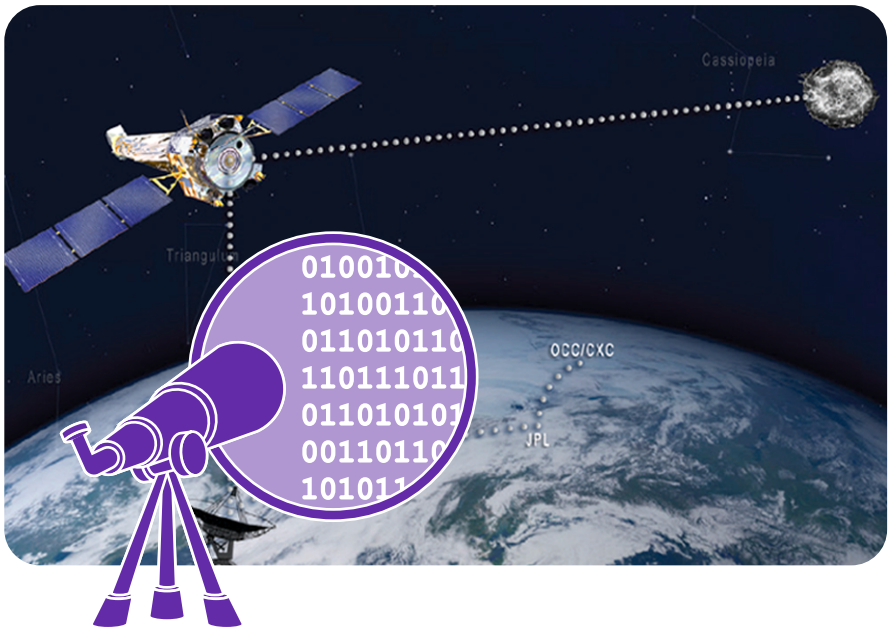
Program Guide:

Data and Image Processing



NASA'S UNIVERSE OF LEARNING

Program guides for additional themes can be found online:
https://www.universe-of-learning.org/program-guides

Program Guide: Data and Image Processing

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QUICK START GUIDE

This Program Guide empowers facilitators to plan STEM-related events using NASA's Universe of Learning resources.

This guide focused on **Data and Image Processing** includes three sample event scenarios, each of which has the following components:

- an **ENGAGEMENT** piece to start
- **INTRODUCTION** to the content
- **WARM-UP** element for participants
- 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 FACILITATOR GUIDE

Step 1 Review the Data and Image Processing Topic Overview and Background Content for the Facilitator.

Step 2 Choose a sample event scenario: Binary Code, Pixels to Images, or Creating Astronomical Images.

> If you are comfortable with NASA's Universe of Learning resources, use our Event Planning Sheet & Checklist to plan your event. You can select items from the Event Activities & Resources section.

Step 3 Look at the Tips & Adaptations section at the end of the chosen scenario for ways to tailor your event for your audience or venue.

Optional Request a Subject Matter Expert (e.g., a scientist, engineer, or other STEM professional) who can provide another engaging component to your event. Email us at info@universe-of-learning.org and let us know about your event or if you need assistance with event planning.

Step 4 Share your event details with your community. Use our media and event resources, such as media templates, photo releases, and virtual meeting backgrounds, to support your event.

DATA AND IMAGE PROCESSING

Topic Overview

NASA scientists explore how the universe works by gathering and analyzing data collected by 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, it does not arrive as an assembled snapshot. Instead, the spacecraft streams data encoded in the form of 1s and 0s, 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 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. The data collected comes down to Earth from the spacecraft via a network in the form of 1s and 0s. 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 transform data into images. Astronomers use telescope images to gather evidence and to learn how the universe works. Coding and programming are important for studying information gathered by 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

Articles about binary code and data processing for kids

- NASA Science Space Place: What's the secret code for talking to spacecraft?
- Imagine the Universe: How Scientists Get Data

