gallery images and save them as part of your project work.

for the Project Helper

Success Indicators:

- Students will take images using different filters, align two of the images in afterglow, and then compare various features on the images.

Life Skills:

- communication, decision-making, critical thinking

National Science Standard:

- MS-PS4-B: Electromagnetic Radiation
- MS-PS4-A: Wave Properties.

Go Further

Discuss your image and your ideas about filters on the SJS Forum with your SJS colleagues. As a good scientist, it's important to get feedback from your peers. Do they agree with your ideas? Do they have a new way of looking at the data that you didn't think of? Expand your experiment with different objects or different filters.

Chapter 3 Questions

In this chapter, you completed activities to familiarize yourself with the Skynet Junior Scholars telescopes and how they operate.

Share

What did you find most interesting about this chapter's activities and why?

Reflect

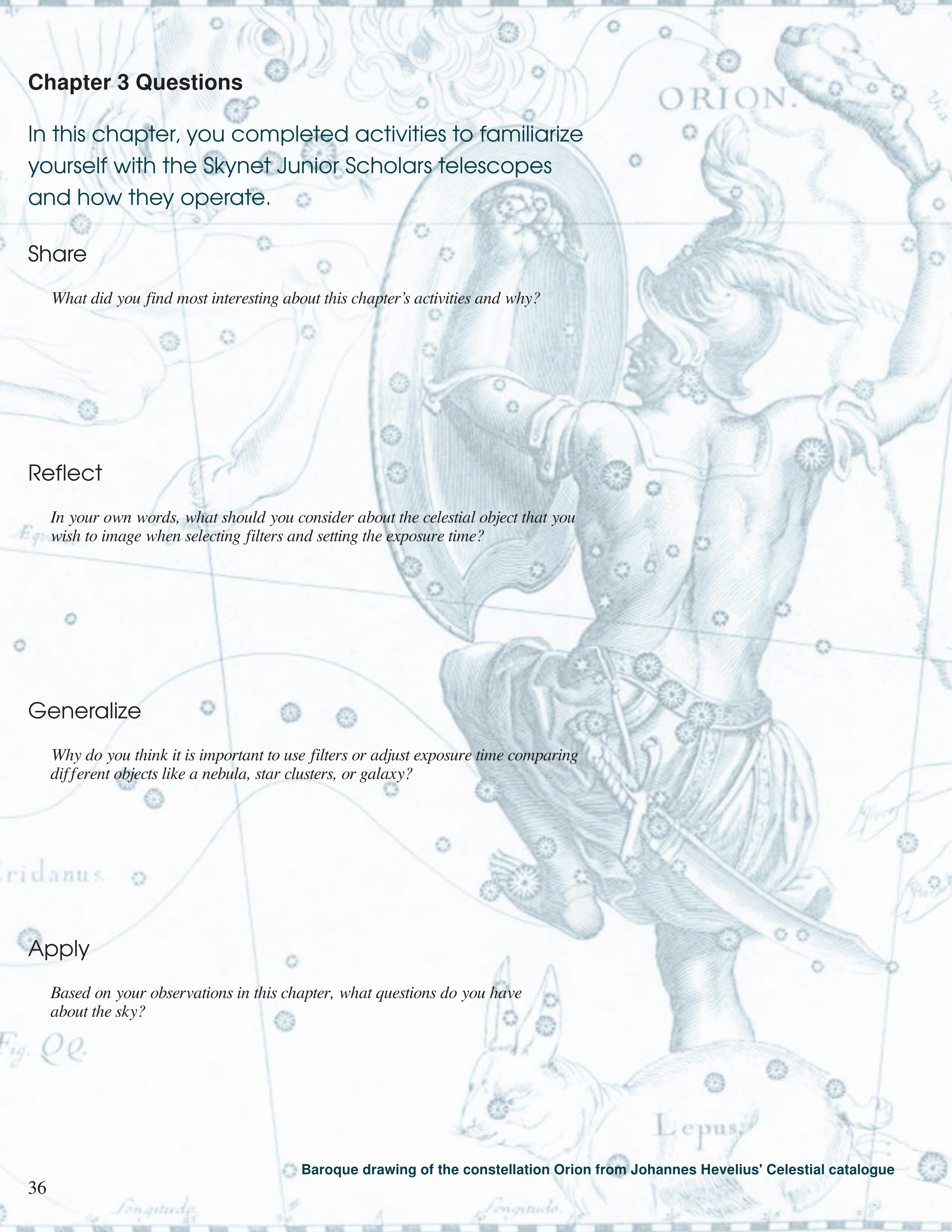
In your own words, what should you consider about the celestial object that you wish to image when selecting filters and setting the exposure time?

Generalize

Why do you think it is important to use filters or adjust exposure time comparing different objects like a nebula, star clusters, or galaxy?

Apply

Based on your observations in this chapter, what questions do you have about the sky?



Baroque drawing of the constellation Orion from Johannes Hevelius' Celestial catalogue

Chapter 4: Explore Further

<4.1> Address in the Sky

For places on Earth we use latitude and longitude, a fixed coordinate system describing a location in relation to north or south of the equator and east (or west) of an imaginary line that runs from the north pole to the south pole called the prime meridian.

But when describing objects in the sky, we need a different system. It's hard to imagine. We look out from the inside to a sphere of sky, like being inside of a starry dome. The stars rise and set every night as our Earth rotates, and the sky appears differently to observers depending on how far north or south their position on Earth. Astronomers created a way to assign a fixed address to any place in the sky.

How do astronomers identify positions in the sky?

How is mapping of the sky similar to mapping on Earth?

for the Project Helper

Success Indicators:

- Demonstration of how celestial coordinates are used to locate objects in space.
- Correct completion of activities.

Life Skills:

- learning to learn, decision-making, problem solving, critical thinking

National Science Standard:

- 4-ESS2-2. Analyze and interpret data from maps. This standard applies to maps of Earth, but SJS provides an additional application.

After completing this activity, you will be able to:

✶ Model a celestial sphere and create vertical lines representing right ascension (RA) and horizontal bands representing declination (dec)

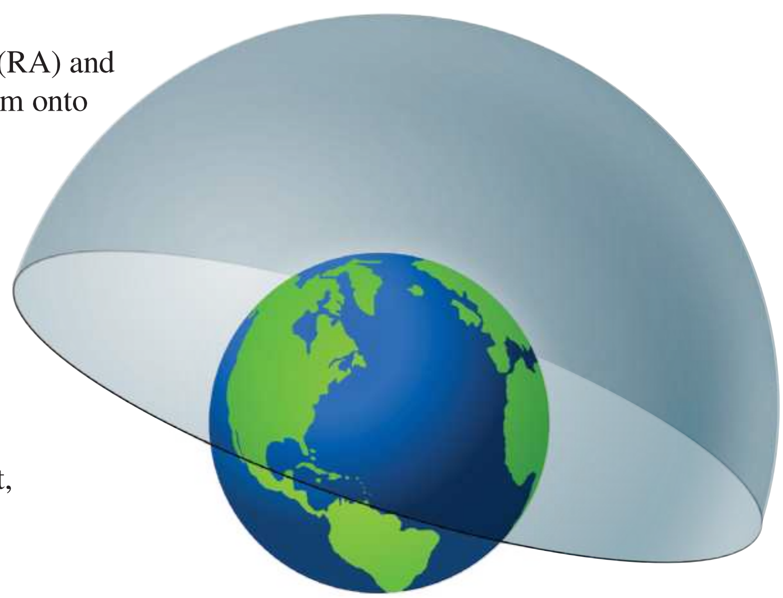
✶ Compare right ascension and declination in the sky to longitude and latitude on the Earth

✶ Using coordinates, locate a position on a celestial sphere or sky map

Astronomers use a coordinate system of right ascension (RA) and declination (dec) to map the sky. They project this system onto a celestial sphere.

Celestial Sphere

To visualize how the system works, astronomers use a tool called a celestial sphere. This system pretends that Earth is the center of the universe with starry and sunny sky surrounding us. Essentially, we create a spherical map, and then imagine ourselves in the center of that sphere. We see half the sphere like a sky-dome rotating overhead. So when you look at the Skyviewer in Skynet, it is important to imagine it as the inside of a sky-dome, not a like globe.



Materials List:

- Orange
- Permanent Marker (Sharpies work the best)
- Something spherical or half spherical like a plastic fillable craft ornament that can be opened into two halves or plastic spherical lids used with milkshakes and slushies, etc.
- Something to make lines and labels: permanent markers, craft sticky tape, etc.
- The appendix has a template and additional instructions for making a paper version of the celestial sphere.

Are you puzzled go to the Forum and ask an expert! Do you have a question

Some of the important places on the celestial sphere are analogous to places on Earth. Imagine the north and south poles of Earth projected outward to create a north celestial pole (NCP) and south celestial pole (SCP). Imagine Earth's equator projected onto the sky and call it the celestial equator.

Vertical lines are called right ascension (RA): Imagine 24 vertical lines connecting the NCP and SCP, beginning at 0. Each segment each represents an hour of time in Earth's rotation. Astronomers chose to divide up the segments into 24, because it takes the Earth 24 hours to rotate each day.

Where to put the 0 hour line?

The 0 hour line represents where the sun appears to be on the first day of spring or the vernal equinox. At midnight on that date we would see the 12 hour line of RA in the middle of the sky. The 0 hour and 24 hour lines of right ascension are the same spot, because once the Earth gets to the 24 hour line in the sky, we start over again with the line 0 hour.

Each hour of RA is subdivided into 60 minutes. Each minute of RA is divided into 60 seconds. So RA is measured in hours (h) minutes (m) and seconds (s). Keep in mind that each star's address in this system is fixed, and the map itself is what appears to rotate overhead. So, the star Vega always has a right ascension of 18 hours, 36 minutes, and 56 seconds, but it will still appear to rise and set every night as Earth itself rotates.

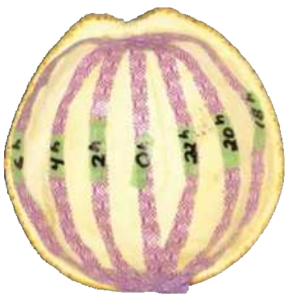
Horizontal bands are called declination (dec): Declination is measured degrees (°), arcminutes ('), and arcseconds ("). Declination is measured above and below the celestial equator. Each degree is 60 arcminutes. Each arcminute is 60 arcseconds. Above the celestial equator is designated as positive, + or N. Below the celestial equator is designated as negative, – or S.

Objects over the north celestial pole stand at +90 degrees declination, while objects over the south celestial pole are at -90 degrees declination. Objects that pass over the celestial equator are at declination 0 degrees.

Let's Do It!

Imagine the celestial sphere as an orange. Oranges have a stem end and a blossom end, which we will imagine as north and south poles. The largest circle you can make in between the poles, we will imagine as the celestial equator of the sky. Where is the Earth in this model? It is inside the orange, and you on the Earth are looking out into the rind imagining it to be the sky with celestial coordinates mapped on its surface.

Right Ascension



Imagine your orange turning around once every 24 hours. If you are using an orange, use a sharpie or sticky tape to mark your lines connecting the top and bottom of the orange. You probably won't make enough north/south lines to create 24 segments, one for each hour, but that is how astronomers think of the celestial sphere. Remember, 24 hours of RA is the same as 0 hours of RA.

Unfortunately, it is tricky to figure out how to label these lines, because we are observing from the inside of the orange. A better method would be to use an object that allows us to see the sphere from the inside.

A fancy version could be the kind of plastic ornament sold at craft stores that can be opened into two halves The ornament spheres can be marked with whatever is convenient. Sticky tape works well, because you can lift it up and reposition as needed. Permanent markers are another great option.

RA gets bigger as the Earth turns, making the sky appear to rise in the east and set in the west. So as you move east, you will be numbering to the left (north at the top of the inside of your sphere). This example is using lines spaced 2 hours apart so there are 12 lines.

Declination

Model a north and south pole. Imagine the top of the orange as the north pole, with the scar on the bottom of the fruit where the flower blossom used to be as the south pole. The top or stem would be +90 degrees north declination, and the scar at the base would be -90 degrees south declination.

To model the celestial equator, mark a big circle around the middle of your model, like you were creating a belt. This would be like the Earth's equator projected into space, and is called the celestial equator. The celestial equator is at 0 degrees, with parallel circles above and below the equator representing degrees north to +90 and south to -90 degrees. Halfway north would be +45 degrees and halfway south would be -45 degrees. Or make two circles between the equator and each of the poles, marking them as +30° and +60° for the north half and -30° and -60° for the south half.

Other ways to create a Celestial Sphere:

If you can't find plastic fillable ornaments, another method would be to cut your orange in half through the top and bottom and scoop it out with a grapefruit spoon. Be sure to let it dry a bit and then mark the lines on the inside of the orange. Other examples from your kitchen might include a hardboiled egg cut in half with the egg scooped out or you might reuse two dome lids like those found on a milkshake or slushy container.

More Resources:

- ✶ The appendix of this book contains instructions for making a Celestial Sphere from strips of paper you cut from a pre-printed template.
- ✶ RA/Dec Celestial Sphere Demonstrator http://astro.unl.edu/classaction/animations/coordsmotion/radecdemo.html
- ✶ Sky and Telescope webpage about Celestial Coordinates http://www.skyandtelescope.com/astronomy-resources/what-are-celestial-coordinates/

Create your own orange model and leave it in the family's fruit basket or create a holiday ornament representing the celestial sphere. Either is sure to draw some attention. You could also bring a bag of oranges to your next club meeting and help your fellow club members make their own celestial sphere. Be sure to explain how astronomers define addresses in the sky!

Go Further

Often referred to as "dirty snowballs," comets take only brief visits to the inner solar system, which is when we see them speed by.

The trick to a comet is finding it. Comets will be visible for a few weeks or months, and then break up as they buzz the sun or fade from sight as they return to the cold reaches of the outer solar system. Check where a comet is expected on a given night by using up-to-date web resources. It may take you a few tries to target the right coordinates.

Comet 252P Linear
by noreen.prestage
"I put in my own coordinates in advance by working out the position and putting these values into the ra and dec."

