Space Science Researcher

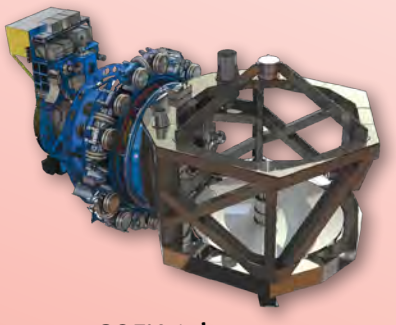
Scientists have used the observation and exploration of light to make discoveries that deepen their understanding of the Sun, stars, and other objects in space. In this badge, you'll re-create some of these scientific experiments, observe the night sky with your own eyes, and explore the possibility of seeing light in new ways.

Steps

1. What more can you see?
2. Explore "invisible" light
3. See the stars in a new way
4. Expand your vision
5. Conserve the night sky

Purpose

When I've earned this badge, I will understand more about the amazing properties of light and how we use it to make discoveries about the Universe and space science.



SOFIA telescope

Credit: Y. Lammen, DSI

"It's an incredible Universe we're in and how could you do anything but try and learn about it?"

—Vera Rubin, astronomer honored with the National Medal of Science who discovered dark matter

Create a Notebook

Go retro! Carrying a notebook is a quick, low-tech way to make sure you're always ready to capture your ideas and discoveries. Successful scientists record everything—including their wildest ideas, the exact details of an experiment's setup, and all the things they've learned. The results can be surprising, or even puzzling, which means that more experiments and observations may be needed!

Every step has three choices. Do ONE choice to complete each step. Inspired? Do more!

STEP 1 What more can you see?

When you study space science, you are studying light from stars and other objects in space, including our Sun. Because visible light reaches our eyes by bouncing off objects, we see green trees, red cars, and planets of different colors. This light from our star—the Sun—appears to be one color. Is it possible it's made of all the colors we see? Let's find out!

CHOICES—DO ONE:

☐ **Construct a spinner.** Discover the dynamic qualities of light by creating a spinner called a Newton Disk.

On your piece of white paper, trace a circle around the outside of the CD and then trace the hole in its center. If you don't have a CD, draw a four-inch circle and a smaller half-inch circle in the middle. Divide the circle into six parts and fill each section with a different color. Then trace the CD and the hole in its center onto the cardboard—or use the same dimensions from the circles on your piece of white paper. Cut out both circles, then glue the paper and cardboard together—color side out. Make two holes on opposite sides of the inner circle that are half an inch apart. Feed each end of the string through each of the holes so that the string makes a loop on one end, the spinner sits in the center, and there are two loose ends of string on the other. Tie the loose ends in a knot. Now spin the disk by twirling the string, periodically pulling the ends of the string taut, then loosening them. Play with different speeds and see what happens to all the colors. What do you see? What does this tell you about white light? The eye perceives a muddy white color because of persistent vision—which is the retina of the eye mixing all the colors into one. Draw a picture of your observations in your notebook. Share your demonstration with friends and family!

You'll need:

- Colored pencils: red, orange, yellow, green, blue, and purple
- Pencil
- Scissors
- Ruler
- CD or DVD as template
- Glue stick
- 1 piece of white paper
- 1 piece of cardboard larger than the CD or DVD
- 36 inches of string
- Notebook

Check out this video to see the spinner in action: **www.girlscouts.org/SpaceScienceColorWheel**