Articles about how colors are used to convey information

- Illuminated Universe – Translating Cosmic Light Blog
- How Are Webb's Full-Color Images Made? – NASA

EVENT ACTIVITIES & RESOURCES
DATA AND IMAGE PROCESSING

Pick and choose from these activities to build your own program. Explore other paper & pencil activities, computer-based activities, and more in our online Resource Catalog. We put together some sample scenarios on the following pages to get you started.

c = computer-based activity
p = paper & pencil activity
c/p = both

ENGAGEMENT

- How STScI Sends Commands to Webb and Receives Its Data (infographic) c/p
- Did You Know: How Images Are Made (ViewSpace Video) c
- Data Sonification: Sounds from Around the Milky Way (sonification) c

BACKGROUND BUILDERS

- Coloring the Universe (article) c/p
- How to Talk to a Spacecraft (article) c/p
- NASA Observatory Communications (article) c/p
- Nuts & Bolts: Coding (videos) c
- Our Colorful Universe: Translating Cosmic Light (video talk) c
- Data and Image Processing (slide deck) c

EXPLORATIONS

- Coloring the Universe with False Color Images (tutorial) c
- Decoding Starlight: From Pixels to Images (middle school activity) p
- Binary Bracelets, Name Tags, Binary Pins (activities) p
- Recoloring the Universe (coding activities) c
- Data and Image Processing (Kahoot Quiz) c

EXTENSIONS

- Create Images with Raw Data (tutorial) c
- Decoding Starlight: From Pixels to Images (high school activity) p
- MicroObservatory /Observing with NASA (capture and process your own image) c
- Universe in 3D: Modeling and Printing Cosmic Objects (3D printing) c

REAL-WORLD CONNECTIONS

- How Do You Make a Picture of a Galaxy? (video) c
- NASA Astrophoto Challenges: Learn from Experts (M81) (videos) c
- NASA Astrophoto Challenges: Learn from Experts (Whirlpool Galaxy) (videos) c

THINGS TO TRY AT HOME

- Behind the Scenes with the Image Makers (interviews) c/p
- MicroObservatory /Observing with NASA (capture and process your own image) c
- Walking Among the Stars (virtual reality) c
- Multiwavelength Visualization of the Crab Nebula or the Whirlpool Galaxy (videos) c

RESOURCES FROM NASA'S UNIVERSE OF LEARNING

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

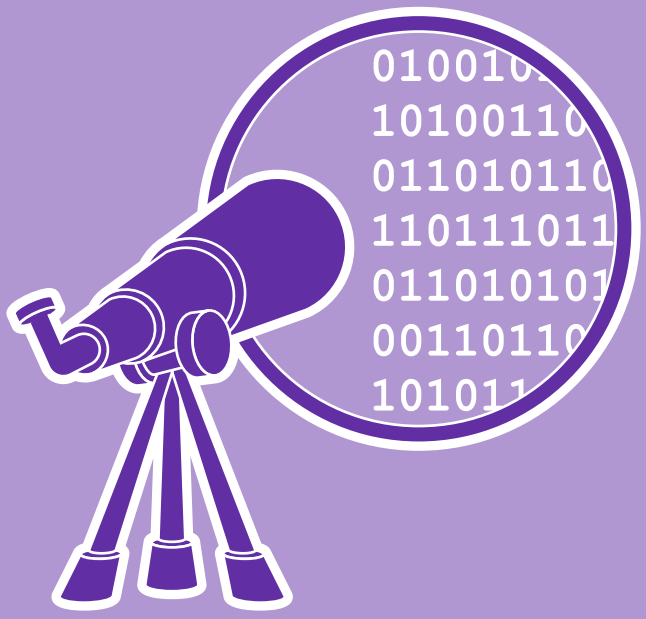
AstroPix – offers access to the public image galleries of many space and ground-based astronomical observatories in one place

NASA's Astrophoto Challenge – allows participants to process images from NASA's Space Telescopes or to capture and process their own images