Photo Credit: https://commons.wikimedia.org/wiki/File:2016-09_Milky_Way_Saguenay_03.jpg

<4.2> Globe at Night - Light Pollution

With more than half of the world's population now living in cities, 3 out of every 4 people in cities have never experienced the inspiration we get from viewing truly dark skies.

How can we convince people that it's worthwhile to take even small steps to help fix this problem?

The first step is to find out how bad the problem really is! You can help by participating in the citizen-science campaign called Globe at Night, and measuring light pollution!! By taking as many measurements as you can from different locations, you will be promoting awareness and helping to monitor light pollution levels locally. The worldwide database is used to compare trends over years and with other data sets (like on animals) to see what effects light pollution has on them. How can you determine how much light pollution there is in your neighborhood? How does the light pollution in your community compare to locations around the globe?

After completing this activity, you will be able to:

- ✶ Understand what light pollution is and how it affects astronomical observing
- ✶ Enter light pollution data to the GLOBE at Night database
- ✶ Use GPS or a web app to gather latitude and longitude coordinates to report your location
- ✶ Identify and locate different constellations
- ✶ Determine the magnitude of the faintest visible star in a constellation
- ✶ Compare personal observations (data) with other observations from around other parts of the world

for the Project Helper

Success Indicators:

- Completion of a Globe at Night Observing campaign, including entering data on the world-wide database.

Life Skills:

- Advocacy, Planning/Organizing, Keeping Records, Communication

National Science Standard:

- 44-PS4-2 Waves and Their Applications
- 5-ESS1-1, 2 Earth's Place in the Universe
- 4-ESS3-1, 5 ESS3-1,MS-ESS3-3, 4, HS-ESS3-3, 4: Earth and Human Activity.

Let’s Do It!

Globe at Night is an international citizen-science campaign to raise public awareness of the impact of light pollution by inviting citizen-scientists to measure and submit their night sky brightness observations. It's easy to get involved - all you need is computer or smart phone!

First go to the website (see URL below) and click on **Observe** to find out when Globe at Night scientists need your help. Then all you have to do is learn how to spot a constellation, observe that constellation, and note which stars are visible. All of the needed links and charts are provided on the website. If you can only see bright starts, you may be in a very light polluted area. If you can see the dimmer ones too, you may be in a nice dark sky environment. You will report your findings to the Globe at Night Database.

Materials List:

- A computer or smart phone with internet access.

1. Go to the Globe at Night website: https://www.globeatnight.org/
2. Click on the **Observe** button at the top of the page.
3. Follow their “Five Easy Star Hunting Steps.”
   a. Find your constellation in the night sky.
   b. Find the latitude and longitude of the location where you are making your observation.
   c. Go outside more than an hour after sunset (8-10 pm local time). The Moon should not be up. Let your eyes become used to the dark for 10 minutes before your first observation.
   d. Match your observation to one of 7 magnitude charts and note the amount of cloud cover.
   e. Using the Report link at the top of the page, report the date, time, location (latitude/longitude), the chart you chose, and the amount of cloud cover at the time of observation. Make more observations from other locations, if possible. You can compare your observation to thousands from around the world using the Map & Data link!
4. Checkout all of the great information about light pollution provided on the Learn link.
5. You might consider sharing what you learned on the Forum.

Share your results:

Date(s) of your Observations: ______________________________

Your Latitude and Longitude: ______________________________ ______________________________

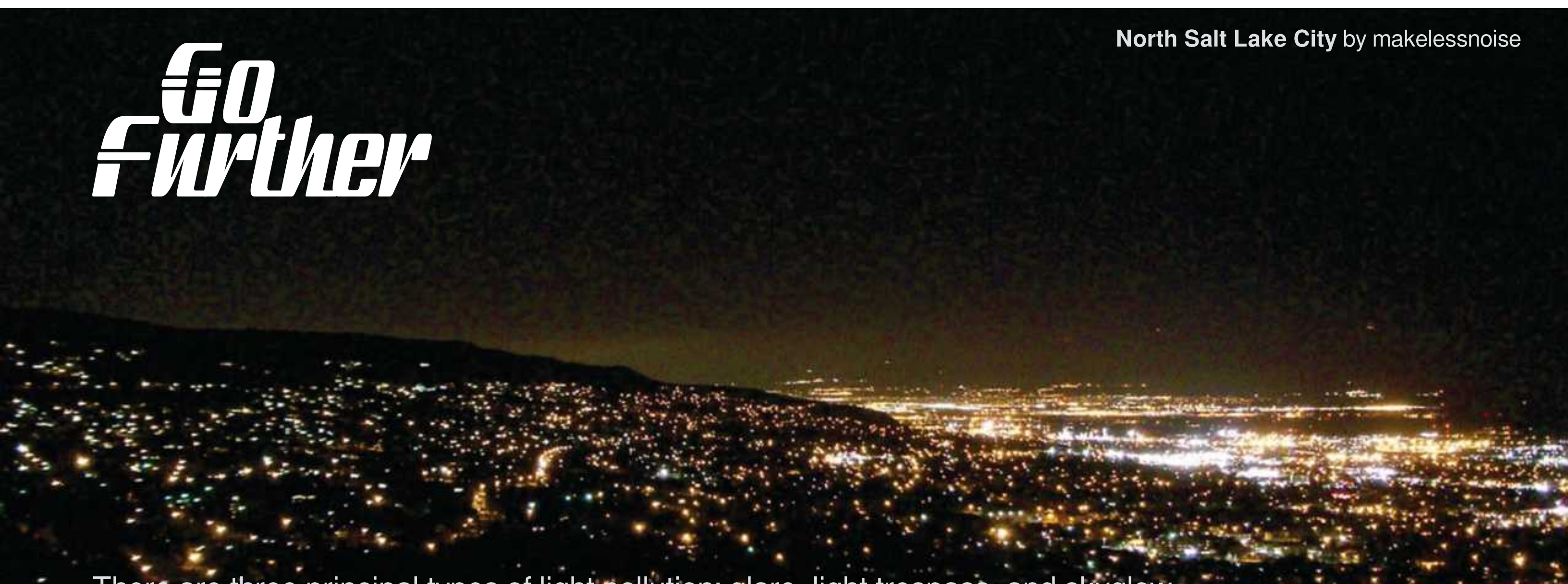
Constellation Observed: ______________________________

Your Results: ______________________________

How did your light pollution compare to other places around the world?

____

North Salt Lake City by makelessnoise



Go Further

There are three principal types of light pollution: glare, light trespass, and skyglow. Glare occurs from unshielded lighting. The light scattering due to glare causes the loss of contrast in the eye. This can sometimes cause temporary blindness and leads to unsafe driving conditions. Light trespass occurs when unwanted light enters your property. For example, a neighbor's garage light shining into your bedroom window when you are trying to sleep. Skyglow refers to the glow effect that can be seen over cities and urban areas. Skyglow is the combination of all the reflected light and upward-directed (unshielded) light escaping up into the sky. The majority of this light is unused and wastes energy. Shielding lights significantly reduces all three of these types of light pollution.

‹4.3› Design Your own Investigation

Photo by Jennifer Murray

for the Project Helper

Success Indicators:

- Learners will create a scientific question arising from data they have viewed from the Skynet program.
- Learners will create an investigation using their archived and/or their own data and the skills they have acquired from the Skynet program.
- Learners will evaluate the data received in their investigation against the scientific question developed.

Life Skills:

- Decision-making, problem-solving, learning to learn, critical thinking, planning/organizing, wise use of resources, keeping records

National Science Standard:

- MS-ETS1.A : Defining and Delimiting Engineering Problems
- MS-ETS1.B: Defining Possible Solutions
- MS-ETS1.C: Optimizing the Design Solution

At this point in time, Skynet Junior Scholars are able to program various filters, exposure time, and telescopes in order to request images of celestial objects. They have used *Afterglow* to measure the brightness of the objects of which they have made requests as well as to more clearly see filter differences in the images. These skills, the countless variations that can be found in images received, plus learning how to create a scientific investigation combines together for an experience in which learners will be practicing the work that astronomers do on a daily basis.

What kinds of things can you measure or experiment with using the Skynet telescopes?

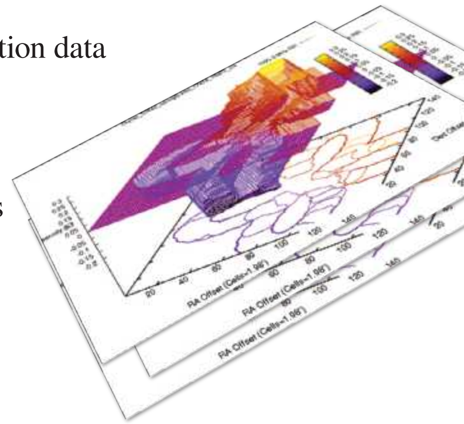
As you have looked at your images these past few weeks, what questions have you thought of related to them?

Materials List:

- Computer and access to the Skynet program
- Skynet observations from the gallery, from the group, and from the learner's personal observatory.

After completing this activity, you will be able to:

- ✶ Understand the value of studying archived data
- ✶ Understand the steps to creating a Skynet facilitated investigation
- ✶ Explore investigative questioning
- ✶ Understand how to evaluate investigation data



Before the Activity:

Participants must have allocated 300 seconds of telescope time to complete this activity.

Let's Do It!

1. If you are not already logged in, go to https://skynetjuniorscholars.org/ and log in with your username and password.
2. Look for the **Explorations** button at the top of the webpage. Click on this button.
3. Look at the Explorations page. When you scroll down the page, you should see several topics like "Become a Skynet Junior Scholar," "Comets to Cosmology," "Starry Skies," and "Asteroid Research."
4. Find the "Become a Skynet Junior Scholar" box and click on the **Continue** button (the button will say **Get Started** if this is your first visit).
5. Now you are on a webpage with all of the online Explorations that you will complete to become a Skynet Junior Scholar. When you scroll down, you will see six Explorations.
6. Find the "Create it Yourself" box and click on the **Get Started** button (the button will say **Continue** if you have already visited this exploration).
7. Read and follow all of the instructions in all four sections of this online exploration.

   A Introduction
   B Design Your Experiment
   C Data Analysis & Results

8. Once you have entered your answers into the online exploration, click the **Submit Exploration** button. A SJS leader will approve your completion online and send an email.
9. In the right column, you will find a **Print** icon button. Click this button to open a print dialog box where you can either immediately print your exploration or save it as a PDF file to take to a printer at a later time.
10. Make a copy of this Exploration and your Gallery images and save them as part of your project work.

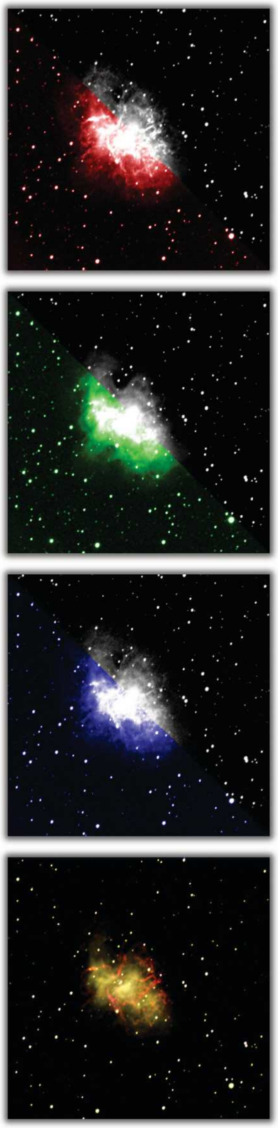
Go Further

Discuss your self-designed investigation on the SJS Forum with your SJS colleagues. As a good scientist, it's important to get feedback from your peers.

Do they agree with your ideas?

Do they have a new way of looking at the data that you didn't think of?

<4.4> Making a color image



M1: SJS Observation ID1113645 by knieu

Most of the time, when we see pictures prepared for the public from observatories like Hubble Space Telescopes or others, the pictures are very colorful!

How do you think the astronomers create color pictures?

Astro Image Processor is one of several different types of software that can be used for creating color images. It enables the learner to align their images and stack them on top of each other to improve contrast and color. Additional color is then added to highlight desired features.

for the Project Helper

Success Indicators:

- Student will create a color image from a set of 3 completed images taken with different filters.

Life Skills:

- Decision-making, critical thinking.

National Science Standard:

- MS-PS4.B: Electromagnetic Radiation
- MS-PS1-A: Structure and Properties of Matter.

After completing this activity, you will be able to:

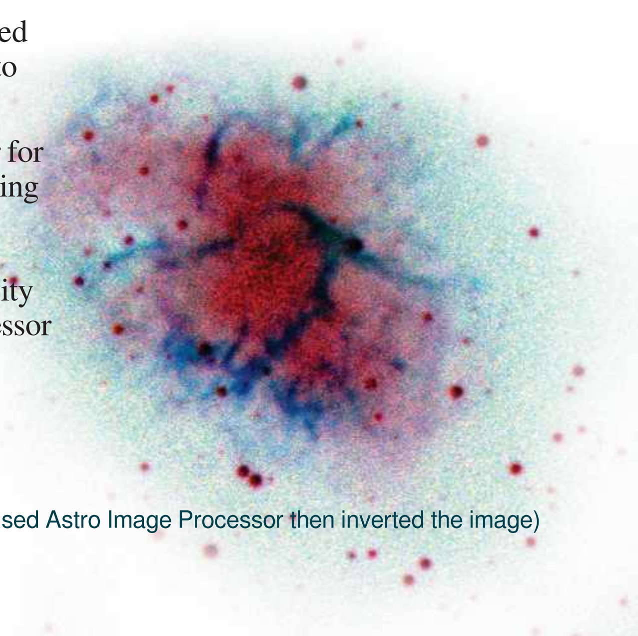
- ✶ Describe how a color image is made
- ✶ Explain why Skynet images received are black and white

Before the Activity

- ✶ Participants must have allocated 90 seconds of telescope time to use to complete this activity.
- ✶ A laptop or desktop computer for this activity is preferable to using a technology tool like a Chromebook, iPod, or tablet which may not have the capacity to load the Astro Image Processor Software.