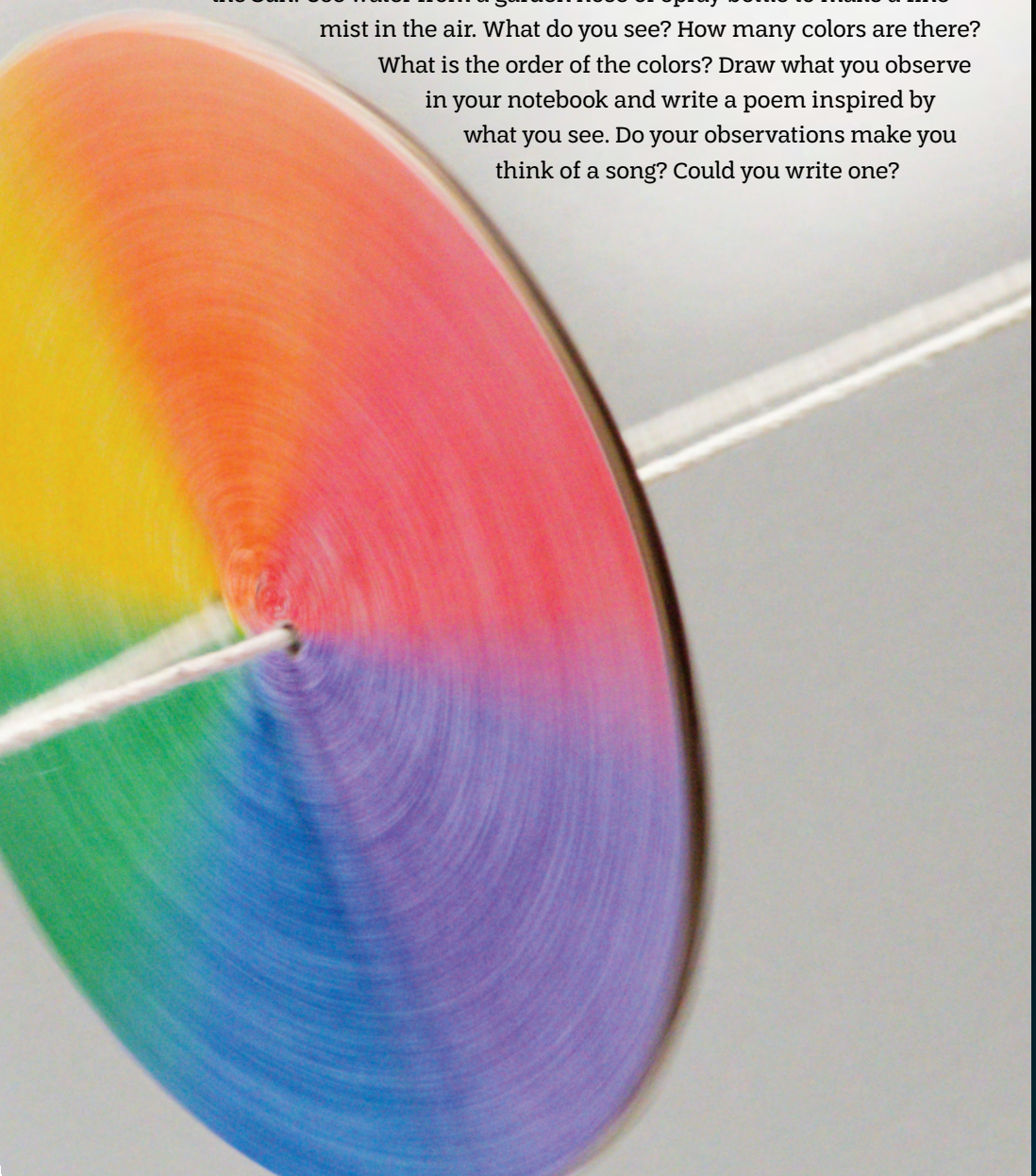
- [ ] **Make prism pictures.** On a sunny day, go to a window and take your notebook, colored pencils, markers, a pen or pencil, and two of the following: a blank CD, prism, clear-faceted crystal, diffraction glasses (to split light), or a glass almost full of water and a piece of white paper (to catch the rainbow). Play with the light-splitting tool until it produces a rainbow, then sketch what you see in your notebook. What do you observe? What do your observations tell you about light? Share your observations with your friends and family.

