NASA’S UNIVERSE OF LEARNING
Girls STEAM Ahead with NASA
Program Cookbook

Find the complete GSAWN Program Cookbook online: https://www.universe-of-learning.org/gsawn
Girls STEAM Ahead with NASA Program Cookbook

Table of Contents

Introduction .................................................................................................................... 3
Quick Start Guide ........................................................................................................ 4
Girls and STEAM: Engagement Strategies ................................................................. 5
Diverse Learners ......................................................................................................... 6
Recipe 1: Electromagnetic Spectrum ........................................................................... 8
  Topic Overview ......................................................................................................... 10
  Background Content for the Facilitator .................................................................. 10
  Menu of Event Activities & Resources .................................................................. 11
  Vocabulary ............................................................................................................... 12
  Sample Event Scenarios ......................................................................................... 16
    Scenario 1: Forms of Light .................................................................................... 16
    Scenario 2: AstroPix Scavenger Hunt ................................................................. 22
Planning Sheet: Building Your Own Event Scenario .................................................. 32
Recipe 2: Data and Image Processing ......................................................................... 35
  Topic Overview ......................................................................................................... 37
  Background Content for the Facilitator .................................................................. 37
  Menu of Event Activities & Resources .................................................................. 38
  Vocabulary ............................................................................................................... 39
  Sample Event Scenarios ......................................................................................... 40
    Scenario 1: Binary Code ....................................................................................... 40
    Scenario 2: Pixels to Images ............................................................................... 45
    Scenario 3: Creating Astronomical Images .......................................................... 55
Planning Sheet: Building Your Own Event Scenario .................................................. 60
The Girls STEAM Ahead with NASA (GSAWN) project within NASA’s Universe of Learning empowers libraries and community-based organizations to engage girls and their families in exploring the wonders of NASA science and celebrate the contributions of women to science, technology, engineering, arts, and mathematics (STEAM). This Program Cookbook is designed to guide you as you create your own Girls STEAM Ahead with NASA event using NASA’s Universe of Learning resources.

Like any typical cookbook, our Program Cookbook includes “recipes” for events, ordered by topic. For each topic, we provide the following sections:

- menu of activities and resources related to the topic
- background resources on the topic
- sample event scenarios
- adaptations for different audiences and tips for extensions
- planning worksheet to develop your own event scenario

Depending on your comfort level with astrophysics topics, you can use a sample event scenario exactly as outlined in the Cookbook. We have provided some sample scripts to help you “talk” through your event. As you get more comfortable with our resources, you can then use the “Menu of Activities and Resources” and planning worksheet to tailor your Girls STEAM Ahead with NASA event for your audience’s needs.

The GSAWN team is ready to assist you in developing your event. Reach out to us at girlsSTEAMahead@universe-of-learning.org for guidance on NASA’s Universe of Learning resources, to be connected with a NASA Subject Matter Experts (e.g., scientists, engineers, STEM professionals) for your GSAWN event, to access to available exhibit materials, and much more.
This Program Cookbook is a guidebook for facilitators planning their own Girls STEAM Ahead with NASA event using NASA’s Universe of Learning resources. This resource is organized by astronomy topic (the “recipe”) and contains supporting information and resources for you to host a GSAWN event. We provide sample event scenarios with components to guide your audience through a particular topic. These components include:

- an opening ENGAGEMENT piece for your audience
- INTRODUCTION to the content
- WARM UP element for the audience
- a group and/or individual ACTIVITY related to the content
- a WRAP UP piece, with follow-up ideas for at-home engagement

HOW TO USE THIS PROGRAM COOKBOOK

Step 1 Choose an astronomy topic for your GSAWN event. Topics included in this Cookbook are: The Electromagnetic Spectrum; Data and Image Processing.

Step 2 Plan your GSAWN event using NASA’s Universe of Learning resources.

Option A If you are unfamiliar with NASA’s Universe of Learning resources:
- Use one of the sample event scenarios, designed as 60-minute events with integrated components to guide your audience through a particular topic.
- Use our sample facilitator scripts for some of the event components.

Option B If you are comfortable with NASA’s Universe of Learning resources:
- Use our Program Cookbook Planning Sheet to plan your GSAWN event.
- Select items from the “Menu of Event Activities & Resources” and insert them into the different components of the Planning Sheet.

Step 3 Look at the “TIPS and ADAPTATIONS” sections for suggestions on how to tailor your event for your audience or for your event venue.

Step 4 Email us at girlsSTEAMahead@universe-of-learning.org and let us know about your event or if you need assistance with event planning. For example, we can connect you with a NASA Subject Matter Expert (e.g., scientists, engineers, STEM professionals) who can provide another engaging component to your GSAWN event.
Science, technology, engineering, and math (STEM) disciplines represent one of the most important learning areas for our nation's youth. Our future depends on the expert knowledge of the STEM workforce and on the diverse individuals in those careers. However, the current demographics of the STEM workforce do not mirror the diversity within our society. Boys and girls have comparable levels of interest in STEM topics by the end of elementary school. But this STEM interest, especially among girls, appears to change or decrease through the middle school years. If youth, especially tweens and teens, have a sense of identity and self-efficacy in science, they are more likely to persevere and pursue a STEM career later on.

Your Girls STEAM Ahead with NASA event for girls and their families can foster each person's STEM identity in different ways. Here are some best practices on how to engage girls in STEM during your event, which helps to engage everyone in your audience, too. When appropriate and applicable, we also include specific engagement tips and resources within the sample event scenarios, too.

- Make your event warm and inviting for all participants.
- Share how STEM content or the process of science is relevant to their lives.
- Provide opportunities to learn about female STEM professionals doing science. You can provide information on how prominent women contributed to a certain field of study. You can invite a female Subject Matter Expert (e.g., scientists, engineers, STEM professionals) to join your event, chat with the audience, or participate in event activities.
- As the facilitator, you are also a role model on how to work with STEM concepts. Be cognizant of how you approach the content, how you guide their learning, and how you give them feedback.
- Provide opportunities to collaborate with their peers.

When you incorporate some of these best practices into your event, you help your audience see that science is for them and that science is something that anyone can do. You encourage the youth to see themselves as the future scientists who can do science, and answer some of the biggest questions out there in our universe.

References
- National Girls Collaborative Project (NGCP)
- SciGirls Strategies: How to Engage Girls in STEM
- Tips for Using SciGirls Strategies
- Changing The Game for Girls in STEM
- Girls and Women in Science, Technology, Engineering, and Mathematics: STEMing the Tide and Broadening Participation in STEM Careers
- Strategies for Increasing Girls' Participation in STEM
- Subtle Linguistic Cues Increase Girls' Engagement in Science
NASA's Universe of Learning is committed to bringing the universe to all learners and meeting them where they are. While GSAWN events and activities are designed to actively engage girls, they are also designed to be accessible to all, regardless of gender/gender identity or expression, background, or ability. Here, we offer some general tips for working with diverse audiences; including learners who are blind/have low vision, have hearing impairments, or who are neurodiverse. These are just a few factors of diversity. Feel free to explore the links included here to learn more tips and strategies for adapting activities for your audiences.

When working with learners who are blind/have low vision, speak upon entering and leaving the room or meeting platform. Always identify yourself by name when speaking and have other participants identify themselves as well. Call the learner by name if you want their attention. Give verbal descriptions for visual materials. Describe, in detail, pertinent visual occurrences of the learning activities. Use descriptive words such as straight, forward, left, etc. in relation to the student's body orientation. Select videos with narration. Offer to read written information for a person with a visual impairment, when appropriate. For in-person events, do not pet or touch a guide dog. Guide dogs are working animals.

Note: people who have low vision may be able to see print if it is large enough. Black print on white paper is best. Standard print is 10–12 point type. Large print is 16–18 point and up, generally an enlargement setting of 160–175% on a copy machine. Many computer programs offer a variety of font types and sizes. Verdana or Arial is preferred. Make use of the Text Zoom feature in web browsers and computer applications when displaying documents or web pages.

When working with learners who have hearing impairments, be aware of noise level and try to reduce background noise as much as possible. Whether or not a learner is using an assistive listening device, they may be sensitive to background sounds, which tend to mask speech. Many individuals with hearing impairments depend on their vision to either speechread a speaker (i.e., interpreting visual clues that accompany talking, such as moving lips or hand gestures) or watch an interpreter. Be sure a learner with hearing impairment is able to sit where they can clearly see you and/or the interpreter. Avoid standing in front of a light source that puts your face in shadow, and if using a microphone, either in person or virtually, keep the microphone below your mouth to facilitate speechreading. Use visual aids whenever possible and make sure videos are captioned.

Preferential seating for in-person events, or allowing learners to select their own seat or workspace, is an effective strategy for all types of learners. This gives learners autonomy and allows them to sit at a location where they feel they will learn best without feeling singled out. In addition, all learners benefit from an environment that minimizes distractions and maximizes positive reinforcement. Share a schedule of the day’s activities with learners in advance. Be aware that some learners may need extra time to complete activities. Have buffer or extension activities ready to go for early finishers, while allowing other learners time to finish up. Also, some learners may learn better with a tactile or kinesthetic approach, while others may have sensitivities to certain textures. Have a variety of tactile materials on-hand and let learners choose for themselves the materials they would prefer to work with.
The Universal Design for Learning (UDL) Framework is a good starting place for designing events and learning experiences that effectively accommodate individual learning differences.

References

- What Neurodiverse Learners Need You To Know
- Valuing Differences: Neurodiversity in the Classroom
- NSTA: Visual Impairments
- Hearing Impairments Factsheet
- Mobility Impairments
RECIPE 1:
ELECTROMAGNETIC SPECTRUM

(From left to right) The Helix Nebula in infrared, visible, and ultra-violet light. The last image on the right is a multiwavelength image. Explore more with the Helix Nebula Interactive on ViewSpace. Image Credits: NASA

Let us know about your event plans by emailing us at girlsSTEAMahead@universe-of-learning.org

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### HOW TO USE THIS PROGRAM COOKBOOK

**Step 1** Choose an astronomy topic for your GSAWN event. Topics included in this Cookbook are: The Electromagnetic Spectrum; Data and Image Processing.