MicroObservatory – network of automated telescopes that can be controlled over the internet

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 is expressed only using 1s and 0s.
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 collected in order to study an object or phenomenon.
Decode	Convert a coded message into something familiar.
Delimeter	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.
Light	Energy that travels as waves at a fixed speed (299,792 km/s or 186,281 miles/s) in empty space. When we talk about light, we usually mean electromagnetic radiation that we can see, but there are other types of radiation like ultraviolet light and infrared light.
Photon	A packet of electromagnetic energy, such as light. A photon is regarded as a charge-less, mass-less particle having an indefinitely long lifetime.
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. Telescopes are usually designed to collect light in a specific wavelength range.



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-inch or 3-inch safety pins

OPTIONAL MATERIALS

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

SCENARIO 2-1:

BINARY CODE

OVERVIEW

Space telescopes "talk" to computers on Earth using binary code, a language based on 1s and 0s. 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 Tips & Adaptations section for a 90-minute version.

TARGET AUDIENCE

Activities ideal for families and learners ages 12+, but can be adapted for younger 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 types 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 light from the object. Ask participants how they think the light collected from the telescopes is turned into pictures like these.

ACCESSIBILITY TIP

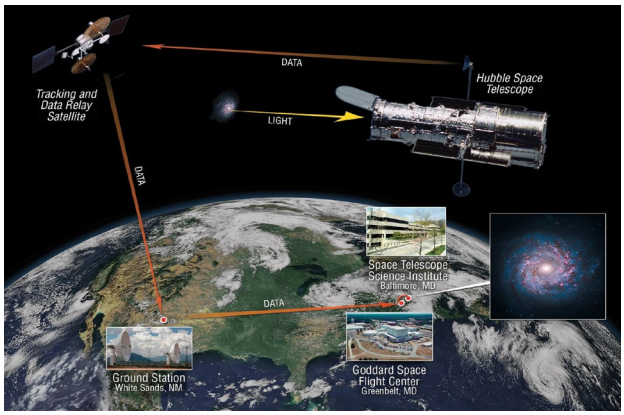
Select videos with narration or captions. For images, verbally describe objects for learners who are blind or have low vision. For in-person events, provide multiple copies of images for close viewing.

2 INTRODUCE THE CONTENT

Display the Observatory Communications graphic or use the Data and Image Processing facilitator slide deck.