  FOR MORE FUN: Build a spectroscope to observe light from the Sun and different varieties of lightbulbs. Look at light reflected from a red car, green wall, etc. Learn to create your own here: **www.girlscouts.org/SpaceScienceSpectroscope**.

  Note: To prevent eye injury, NEVER look directly at the Sun.

OR

- [ ] **Create a rainbow.** Go outside on a sunny day and turn your back to the Sun. Use water from a garden hose or spray bottle to make a fine mist in the air. What do you see? How many colors are there? What is the order of the colors? Draw what you observe in your notebook and write a poem inspired by what you see. Do your observations make you think of a song? Could you write one?



Courtesy: NASA

White Light

Isaac Newton discovered that when a narrow beam of sunlight passes through a prism, it emerges as different bands of color. When writing about this discovery in his book *Opticks*, he was the first person to describe these bands of colors using the word "spectrum." To demonstrate that white light is made of colors, he recombined the colors with a second prism. He also made a spinner just like yours to recombine the colors into white light. Today, we call these spinners "Newton Disks."

STEP 2 Explore "invisible" light

The light we see with our eyes, called visible light, is just a small part of the light around us. All light is made up of energy, and some types of light have more energy than visible light: UV, X-rays, and gamma rays. Some types of light have less: infrared, microwaves, and radio waves. We call all of these different types of light the electromagnetic spectrum—even the light we cannot see! Dig deeper to explore this "invisible" light.

More to explore: Take a tour of the Electromagnetic Spectrum with NASA: **www.girlscouts.org/SpaceScienceEMS**

CHOICES—DO ONE:

☐ **Make a Sun print.** On a sunny day, go outside with a piece of blue construction paper, a sheet of plastic film, and a tube of sunscreen (with at least SPF 30 and no metal oxides). Squirt a small amount of sunscreen onto your hands and spread a thin layer over your fingers and palms. Place the sheet of plastic film over the construction paper, then press your hands firmly onto the plastic, making hand prints. Set the construction paper, with the plastic film on top, in a sunny place and be sure to weigh it down so it doesn't blow away. Wait three or four hours, then check out your print! What do you see? Why did this happen? Test different types of sunscreen to see if you get different results. Draw what you see in your notebook.

OR

☐ **Detect infrared signals.** Infrared light is all around us because everything that is warm emits infrared light. Firefighters use infrared goggles to find people in smoke-filled buildings because our bodies give off heat—and we glow in infrared light! In the same way, astronomers use infrared telescopes to see through dust to hot stars.

Many remote controls use infrared light to send signals. Find a remote control and a digital camera or a smartphone. Look at the bulb on the end of the remote control and press one of the buttons. What happens? Do you see anything? Now look at the bulb through a digital camera or smartphone camera. (Hint: You may need to put your phone in "selfie" mode. Try a few different remote/camera combinations. What are the differences?) What happens when you push different buttons? Write or sketch what you see in your notebook. Why do you think you can see the signal from the remote through the camera but not with your eyes? Now see if you can block the infrared signal. Try putting a black plastic trash bag over the remote. Can you still see it? How about sending the signal through a pane of glass or someone's eyeglasses? Does it work with sunglasses? What other materials can you try? Both visible and infrared colors are forms of light but with different energies. How do these experiments show the different properties of each?

"Detect infrared signals" activity is adapted from "The SETI Institute's NASA AAA EM Spectrum Curriculum."

Caroline and William Herschel

In 1800, William Herschel wanted to measure the amount of heat from each color of sunlight. He was surprised to find that the thermometer outside the visible spectrum had the highest temperature reading. Herschel discovered invisible light! His sister, Caroline Herschel, was his partner in astronomy. She discovered several comets and kept detailed notebooks of their observations. She made major contributions to the first catalogs of nebula and star clusters and was the first woman to be paid for her scientific work.