Materials List:

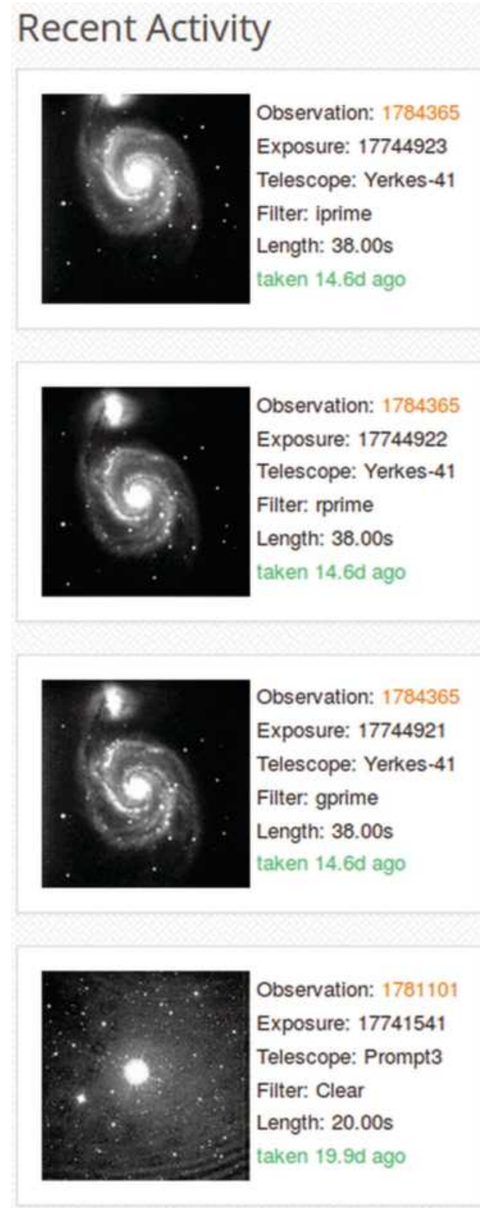
- Computer with **Astro Image Processor** downloaded and running.
- 3 completed images of an object taken with different filters; but at the same time, with the same exposure time, with the same telescope.



Crab Nebula by epjmm15 (used Astro Image Processor then inverted the image)

Let’s Do It!

1. If you are not already logged in, go to https://skynetjuniorscholars.org/ and log in with your username and password.
2. Look for the **Explorations** button at the top of the webpage. Click on this button.
3. Find the “Become a Skynet Junior Scholar” box and click on the **Continue** button (the button will say **Get Started** if this is your first visit)..
4. Now you are on a webpage with all of the online Explorations that you will complete to become a Skynet Junior Scholar. When you scroll down, you will see six Explorations.
5. Find the "Make a Color Image" box and click on the **Get Started** button (the button will say **Continue** if you have already visited this exploration).
6. Read the introduction to the *Make a Color Image* activity.
7. Download Astro Image Processor and save it to your desktop if possible.
   You can always download it through the *Make a Color Image* exploration if is not on your computer.



Take your Image

8. Take Skynet images of one object in three different filters.
9. Use filters other than **HiThru**, **open**, **clear**, or **Lum** as these are not color filters.
10. Use the same telescope and program in the images with the same exposure time. Use a variety of filters so that you can pick the best to use with Astro Image Processor.

Processing you Images in Astro Image Processor

11. You can watch the tutorial prior to the completion of the images. A video transcript is available and may be helpful since it may take some time to remember the steps from beginning to end without assistance. You can always stop and start the video as needed.
12. When your images have been completed and you are ready to make a color image, pick out 3 images, each one from a different filter. Find the icon to the right of the image for **download fits**, right click it, and choose **save link as** to save each selected image as a fits file to your desktop or jumpdrive.
13. Now proceed with the rest of the instructions given in the video and transcript.

14. Once you have created a color image, read and follow all of the instructions in the remaining sections of the online exploration:

    B Log Your Images
    C Analysis

15. On the analysis page, complete the Astro Image Processor Matching Game (there is a direct link right above *Go Deeper*). Print your certificate at the end of the game and save as part of your project work. If you can't print it out immediately, save it as a PDF file for you to take to a printer at a later time.
16. Once you have entered your answers into the online exploration, click the **Submit Exploration** button. A SJS leader will approve your completion online and send an email.
17. In the right column, you will find a **Print** icon button. Click this button to open a print dialog box where you can either immediately print your exploration or save it as a PDF file to take to a printer at a later time.
18. Make a copy of this Exploration and your Gallery images and save them as part of your project work.

Go Further

Discuss your image and your ideas about colored images on the SJS Forum with your SJS colleagues.

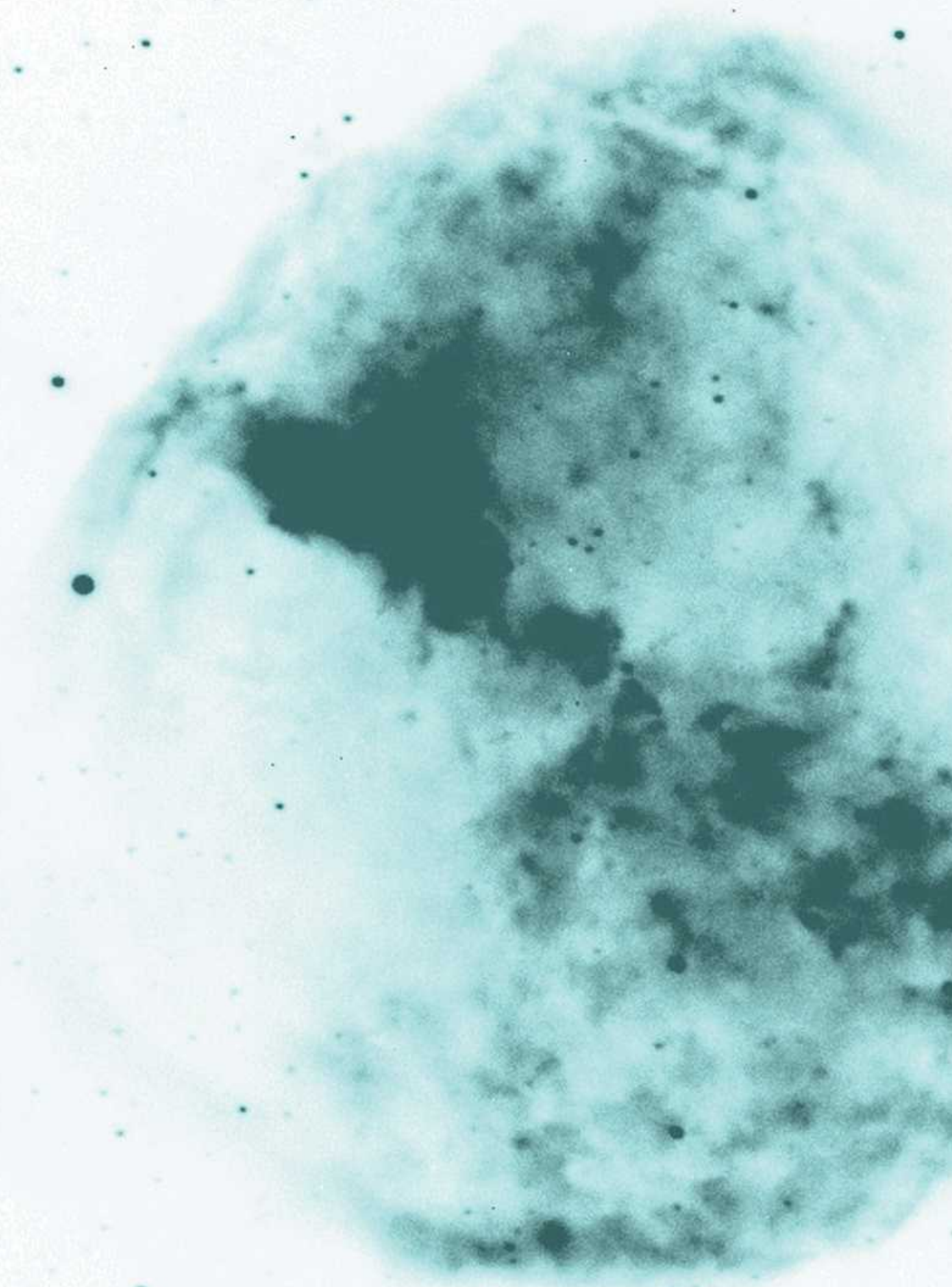
As a good scientist, it's important to get feedback from your peers.

Do they agree with your ideas?

Do they have a new way of looking at the data that you didn't think of?

Expand your experiment by combining different filters to compare colored images of the same object.

Play the Astro Image Processor Matching Game



background image based on **H-alpha Image of the Dumbbell Nebula** by vhoette inverted and recolored by cliff_n

Chapter 4 Questions

In this chapter, you completed activities to deepen your understanding of the night sky.

Share

Which one of the activities interested you the most? Why?

Reflect

What did you learn about the work of astronomers as the result of doing these activities?

Generalize

How can you educate others in your 4-H club or community about one of the activities that you completed in this chapter?

Apply

What other opportunities do you have to be part of citizen science?

Glossary

If there a term that you can't find it in this glossary, try the
Skynet Junior Scholars Online Glossary of terms at:
https://skynetjuniorscholars.org/glossary

Align	Images are aligned when their features overlap and are not offset.
Angular Size	An object's angular size is the angle between the lines of sight to its two opposite sides. An object's angular size is a measure of how large the object appears to be. In astronomy, the angular sizes of most objects are much smaller than even one degree. To measure these tiny angular sizes, astronomers use units of arcminutes (') and arcseconds ("). There are 60 arcminutes in a degree and 60 arcseconds in an arcminute.
Aperture	The opening of a telescope that lets light in. A wider (larger diameter) telescope has a larger aperture.
Arcminute	There are 60 arcminutes in a degree. Most astronomical objects appear much smaller than a degree in the sky, so arcminutes are more useful for measuring their size. The full moon is 30 arcminutes in the sky.
Arcsecond	There are 60 arcseconds in an arcminute, so 3600 arcseconds in a degree.
Asteroid	A small rocky object in our solar system; can range in size from 30 feet to 600 miles in diameter
Celestial Body	Any object in space that was not man-made (i.e. not a satellite).
Chronological	Arranged in the order of time, from first to last.
Concave	The inward, bowl-like side of a curved surface.
Convex	The outward, ball-liked side of a curved surface.
Dark Nebula	a dense cloud of gas and dust that blocks background light, and therefore appears dark
Degree	A measure of angular extent. For example, a whole circle has 360 degrees. So, if you cut a circular pizza into 6 slices, each slice would cover an angular extent of 60 degrees. For an astronomy example, the angular extent of the full moon is 1/2 degree in the sky.

Emission Nebula	a hot cloud of gas that emits light, usually because hot new stars within it are exciting the gas atoms.
Exposure time	The amount of time the camera collects light from an object. Faint objects need long exposure times so the camera has time to collect more light. Bright objects need short exposure times.
Filter	A piece of glass or plastic that covers the telescope or camera and only allows certain wavelengths of light through.
Flux	Flux is a measure of the apparent brightness of a star.
Globular Cluster	a large cluster of old stars, densely packed in a spherical shape
Histogram	A function of Afterglow that recalibrates the brightness of the image. To see fairly bright things, such as planets, it may help to give a high value to the histogram value so that there is a wide range of light and dark values in the image which will allow you to see specific features of the planet.
Hot Spots	The detectors on telescopes and cameras are not perfect. Some individual pixels show up brighter than they should on images. These pixels are called Hot Spots.
Image	The result of what is produced when light gathered by the telescope hits the camera. Since the camera just records how much light it receives, images are always on a grey scale with white representing more light received and black representing less or no light detected.
Light gathering power	A telescope's ability to collect light and measure faint objects. Bigger telescopes with a larger aperture have more light gathering power.
Magnitude	A measure of the brightness of objects. Higher magnitude numbers equal dimmer dimmer objects! The human eye has trouble detecting magnitudes higher than about 6. Really bright objects will have negative magnitudes. An object can be brighter in some colors than in others, so the magnitude you measure can be dependent on which filter you use.
Normalize	An image processor that normalizes an image finds the darkest pixel and makes it pure black, then finds the brightest pixel and makes it pure white. Then it adjusts the rest of the pixels accordingly so that the grey scale sues the whole range from black to white. This brings out the contrast in images.

Open Cluster	a loose cluster of a few hundred stars that formed out of the same nebula
Parallel	Lines are parallel when they are lined up side by side and never cross.
Photometer	A device to measure the magnitude or brightness of objects such as a star. It does this by comparing the brightness of the star to the darkness of the background space.
Photon	A small packet of a light wave; it can be thought of as a particle of light. More photons means the brighter the image will be.
Planetary Nebula	expanding outer shell of gas ejected from a low mass star at the end of its life
Pseudo Cluster	a huge star cloud in our galaxy revealed by a hole in the interstellar dust.
Pupil	The black opening in the center of the eye. Light enters through the pupil and goes through the lens which focuses the image that we 'see' at the back of the eye.
Skynet	A community of online system robotic telescopes that are remotely controlled all across the globe.
Spiral Galaxy	a large system of millions or billions of stars and other matter held together by gravity. In spiral galaxies, this matter is concentrated into spiral arms
Supernova Remnant	an expanding shell of gas created when massive stars explode at the end of their lives.
Vmag	Vmag is short for visual magnitude, and is a measure of the apparent brightness of an object through a filter that is similar to our eye's response. NOTE: The bigger the v mag number the DIMMER the apparent brightness of the object!!
Wavelength	The length measurement of one part of a wave to another such as from crest to crest or from trough to trough. Different colors of light have different wavelengths within the visible spectrum.