5 MIN. SHOW: Project on a screen or hand out the Observatory Communications. The print out is in the next page.

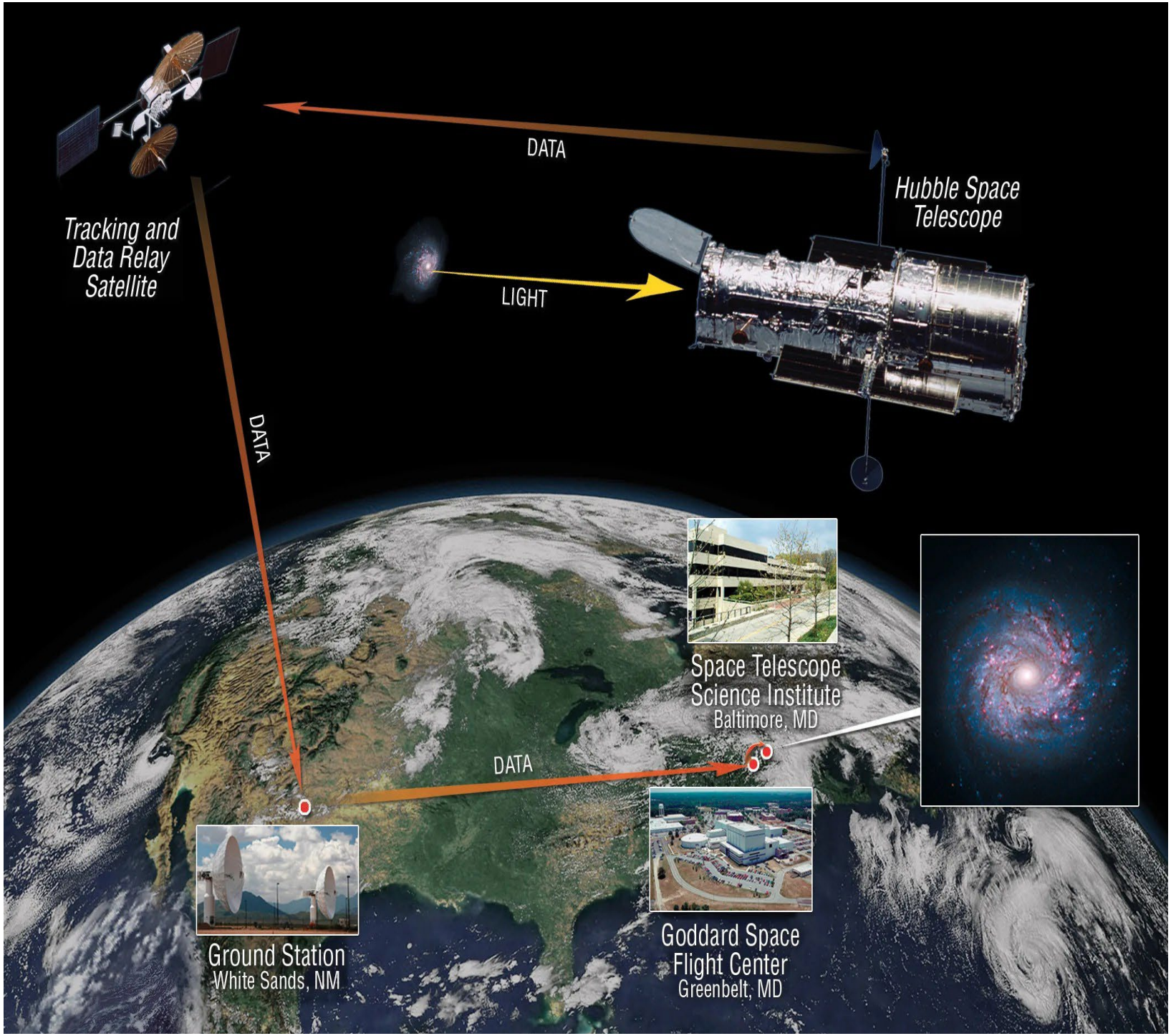
STATE: The image you are seeing shows an example of how data is sent from space observatories to Earth for image processing and analysis. The information is transmitted as a series of 1s and 0s not as the beautiful pictures just seen.



VOCABULARY TIP

Introduce new vocabulary at events by bolding terms on slides. You can also display and define new words around the event space.

FOLLOW UP: You can show the Nuts and Bolts video Coloring the Universe: Part 2, or as an 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.


DATA
Hubble Space Telescope
Tracking and Data Relay Satellite
LIGHT
DATA
Space Telescope Science Institute
Baltimore, MD
DATA
Ground Station
White Sands, NM
Goddard Space Flight Center
Greenbelt, MD

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 1s and 0s. 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 (e.g., different shapes of pasta or different sizes of clay balls) on-hand for creating tactile versions of binary code. 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 objects in the room, then write the object names in binary code. Teams can then switch papers and decode each other's words to identify the mystery objects.