Courtesy: NASA

Courtesy: NASA

(left) Enhanced image of the M51 spiral galaxy captured by Hubble's Advanced Camera for Surveys. (right) The M51 spiral galaxy captured by the Hubble Space telescope in infrared light—with all visible light from the stars subtracted.

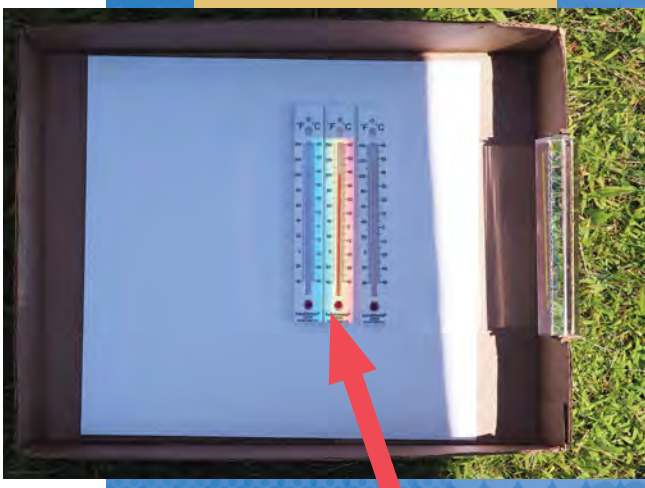
FOR MORE FUN: Contact your local fire, police, or sheriff's office and ask them to demonstrate their infrared cameras, or visit NASA Jet Propulsion Laboratory's "Cool Cosmos" at: **www.girlscouts.org/SpaceScienceCoolCosmos**.

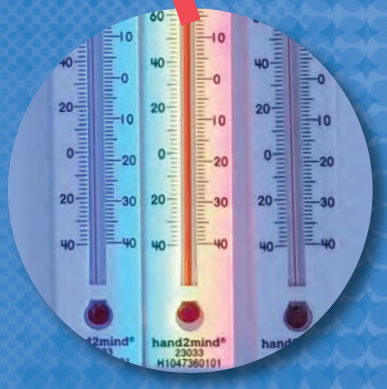
OR

You'll need:

- Notebook
- Colored pencils or pens
- 1 equilateral glass prism (this experiment does not work with plastic prisms)
- 3 alcohol thermometers
- Transparent tape
- Black marker
- Cardboard box
- Scissors or craft knife
- 1 sheet white paper

☐ **Explore more than the eye can see.** Sunlight is called white light, but it's more complex than that. A prism disperses (spreads) the light into color bands called the visible spectrum—but is that all there is? Build an experiment to test this question on a sunny day.





Once you have your supplies, you're ready to start exploring. Before you begin, make a prediction about what you think will happen.

1. Tape the thermometers together side by side, and blacken the thermometer bulbs with a marker so they can better absorb the light.
2. Cut a slot in one end of the cardboard box, a little smaller than the prism, then insert the prism into it.
3. Record the temperature of each thermometer before it is exposed to the Sun.
4. Place the white paper and thermometers into the bottom of the box.
5. Take your box outside, or place it in front of an open window facing the Sun. Move the prism around until you see a bright spectrum on the bottom of the box.
6. When you see the spectrum on the bottom of the box, place the thermometers into it so that the left one is in the blue light, the middle one is in the yellow light, and the right one is just beyond the red light. Can you predict what will happen? Record your guesses.
7. Wait for at least one minute and then record the temperature from each thermometer in your notebook.
8. Continue to measure and record the temperatures for about 10 minutes—you may need to move the thermometers or prism to keep the colors and thermometers in line with the Sun. What did you discover? How did your observations compare to your predictions? Is anything puzzling?
9. Draw a picture of your experiment and describe it in your notebook. Share your results with your friends and family.

"Explore more than the eye can see" activity is adapted from NASA's "Cool Cosmos."