**Step 2** Plan your GSAWN event using NASA’s Universe of Learning resources.

**Option A** If you are unfamiliar with NASA’s Universe of Learning resources:
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- Use our sample facilitator scripts for some of the event components.

**Option B** If you are comfortable with NASA’s Universe of Learning resources:
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- Select items from the “Menu of Event Activities & Resources” and insert them into the different components of the Planning Sheet.

**Step 3** Look at the “TIPS and ADAPTATIONS” sections for suggestions on how to tailor your event for your audience or for your event venue.

**Step 4** Email us at girlsSTEAMahead@universe-of-learning.org and let us know about your event or if you need assistance with event planning. For example, we can connect you with a NASA Subject Matter Expert (e.g., scientists, engineers, STEM professionals) who can provide another engaging component to your GSAWN event.
The electromagnetic spectrum (EMS) is the full range of all forms of light. Light comes in different forms. Human eyes can only sense visible light, which is just a small fraction of the electromagnetic spectrum. The electromagnetic spectrum includes gamma-rays, X-rays, ultraviolet, visible, infrared, microwave, and radio waves.

Light can be described as a wave, with characteristics and behavior that depends on how far apart the crests from each of its waves are spread (its wavelength). Alternatively, light can be viewed as composed of a stream of photons, with energies related to the various wavelengths of light; short wavelengths correspond to high energies. In a vacuum, light travels at about 300,000 kilometers (186,000 miles) per second. This means light could circle the Earth 7.5 times in one second!

In astronomy, light is the primary cosmic messenger, bringing us information about distant objects. Astronomers use telescopes on the ground and in space to collect this cosmic light, which is our data from the universe. Telescopes are designed to detect certain types of light. For example, the Spitzer Space Telescope detected infrared light and the Chandra X-ray Observatory detects X-ray light. Both of these observatories were placed in orbit around Earth because those forms of light do not pass through the Earth’s atmosphere. Some telescopes, like the Hubble Space Telescope, can detect visible, ultraviolet, AND infrared light. Not all telescopes are in space and there are many ground-based observatories that are home to different types of optical and radio telescopes.

With the following NASA’s Universe of Learning resources, your event participants will learn that:

• The electromagnetic spectrum contains all types of light.
• Our eyes only detect one type of light from the electromagnetic spectrum (visible light).
• Objects in the universe can appear different when detected using different kinds of light, which can tell us something about that object.
• Different telescopes are used to collect different kinds of light from space.

These concepts are important because light is how astronomers gather evidence from objects in space. Because there is more than one type light, multiwavelength observations are key to understanding the object at an in-depth level.
# Menu of Event Activities & Resources: Electromagnetic Spectrum

## Engagement

<table>
<thead>
<tr>
<th>Activity</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>ViewSpace Interactives: explore science content</td>
<td>c</td>
</tr>
<tr>
<td>ViewSpace – “In a Different Light” videos</td>
<td>c</td>
</tr>
<tr>
<td>Collection of Telescope Images</td>
<td>c</td>
</tr>
<tr>
<td>AstroPix – database of astronomy images</td>
<td>c</td>
</tr>
</tbody>
</table>

## Background Builders

<table>
<thead>
<tr>
<th>Activity</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction to the EMS (info)</td>
<td>c</td>
</tr>
<tr>
<td>EMS Poster (displaying the Whirlpool Galaxy)</td>
<td>c</td>
</tr>
<tr>
<td>ViewSpace Interactives: explore science content</td>
<td>p</td>
</tr>
<tr>
<td>Telescope paper models</td>
<td>p</td>
</tr>
<tr>
<td>Universe Unplugged: EMS Musical (video)</td>
<td>c</td>
</tr>
</tbody>
</table>

## Explorations

<table>
<thead>
<tr>
<th>Activity</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>AstroPix Scavenger Hunt: Find an object with the most images in different kinds of light</td>
<td>p</td>
</tr>
<tr>
<td>Multiwavelength BINGO Activity: game to learn about images in different forms of light</td>
<td>c</td>
</tr>
<tr>
<td>“Fishing for Supernova” Go-Fish Game: learn about supernova remnants</td>
<td>c</td>
</tr>
</tbody>
</table>

## Extensions

<table>
<thead>
<tr>
<th>Activity</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>MicroObservatory/Observing with NASA: Capture and process your own image</td>
<td>c</td>
</tr>
<tr>
<td>NASA Astrophoto Challenge: create your own image from NASA Space Telescopes</td>
<td>p</td>
</tr>
</tbody>
</table>

## Real-World Connections

<table>
<thead>
<tr>
<th>Activity</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>NASA Astrophoto Challenges: Learn from Experts (M82) (videos)</td>
<td>c</td>
</tr>
<tr>
<td>NASA Astrophoto Challenges: Learn from Experts (Whirlpool Galaxy) (videos)</td>
<td>c</td>
</tr>
<tr>
<td>Science Visualization of the Whirlpool Galaxy (Video)</td>
<td>c</td>
</tr>
</tbody>
</table>

## Things to Try at Home

<table>
<thead>
<tr>
<th>Activity</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Fishing for Supernova” Go Fish Card Game: learn about supernova remnants</td>
<td>p</td>
</tr>
<tr>
<td>Telescope paper models</td>
<td>p</td>
</tr>
<tr>
<td>NASA Astrophoto Challenge: create your own image from NASA Space Telescopes</td>
<td>c</td>
</tr>
<tr>
<td>Multiwavelength Visualization of the Crab Nebula or the Whirlpool Galaxy (videos)</td>
<td>c</td>
</tr>
</tbody>
</table>

Pick and choose from this menu to build your own program. We put together some Sample Scenarios on the following pages to get you started.
an object so small and dense that inside its event horizon, the escape velocity is faster than the speed of light. In an active galaxy, the central black hole may have millions or even billions of times the Sun's mass. One type of black hole is formed from the collapsed core of a star after it goes supernova. Its gravity is so intense not even light can escape from inside the event horizon.

NASA's space-based observatory which looks at X-ray light. One of NASA's “Great Observatories,” it was launched in 1999 and as of 2020, continues operating.

a device, or devices, used to detect photons, or in some cases other particles like protons, electrons, etc.

the full range of wavelengths (or, equivalently, frequencies), from radio waves to gamma rays, that characterizes light.

This image displays the electromagnetic spectrum, ordered by decreasing wavelength. For each type of light, a corresponding image depicts the approximate wavelength size. For example, the wavelength of visible light is similar in size as the dimensions of bacteria. Image Credit: NASA/STScI
energy in this context, the amount of energy available in a single photon of a particular type of light. For example, an X-ray photon has more energy than an infrared photon.

**Fermi Gamma-Ray Space Telescope** NASA's space-based observatory which looks at gamma-ray light. It was launched in 2008 and as of 2020, continues operating.

**frequency** a property of a wave that describes how many wave patterns or cycles pass by in a period of time.

**galaxy** a collection of gas, dust, and billions of stars held together by its gravity.

**galaxy cluster** thousands of galaxies that are gravitationally bound together into a large group.

**Galaxy Evolution Explorer (GALEX)** NASA's space-based observatory which looked at ultraviolet light. It was launched in 2003 and ended operations in 2013.

**Gamma-rays** the very highest energy end of the electromagnetic spectrum, with the shortest wavelengths. Gamma-rays typically have wavelengths a few hundred times shorter than low-energy X rays, and are usually shorter than a few hundred picometers (pm, \(10^{-12}\) m).

**Hubble Space Telescope (HST)** NASA's space-based observatory which looks at ultraviolet, optical, and near-infrared light. One of NASA's “Great Observatories,” it was launched in 1990 and as of 2020 continues operating.

**infrared light** this band of the electromagnetic spectrum has wavelengths in the micron (\(\mu\)m, \(10^{-6}\) m) range. They are correspondingly more energetic than microwaves and radio waves.

**light-year** the distance light travels in one year; approximately 9.5 trillion (9.5 \(x\) 10^{12}) kilometers. Since light travels so fast, it covers a lot of distance in a small amount of time and because the universe is so large it makes it easy for astronomers to use light-years as a measuring stick.

**microwave** the energy of microwaves is a bit higher than radio waves. Their wavelengths are therefore shorter, and are typically measured in centimeters (cm or \(10^{-2}\) m).

**multi-wavelength astrophysics** using more than one part of the electromagnetic spectrum to learn about objects in space. Different parts of the spectrum (sometimes called “different wavelengths” or “different kinds of light”) can show perspectives that do not appear in other parts of the spectrum.
nebula  A diffuse mass of interstellar dust and gas.

neutron star  the extremely dense core of a star after it has exploded as a supernova. A neutron star has a mass of ~1.2 solar masses to as much as three times the mass of the Sun, but may be only a few kilometers across.

photon  an individual quantum or particle of light. A single packet of light, characterized by its wavelength, frequency, or energy.

radiation (or, electromagnetic radiation)  another word for light, usually used in the context of light emitted by an object (not to be confused with atomic radiation, which refers to the tendency of unstable atomic nuclei to emit particles and photons).

radio waves  the lowest energy region of the electromagnetic spectrum. Radio waves have wavelengths of meters (m), or even kilometers (km, \(10^3\) m).

spectrum  the distribution of photons according to wavelength or frequency. Usually used to observe which frequencies of light are emitted more/less by a particular object.