ACCESSIBILITY TIP

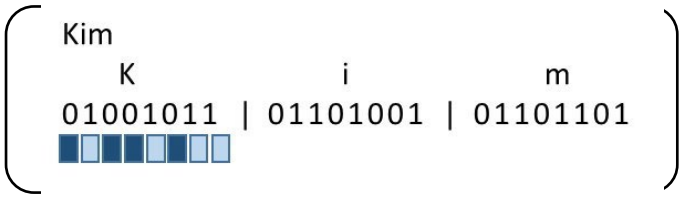
Have a few examples of words written in binary code and in a tactile format available in advance. Have learners explore the examples via touch to see if they can guess the words. Create a handout that has the names of three mystery objects written out in binary code. Include a word bank on the handout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

5 INDIVIDUAL ACTIVITY

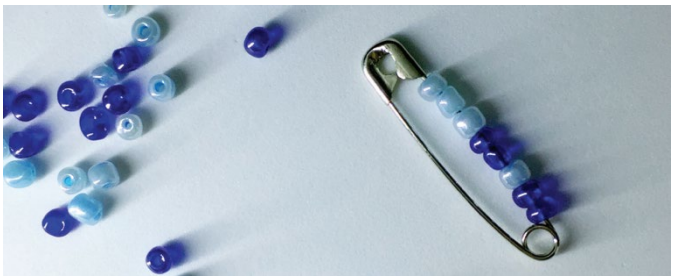
Participants make binary pins.

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 0s, shade in the box one color. For the 1s, 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, not their full names, into binary code.



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 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 1s and 0s, two different letters, or two different symbols.

6 WRAP-UP

Put 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 brightness 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 1s and 0s to represent the light collected and its brightness. Provide participants with follow-up activity ideas to do on their own.

TIPS & ADAPTATIONS

Beginners/Young Learners

- Introduce binary code as the language (like Spanish or English) we use to talk to machines. However, unlike Spanish or English that have multiple characters in the alphabet to make words, machines can only understand two digits: 0 and 1. The "bi" in binary means "two," like a "bicycle," which has two wheels.
- You can think of the 0s and 1s as ON/OFF light switches that computers use to understand and process information, and by making different combinations of 0s and 1s, the computer can represent numbers, letters, and other data, like pictures.
- The Warm-up can be simplified by having participants write their initials instead of their first names. These initial nametags will serve as models for creating binary pins. Use a pre-prepared list of object names in binary code rather than having participants generate random binary messages.
- Participants can work in pairs or teams to decode and name the objects. Provide a word bank on the handout or, give them one object word to decode. Once decoded, participants can find the object in the room, which incorporates movement into the activity. 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 about Binary Number System, Binary Digits, and Hexidecimal Colors. 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

Participants can access and download the instructions for the activities online. Different materials can be substituted for the beads to make the binary pins/bracelets. For example, participants joining from home can try incorporating two different colors or two different shapes of pastas strung along on a piece of string, or use other craft materials like colored clay, or different styles of buttons. 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, participant can work together in teams using breakout rooms. Find online tips for virtual presentations at Memory, Virtual Speaking, and Covid-19 and 10 Tips for Giving Effective Virtual Presentations.

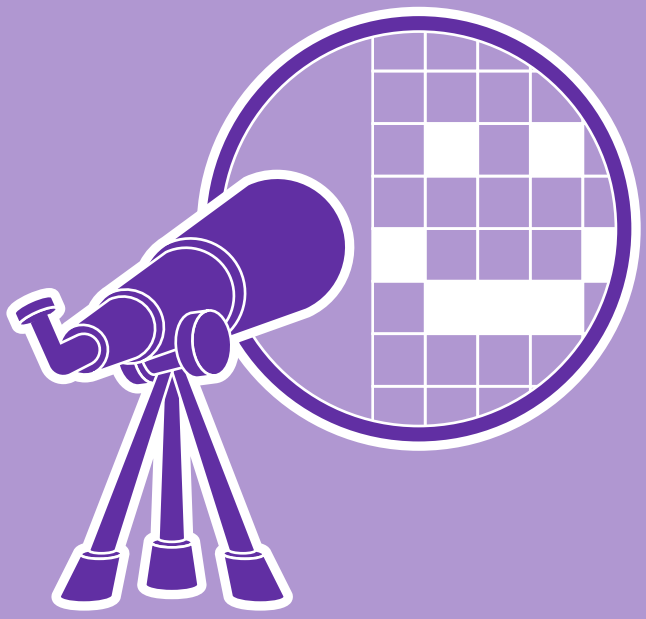
Low-tech Learning

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 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 activity in addition to, or in place of, the Binary Pins activity.