Courtesy: NASA

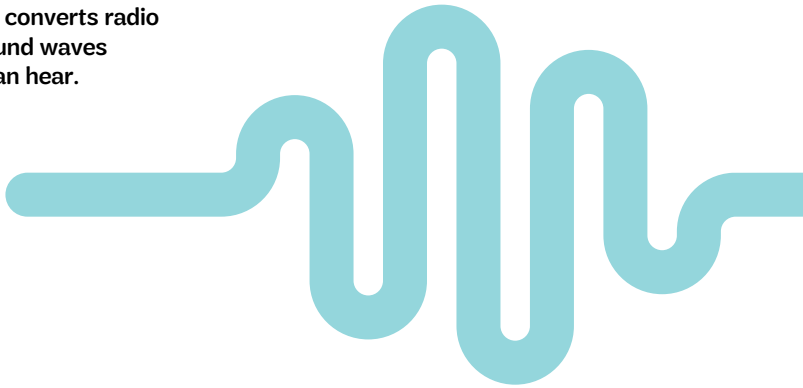
Wavelengths

Electromagnetic energy travels in waves and spans a large spectrum from long radio waves to short gamma rays. Stars emit light across this entire spectrum. However, they do not emit the same amount of energy at all wavelengths. With higher energy and higher temperature, wavelength decreases and frequency increases. Lower energy and lower temperatures produce increased wavelengths and decreased frequency. The chart to the right illustrates the electromagnetic spectrum and highlights different, mostly non-star electromagnetic energy (light) sources. Explore the electromagnetic spectrum and its relationship to the world around you.

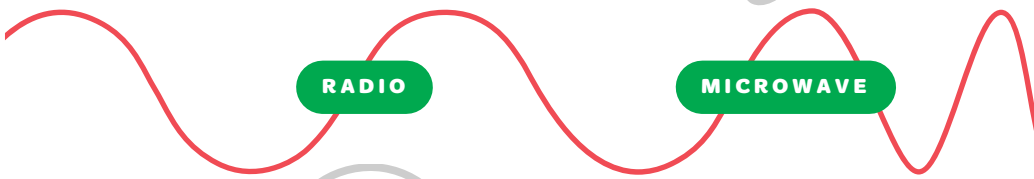
ELECTROMAGNETIC SPECTRUM: FUN FACTS

RADIO WAVES are the longest waves in the electromagnetic spectrum—some are even longer than the width of the Earth! If you ever listen to the radio, you are listening to radio waves of light. The radio converts radio waves to sound waves that we can hear.

MICROWAVES are about the size of butterflies and insects and are not just for food—they are also used in radar.

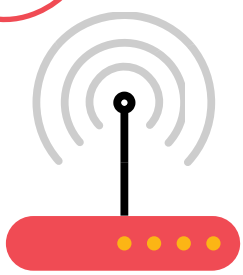


RELATIVE SIZES OF WAVELENGTHS COMPARED TO OBJECTS:



Longer wavelength, lower frequency, lower energy

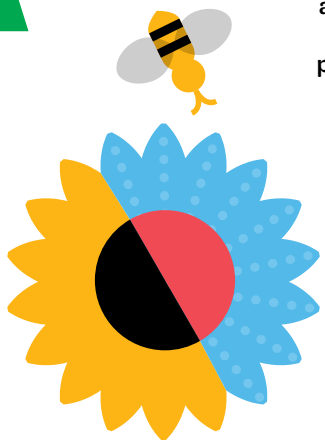
SOURCES OF ELECTROMAGNETIC WAVES:



INFRARED LIGHT is being given off by your body right now in the form of heat. "Night vision" goggles see your body's infrared output and turn it into an image your eyes can see.

Firefighters use infrared to find people in smoke-filled buildings.

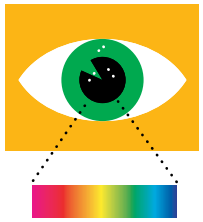
X-RAYS are high energy and small enough to penetrate your skin.