Spitzer Space Telescope  NASA's space-based observatory which looks at infrared light. One of NASA's “Great Observatories,” it was launched in 2003 and ended operations in 2020.

supernova (pl. supernovae)  two types:
• the titanic explosion of a massive star at the end of its life. The outer layers explode outward, creating a supernova remnant, while the inner core collapses to become a neutron star or black hole.
• a huge thermonuclear explosion resulting when certain white dwarf stars exceed 1.4 times the mass of the Sun.

supernova remnant  the expanding gas left over from a supernova, the titanic explosion of a massive star at the end of its life.

telescope  instrument used to capture as many photons as possible from a given region of the sky and concentrate them into a focused beam for analysis (distinct from a detector, which is one of the components in a telescope.)

ultraviolet light  electromagnetic radiation beyond the blue/violet end of visible light. Ultraviolet radiation is more energetic than visible light but less than X-rays. Ultraviolet wavelengths are typically measured in nanometers (nm, \(10^{-9}\) m).

visible light  the part of the electromagnetic spectrum that is visible to human eyes. Visible light ranges from red to violet (from 380 to 700 nanometers).
wave  a pattern that repeats itself cyclically in time and space. Waves are characterized by the velocity with which they move, their frequency, and their wavelength.

wavelength  two uses:
• wavelength of light – a property of a wave that is the distance between the crests (or troughs) of two consecutive waves.
• a more colloquial use is as a synonym for spectral bands (“We look at this in many wavelengths” usually is referring to observing an object in multiple bands, not at multiple individual wavelengths).

white dwarf  the dense core of a star like the Sun as it ends its life. A white dwarf has as much mass as the Sun, but the diameter of the Earth.

X-rays  A form of high energy light in the electromagnetic spectrum; X-ray photons have more energy than ultraviolet light, but less than gamma rays.
In this sample event the audience will learn about different forms of light. Engage your audience by showing images of different space objects in different kinds of light. Next, the audience will explore (via ViewSpace Interactive) a particular scene on Earth in different types of light. Similarly, astronomers explore the universe in different types of light too, which allows us to better understand those objects. The multiwavelength BINGO game reinforces this idea and introduces content about the images in multiple types of light.

**MATERIALS**

- Internet-connected computer with a large screen or display to work with ViewSpace.

- Images (digital or paper versions) from ViewSpace Interactives, AstroPix, the Electromagnetic Spectrum poster of the Whirlpool galaxy, or other visuals of astronomical objects.

- Handouts for the Multiwavelength BINGO game, including a BINGO card, flashcard, and tokens for each participant.

**OVERVIEW**

In this sample event the audience will learn about different forms of light. Engage your audience by showing images of different space objects in different kinds of light. Next, the audience will explore (via ViewSpace Interactive) a particular scene on Earth in different types of light. Similarly, astronomers explore the universe in different types of light too, which allows us to better understand those objects. The multiwavelength BINGO game reinforces this idea and introduces content about the images in multiple types of light.

**ACTIVITY LENGTH**

60 minutes. See the following “Tips and Adaptations” for 90 minute options.

**TARGET AUDIENCE**

Activities are ideal for families and learners ages 10+, but can be adapted for younger audiences. See our “Tips and Adaptations” suggestions at the end of this Scenario section.
**ENGAGEMENT**

Play a ViewSpace video, display a variety of space images from AstroPix, show the Electromagnetic Spectrum poster, or show your favorite astronomy images.

**5 MIN.** Get your audience excited by showing them stunning images of galaxies, supernova remnants, or star-forming regions. You can also focus on one astronomical object viewed in different kinds of light. (Example: This is a ViewSpace Image Tour video of the Antennae Galaxies.)

**ACCESSIBILITY TIP**

Select videos with narration or captioning. If using images, orally give the names and descriptions of objects for learners who are blind/have low vision. For in-person events, have multiple copies of images available to distribute to learners for up-close viewing.

**INTRODUCE THE CONTENT**

Types of light around you

**5 MIN.** STATE: What kind of light do your eyes see? Are there other kinds of light that we can see? How about types of light that we cannot see? (Alternative ways to ask the question: What kind of light can human eyes detect? Are there other kinds of light that human eyes can detect? Cannot detect?)

We know that visible sunlight is composed of different colors (e.g., red, orange, yellow, green, blue, indigo, and violet). We know the Sun gives off ultraviolet light too. We can't see it, but our skin acts like a detector, absorbing that energy. You might have heard about infrared cameras and how they can detect the light that your bodies give off. You can't see that heat, but you can feel it.
SHOW: Use this ViewSpace Interactive on the “Forms of Light: Electromagnetic Spectrum” with optional facilitator script.

Be sure to toggle the Interactive labels “OFF” for now. Demonstrate how to use the Interactive for the group or if your audience has their own access to a computer, tablet, or a smart phone, they can explore the Interactive for a couple of minutes. The default stop is at “Visible”; you can slide the bar left or right to explore the scene in different kinds of light.

ACCESSIBILITY TIP
Read out the stop caption for young learners. Describe the ViewSpace “stop” for your audience. For in-person events, have multiple copies of ViewSpace stops available to distribute to learners for up-close viewing. You can do this by making screenshots of the views. Individual users can zoom in on the ViewSpace stop images for closer inspection.

SET THE STAGE: Engage the audience by asking what parts of this scene might “glow” when you move the slide bar to the infrared. What do you think might glow in the ultraviolet? In the radio light?

If you choose to let them explore independently for a few minutes, you can bring them back together by asking them to tell you some interesting sources that produce X-rays, infrared, radio, etc.

3 WARM-UP
State the outcome and model the activity.

15 MIN. STATE: Astronomers study objects by looking at them in many kinds of light.

Choose any multiwavelength Interactive from ViewSpace that is NOT one of the objects in the Multi-wavelength BINGO activity, which follows. We suggest that you use the Eagle Nebula.

https://viewspace.org/interactives/unveiling_invisible_universe/star_formation/eagle_nebula
As you slide back and forth, encourage your audience to think about what they see that is the same or different about each image.

ENGAGE: Now ask them, why do you think the images look different? Answer: Images taken in different types of light may emphasize different parts of the object that have different composition or temperatures. Images obtained in some types of light let you “see” inside or to see glowing gas. Astronomers study the universe in many kinds of light, so they can get a better understanding of what is happening.

ACCESSIBILITY TIP

After participants provide their descriptions, summarize each image again, but add some more visual details for learners who are blind/have low vision. For in-person events, have multiple copies of images available to distribute to learners for up-close viewing.

GROUP ACTIVITY

Multiwavelength BINGO [Optional script available] Click for full game instructions.

20 MIN. Each participant should get a BINGO board, tokens (optional), and a set of flashcards. The facilitator will have the BINGO calling cards in a container ready for random selection. When ready, a caller will select and read a BINGO calling card from the container. Participants will look at their flashcards for the object, and, if they have it, mark their BINGO board. Continue this until someone calls BINGO.
If time permits, you can talk about the different objects that allowed them to call BINGO. Also, when someone calls BINGO, you can talk about the images and what they are telling us about the object.

**ACCESSIBILITY TIP**
Refer to activity instructions.

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**5 WRAP-UP**
Putting it all together.

**10 MIN.** ENGAGE: Ask the audience what differences they saw in images of M101 (the Pinwheel Galaxy), one of the objects in the BINGO game.

STATE: Astronomers can learn a lot about an object by looking at it in different types of light. A galaxy might look very interesting in visible light, but it can look different in X-rays or in the infrared. The puzzle is trying to figure out how the pieces fit together to tell the story about what is happening in that object. Remember when we looked at the ViewSpace Interactive that shows how our environment looks different in different forms of light? Space is also like that. You can end your event by watching this ViewSpace “In a Different Light” video about M101.
**TIPS AND ADAPTATIONS**

**Beginners/Young Learners:**
The Multiwavelength BINGO game can include an additional matching component to it. After you read out the description on each drawn BINGO calling card, show the group the card with the image on it. That way, younger learners can match that image to one on their Bingo boards.

**Advanced Learners:**
For the Multiwavelength BINGO, you can talk about the physics of why the image looks different in different forms of light.

**Virtual Learning:**
Participants can access and download the Multiwavelength BINGO activity materials. The facilitator can still call out and show the BINGO calling cards. When someone has BINGO, they can unmute their mics, type BINGO in the chat window, or hold it up to the camera. You can also find online tips for virtual presentations, such as Memory, Virtual Speaking, and Covid-19 and 10 Tips for Giving Effective Virtual Presentations.

**Low-tech Learning:**
Print screenshots of each stop of the ViewSpace Interactive and let participants explore the images. The Multiwavelength BINGO is a low-tech activity already. If you choose to extend this activity and use AstroPix, you can provide a montage of printed-out images.

**Girls and STEM:**
Use our Women in STEM poster series to highlight certain female scientists who have had a big role in astronomy, like Nancy Grace Roman and her role as the first Chief Astronomer at NASA in developing the Hubble Space Telescope, or Vera Rubin's discovery of dark matter using ground-based optical telescopes. Alternatively, you can end your event by sharing a video of a female astronomer discussing how she uses telescopes to study the universe in a very specific form of light, like X-rays. You can search the Women@NASA page or contact the GSAWN team to connect you with a Subject Matter Expert for your event.

**90 MINUTE OPTIONS**

**Option #1:** Provide the opportunity to put together paper models of some space-based telescopes that observe the universe in different kinds of light. Wrap up by stating that the telescope design and the types of detectors are unique to detect that particular type of light.

**Option #2:** Use AstroPix to explore more images of the celestial objects from the BINGO game.

**Option #3:** Search the ViewSpace page for multiwavelength interactives or videos related to the types of objects in the BINGO game. Ask participants to explore and share new information they learned beyond what appeared on the BINGO flash cards.
In this sample event, the “Electromagnetic Spectrum: the Musical” video introduces your audience to the different forms of light. Then, the audience will explore AstroPix, a searchable database of press release images from telescopes around the world and in space. The images are categorized in many ways, but most important for us, they are all categorized by the wavelengths in which the images were taken. Your audience will work together and individually to hunt for a celestial object with the most number of images in different types of light. The goal is for participants to understand how different wavelengths of light are represented in pictures and to notice how images of the same object in different types of light can reveal details about that object. This scenario contains instructions for the facilitator, as well as some guided questions to ask the audience.