Alternative: Display the images from the engagement with the object names written in binary code. You may also select different images that have short, text-based names. Challenge participants to decode the name of each object using the key on the How to Talk to a Spacecraft: A Stream of 1's and 0's handout. You may want to provide the text names on a handout to help with decoding/matching.



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

SCENARIO 2-2:

PIXELS TO IMAGES

OVERVIEW

Binary code is a language based on 1s and 0s 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 brightness 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 Tips & Adaptations section for a 90-minute version.

TARGET AUDIENCE

Activities ideal for families and learners ages 12+, but can be adapted for younger 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 types 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 light from the objects. 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 in 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.

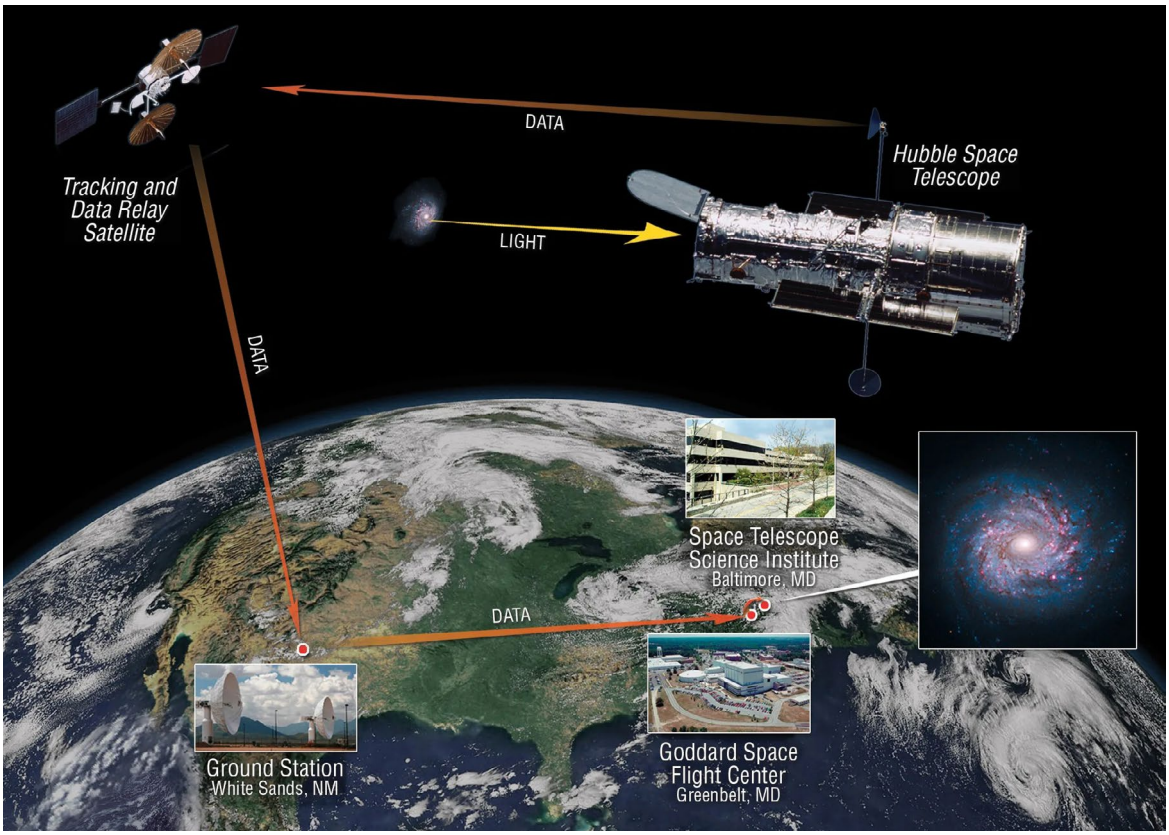
ACCESSIBILITY TIP

Select videos with narration or captioning. Describe objects verbally for blind/low-vision learners. For in-person events, provide multiple copies of images for up-close viewing. Leverage the Accessible Learning Resources like sonification resources that NASA's Universe of Learning offers.