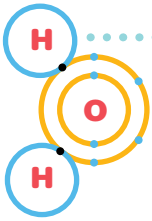
Some birds and bees can see in UV, so flowers send special **ULTRAVIOLET** light signals to these pollinators.

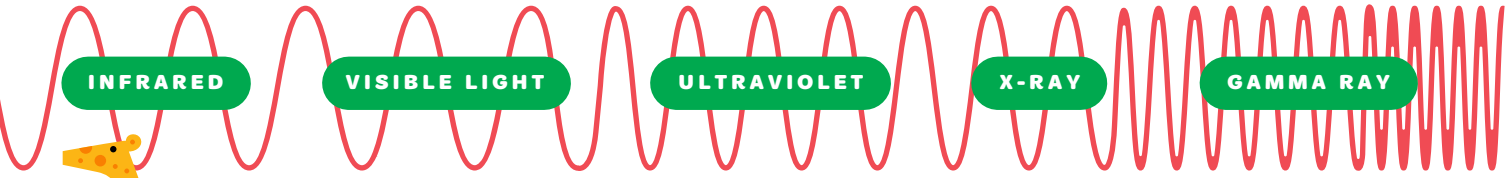
Doctors use **GAMMA RAYS** for medical treatments.

Snakes and mosquitos can see in infrared!

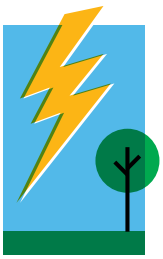


VISIBLE LIGHT is what our eyes can see, and its wavelength is tiny—from 350–700 nm, about the size of a single cell.





(The Sun is also a source for the entire electromagnetic spectrum.)



Shorter wavelength, higher frequency, higher energy

STEP

3 See the stars in a new way

As the Earth orbits the Sun (our Solar System's star), our view of the sky changes from night to night and from season to season. Use your eyes, take photographs, and learn to see the stars in a new way.

CHOICES—DO ONE:

☐ **Be an astrophotographer.** Capture images of stars, planets, and the Moon with a digital camera or smartphone to share with others. Here are some tips before you start:

- To avoid blurry photos, use a tripod, beanbag, or bag of rice to hold your camera or smartphone steady.
- Get the right app for your smartphone—look for "low-light photography" apps.
- Turn off the flash.
- Learn how to take timed photos from one second up to one hour.
- Find a dark location—city lights wash out photos!
- Pick a safe place. Bring an adult, appropriate clothes, snacks, and a flashlight.
- Practice makes perfect—you may need to take several photographs to get one you like!

Now it's time to get started. Here are some ideas:

- Take a photo of sunrise or sunset.
- Take photos of the Moon with exposures lasting ¼ second, ½ second and 1 second. Which one is your favorite?
- Take a ten-second exposure of the stars. What can you see? Can you see colors?
- Take a one-minute exposure of the same stars. What is different?
- Take a 15-minute exposure with the North Star, Polaris, in the center of the photo. Any surprises? Can you predict what will happen if you take a 60-minute exposure?
- Take a 10 to 15-minute exposure of the sky. Near the end of the exposure, briefly use a flashlight to illuminate things in the field of view. Try illuminating people, bushes, trees, etc.—see what happens!
- Take photographs of your favorite constellations.

Share your photographs with friends or family, and print copies to put into your notebook. What surprised you? What did you learn? Which images have more details? How did the images change as you increased the exposure time? Did you observe any patterns?

For More FUN: See the Astronomy Picture of the Day at **www.girlscouts.org/SpaceScienceAPOD**. A different image of our Universe is featured every day along with a brief explanation written by a professional astronomer.

OR

☐ **Observe with NASA.** Space science researchers control some of the world's most sophisticated space probes and orbiting telescopes. This equipment provides amazing images of objects in space. You can capture your own astronomical images from the ground-based MicroObservatory—a real robotic telescope that you can direct. To capture a digital image, request an observation at **www.girlscouts.org/SpaceScienceOWN**—you'll need a computer with access to the internet and an email address. Once your image is ready, typically in one to two days, you'll receive an email with a link to download it. Compare multiple photos and draw or record your observations in your notebook. What are some things you notice? Which images turned out best? Why? Capture another image using what you know now.