Resources

Chapter 1

1.1 - First Light Exploration

SEDS. The Messier Catalog. http://messier.seds.org/

YouTube: Messier Objects – Deep Sky Videos:
https://youtu.be/B0nq7OD1rVM?list=PLC9FC5F6773B383D5

1.2 - Sizing Up the Moon

Skynet Junior Scholars website Resources: Sizing Up the Moon.
https://skynetjuniorscholars.org/supplements/61/file

Exploratorium. Make a scale model of the Solar System and learn the REAL definition of "space."
http://www.exploratorium.edu/ronh/solar_system/index.html

Skynet Junior Scholars website Resources: Observing the Moon with Skynet Telescopes -
https://skynetjuniorscholars.org/supplements/19/file

1.3 - Pocket Solar System

Skynet Junior Scholars website Resources: Pocket Solar System.
https://skynetjuniorscholars.org/supplements/62/file

Youtube.com: The Solar System: Crash Course Astronomy #9 https://youtu.be/TKM0P3XlMNA

Youtube.com: Orbits are odd: Crash Course Kids #22.2 https://youtu.be/aGVXyCrpUn8

Youtube.com: Gravity Compilation: Crash Course Kids https://youtu.be/EwY6p-r_hyU

1.4 - Cosmos in Perspective

Skynet Junior Scholars website Resources: The Cosmos in Perspective.
https://skynetjuniorscholars.org/supplements/63/file

For online access to the booklet "how big is our universe?" go to:
http://cfa-www.harvard.edu/seuforum/howfar/index.html

Chapter 2

2.1 - Skynet Scavenger Hunt

Skynet Robotic Telescope Network. https://skynet.unc.edu/live

2.2 - Anatomy of a Telescope

Faulkes-Telescope. Animation of how an optical telescope works.
http://www.faulkes-telescope.com/files/faulkes-telescope.com/archive/flash/ft_light.swf

2.3 - Field of View – Why we can't take an Image of a Constellation

Skynet Telescopes Field of View: https://skynetjuniorscholars.org/pdfs/field-of-view-activity-001.pdf

Youtube.com: Seeing Stars: Crash Course Kids #20.1 https://youtu.be/M41yLjQ2ot0

Youtube.com: Super Stars (constellations) Crash Course Kids #31.1 https://youtu.be/MZffhapfOgg

Youtube.com: Glow on: Crash Course Kids #20.2 https://youtu.be/Zo-sKzMWYFA

Skynet Junior Scholars website Resources: How to Image the Moon
https://skynetjuniorscholars.org/supplements/13/file

Solar System Dynamics. SB What's Observable. http://ssd.jpl.nasa.gov/sbwobs.cgi

2.4 - Find Me in the Forum

Skynet Junior Scholars Forum. https://discourse.skynetjuniorscholars.org/

About, FAQ, Terms of Service, and Privacy information for the Skynet Junior Scholars Forum:
https://discourse.skynetjuniorscholars.org/about

Find a local astronomy club. http://www.skyandtelescope.com/astronomy-clubs-organizations/

Chapter 3

3.1 - Astrophotography

SJS: Starry Skies

Animation – How a CCD Camera works
http://support.faulkes-telescope.com/multimedia/ccd/CCD%20Fullscreen.swf

CCD Cameras:

https://www.youtube.com/watch?v=MytCfECfqWc

http://www.specinst.com/What_Is_A_CCD.html

Astrophotography:

http://iphonephotographyschool.com/night-sky/

http://www.space.com/33191-take-astronomy-pictures-with-mobile-devices.html

3.2 - Investigate Exposure Time

Skynet Robotic Telescope Network. https://skynet.unc.edu/

3.3 - Fun with Filters

There is a neat animation that shows astronomical filters in use here:
http://support.faulkes-telescope.com/multimedia/ccd/CCD%20Fullscreen.swf

On-Line Alien Eyes Slides: https://skynetjuniorscholars.org/supplements/78/file

Alien Eyes Presentation Download: https://skynetjuniorscholars.org/supplements/106/file

EM Spectrum War Card Template: https://skynetjuniorscholars.org/supplements/35/file

Tour of the Electromagnetic Spectrum: http://missionscience.nasa.gov/ems/index.html

The Meaning of Color in Hubble Images:

http://hubblesite.org/gallery/behind_the_pictures/meaning_of_color/

3.4 - Investigate Filters

Youtube.com Light: Crash Course Astronomy #24

Skynet Telescope Filters handout https://skynetjuniorscholars.org/pdfs/skynet-filter-descriptions-001.pdf

Chapter 4

4.1 - Address in the Sky

RA/Dec Celestial Sphere Demonstrator
http://astro.unl.edu/classaction/animations/coordsmotion/radecdemo.html

Sky and Telescope webpage about Celestial Coordinates
http://www.skyandtelescope.com/astronomy-resources/what-are-celestial-coordinates/

4.2 - Globe at Night - Light Pollution

Find your constellation https://www.globeatnight.org/finding

Find your latitude and longitude https://www.globeatnight.org/lat-long.php

Star Magnitude Charts https://www.globeatnight.org/magcharts

4.3 - Design Your Own Investigation

Skynet Resources Page: Darks, Bias, Flats, Oh My!

4.4 - Making a Color Image

Hubblesite. The Meaning of Color in Hubble Images
http://hubblesite.org/gallery/behind_the_pictures/meaning_of_color/

Acknowledgements

Chapter 1

1.1 - First Light Exploration

Skynet Junior Scholars Module Development Team.

1.2 - Sizing up the Moon

Originally developed by Dennis Schatz (Pacific Science Center) for Family ASTRO.
Adapted by Anna Hurst for Astronomy from the Ground Up, a program of the Astronomical Society of the Pacific, and modified slightly by SJS staff.

1.3 - Pocket Solar System

Originally developed by Amie Gallagher (Raritan Valley Community College).
Adapted by Suzanne Gurton and Anna Hurst, of the Astronoical Society of the Pacific for Astronomy from the Ground Up. Modified for Skynet Junior Scholar.

1.4 - Cosmos in Perspective

This activity is adapted for Skynet Junior Scholars from *“A Universe of Galaxies”*, which was created by the Astronomical Society of the Pacific for the Night Sky Network.

Chapter 2

2.1 - Skynet Scavenger Hunt

Skynet Junior Scholars Module Development Team.

2.2 - Anatomy of a Telescope

Adapted by The Skynet Junior Scholars Module Development Team from
“It’s all Done with Mirrors: How telescopes use mirrors to focus light from distant objects”
from the Night Sky Network.

2.3 - Field of View – Why we can't take an Image of a Constellation

Adapted by the Skynet Junior Scholars Module Development Team from *"Ready to Observe? How to Enhance Your Experience at the Telescope"* and *"Magnification vs. Resolution: Can you see the flag on the Moon?"* From the Night Sky Network.

2.4 - Find Me in the Forum

Skynet Junior Scholars Module Development Team.

Chapter 3

3.1 - Astrophotography

Portions of this activity were adapted by the Skynet Junior Scholars Module Development Team from a CCD animation created by the Faulkes Telescope Project.

3.2 - Investigate Exposure Time

Skynet Junior Scholars Module Development Team

3.3 - Fun with Filters

Alien Eyes is derived from the activity: *"Seeing through Alien Eyes"*, originally created by Dennis Schatz (Pacific Science Center), Suzanne Gurton and Dan Zevin for Family Astro and adapted by Anna Hurst.

3.4 - Investigate Filters

Skynet Junior Scholars Module Development Team.

Chapter 4

4.1 - Address in the Sky

4.2 - Globe at Night - Light Pollution

This activity were adapted by the Skynet Junior Scholars Module Development Team from the Globe at Night website: https://www.globeatnight.org/

4.3 - Design Your Own Investigation

Skynet Junior Scholars Module Development Team.

4.4 - Making a Color Image

Skynet Junior Scholars Module Development Team.

Skynet Junior Scholars 4-H Project Design Team

Jason Burnside, Extension Instructor, West Virginia University Extension Service

Lynn Feldman, Extension Instructor, University of Wisconsin-Extension

Sue Ann Heatherly, Education Officer, Green Bank Observatory

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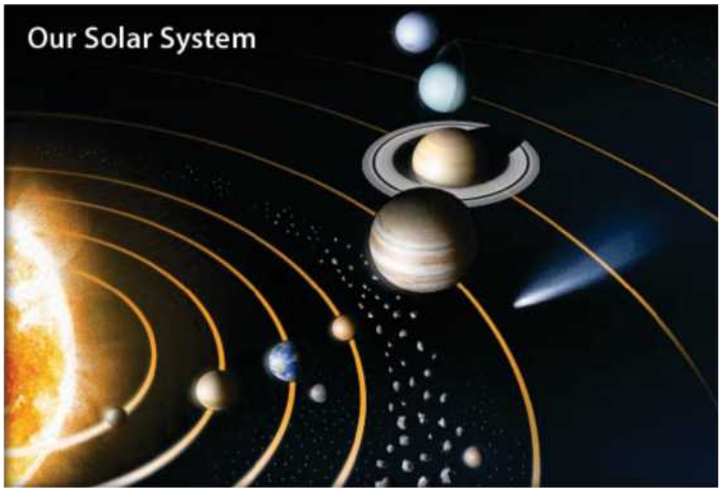
Jennifer Murray, Assistant Professor, West Virginia University Extension Service

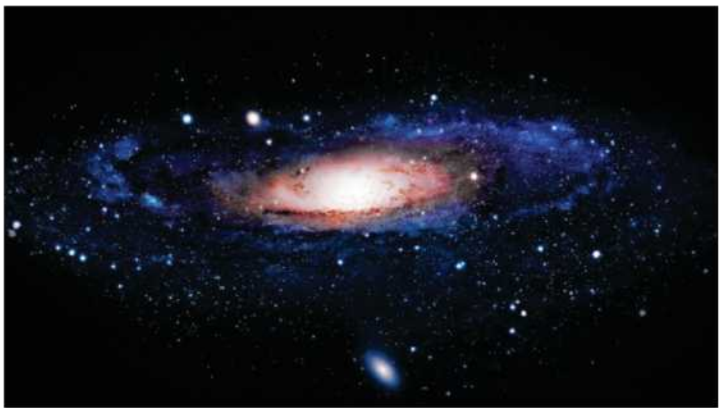
Cliff Nieuwenhuis, Skynet Junior Scholars leader and 4-H volunteer, University of Wisconsin-Extension

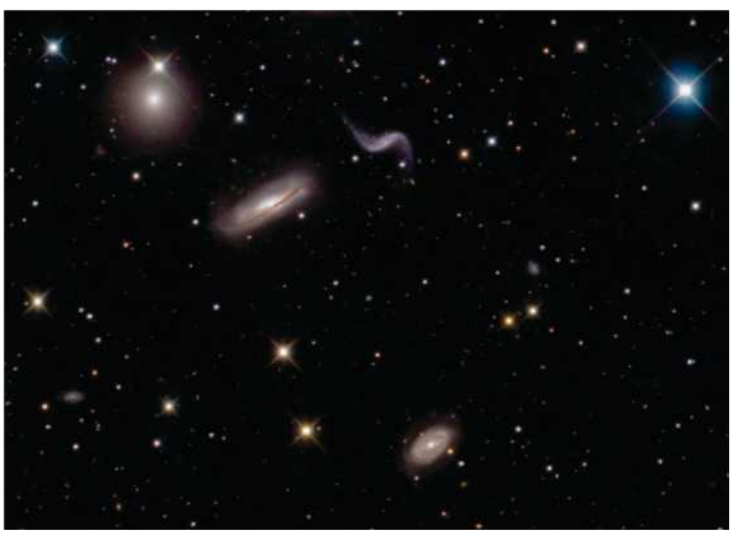
Dr. Jennifer Robertson-Honecker, Assistant Professor, West Virginia University Extension Service

Templates

Cosmic Address Photos. Cut out for youth to sort.


Our Solar System





FRONT

A UNIVERSE OF GALAXIES

Milky Way Galaxy

YOU ARE HERE

- We live about halfway out from the center of our galaxy
- The Sun is an average star. The Milky Way Galaxy, which is 100,000 light years across, contains about 200 billion other stars.
- The ratio of our galaxy's width to thickness is almost the same as this CD approximately 100:1

Scale: 1 Million Light Years = 1 meter

Using this CD as our Galaxy, other galaxies would be at the following approximate distances from us:

M31:	2.3 m	**M33:**	2.4 m	**M81:**	12 m
NGC4565:	31 m	**M66:**	35 m	**M51:**	37 m
M104:	50 m	**M87:**	60 m	**3C273:**	2.5 km

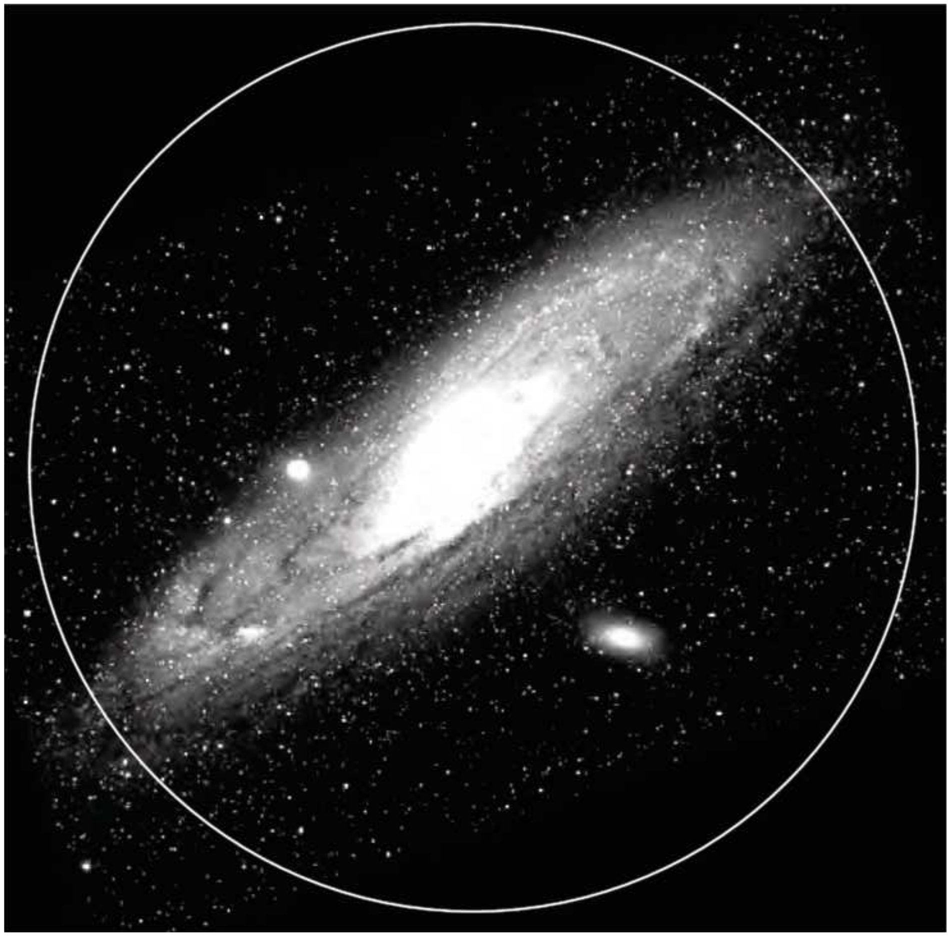
Hubble Deep Field
(representing the limit of observable universe)**:** 13.7 km

Image Credit: NASA

www.astrosociety.org

BACK

Instructions:
Cut out each circle and glue the "FRONT" to the label side of a used CD. Glue the "BACK" to the other side of the CD.