2 INTRODUCE THE CONTENT

Display the Observatory Communications graphic or use the Data and Image Processing facilitator slide deck.

10 MIN.



This graphic shows an example of how data is sent from space observatories to Earth for image processing and analysis. Data is not transmitted as the beautiful pictures just seen. Instead, they are transmitted as a series of 1s and 0s. 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 squares make up images on screens and computer displays, and are the smallest controllable element of on-screen images.

ACCESSIBILITY TIP

Make enlarged copies of handouts for learners with low vision.

Read handouts aloud for learners, as appropriate.

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?

VOCABULARY TIP

Introduce new vocabulary at events by bolding terms on slides. You can also display and define new words around the event space.

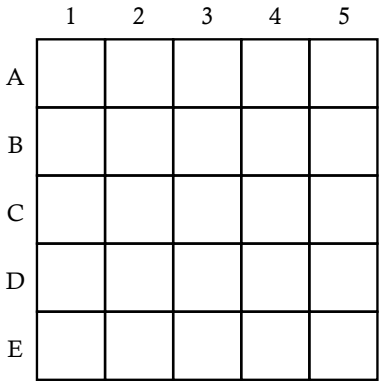
3 WARM-UP

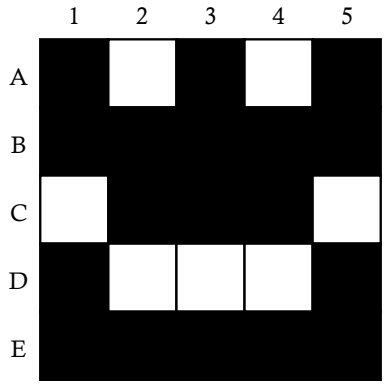
State the outcome and model the activity.

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 by 5 grids and pencils to participants. (See attached grid worksheets at the end of this scenario.)

Call out: A2, A4, C1, C5, D2, D3, D4
State: Now, shade in the squares that are **not** marked with an X.
Ask: What image did you capture?

Answer: Smiley face

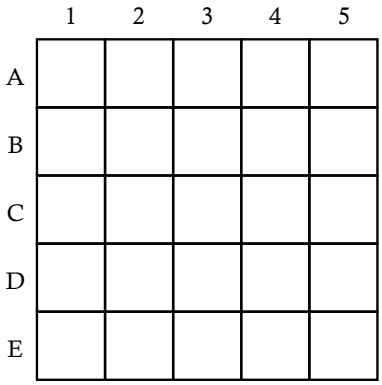


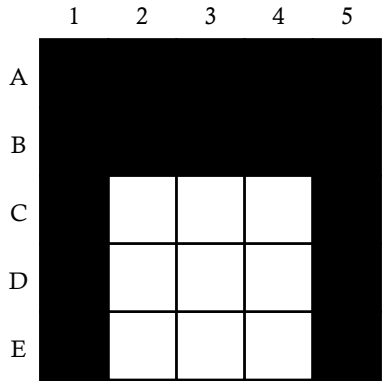


Now, we're going to try one more. Give participants another blank 5 by 5 grid.

Call out: C2, C3, C4, D2, D3, D4, E2, E3, E4
State: Now, shade in the squares that are not 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.

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 by 10 grids. (See attached grid worksheets at the end of this scenario.) STATE: This time, we're going to use smaller pixels and include 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 few 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.