OR

☐ **Classify the stars.** When we gaze at the nighttime stars, they look like tiny points of light—some are bright and others are dim. Have you noticed that some stars even show a hint of color? People were puzzled by the color of stars for centuries until Annie Jump Cannon figured out how to classify them. You can, too!

You'll need:

- Scissors
- Glue stick
- Marker
- Pack of construction paper—various colors (red, yellow, orange, light blue, white)
- Printed copy of Among the Stars cards (found at **www.girlscouts.org/SpaceScienceAmongtheStars**)
- Space to move around

Once you've gathered your supplies, you're ready to start classifying stars. Glue each Among the Stars card to a piece of construction paper that matches its peak star color, then write the star's name and constellation on the back. Gather a group of people—ten or more works well—and hand out your star cards. Have everyone decide how they might organize themselves in a line according to the information found on their cards. Explore different methods for classification. Can you find a pattern that relates star color to any other characteristic?

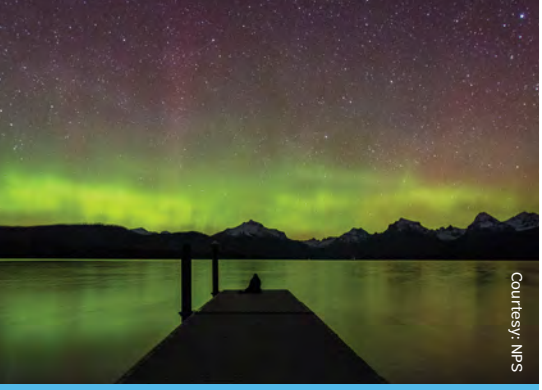
For More FUN: At night, go outside and try to locate the stars on your cards. Can you see hints of their color?

Oh, Be A Fine Girl/Guy, Kiss Me!

Courtesy: Hulton Archive

Annie Jump Cannon

Annie Jump Cannon was an American astronomer who classified more than 225,000 stars, compiled the largest accumulation of astronomical information ever assembled by a single individual, and perfected the star classification system we use today. Annie organized the stars into classes from hottest to coolest (O, B, A, F, G, K, M) by analyzing photographs of stellar spectra—the fingerprints of elements that make up each star. To help remember the order, she invented the mnemonic Oh, Be A Fine Girl/Guy, Kiss Me! Can you invent your own phrase to remember the classes of stars?



Courtesy: NPS

What Does Your Night Sky Look Like?

Depending on where you live, the night sky can look very different. As you explore this step, see if the night sky nearest you is best for observation—or, if a spot a short distance away might be better.

Courtesy: NPS

STEP
4 Expand your vision

Thousands of years ago, people began cataloging the stars by brightness and organizing the sky into constellations for calendaring, knowing when to plant and harvest, navigating, and passing down moral codes. Then, in the 1600s, the invention of the telescope helped to expand their view. Expand your view by looking up and exploring the night sky.

CHOICES—DO ONE:

☐ **Be a night sky observer.** On a moonless night, when the sky is dark and perfect for stargazing, gather your notebook, a pencil, a flashlight covered with transparent red plastic or cellophane (so that your eyes will stay dark adapted), and check out this site to see what's happening in the sky: **www.girlscouts.org/SpaceScienceSkyMaps**. Then, grab an adult, head outside, and look up. If you are in the country, you may see hundreds to thousands of stars, while city dwellers may see only a few. What do you observe? What color do the stars appear to be? How bright are they? Can you identify any stars or constellations and name them? (A Star Wheel or smartphone app can help you.) In your notebook, draw a constellation with notes identifying each star's name, color, and brightness. Can you identify anything else?