**OVERVIEW**

In this sample event, the “Electromagnetic Spectrum: the Musical” video introduces your audience to the different forms of light. Then, the audience will explore AstroPix, a searchable database of press release images from telescopes around the world and in space. The images are categorized in many ways, but most important for us, they are all categorized by the wavelengths in which the images were taken. Your audience will work together and individually to hunt for a celestial object with the most number of images in different types of light. The goal is for participants to understand how different wavelengths of light are represented in pictures and to notice how images of the same object in different types of light can reveal details about that object. This scenario contains instructions for the facilitator, as well as some guided questions to ask the audience.

**ACTIVITY LENGTH**

60 minutes. See the following “Tips and Adaptations” for 90 minute options.

**TARGET AUDIENCE**

Activities ideal for families and learners 12+, but can be adapted for younger audiences. See our “Tips and Adaptations” suggestions at the end of this Scenario section.
ENGAGEMENT

Watch the video “Electromagnetic Spectrum: The Musical”

7 MIN.  Listen and don't mind if your feet start tapping into the rhythm as a science-mad A.I. system (voiced by GLaDOS actress Ellen McLain) uses a song to educate a computer technician (Ed Wasser) about the nature and utility of the electromagnetic spectrum.

https://universeunplugged.ipac.caltech.edu/video/not-glados-electromagnetic-spectrum-the-musical

ACCESSIBILITY TIP
Turn on video captioning.

INTRODUCE THE CONTENT

Different forms of light

10 MIN.  The goal is for participants to understand how different wavelengths of light are represented in pictures. Recap the names of the different types of light, which are radio, microwave, infrared, visible (or optical), ultraviolet, X-ray, and gamma-ray. Depending on the age of your audience, you could also recap the energy and wavelength trends for light too.

If your audience needs more background context for light, use this ViewSpace Interactive, called “Forms of Light: Electromagnetic Spectrum” to walk through the different forms of light. An optional script is available for this Interactive.

ACCESSIBILITY TIP
Be descriptive as you explain the ViewSpace Interactive.
3 WARM-UP
Introduce the audience to AstroPix.

8 MIN. Start on the main AstroPix main page – https://astropix.ipac.caltech.edu/.
There are several ways to do an image search, but the goal right now is to show them what type of information is displayed when they click on any image.

CLICK on any image in AstroPix.

The image and supplemental information related to the object will be displayed, similar to the example at right.

Talk about the different information in the various boxes, like the text description below each image and specific reference information on the right-hand side of the screen. Emphasize the “Color Mapping” box on the lower right side because it lists the wavelength(s) of light displayed in the image.

Next, walk your audience through an example search. Start on the “Advanced Search” page on AstroPix: https://astropix.ipac.caltech.edu/advanced_search
Image searches are based on specific wavelengths of light or combinations of wavelengths of light.

Now, your search appears as “Spectral Band” “is” “undefined” (see reference image below). The rightmost drop-down box, which is currently set to “undefined,” provides all the options to search for images taken in different wavelengths of light: Radio, Millimeter (a portion of the infrared band), Infrared, Optical (Visible), Ultraviolet, X-ray, and Gamma-ray.

SELECT “Spectral Band” in the left-most drop-down column, that currently has the word “Title” in the box.

SELECT the wavelength “Radio” menu (or a different wavelength selection) in the “undefined” drop-down and press “Run Query.”

The images returned by this query will have a radio image incorporated in them. (Image of an example query result is at left.)

Some of the images from this search are colorful in appearance and seem to have more than one type of light in them.

That is, the image contains the radio image plus overlapping images at different colors of light.
So, you might wonder how to look for images with just a radio image. How can you identify a “radio only” image from results that include many other wavelengths? The first step is to perform a “Run Query” that includes a single color of light – in this case, the “color” is radio waves. But our eyes cannot detect radio wave light. In these images the radio wavelength information is represented, or translated, into the colors of light our eyes can see, which is visible light. Without this translation, you would not be able to see anything but a black screen.

A good example is this Galaxy image seen in radio wavelengths of light: https://astropix.ipac.caltech.edu/image/esahubble/opo0402e

Notice that the radio image is displayed in red (but it could have been any color) to represent or translate where the radio light is detected in this object.

The single color here implies that it is only displaying one specific wavelength of light. This is verified by looking at the “Color Mapping” box on the lower right side of the screen.

We will use this example as the basis of our first search. Go back to your query results and ask your participants which images look to have only ONE color? Click on the image and remind the participants to look at the “Color Mapping” box on the lower right side of the screen to confirm that the image is only in radio light.

HOW DO YOU SAVE YOUR QUERY RESULTS?

After you “Run Query,” you can save your search results by PRESSING the blue “Link to This Search” button on the right side of your search result.

This will update the URL in your browser, which you can copy (see reference image below). Notice that the URL has changed and the “Link to This Search” button is no longer present. For example, this URL will give you the query results for “Spectral Band” and “is” and “Radio” – https://astropix.ipac.caltech.edu/link/afn
GROUP ACTIVITY
Find images that are taken in only ONE wavelength of light

10 MIN. SEARCH #1 - Explore images that are taken only in ONE wavelength of light in the gallery for the whole range of possibilities from radio to X-rays. NOTE: No single wavelength image of a single object exists for gamma rays! Do this first search as a group, so the participants become familiar with using the AstroPix search tool.

ENGAGE the audience. Ask what wavelength of light they should explore first. Follow-up by asking why they want to start with that particular wavelength of light.

Do an image search using their chosen wavelength of light. Remember since we are selecting an image based on a single wavelength, the images will not be colorful and will have only one color representing the astronomical object. ASK the audience if any of the images look to only have one “color” in the image?

In teams, have them identify images that have been taken in only ONE wavelength. Remind the participants to check their guess by looking at the “Color Mapping” box in the lower right side of the screen for each image. Ask the participants to find the name of the object, and what type of object (e.g., galaxy, star, nebula, etc.) is being displayed. Ask them to find the approximate distance to the object, as well as the wavelength of the light of the image. (Suggestion: Create a fun worksheet that they can fill out as they conduct these searches or ask them to copy and paste images into a presentation slide to make a fun collage of images.)

ACCESSIBILITY TIP
Orally give the names and descriptions of images for learners who are blind/have low vision.

INDIVIDUAL ACTIVITY
“The Scavenger Hunt” to find images taken in two, three, and more than three wavelengths of light.

20 MIN. SEARCH #2 - Now that you know how to visually pick out images that are taken in one wavelength, try picking out images that only have two wavelengths used to create them.

You can use the advanced search tool by CLICKING on the “+” and then choosing a second wavelength in addition to the first one.
The telltale sign of images using only two wavelengths is they tend to be less colorful than images made using many wavelengths of light. A good example of an image created using a combination of radio and optical light is the binary star LL Pegasi: https://astropix.ipac.caltech.edu/image/eso/potw1710b.

Refer to the “Color Mapping” key in the bottom right corner to see which color is used for each wavelength of light. Try multiple pairs of different wavelengths.

**SEARCH #3** - Now search for images that contain *only* three different wavelengths. As an example, let’s do Radio, Optical, and X-ray. First click on “Advanced Search” to reset your search tool. Then select the “Spectral Band” option and “Radio.” Now you will need to use the “<>” nesting function.

**CLICK** on “<>” and it will give you a second option, but now the second option will be only for images that have the wavelength that you requested in the first option. For the second wavelength choose “Optical” and then use the “<>” again for a third option for “X-ray.” Your search should look like the image at left.

Notice that the second and third wavelength choices appear to be offset from the first wavelength choice. The offsets show that it is a nested query as opposed to when we use the “+” and those are additional requests. A good example of an image with all three wavelengths is this galaxy cluster: https://astropix.ipac.caltech.edu/image/chandra/610d
SEARCH #4 - Be sure to click on “Advanced Search” to reset your search tool. Now try a wavelength search where multiple wavelengths are used but within the same region of the spectrum. For example, try looking for images created from multiple radio wavelengths or multiple infrared wavelengths. This will be more difficult because the images with multiple wavelengths will all be very colorful as they will have multiple wavelengths used to create their optical representation, but those multiple wavelengths will not necessarily all be from the same wavelength region. Here is a good example of an image made from just infrared wavelengths: https://astropix.ipac.caltech.edu/image/spitzer/ssc2011-03a1

SEARCH #5 - First click on “Advanced Search” to reset your search tool. Now for the toughest search. Find which image in the AstroPix archive has the most number of wavelengths used to create the image. This can be made into a competition to see who finds the highest number. Remember that participants can send you their “Link to This Search” so that you can check their results. This is helpful for virtual events when you want to look at their work or if you want to save their queries for a later event.

Hint: Your eyes may be your best search tool here since the image with the most wavelengths used to create it will be the most colorful.
5 MIN.  Display the first image with a single wavelength from earlier and the final image with multiple wavelengths and look at the first one then the other. Each image is a representation or translation of light emitted by an astronomical object. Most of the wavelengths that are represented are not light that our eyes can see, but by translating those unseen wavelengths into the wavelengths our eyes can see, we can make images of objects using all the wavelengths of light. Astronomers refer to these compositions as multiwavelength images. Here is an example, comparing the single radio image of Abell Cluster 2125 to a colorful, multiwavelength image of the Crab Nebula.

Provide your audience a follow-up activity to try at home. For example, they can explore ViewSpace Multiwavelength Interactives OR ViewSpace “In a Different Light” videos series OR SME videos of how images in different wavelengths can tell us different aspects of an object, like the Whirlpool Galaxy or the star-bursting galaxy M82.

TIPS AND ADAPTATIONS

Beginners/Young Learners:
You can focus the younger audiences’ attention by asking to find a single-color image of a certain type of object, like a planet, a supernova remnant, or a spiral galaxy. Have them discuss the parts of the image that they find pretty and why. Then, you can ask the group to decide on ONE kind of object and just explore the AstroPix database for images in two wavelengths.