FRONT

M31 – The Andromeda Galaxy

(Oct-Jan)

Spiral Galaxy
Distance: 2.3 million light years
Size: 150,000 light years across

CD Distance Scale:

2.3 meters

Size: 15 cm across (salad plate)

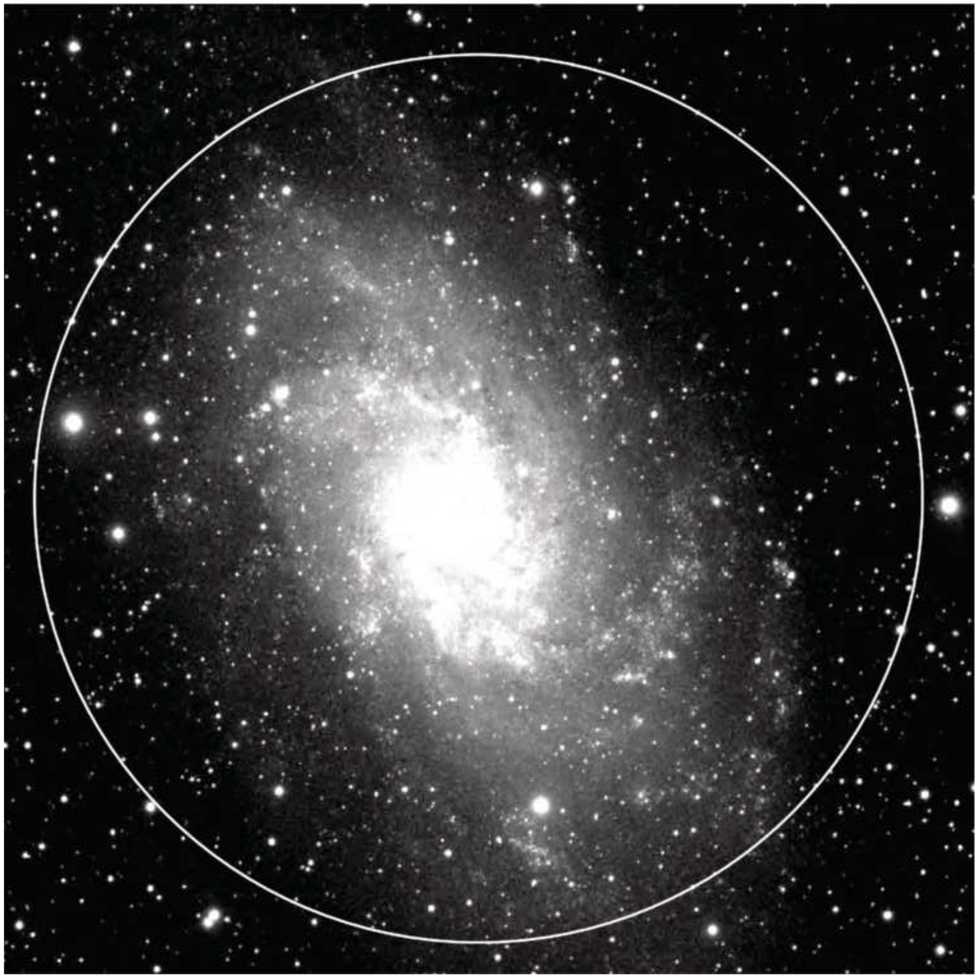
M31 photo courtesy John Gleason

www.astrosociety.org

A UNIVERSE OF GALAXIES

BACK

Instructions:
Cut out each circle and glue the "FRONT" to the label side of a used CD. Glue the "BACK" to the other side of the CD.



FRONT

M33 – The Pinwheel Galaxy

(Oct-Jan)

Spiral Galaxy
Distance: 2.4 million light years
Size: 60,000 light years across

CD Distance Scale:

2.4 meters

Size: 6 cm across

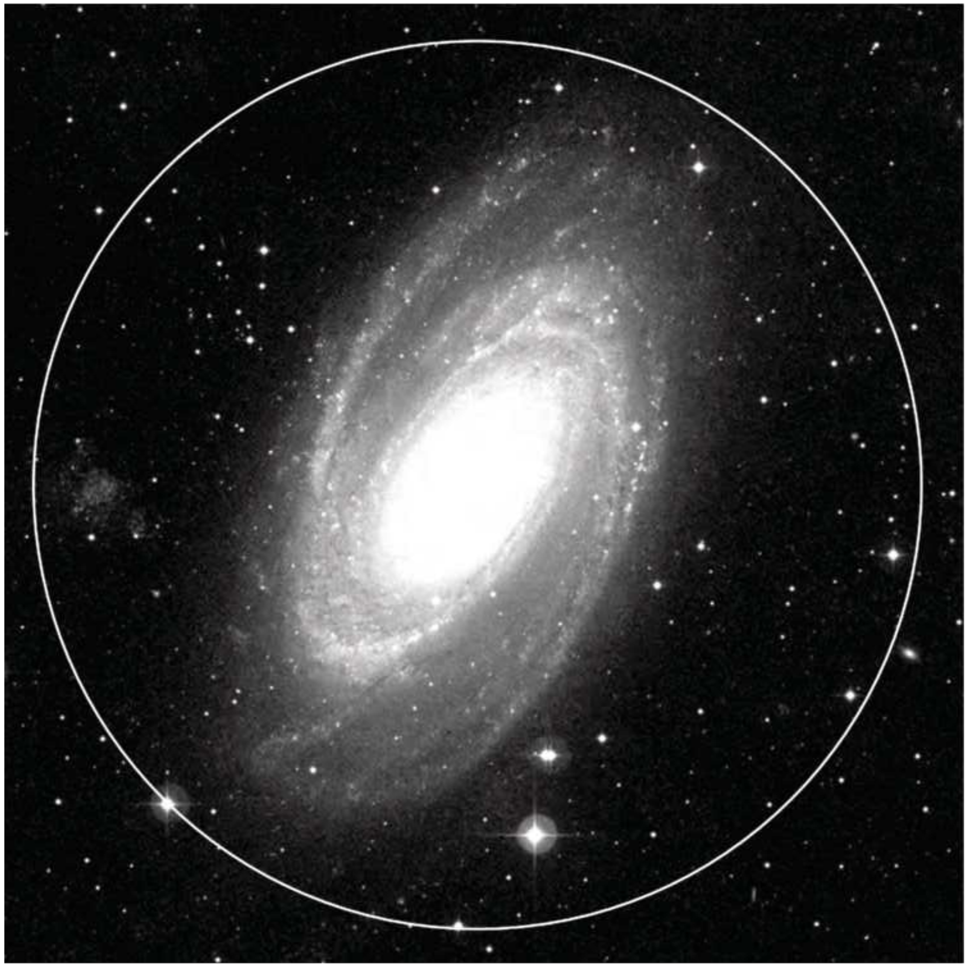
M33 photo courtesy Paul Mortfield © 2003

www.astrosociety.org

A UNIVERSE OF GALAXIES

BACK

Instructions:
Cut out each circle and glue the "FRONT" to the label side of a used CD. Glue the "BACK" to the other side of the CD.



FRONT

M81

(Feb-Jun)

Spiral Galaxy
Distance: 12 million light years
Size: 75,000 light years across

CD Distance Scale:

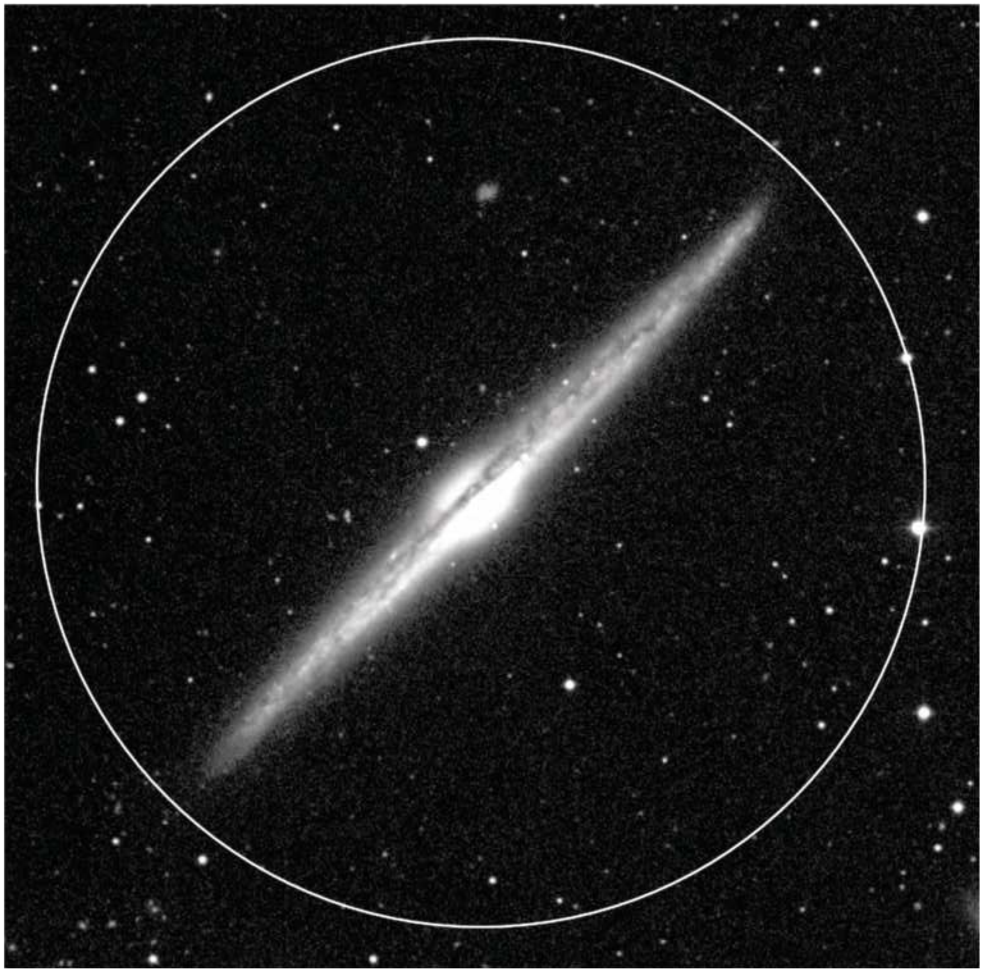
12 meters

Size: 7.5 cm across

A UNIVERSE OF GALAXIES

BACK

Instructions:
Cut out each circle and glue the "FRONT" to the label side of a used CD. Glue the "BACK" to the other side of the CD.



FRONT

NGC4565

(Apr-Jul)

Spiral Galaxy – viewed edge-on
Distance: 31 million light years
Size: 150,000 light years across

CD Distance Scale:

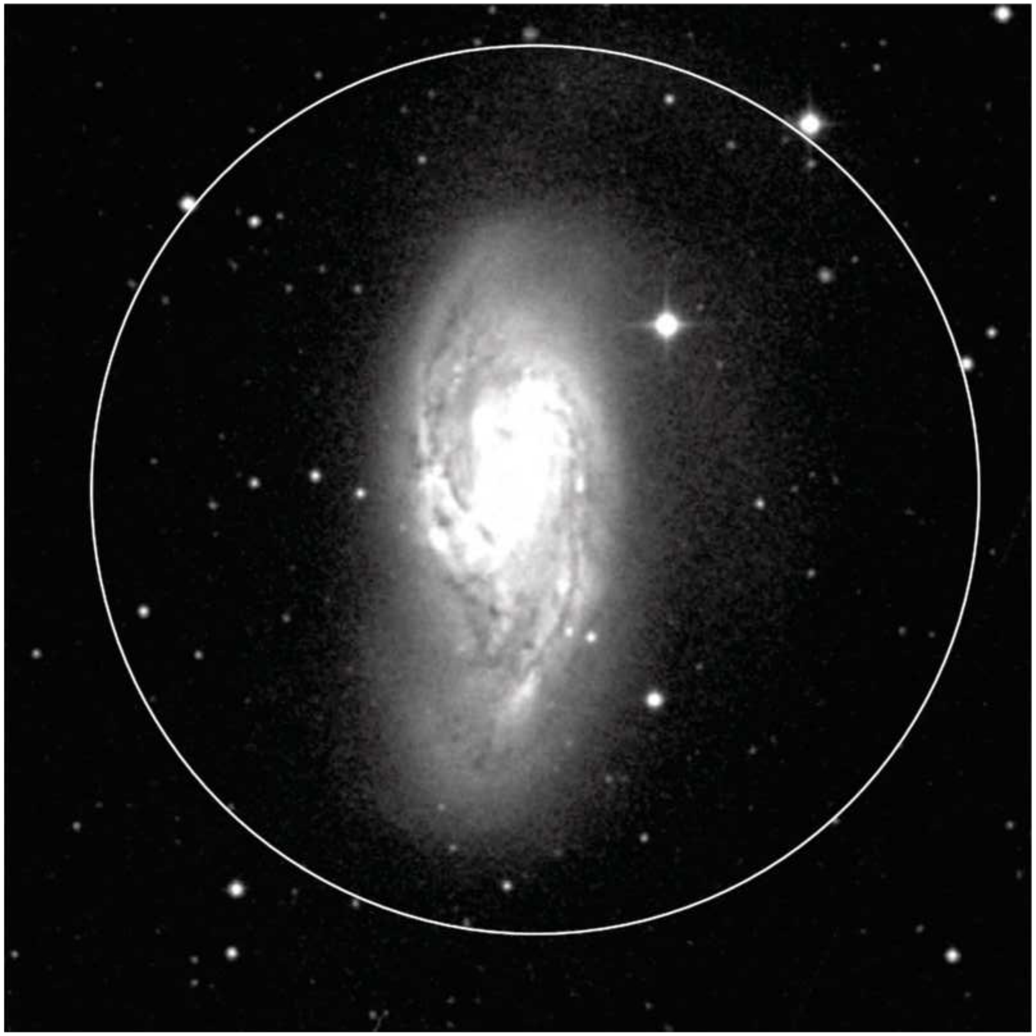
31 meters

Size: 15 cm across (salad plate)

A UNIVERSE OF GALAXIES

BACK

Instructions:
Cut out each circle and glue the "FRONT" to the label side of a used CD. Glue the "BACK" to the other side of the CD.