FOR MORE **FUN:** Look north to locate the Big Dipper or Cassiopeia or choose a constellation from a star chart. Sketch the constellations you can see and label their stars.

OR

☐ **Find a dark sky.** Have you been to a place so dark that there are too many stars to count? Our national parks protect these dark places and hold some of the last remaining dark sky preserves. Plan a trip to visit one with your family or Girl Scout friends, and get out into the dark! Bring your notebook to sketch and record your observations. What does the night sky look like? What can you see? Is it different from where you live? Learn more about the national parks and the steps they're taking to preserve the dark here: **www.girlscouts.org/SpaceScienceNightSkies**.

OR

☐ **Observe with a telescope.** If you or a friend have a telescope, spend an evening looking through it at celestial objects: stars, galaxies, nebulae, planets, the Moon, etc. Use your notebook to take notes and sketch what you see. You can also use your smartphone to snap a photo through the eye piece. If you do not have a telescope, find a local astronomy club through the Night Sky Network, and attend a stargazing event. The Night Sky Network connects nearly 500 amateur astronomy clubs across the United States. If you are interested in attending an event hosted by your local astronomy club—explore upcoming opportunities at **www.girlscouts.org/SpaceScienceNSN**.

STEP

5 Conserve the night sky

Darkness at night is good for living things. When there's too much light at night, it wastes energy and has negative effects on the health and safety of animals, including humans. This excess light is called light pollution. Lights shining toward the sky, using energy in a way that has no benefit to us, is an example of light pollution and negatively affects the work of astronomers. Find out ways you can help fix light pollution in your area and beyond.

CHOICES—DO ONE:

- ☐ **Become a citizen scientist.** Citizen science combines data and analysis from professional scientists and the general population—including girls like you. The Globe at Night program is an international citizen science campaign that raises public awareness about the negative impacts of light pollution. Light pollution threatens not only our "right to starlight," but can affect energy consumption, wildlife, and our health. More than 100,000 sky measurements have been contributed from people in 115 countries. Join the campaign and become a citizen scientist by observing and reporting on the conditions of the night sky where you live. To help preserve the night sky, all you need are your eyes to observe and a computer or smartphone to report your data. Visit **www.girlscouts.org/SpaceScienceGlobeatNight** or **www.girlscouts.org/SpaceScienceLossoftheNight** to get started.

OR

- ☐ **Look at light with new eyes.** Take pictures of the light fixtures around your home or neighborhood. Find instances of glare, light trespass, unshielded lights, and excess lighting. What are some ways you can take action to reduce the bad lighting near you? Work with an adult and some of your Girl Scout friends to put your plan into action.

OR

- ☐ **Make a change.** How would you fix the problem of light pollution? Design and create a light fixture or shade that directs light downwards onto the ground where we need it—not up into the sky creating light pollution. The International Dark Sky Association champions the importance of night and has information about changes you can make in your community to help save the night skies. Learn more here: **www.girlscouts.org/SpaceScienceDarkSky**.

Light Pollution

Light pollution negatively affects all living creatures. Light trespass on beaches can cause baby sea turtles to crawl in the wrong direction—away rather than to the ocean when they hatch. It can also throw off the migratory patterns of birds and make it more difficult for nocturnal animals to hunt. As for humans, regular exposure to light at night—including light from electronic screens—can affect sleep patterns and disturb our bodies' natural rhythms.

Going on a Journey? Do some badge work along the way.

Harness the strength of social media as you showcase your passion for astrophotography in *MEdia*. Use the skills you gained while earning this badge to influence and cultivate your online presence. Explore the multiple ways your interests in space science can shape how others see you. How can you share what you've discovered with the world?

Now that I've earned this badge, I can give service by:

- Partnering with community leaders to find creative solutions for preserving the night sky.
- Sharing with younger Girl Scouts how they can see stars in a new way.
- Showing my family and friends how to explore more than their eyes can see.

I'm inspired to:

Courtesy: NPS

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