Advanced Learners:
You can highlight how images at shorter wavelengths (more energetic light) tends to capture more energetic processes too. For example, X-ray light can capture locations where the gas is hot, while radio waves tend to capture cold gas and dust. You can explore the physical conditions of the regions by exploring an object across different wavelengths, which is why astronomers tend to have multiwavelength observations of objects.
Virtual Learning:
The resources for this particular scenario are well-suited for a virtual event as long as participants have internet access and a web browser to access AstroPix and ViewSpace.

Low-tech Learning:
None at this time.

Girls and STEM:
Use our Women in STEM poster series to highlight certain female scientists who have had a big role in astronomy, like Nancy Grace Roman and her role as the first Chief Astronomer at NASA in developing the Hubble Space Telescope, or Vera Rubin’s discovery of dark matter using ground-based optical telescopes. Alternatively, you can end your event by sharing a video of a female astronomer discussing how she uses telescopes to study the universe in a very specific form of light, like X-rays. You can search the Women@NASA page or contact the GSAWN team to connect you with a Subject Matter Expert for your event.

90 MINUTE OPTIONS

Option #1: Depending on types of objects that the participants might find, ask them which multiwavelength images were the most interesting to them and why. Could they see which parts of the image had overlapping coverage at different wavelengths? How about any regions that could only be seen in one color?

Option #2: Invite participants to explore one or two ViewSpace Interactives that have a multi-wavelength component to them (e.g., Helix Nebula, a planetary nebula or the Lagoon Nebula, a star-forming region or the Antennae Galaxies, a merging system of galaxies). After several minutes of exploration, have a volunteer explain the differences or similarities that they noticed when viewing individual color images instead of a composite image.

Option #3: With the given event scenario, you could create a “tally board” that lists the names of the objects that people identify for each of the searches. Once you have the tally board, you can organize them by type of object or distance from Earth. You also can ask each participant to share a fun fact about their object in the search.
PLANNING SHEET: BUILD YOUR OWN EVENT SCENARIO

I. ENGAGEMENT

RESOURCES:

ESTIMATED TIME: __________________________

NOTES:

II. WARM-UP

RESOURCES:

ESTIMATED TIME: __________________________

NOTES:
III. ACTIVITY

RESOURCES:

ESTIMATED TIME: _________________________

NOTES:

IV. WRAP-UP

RESOURCES:

ESTIMATED TIME: _________________________

NOTES:
V. TAKE-HOME/FOLLOW-UP IDEAS
RECIPE 2:
DATA AND IMAGE PROCESSING

The data path from the cosmic source, to the satellite, to Earth. The data transmitted in binary code before being translated into a visual representation of the object. Credit: NASA/CXC/SAO

Let us know about your event plans by emailing us at girlsSTEAMahead@universe-of-learning.org

Find the complete GSAWN Program Cookbook online: https://www.universe-of-learning.org/gsawn
This Program Cookbook is a guidebook for facilitators planning their own Girls STEAM Ahead with NASA event using NASA’s Universe of Learning resources. This resource is organized by astronomy topic (the “recipe”) and contains supporting information and resources for you to host a GSAWN event. We provide sample event scenarios with components to guide your audience through a particular topic. These components include:

- an opening ENGAGEMENT piece for your audience
- INTRODUCTION to the content
- WARM UP element for the audience
- a group and/or individual ACTIVITY related to the content
- a WRAP UP piece, with follow-up ideas for at-home engagement

**HOW TO USE THIS PROGRAM COOKBOOK**

**Step 1** Choose an astronomy topic for your GSAWN event. Topics included in this Cookbook are: The Electromagnetic Spectrum; Data and Image Processing.

**Step 2** Plan your GSAWN event using NASA’s Universe of Learning resources.

**Option A** If you are unfamiliar with NASA’s Universe of Learning resources:

- Use one of the sample event scenarios, designed as 60-minute events with integrated components to guide your audience through a particular topic.
- Use our sample facilitator scripts for some of the event components.

**Option B** If you are comfortable with NASA’s Universe of Learning resources:

- Use our Program Cookbook Planning Sheet to plan your GSAWN event.
- Select items from the “Menu of Event Activities & Resources” and insert them into the different components of the Planning Sheet.

**Step 3** Look at the “TIPS and ADAPTATIONS” sections for suggestions on how to tailor your event for your audience or for your event venue.

**Step 4** Email us at girlsSTEAMahead@universe-of-learning.org and let us know about your event or if you need assistance with event planning. For example, we can connect you with a NASA Subject Matter Expert (e.g., scientists, engineers, STEM professionals) who can provide another engaging component to your GSAWN event.
NASA scientists explore how the universe works by gathering and analyzing data by some of the world’s foremost ground-based and space-borne observatories. But, how do you make images of things in space? Moreover, how do you make images of objects in space that are taken in a kind of light undetectable (not visible) to the human eye?

When a telescope captures data, they do not arrive as an assembled snapshot. Instead, the spacecraft streams data encoded in the form of 1’s and 0’s, which are eventually translated into various formats, including images. To understand this translation process, we need to discuss what astronomical data is – and is not. Satellite and spacecraft images are not really photographs, but pictorial presentations of measured data in different bands of the electromagnetic spectrum (i.e., radio, infrared, visible, ultraviolet, X-ray, gamma ray).

When a satellite observes an object in space, its camera records light particles, called photons. These photons come down to Earth from the spacecraft via a network in the form of 1’s and 0’s. Scientific software then translates that data into an event table that contains the time, energy and position of each photon that struck the detector during the observation. The data is further processed with software to form the visual representation of the object. One full-color image is then assembled from separate black and white images taken through colored filters.

Computer-aided data collection and processing is an essential part of research using space- and ground-based telescopes. Scientists rely on computers, not only to do calculations, but also to change data into images. Astronomers use telescope images to gather evidence and to learn how the universe works. Coding and programming are a just one of many “tools” that astronomers need in order to study the information from our space telescopes.

With the following NASA’s Universe of Learning resources, your event participants will learn that:

- astronomical information and resulting images help inform scientists about phenomena and characteristics of objects in space.
- astronomical images are produced from data. The data is typically from light collected by telescopes.
- making astronomical images is a process, a translation of information from one form to another.

**Background content for the facilitator**

- Illuminated Universe ([illuminateduniverse.org](http://illuminateduniverse.org)) – blog posts about behind-the-scenes look at how astronomy images from NASA Space Telescopes are created
## MENU OF EVENT ACTIVITIES & RESOURCES: DATA AND IMAGE PROCESSING

### ENGAGEMENT

<table>
<thead>
<tr>
<th>Activity</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>AstroPix – database of astronomy images</td>
<td>C</td>
</tr>
<tr>
<td>ViewSpace Videos &amp; Interactives – explore science content</td>
<td>C</td>
</tr>
</tbody>
</table>

### BACKGROUND BUILDERS

<table>
<thead>
<tr>
<th>Activity</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coloring the Universe (info)</td>
<td>C</td>
</tr>
<tr>
<td>How to Talk to a Spacecraft: A Stream of 1's and 0's Reading (info)</td>
<td>P</td>
</tr>
<tr>
<td>NASA – Observatory Communications (info)</td>
<td>C</td>
</tr>
<tr>
<td>Nuts &amp; Bolts: Coding Videos</td>
<td>C</td>
</tr>
<tr>
<td>Observatory Communications Graphic (Visual)</td>
<td>C</td>
</tr>
<tr>
<td>Our Colorful Universe: Translating Cosmic Light (Video Talk)</td>
<td>C</td>
</tr>
</tbody>
</table>

### EXPLORATIONS

<table>
<thead>
<tr>
<th>Activity</th>
<th>Type</th>
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</thead>
<tbody>
<tr>
<td>Coloring the Universe with False-Color Images (info)</td>
<td>P</td>
</tr>
<tr>
<td>Decoding Starlight: Middle School: Pixels to images activity handout</td>
<td>P</td>
</tr>
<tr>
<td>How to Talk to a Spacecraft: Binary Code Activities, including Binary Bracelets, Name Tags, or Binary Pins (low-tech activities)</td>
<td>P</td>
</tr>
<tr>
<td>Recoloring the Universe: Activity using coding to create images and understand astronomical data</td>
<td>C</td>
</tr>
</tbody>
</table>

### EXTENSIONS

<table>
<thead>
<tr>
<th>Activity</th>
<th>Type</th>
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</thead>
<tbody>
<tr>
<td>Create Images with Raw Data</td>
<td>C</td>
</tr>
<tr>
<td>Decoding Starlight: High School: Pixels to images activity handout</td>
<td>P</td>
</tr>
<tr>
<td>MicroObservatory/Observing with NASA: Capture and process your own image</td>
<td>C</td>
</tr>
<tr>
<td>Tinkercad: Universe in 3D: Use 3D printing to explore the universe</td>
<td>C</td>
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</tbody>
</table>

### REAL-WORLD CONNECTIONS

<table>
<thead>
<tr>
<th>Activity</th>
<th>Type</th>
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</thead>
<tbody>
<tr>
<td>How do you Make a Picture of a Galaxy? (Video)</td>
<td>C</td>
</tr>
<tr>
<td>NASA Astrophoto Challenges: Learn from Experts (M82) (videos)</td>
<td>C</td>
</tr>
<tr>
<td>NASA Astrophoto Challenges: Learn from Experts (Whirlpool Galaxy) (videos)</td>
<td>C</td>
</tr>
<tr>
<td>How to be a Scientist: Careers in Astronomy</td>
<td>C</td>
</tr>
</tbody>
</table>

### THINGS TO TRY AT HOME

<table>
<thead>
<tr>
<th>Activity</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Universe of Making and Doing: Paper Circuits (activities)</td>
<td>P</td>
</tr>
<tr>
<td>Behind the Scenes with the Image Makers (info)</td>
<td>P</td>
</tr>
<tr>
<td>MicroObservatory/Observing with NASA: Capture and process your own image</td>
<td>C</td>
</tr>
<tr>
<td>ViewSpace Videos &amp; Interactives</td>
<td>C</td>
</tr>
<tr>
<td>Walking Among the Stars VR Experience</td>
<td>C</td>
</tr>
<tr>
<td>Multiwavelength Visualization of the Crab Nebula or the Whirlpool Galaxy (videos)</td>
<td>C</td>
</tr>
</tbody>
</table>

Pick and choose from this menu to build your own program. We put together some Sample Scenarios on the following pages to get you started.
SHORT DESCRIPTIONS OF SOME RESOURCES FROM NASA’S UNIVERSE OF LEARNING

**ViewSpace** – free, web-based collection of digital interactives and videos highlighting the latest developments in astronomy and Earth science.