FRONT

M66

(Apr-Jun)

Spiral Galaxy
Distance: 35 million light years
Size: 80,000 light years across

CD Distance Scale:

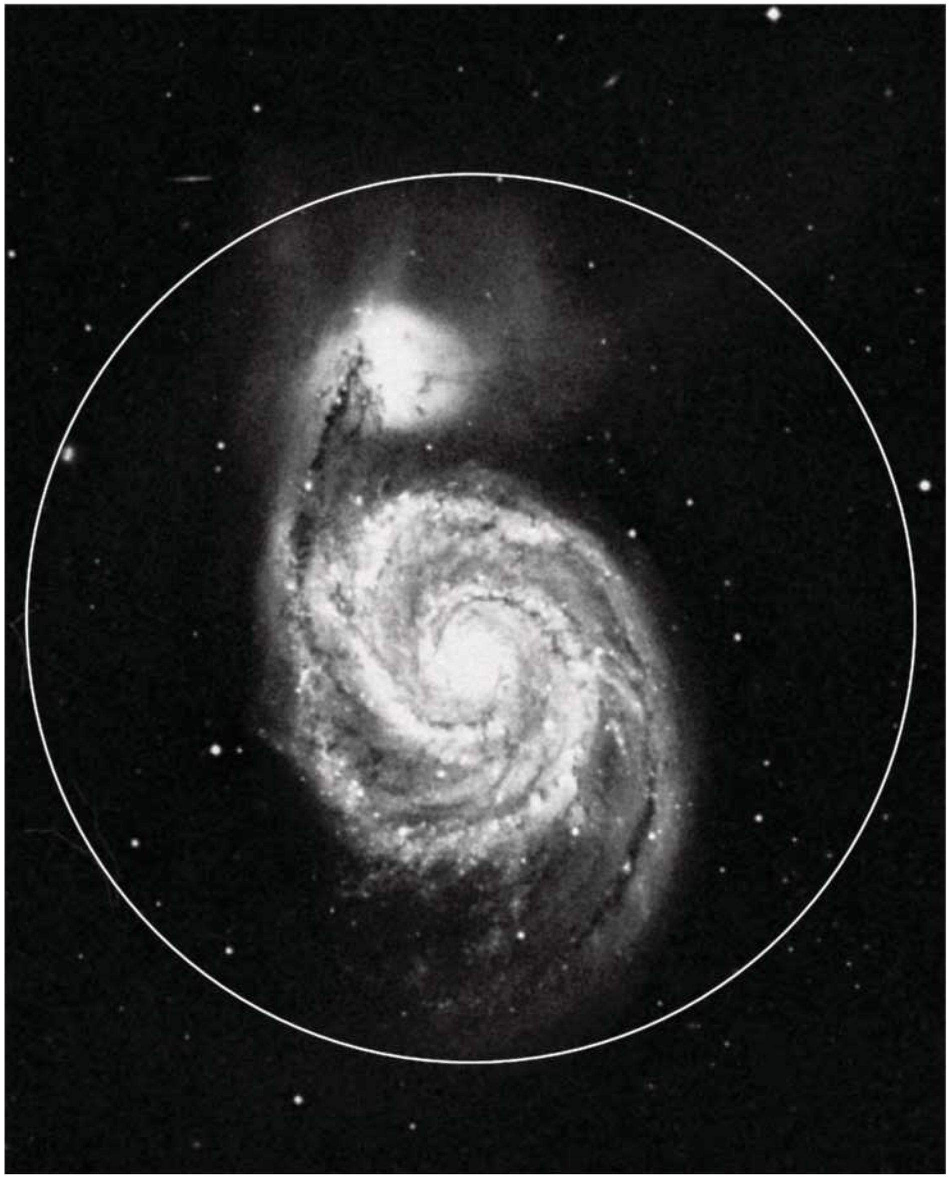
35 meters

Size: 8 cm across

A UNIVERSE OF GALAXIES

BACK

Instructions:
Cut out each circle and glue the "FRONT" to the label side of a used CD. Glue the "BACK" to the other side of the CD.



FRONT

M51 – Whirlpool Galaxy

(Apr-Aug)

Spiral Galaxy with companion galaxy
Distance: 37 million light years
Size: 120,000 light years across

CD Distance Scale:

37 meters

Size: 12 cm across

A UNIVERSE OF GALAXIES

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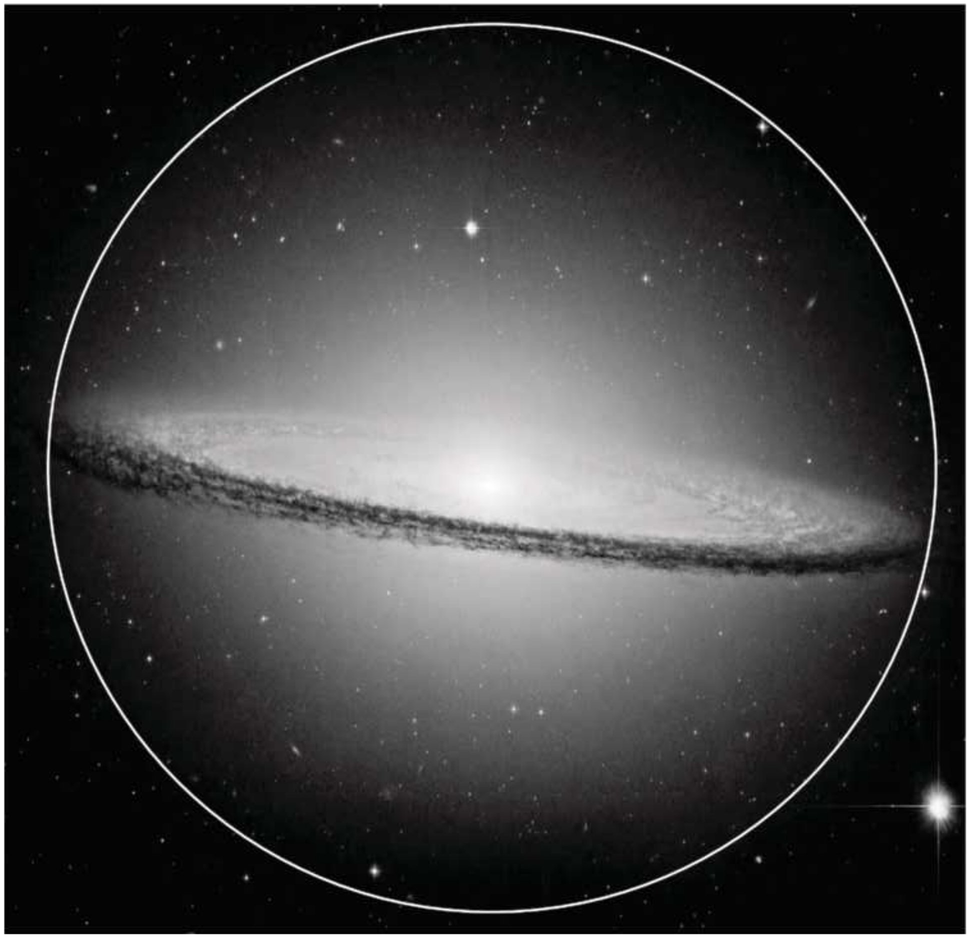

FRONT

M104 – Sombrero Galaxy

(May-Jun)

Spiral Galaxy – viewed edge-on
Distance: 50 million light years
Size: 75,000 light years across

CD Distance Scale:

50 meters

Size: 7.5 cm across

M104 photo Space Telescope Science Institute

www.astrosociety.org

A UNIVERSE OF GALAXIES

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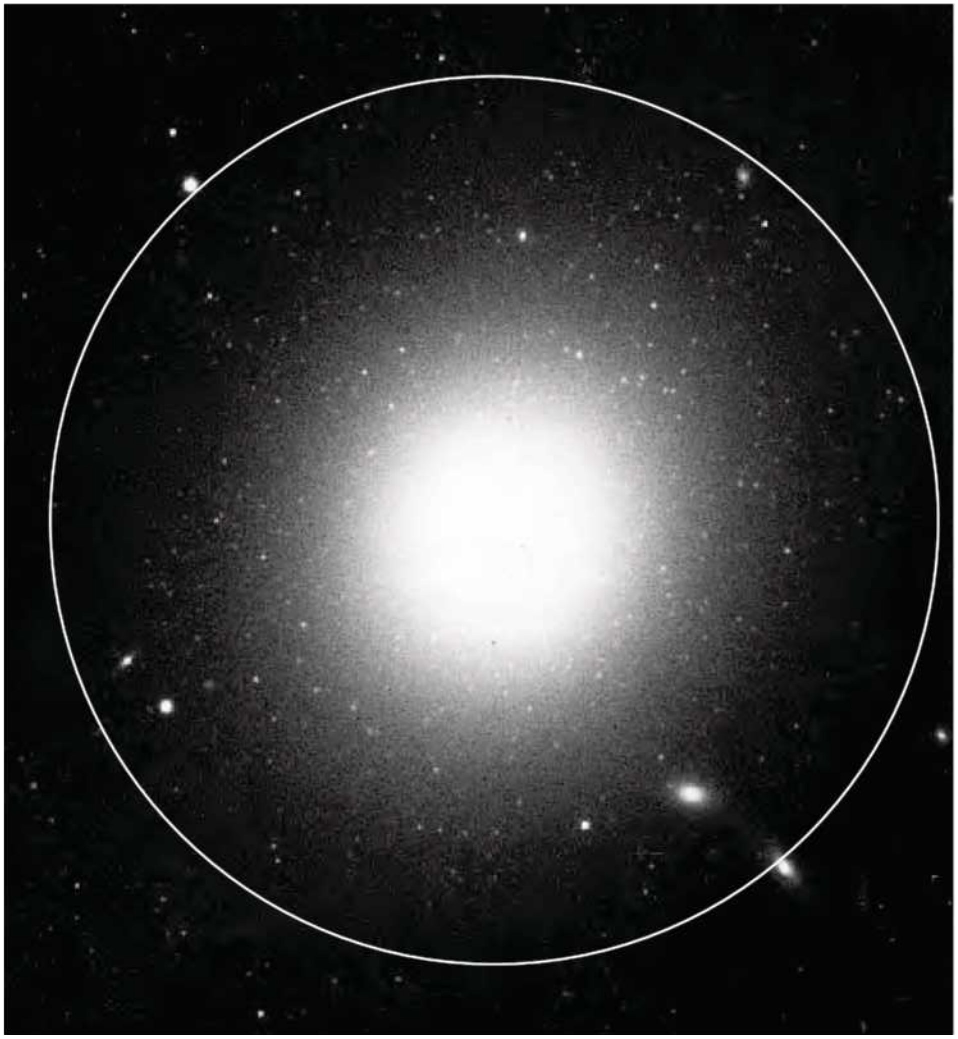

FRONT

M87

(Apr-Jul)

Elliptical Galaxy
Distance: 60 million light years
Size: 120,000 light years across

CD Distance Scale:

60 meters

Size: 12 cm across – like a softball

A UNIVERSE OF GALAXIES

BACK

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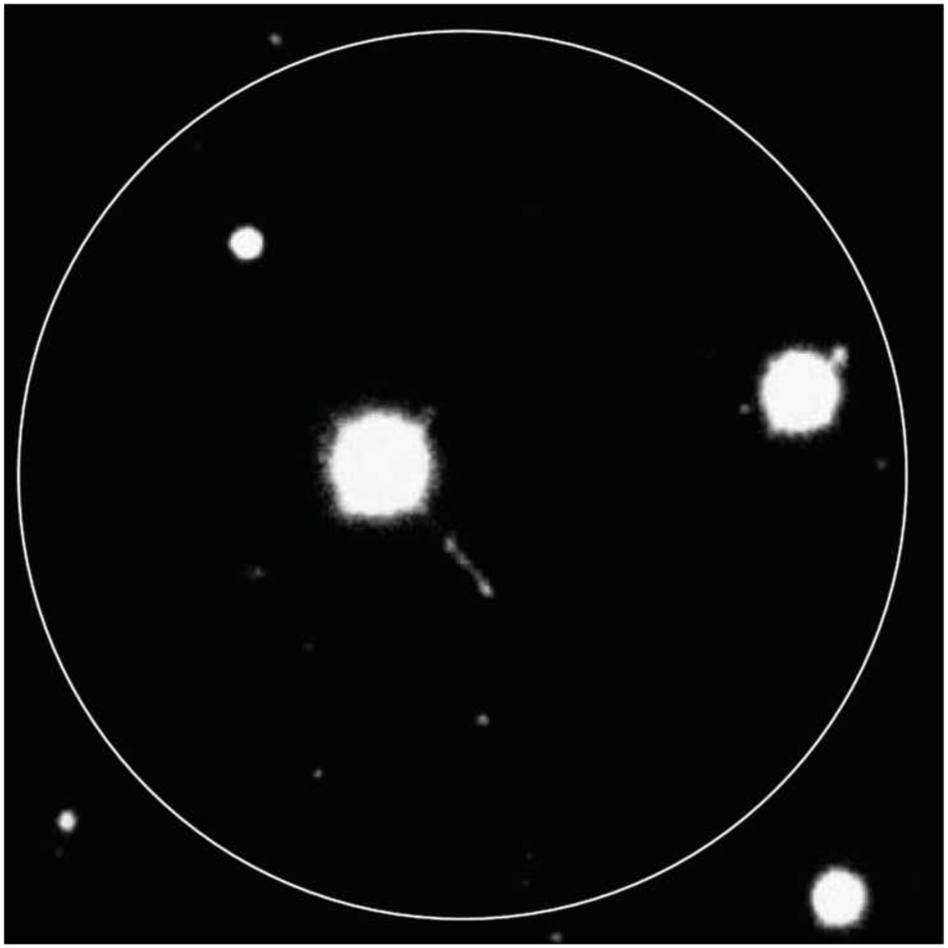

FRONT

Quasar 3C-273

(Apr-Jul)

Elliptical Galaxy
Distance: 2.5 billion light years
Size: 120,000 light years across

CD Distance Scale:

2.5 kilometers

Size: 12 cm across – like a softball

This is the most distant object that can be seen with most backyard telescopes.