**AstroPix** – offers access to the public image galleries of many of the leading astronomical observatories under a single unified interface.

**NASA’s Astrophoto Challenges** – allow participants to process images from NASA’s Space Telescopes or to capture and process your own image.

**MicroObservatory** – network of automated telescopes that can be controlled over the Internet.

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**VOCABULARY**

- **binary** a notation that utilizes only two options for each selection.
- **binary number** a number in a numerical system that uses base 2 and only expressed using 1's and 0's.
- **bit** short for binary digit. It is one digit’s location in a binary number.
- **code/coding** transformation from one representation to another.
- **data** information in digital form that can be transmitted or processed.
- **decode** convert a coded message into something familiar.
- **delimiter** one or more characters that separates text strings.
- **encode** convert a message into code.
- **filter** a device or material that absorbs certain colors of light while allowing others to pass through. Filters are used on telescopes to observe how celestial objects appear in certain colors of light or to reduce the light of exceptionally bright objects.
- **photon** an individual quantum or particle of light. A single packet of light, characterized by its wavelength, frequency, or energy.
- **pixel** very small dots that make up images on screens and computer displays, and are the smallest controllable element of on-screen images.
- **telescope** an instrument used to observe distant objects by collecting and focusing their electromagnetic radiation.
SCENARIO 2-1: BINARY CODE

MATERIALS

- Internet-connected computer with a large screen or display
- images from ViewSpace or AstroPix
- Observatory Communications graphic
- Nuts and Bolts video Coloring the Universe: Part 2
- How to Talk to a Spacecraft: A Stream of 1's and 0's handout
- How to Talk to a Spacecraft: Binary Pins handout
- scrap paper, pencils
- multicolored bead set
- 2” or 3” safety pins

OPTIONAL MATERIALS

- How to Talk to a Spacecraft: Binary Bracelets handout, thin string or cording for bracelets.

OVERVIEW

Space telescopes “talk” to computers on Earth using binary code, a language based on 1’s and 0’s. Astronomy images are composed of binary numbers, which represent the amount of light measured by the telescope’s detectors. In this scenario, participants learn about binary code and how to write their name using tactile materials.

ACTIVITY LENGTH

60 minutes. See the following “Tips and Adaptations” for a 90 minute version.

TARGET AUDIENCE

Activities ideal for families and learners ages 12+, but can be adapted for younger audiences.

These activities were created and tested with different youth audiences, including female audiences. Assessments (formative and summative) ensured that these activities are engaging, relevant, effective, and enjoyable for all audiences.
1 **ENGAGEMENT**

Play a [ViewSpace](#) video or display a variety of space images from [AstroPix](#).

5 MIN. Elicit discussion by asking participants if they know what some of the images are called or what type of objects they are. Show a variety of images from different telescopes and state that these objects are observed and studied using telescopes that collect the objects’ light. Ask: How does the light collected by telescopes become beautiful pictures like these? Today we’ll find out!

### ACCESSIBILITY TIP

Select videos with narration or captioning. If using images, orally give the names and descriptions of objects for learners who are blind/have low vision. For in-person events, have multiple copies of images available to distribute to learners for up-close viewing.

2 **INTRODUCE THE CONTENT**

Display the [Observatory Communications](#) graphic.

5 MIN. This graphic shows an example of how data are sent from space observatories to Earth for image processing and analysis. Data are not transmitted as the beautiful pictures just seen. Instead, they are transmitted as a series of 1’s and 0’s. As a follow-up, or for elaboration, show the Nuts and Bolts video [Coloring the Universe: Part 2](#). Alternative: Display or provide print copies of the [How to Talk to a Spacecraft: A Stream of 1’s and 0’s](#) text for review.
3 WARM-UP
State the outcome and model the activity.

15 MIN. State: Today we’re going to learn how satellites “talk” to computers here on Earth using binary code, a language based on 1’s and 0’s. Display or provide print copies of the How to Talk to a Spacecraft: A Stream of 1’s and 0’s text for reference. Show how you would write your name using binary code as an example. Challenge participant to write their own names in binary code or create binary nametags using paper and the alphabet key on the handout. Participants can do a brief “meet-and-greet” and introduce themselves to each other in binary, as appropriate or as time allows.

ACCESSIBILITY TIP
Make enlarged copies of handouts for learners with low vision. Read handouts aloud for learners, as appropriate. For in-person events, have tactile materials on-hand for creating tactile versions of binary code. For example, different shapes of pasta or different sizes of clay balls. Create a tactile version of your name on a large piece of construction paper or tag board for learners to explore via touch.

4 GROUP ACTIVITY
Participants create words/messages in binary code.

15 MIN. Using paper, participants can work in teams to identify an object(s) in the room, then write the object names in binary code. Teams can then switch papers and decode each other’s messages to identify the mystery objects.

ACCESSIBILITY TIP
Have a few examples of words/objects written in binary code and in a tactile format available in advance. Have learners explore the examples via touch to see if they can guess the word/object. Create a handout that has the names of three mystery objects written out in binary code. Include a word bank on the handout to help learners with decoding the names of the mystery objects. Simplify examples by only proving a letter in binary code. Learners decode and identify the letter and then list as many words that they can that begin with that letter.

5 INDIVIDUAL ACTIVITY
Participants make binary pins.

15 MIN. Provide participants with print copies of the handout for How to Talk to a Spacecraft: Binary Pins. Referring back to the earlier example that shows your name in binary code, draw a box under each digit or “bit” in your first initial. For the 0’s, shade in the box one color. For the 1’s, shade the box with another color.
For example, boxes for 0 could be dark blue and boxes for 1 could be light blue. Your model should now look something like this:

This provides a model for how to create binary pins using two different colored beads. Note: For binary pins, participants translate their initials into binary code and not their full names.

**ACCESSIBILITY TIP**

Make enlarged copies of handouts for learners with low vision. Read handouts aloud for learners, as appropriate. For in-person events, give learners the option of using larger, tactile materials for creating their initials – like different shapes of pasta or punch-out shapes from construction paper or felt. Learners can create their binary names or initials by gluing pasta or shapes onto large sheets of construction paper. Another option for diverse learners is to create paper loops in two different colors of construction paper. Learners connect the loops together into a chain to show their names or initials. For virtual events, learners can type out their names or initials in binary code using 1’s and 0’s, two different letters, or two different symbols.

**WRAP-UP**

Putting it all together.

**5 MIN.** Refer back to the images shown in the beginning. State: With space images, binary data does not translate into words or phrases. Instead, it translates into a series of “on’s” and “off’s” to indicate the presence and intensity (or absence) of light collected from an object in the universe. Black areas in an image would be 0 for zero, indicating no light or photons were collected. Light areas would be a combination of 1’s and 0’s to represent the light collected and its intensity. Provide participants with follow-up activity ideas to do on their own/at-home.

**TIPS AND ADAPTATIONS**

**Beginners/Young Learners:**
The warm-up for this scenario can be simplified by having participants write-out code for their initials instead of their first names. The nametag with initials can then be used as a ready-made model to assist with making the binary pins. Instead of having participants create binary messages based on random objects, have a ready-made list of object names written in binary code.
Have participants work in pairs or teams to decode and name the objects. Provide a word bank on the handout if necessary. Or, give each participant or team one object word to decode. Once it is decoded, have participants find the object in the room and stand near it. This will incorporate movement into the activity. To support reading and word-building skills, create a handout with the word “at” and give its binary equivalent. Then list several “at” words such as bat, cat, hat, mat, rat, sat in binary code. Learners only have to decode the first letter to make the word.

**Advanced Learners:**
Reinforce listening skills by playing a game of “Guess the Word.” You can call out the binary code for several different words. For each word, participants have to record the code and decode it to determine what the word is. Participants can learn more about binary code and its relationship to Red/Green/Blue (RGB) colors by exploring “Math is Fun” pages on the [Binary Number System](https://www.mathsisfun.com), [Binary Digits](https://www.mathsisfun.com), and [Hexidecimal Colors](https://www.mathsisfun.com). You can create a handout with words and/or phrases written in binary code – except when it is decoded, there are errors/misspellings. Participants have to locate and “fix” the broken code.

**Virtual Learning:**
If presenting this scenario virtually, participants can access and download the instructions for the activities online. Different materials can be substituted in for the beads in order to make the binary pins/bracelets. For example, participants listening in from home can try incorporating two different colors or two different shapes of pastas, or even two different kinds of popcorn strung along on a piece of string. If various craft materials are handy, participants can make two different colored balls from bits of dried clay, make construction paper beads or loops in alternate colors, or use two different styles of buttons, all of which can be strung across thread, twine, or cording. Using two different colors or types of yarn, pom poms, or other textile materials can work as well. Instead of making pins or bracelets, participants can opt to create their names or initials with different materials that can be glued to a sheet of paper. Depending on the presentation platform being used, participants can work together in teams using breakout rooms. You can also find online tips for virtual presentations, such as [Memory, Virtual Speaking, and Covid-19](https://www.mathsisfun.com) and [10 Tips for Giving Effective Virtual Presentations](https://www.mathsisfun.com).

**Low-tech Learning:**
This scenario involves hands-on activities, and is based primarily on paper and pencil resources that can be printed in advance. If a computer and display are not available for a large-group presentation, consider printing astronomical images ahead of time to use during the event for display and/or as handouts.

**90 MINUTE OPTIONS**

Depending on the needs and interests of participants, this event scenario can be extended by including the [How to Talk to a Spacecraft: Binary Bracelets](https://www.mathsisfun.com) activity in addition to, or in place of, the “Binary Pins” activity.

Alternative: Display the images from the engagement with their names written in binary code. Or, select different images that have short, text-based names. Challenge participants to identify the text name of each object by decoding the binary names using the key on the [How to Talk to a Spacecraft: A Stream of 1’s and 0’s](https://www.mathsisfun.com) handout. As a modification, give participants the text names of the objects written on a handout to help with decoding/matching.
SCENARIO 2-2:

PIXELS TO IMAGES

MATERIALS

- Internet-connected computer with a large screen or display
- Images from ViewSpace or AstroPix
- Observatory Communications graphic
- Andromeda Galaxy with a pixelated star image and/or What are pixels and how do they work? video
- Printouts of blank grids
- Pencils, crayons/colored pencils
- Recoloring the Universe: Decoding Starlight activity
- Multiwavelength image of Cassiopeia A

OPTIONAL MATERIALS

- Journey through an Exploded Star, Online Field Guide on Supernovae & Supernova Remnants

OVERVIEW

Binary code is a language based on 1’s and 0’s and astronomy images are transmitted as a series of these numbers. These numbers translate into a series of “on’s” and “off’s” to indicate the presence and intensity of light collected from an object in the universe. In this scenario, participants explore how data from telescopes is translated into pixels for making astronomical images.

ACTIVITY LENGTH

60 minutes. See the following “Tips and Adaptations” for a 90 minute version.

TARGET AUDIENCE

Activities ideal for families and learners ages 12+, but can be adapted for younger audiences.

The “Recoloring the Universe: Decoding Starlight” activities in this scenario were created and tested with different youth audiences, including female audiences. Assessments (formative and summative) ensured that these activities are engaging, relevant, effective, and enjoyable for all audiences.
Elicit discussion by asking participants if they know what some of the images are called or what type of objects they are. Show a variety of images from different telescopes and state that these objects are observed and studied using telescopes that collect the objects’ light. ASK: How does the light collected by telescopes become beautiful pictures like these? Today we’ll find out!

Alternative if the audience has participated in Scenario 1. Previously, we learned how data is collected by telescopes and transmitted with binary code so that it can be analyzed and used to create images. Who remembers something about binary code that they would like to share with the group? Today, we’ll learn more by exploring the connection between data and pixels, and pixels and images.

**ACCESSIBILITY TIP**

Select videos with narration or captioning. If using images, orally give the names and descriptions of objects for learners who are blind/have low vision. For in-person events, have multiple copies of images available to distribute to learners for up-close viewing.
This graphic shows an example of how data are sent from space observatories to Earth for image processing and analysis. Data are not transmitted as the beautiful pictures just seen. Instead, they are transmitted as a series of 1’s and 0’s. This code translates into a series of “on’s” and “off’s” to indicate the presence and intensity of light collected from an object in the universe. These “on’s” and “off’s” can be used to create images with pixels. The term pixel is short for Picture Element. These very small dots make up images on screens and computer displays, and are the smallest controllable element of on-screen images.

As a follow-up, or for elaboration, show this image of the Andromeda Galaxy with a pixelated star and/or show the video What are pixels and how do they work?

**ACCESSIBILITY TIP**

Make enlarged copies of handouts for learners with low vision.

Read handouts aloud for learners, as appropriate.
**WARM-UP**

State the outcome and model the activity.

10 MIN.  State: Today we’re going to learn how data is translated into pixels for making astronomical images. We’re going to see an example of how this works by playing Pixel Battleship. I’m going to be an object that is sending you photons of light, and you’re going to be the detectors. I’ll give you the coordinates for where I’m sending the photon, and you mark that spot on your grid with an X. Each square on the grid represents a pixel. Distribute blank 5 x 5 grids and pencils to participants. [See attached grid worksheets at the end of this scenario section.]

**Call out:** A2, A4, C1, C5, D2, D3, D4  
**State:** Now, shade in the squares that are marked with an X.  
**Ask:** What image did you capture?

**Answer:** Smiley face

Now, we’re going to try one more. Give participants another blank 5x5 grid.

**Call out:** C2, C3, C4, D2, D3, D4, E2, E3, E4  
**State:** Now, shade in the squares that are marked with an X.  
**Ask:** What image did you capture?

**Answer:** Square

**FACILITATOR TIP**  Write your coordinate numbers on the board or show a card with the coordinate on it. This helps all learners in your audience.
ASK: What if instead of a square, the object was really a house? How could we improve our results so that they better show a house? [Answer: You would need to be able to show more shape and detail. So, you would need more squares and smaller squares (pixels). You would also need variation in color to show features that make it look more like a house - like windows and a door.]

Give participants blank 10 x 10 grids. [See attached grid worksheets at the end of this scenario section.] STATE: This time, we're going to use smaller pixels and include intensity or shading to show more detail in our image. Take note of the shading key at the bottom of the grid. Areas with a 0 have little to no photons and will be very dark. Lighter areas will have more photons and will have a higher number (1, 2 or 3). So, this time, we'll use numbers in our grid instead of X's.

**Call out:**

For 0 — E5, E6, F4, F5, F6, F7, F8, G4, G5, G6, G7, G8, H4, H7, I4, I5, I6, I7, J4, J5, J6, J7

For 1 — H8, I8, J8

For 2 — H5, H6

All other squares are a 3 and can be left blank.

Give participants time to shade in their marked squares according to the Shading Values key:

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

![Shading Values Key](image1.png)

This may not look exactly like a house, but by using shading and smaller pixels, we can see more details. So, it now looks a little more like a house and not just a black square.
Give learners the option of using tactile materials to mark the appropriate boxes on their grids – such as different color chips, game pieces, or removable sticky dots. Use different types of shapes/materials for learners who are blind/have low vision – such as different types of craft supplies or textiles. For in-person events, create tactile versions of the answer keys using felt or other textiles. Have learners explore the tactile versions via touch. Another option for diverse learners is to give them grids along with the callouts and do a role reversal. Have learners take turns giving the callouts while you show the answer using a large display grid.

**GROUP OR INDIVIDUAL ACTIVITY**
Participants apply pixels to an astronomical object.

**30 MIN.** Distribute crayons/colored pencils and copies of the Recoloring the Universe: Decoding Starlight activity to participants. State: Now we’re going to use pixels to recreate an image of a real astronomical object. But this time, we have an added challenge. We are missing some data! (Example of the data table below.)

<table>
<thead>
<tr>
<th>Missing Grid Coordinate</th>
<th>Observation 1</th>
<th>Observation 2</th>
<th>Observation 3</th>
<th>Observation 4</th>
<th>Observation 5</th>
<th>Average Number of Photons</th>
</tr>
</thead>
<tbody>
<tr>
<td>C3</td>
<td>50</td>
<td>54</td>
<td>52</td>
<td>50</td>
<td>54</td>
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<td>E8</td>
<td>214</td>
<td>210</td>
<td>210</td>
<td>210</td>
<td>214</td>
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<tr>
<td>F6</td>
<td>148</td>
<td>135</td>
<td>missing</td>
<td>missing</td>
<td>130</td>
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<td>H10</td>
<td>73</td>
<td>83</td>
<td>missing</td>
<td>80</td>
<td>81</td>
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<tr>
<td>I5</td>
<td>58</td>
<td>69</td>
<td>54</td>
<td>missing</td>
<td>65</td>
<td></td>
</tr>
</tbody>
</table>

Take time to review the activity with participants, pointing out the need to calculate averages to add in the missing data. Depending on the needs and/or age of participants, review how to calculate an average or find the averages together as a group. Also, point out the need to use crayons or colored pencils to create their own Color Legend. Remind them how previously, fewer photons meant darker areas, and that this should guide their colors or shading in the Color Legend.

Allow time for participants to complete the activity and share their results with each other. Optional: Participants can complete the activity in pairs or teams.

**ACCESSIBILITY TIP**
This part of the scenarios can be adapted for diverse learners. In place of the Decoding Starlight activity, learners can label a printout of an existing astronomical object with sticky notes and numbers. They can label dark areas with a 0, brighter areas with a 1 or a 2, and very bright areas with a 3.
WRAP-UP
Putting it all together.

5 MIN. Refer back to the image of Cassiopeia A shown in the Decoding Starlight activity. Summarize how this is one representation of the image, colorized to show the different levels of energy in the supernova remnant. Low-energy X-rays are red, medium-energy X-rays are green, and high-energy X-rays are blue.

However, this is not the only way to study the data or this object. Show the multiwavelength image of Cassiopeia A from AstroPix (featuring Chandra, Hubble, and Spitzer data). Point out how this image’s colors represent different wavelengths of light, including X-rays. This example shows how studying objects with different telescopes and types of light go hand-in-hand with image processing to increase our understanding of objects and phenomenon in the universe. The colors in this version of the image highlight structure and temperature:

- Infrared data from the Spitzer Space Telescope is shown in red. It reveals warm dust in the outer shell about three degrees Kelvin (80 degrees Fahrenheit) in temperature.
- Visible light data from the Hubble Space Telescope is shown in yellow. It highlights filamentary structures of hot gases about 10,000 degrees Kelvin (18,000 degrees Fahrenheit).
- Chandra data, shown in blue and green, probes unimaginably hot gases, up to about 10 million degrees Kelvin (18 million degrees Fahrenheit). These extremely hot gases were created when ejected material from Cassiopeia A smashed into surrounding gas and dust. Chandra can also see Cassiopeia A’s neutron star (turquoise dot at center of shell).