A Universe of Galaxies

BACK

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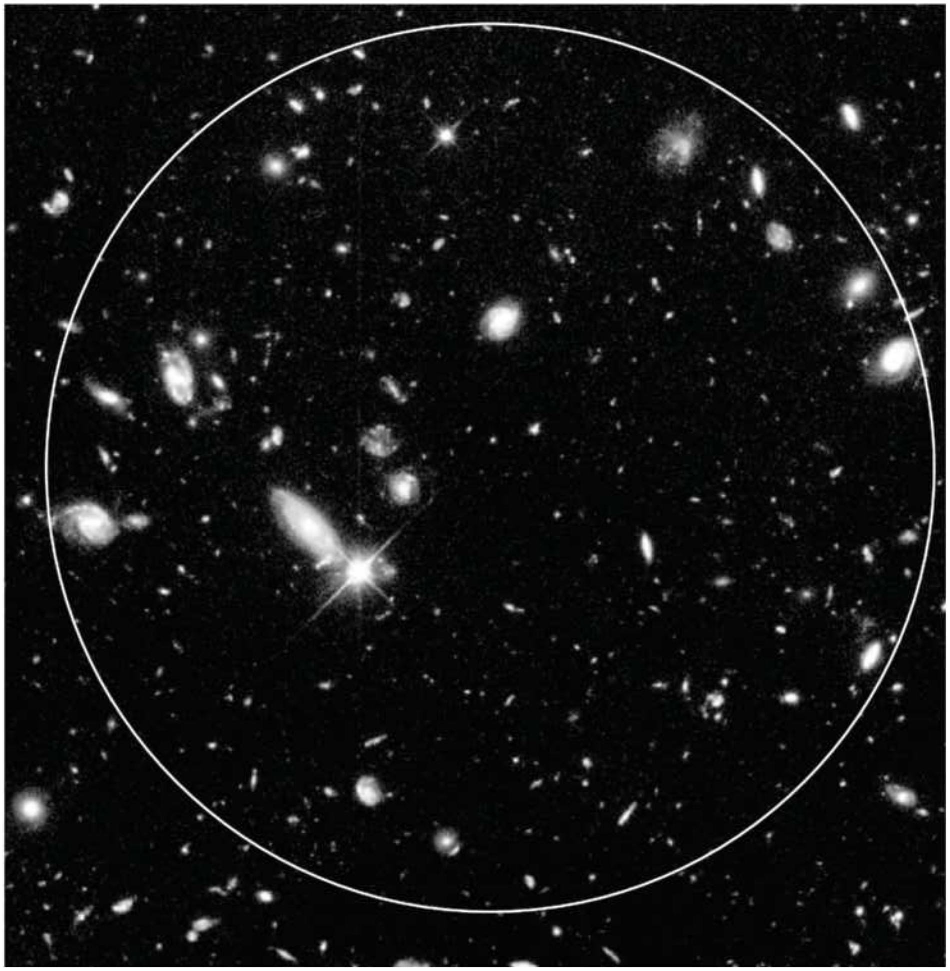


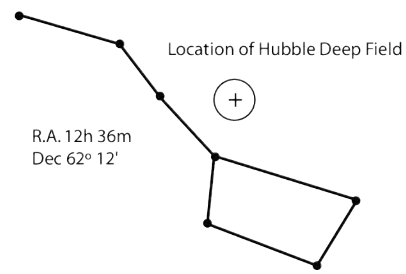
FRONT

Hubble Deep Field

The **Hubble Deep Field** shows some of the most distant galaxies. This image is used to represent the limit of our observable universe: a distance of 13.7 billion light years.

CD Distance Scale:

13.7 kilometers



Hubble Deep Field photo Space Telescope Science Institute

www.astrosociety.org

A UNIVERSE OF GALAXIES

BACK

Instructions:
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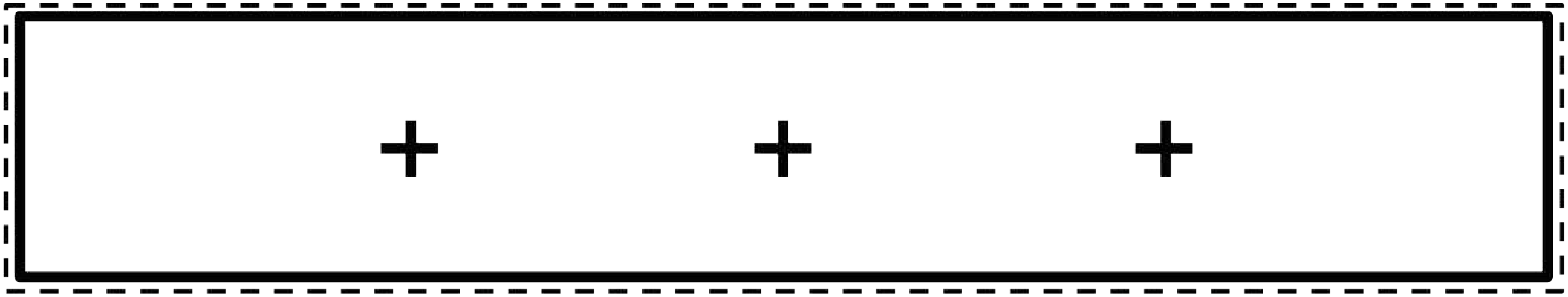
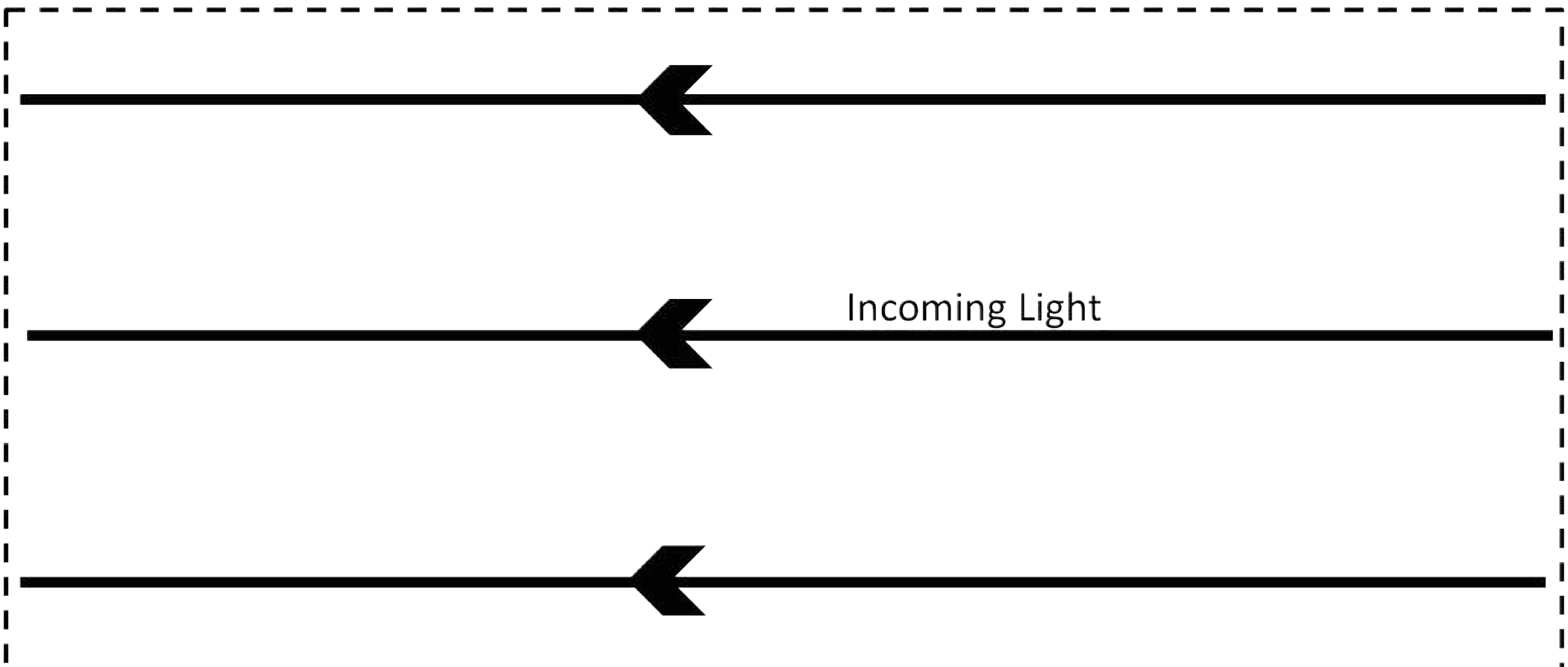
Foam Strip Template





Skynet Junior Scholars

How much sky can the telescope see?

These holes represent different "Fields of View". They illustrate how much sky a telescope can see. Compare these to the fields of view for select Skynet Telescopes on the other side of the card. Fields of view in arc minutes are shown in parentheses.

DIRECTIONS:

- Hold this card at arm's length.
- Close one eye.
- Look through the different holes.
- Estimate how much sky the Skynet telescope images cover.

Notes:

1. The Hubble Space Telescope is only used for reference and is not part of the Skynet network.
2. There are 60 arc minutes in 1 degree,
3. The moon is 30 arcmins across.

One degree
(60 arcmins)

30 arcmins

15 arcmins

5 arcmins

3 arcmins
(compare to Hubble)