Provide participants with follow-up activity ideas from the menu of resources that they can do on their own/at-home.
Beginners/Young Learners:
This scenario can be simplified by reducing the level of effort required for the Decoding Starlight activity. Before making copies of the handout, it can be simplified by having the averages and missing numbers in the grid already filled in for participants. This allows participants to focus on shading and creating the image of the supernova remnant without having to calculate averages. Instead of doing the Decoding Starlight activity, you can produce additional blank grids and continue the “Pixel Battleship” game by having participants recreate images of basic objects and shapes such as a heart, circle, triangle, etc. With additional grids, participants can also be challenged to create their own pictures and play “Pixel Battleship” with each other.

Advanced Learners:
Participants can complete the high-school version of the Decoding Starlight activity. If the event is virtual, or participants have access to internet-connected computers, they can complete Recoloring the Universe: Lessons 1–3 afterwards to see the relationship between computer code and RGB colors.

Virtual Learning:
If presenting this scenario virtually, participants can access and download the instructions for the Decoding Starlight activity online. An online demonstration of Recoloring the Universe: Lessons 1–3 can be used as a substitute for the “Pixel Battleship” activity. Participants can explore the Recoloring the Universe activity more independently in Scenario 3. Depending on the presentation platform being used, participants can work together in teams using breakout rooms, but plan for extra time to resolve unexpected (technical) issues. You can also find online tips for virtual presentations, such as Memory, Virtual Speaking, and Covid-19 and 10 Tips for Giving Effective Virtual Presentations.

Low-tech Learning:
This scenario is based primarily on paper and pencil resources that can be printed in advance. If a computer and display are not available for a large-group presentation, consider printing astronomical images ahead of time to use during the event for display and/or as handouts.

90 MINUTE OPTIONS
This activity can be extended with the following options:

- Participants can learn more about Cassiopeia A by exploring the online interactive Journey through an Exploded Star.
- Participants can learn about supernovas and supernova remnants by exploring this Online Field Guide.
- Participants can explore other images of Cassiopeia A in AstroPix.
- Participants can further analyze the multiwavelength image of Cassiopeia A by labeling its structures on a printout of the image: warm dust, hot gases, extremely hot gases, neutron star.
5x5 PIXEL GRID WORKSHEET

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SCENARIO 2-3: CREATING ASTRONOMICAL IMAGES

MATERIALS

- Internet-connected computer with a large screen or display
- Images from ViewSpace or AstroPix
- Coloring the Universe with False-Color Images background text
- Recoloring the Universe activity

OVERVIEW

In this event scenario the audience will learn how black and white images are colorized using computers.

ACTIVITY LENGTH

60 minutes. See the following “Tips and Adaptations” for a 90 minute version.

TARGET AUDIENCE

Activities ideal for families and learners 12+, but can be adapted for younger audiences.

The “Recoloring the Universe: Decoding Starlight” activities in this scenario were created and tested with different youth audiences, including female audiences. Assessments (formative and summative) ensured that these activities are engaging, relevant, effective, and enjoyable for all audiences.
1 ENGAGEMENT
Play a ViewSpace video or display a variety of space images from AstroPix.

5 MIN. Elicit discussion by asking participants if they know what some of the images are called or what type of objects they are. Show a variety of images from different telescopes and state that these objects are observed and studied using telescopes that collect the objects’ light. Ask: How does the light collected by telescopes become beautiful pictures like these? Today we’ll find out!

Alternative if the audience has participated in Scenario 2: Previously, we learned how telescope data relates to pixels and astronomical imaging. Today, we’ll learn more by colorizing our very own space images.

ACCESSIBILITY TIP
Select videos with narration or captioning. If using images, orally give the names and descriptions of objects for learners who are blind/have low vision. For in-person events, have multiple copies of images available to distribute to learners for up-close viewing.

2 INTRODUCE THE CONTENT
Give participants background.

5 MIN. Provide participants with printouts of the background from Coloring the Universe with False-Color Images. Allow time for participants to read and discuss this material. It provides an explanation for how raw (black & white) astronomical images are colorized to reflect invisible wavelengths of light, or reveal information that scientists want to specifically see and study. It also provides background on filters.

As a follow-up, or for elaboration, show the Recoloring the Universe Intro Video for Lesson 1.

ACCESSIBILITY TIP
Make enlarged copies of handouts for learners with low vision. Read handouts aloud for learners, as appropriate.

Lesson 1: Recoloring the Universe Intro
STATE: Today we’re going to learn how black and white astronomical images are colorized using computers. We’ll also see how colorized images help scientists learn about an object in space. With a computer and display, show the Recoloring the Universe coding activities and launch Lesson 2. You can choose to show the video or you can hide it by clicking “Guide.” Click the arrow to run the program and a red square should appear on the right.

STATE: Computers can be used to create code for colorizing images. For example, here we see a red square. Does anyone know why this square is red? [Answer: Because it has a value of 255. But green and blue are set to 0. So right now, we see red.] Ask: What would I have to do to make the square green? How about blue? Demonstrate these color changes. Then, challenge participants to think of ways to create other colors or shades of colors for the square. What if I wanted to make the square black? Or, how about white? If necessary, model examples, like yellow [red + green] or magenta [red + blue] using the think-aloud strategy.

Participants can write codes for other colors and shades on scrap paper while you demonstrate for the group. If appropriate, participants can test out their code on their own computers. Or, rather than trying to create specific colors, participants can experiment with codes on their computers to see how many different colors they can make. They can create a list of the colors along with the codes to see if they notice any patterns.
GROUP ACTIVITY
Participants colorize images.

30 MIN. Use the “Guide” button to skip ahead to Lesson 4. You can choose to show the video or use the “Guide” button to hide it. This section of the activity illustrates the challenge of viewing image data in only one color. The example given is red. For interaction and discussion, participants can think of and share questions they have about the image. They can then be challenged to adjust the colors in the image in a way that might help answer their questions.

In Lesson 5, participants create a “mash up” by colorizing two flower images that are merged together. Challenges here include:

- What if you only wanted to see the red flower and not the purple one?
- What if you only want to see the purple flower?
- What if you wanted to change the color of the flowers, or reverse the flower color and the leaf color?
- How could you see both images together, but make one stand out more than the other?
- What other color combinations can you create?

Continuing throughout the activity, participants colorize real astronomical images, and use representative color for different wavelengths of light:

- Lesson 6: Supernova Remnant Kes 73
- Lesson 7: Star-forming Region
- Lesson 8: Kepler’s Supernova Remnant

ACCESSIBILITY TIP
If there is access to a 3D printer, this activity can replaced with 3D Printing the X-Ray Universe.

WRAP-UP
Putting it all together.

5 MIN. Share the Recoloring the Universe Review Video for Lesson 8. Provide participants with follow-up activity ideas to do on their own/at-home.
TIPS AND ADAPTATIONS

Beginners/Young Learners:
This scenario can be simplified by focusing more on Lessons 1–3 of the Recoloring the Universe activity. Participants can explore colorizing the flower images in Lessons 4–5. Lessons 6–8 can be done as a demonstration. Or, following Lesson 4, participants can change the word “tulip” in the recolor link to something else in order to import and recolor different images. Suggestions include "/img/400x600-cat," "/img/400x600-rainbow," and "/img/400x600-beach."

Advanced Learners:
Participants can complete additional image-processing activities using a web-based astronomical image analysis software, called JS-9, such as Coloring the Universe with False-Color Images, Create Images with Raw Data, or Observing with NASA. Participants can also go further by completing Tinkercad: Universe in 3D activities such as Coding the Stars.

Virtual Learning:
This scenario lends itself well to virtual learning because it is based primarily on computer-based resources that can be accessed by learners who have internet-connected computers at home. Recoloring the Universe is packaged into separate lessons with accompanying videos, so this can be used as a self-guided activity for at-home learners. Depending on the presentation platform being used, participants can work to share strategies and coding tips in breakout rooms. You can also find online tips for virtual presentations, such as Memory, Virtual Speaking, and Covid-19 and 10 Tips for Giving Effective Virtual Presentations.

Low-tech Learning:
This scenario is based primarily on computer-based resources. The Decoding Starlight activities can be used in place of Recoloring the Universe if they were not already used with participants as part of Scenario 2. If there is access to one internet-connected computer with a large screen or display, the activities can be replaced with pre-recorded expert talks that put the previous scenarios into context. Examples include How do you Make a Picture of a Galaxy?, How to be a Scientist: Careers in Astronomy, TEDx Talk: How to Hold a Dead Star in Your Hand, Our Colorful Universe: Translating Cosmic Light.

Depending on the needs and interests of participants, this event scenario can be extended by spending more time on each section of the Recoloring the Universe activity. Participants can follow-up on images from the activity, like Kes 73 and Kepler’s Supernova Remnant, to learn more about them.

After spending some time working with Recoloring the Universe, participants can access and colorize raw astronomical data with activities such as Coloring the Universe with False-Color Images, Create Images with Raw Data, or Observing with NASA.
# PLANNING SHEET:
## BUILD YOUR OWN EVENT SCENARIO

### I. ENGAGEMENT

**RESOURCES:**

**ESTIMATED TIME:** ________________

**NOTES:**

### II. WARM-UP

**RESOURCES:**

**ESTIMATED TIME:** ________________

**NOTES:**
### III. ACTIVITY

**RESOURCES:**

**ESTIMATED TIME:** ________________

**NOTES:**

### IV. WRAP-UP

**RESOURCES:**

**ESTIMATED TIME:** ________________

**NOTES:**
NASA’s Universe of Learning materials are based upon work supported by NASA under award number NNX16AC65A to the Space Telescope Science Institute, working in partnership with Caltech/IPAC, Center for Astrophysics | Harvard & Smithsonian, Jet Propulsion Laboratory, and Sonoma State University. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Aeronautics and Space Administration.

Version 2.0; May 2021

63