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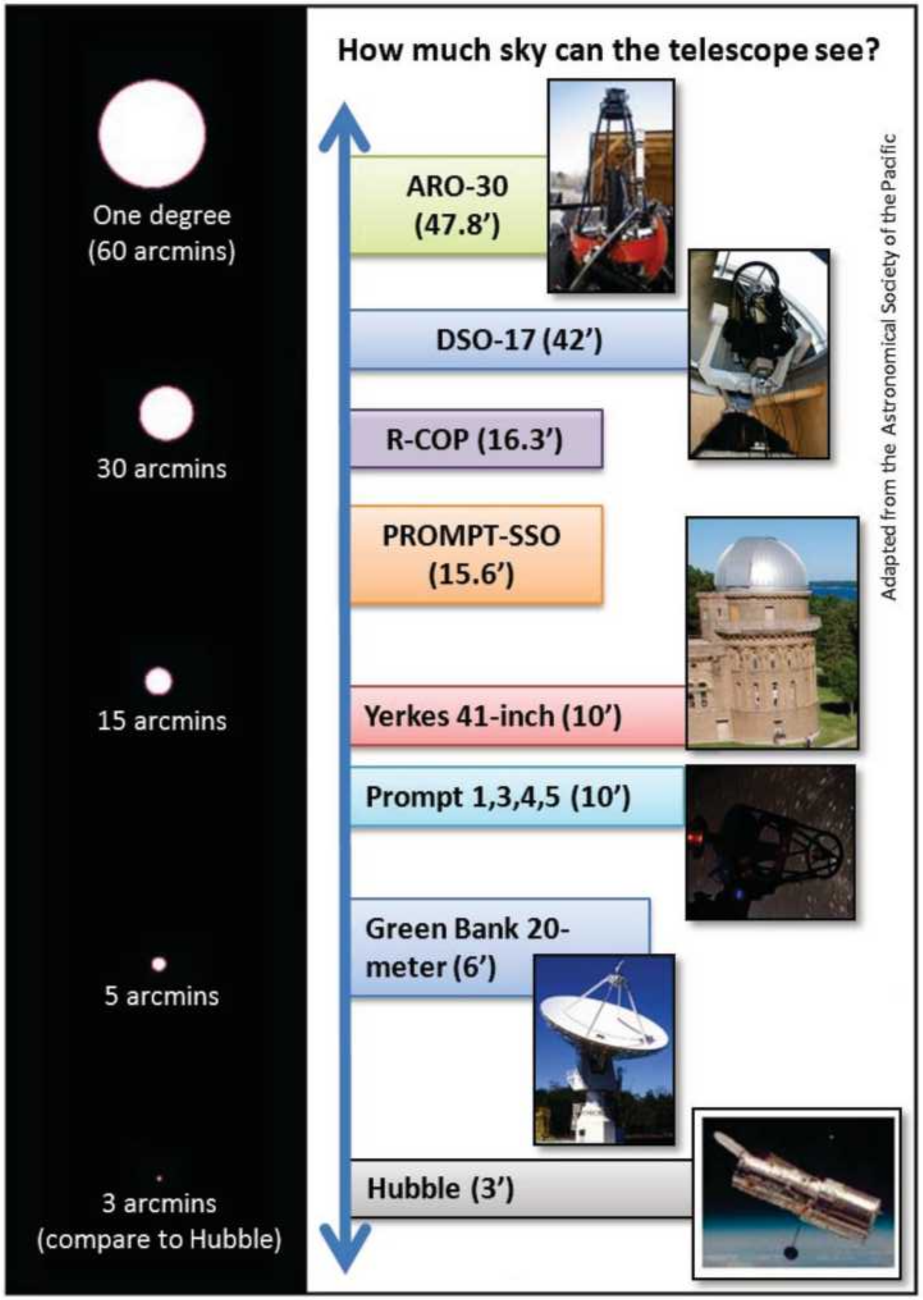
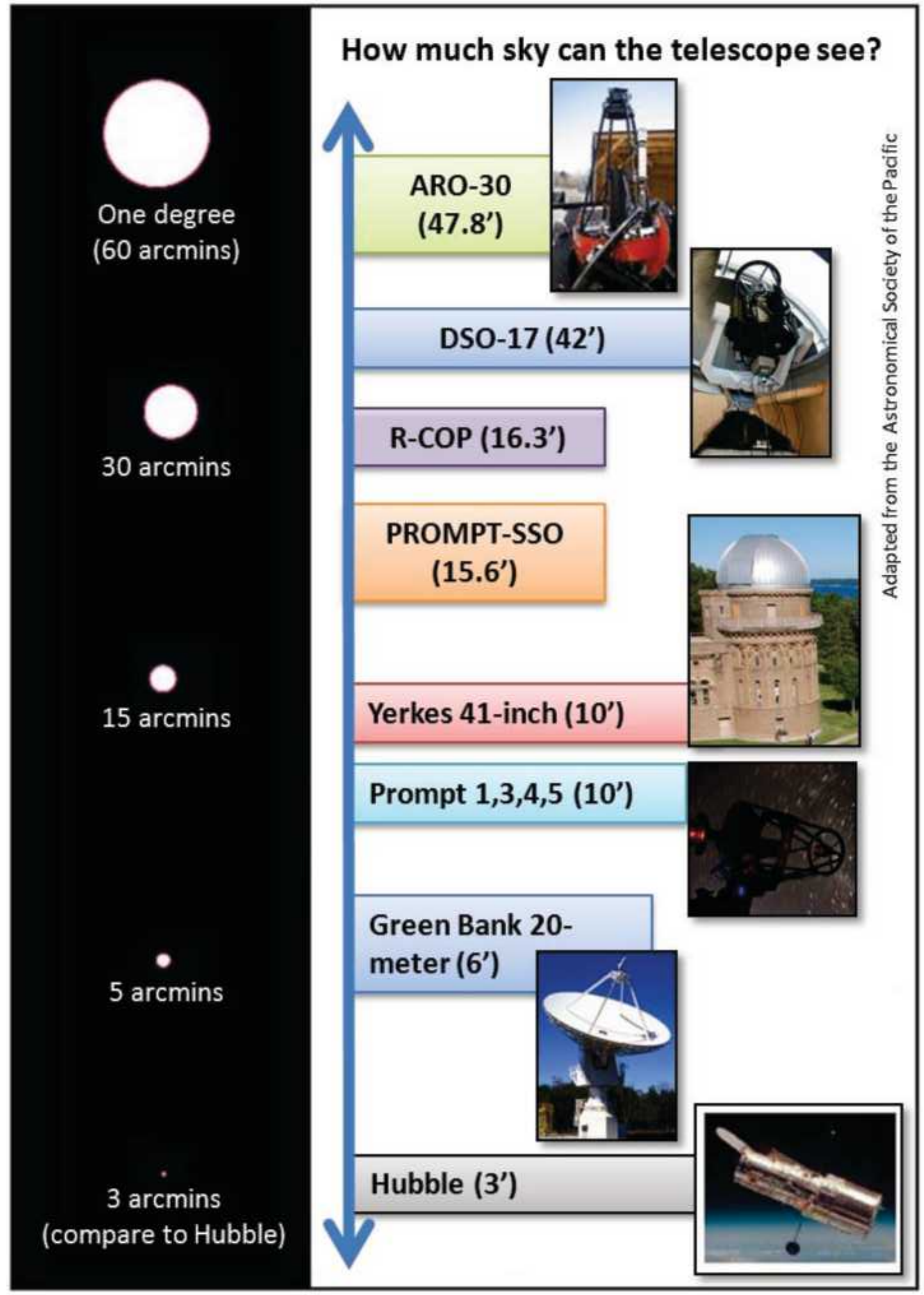

How much sky can the telescope see?
One degree (60 arcmins)
30 arcmins
15 arcmins
5 arcmins
3 arcmins (compare to Hubble)
ARO-30 (47.8′)
DSO-17 (42′)
R-COP (16.3′)
PROMPT-SSO (15.6′)
Yerkes 41-inch (10′)
Prompt 1,3,4,5 (10′)
Green Bank 20-meter (6′)
Hubble (3′)
Adapted from the Astronomical Society of the Pacific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Skynet Telescope Filters

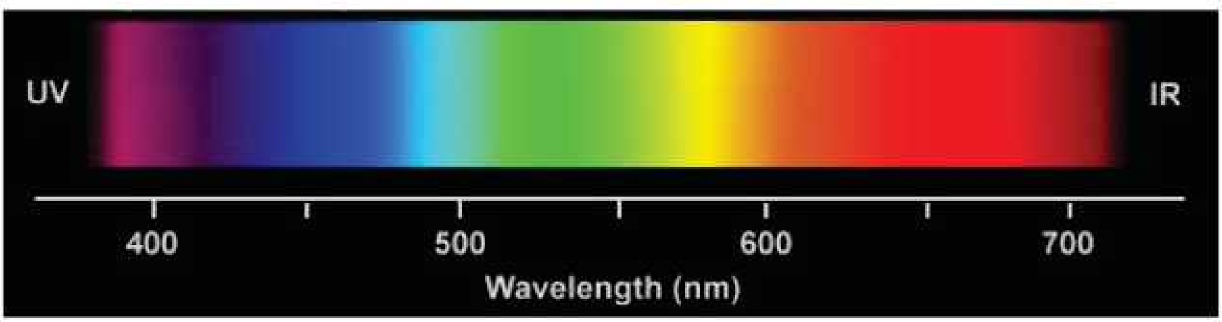
Filter Wheel for Yerkes 41-inch Telescope

Filters can be placed just before a telescope's camera to allow some colors or wavelengths of light to pass through while blocking others. Different telescopes on the Skynet Telescope Network have different filter combinations. Here is a brief description.

Sloan Digital Sky Survey (SDSS) Filters

These are the standard filters used for the Sloan Digital Sky Survey, and are the most common filter set used today. Even the Hubble Space Telescope uses SDSS filters. (These filters are properly represented with lower case letters. In some of our telescopes the SDSS filters might be listed with the word prime or as u′ g′ r′ I′ z′.)

Filter	Description	Central Wavelength
u	Passes ultraviolet light.	350 nanometers
g	Passes a combination of green-blue light	480 nanometers
r	Passes red-yellow light, but not all the red light.	625 nanometers
i	Passes long wavelength red light.	770 nanometers
z	Passes short wavelength infrared light.	910 nanometers



Visible light spectrum showing colors and wavelength

Johnson/Cousins Filters

These are filters for the UBVRI photometric system. The UBV filter system established by Johnson and Morgan has been the main means of measuring brightness and color in astronomy since 1953, but there have been some modifications. A major one was the addition of R and I filters by Kron and Cousins.

Filter	Description	Central Wavelength
U	Passes ultraviolet light.	360 nanometers
B	Passes blue light.	415 nanometers
V	V stands for visual. Passes yellow light.	520 nanometers
R	Passes red light.	600 nanometers
I	Passes infrared light.	800 nanometers

Narrow-Band Filters

These filters pass a very narrow range of light around a single wavelength or "spectral line." Atoms may emit or glow with light of very specific wavelengths. They are called "spectral lines." These filters are useful for observing objects like nebulae such as H II regions (Orion Nebula), planetary nebulae (Ring Nebula), and supernova remnants (Crab Nebula).

Filter	Description	Central Wavelength
H-alpha	Corresponds to emission from hydrogen, when an electron falls from third to second lowest energy level. Shows up in the red part of the spectrum.	656 nanometers
O III	Corresponds to emission from oxygen atoms that are missing two electrons. Shows up in the green part of the spectrum.	501 nanometers

Astrophotography Filters

Ordinary digital cameras make color images by combining light separately detected as Red (R), Green (G), and Blue (B). We can simulate the same approach by taking three black-and-white photographs through the Red, Green, and Blue colored filters, and sometimes adding a Luminance (Lum) that lets through most of the light and provides greater brightness. Note that good color images can also be made with the astronomically calibrated filter sets mentioned above.

Filter	Description
Lum (Luminance)	All optical light passes through but ultraviolet and infrared light does not.
Red	These filters are designed to mimic the response of the human eye. By taking images with each filter, the results can be combined into a single color image.
Green	
Blue	

Maximum Light Filters

These filters are useful for faint moving targets. Usually, you won't be able to see a difference between 'Open', 'Clear', and 'Lum'.

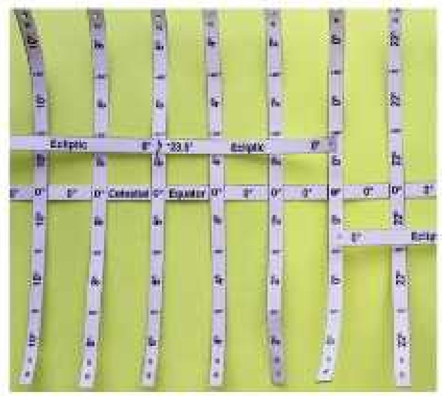
Filter	Description
Open	No filter. All light passes directly to the camera
Clear	Similar effect as 'Open' except light passes through clear piece of glass

CELESTIAL SPHERE

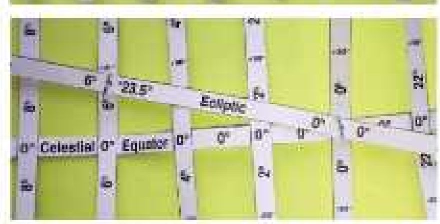
1 Using scissors, cut dotted lines for strips of RA hours, celestial equators & ecliptic. Glue the celestial equator strips together at either the 12h end or the 0h end so you have one long horizontal strip representing the celestial equator. (If constructing with brads, punch the black dots.)

2 Lay the hour angle (RA) strips out at right angles to the celestial equator. Make sure that when you read the words "celestial equator" that the N ends of the hour strips are at the top. Glue RA strips to celestial equator, each crossing the celestial equator at a right angle. Match the RAs at center, so 0° overlaps the corresponding RA hour division on the celestial equator.

3 Match & attach each ecliptic strip to 6 h or 18 h strip at the ● using either glue or a small brad.

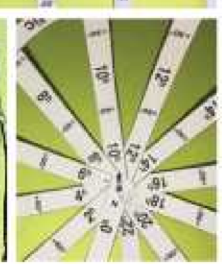


4 Where the celestial equator meets either the 0 h or 12 h strip, glue or brad together the celestial equator and the RA cross strip. Then join the ecliptic ends at a slight angle on the inside. The printing on the strips should be facing the inside of the sphere.



5 Join celestial equator ends with celestial equator grid on the inside.

6 Gather and attach the N ends with a big brad or glue and do the same with the S ends. Strips should be curving inward.



7 Make a ring stand from the remaining Celestial Sphere strip by gluing ends together.

Celestial Sphere

Skynet Junior Scholars https://skynetjuniorscholars.org

•	12^h		$0°$	10^h	$0°$	8^h	Celestial	6^h	Equator	4^h	$0°$	2^h	$0°$	0^h	•
•	0^h		$0°$	22^h	$0°$	20^h	$0°$ skynetjuniorscholars.org	18^h	$0°$	16^h	$0°$	14^h	$0°$	12^h	•
•		S	22^h	$-60°$	22^h	$-30°$	22^h	$0°$	22^h	$+30°$	22^h	$+60°$	22^h	N	•
•		S	20^h	$-60°$	20^h	$-30°$	20^h	$0°$	20^h	$+30°$	20^h	$+60°$	20^h	N	•
•		S	18^h	$-60°$	18^h	$-30°$	• 18^h	$0°$	18^h	$+30°$	18^h	$+60°$	18^h	N	•
•		S	16^h	$-60°$	16^h	$-30°$	16^h	$0°$	16^h	$+30°$	16^h	$+60°$	16^h	N	•
•		S	14^h	$-60°$	14^h	$-30°$	14^h	$0°$	14^h	$+30°$	14^h	$+60°$	14^h	N	•
•		S	12^h	$-60°$	12^h	$-30°$	12^h	$0°$	12^h	$+30°$	12^h	$+60°$	12^h	N	•
•		S	10^h	$-60°$	10^h	$-30°$	10^h	$0°$	10^h	$+30°$	10^h	$+60°$	10^h	N	•
•		S	8^h	$-60°$	8^h	$-30°$	8^h	$0°$	8^h	$+30°$	8^h	$+60°$	8^h	N	•
•		S	6^h	$-60°$	6^h	$-30°$	6^h	$0°$	6^h •	$+30°$	6^h	$+60°$	6^h	N	•
•		S	4^h	$-60°$	4^h	$-30°$	4^h	$0°$	4^h	$+30°$	4^h	$+60°$	4^h	N	•
•		S	2^h	$-60°$	2^h	$-30°$	2^h	$0°$	2^h	$+30°$	2^h	$+60°$	2^h	N	•
•		S	0^h	$-60°$	0^h	$-30°$	0^h	$0°$	0^h	$+30°$	0^h	$+60°$	0^h	N	•

• $0°$ Ecliptic 6^h • $+23.5°$ Ecliptic 0^h •

• $0°$ Ecliptic 18^h • $-23.5°$ Ecliptic 12^h •