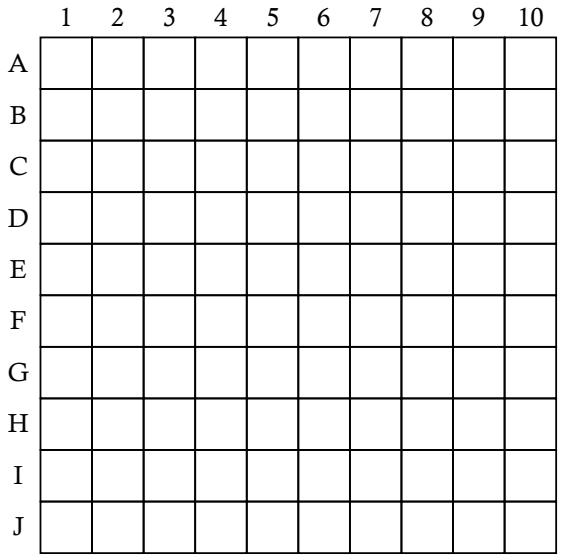
Call out:

Write the number 3 in these squares: E5, E6, F4, F5, F6, F7, F8, G4, G5, G6, G7, G8, H4, H7, I4, I5, I6, I7, J4, J5, J6, J7

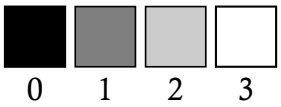
Write the number 2 in these squares: H8, I8, J8

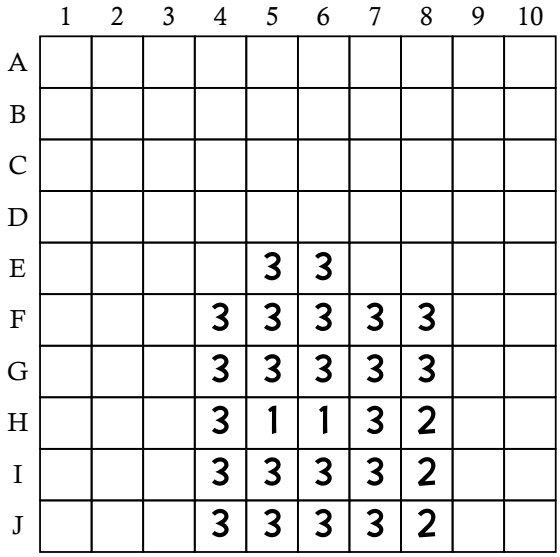
Write the number 1 in these squares: H5, H6

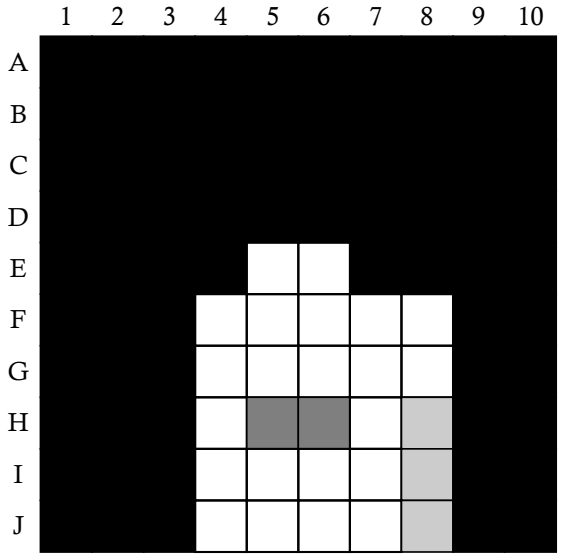
All other squares should be labeled 0.



Give participants time to shade in their marked squares according to these shading values key:







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 white square.

ACCESSIBILITY TIP

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 shapes or textures for those with visual impairments. For in-person events, create tactile answer keys with felt or textiles for learners to explore by touch. Additionally, allow learners to take turns giving callouts while displaying answers on a large grid.

4 GROUP OR INDIVIDUAL ACTIVITY

Participants color pixels to create a color image.

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.)

Missing Grid Coordinate	Observation 1	Observation 2	Observation 3	Observation 4	Observation 5	Average Number of Photons
C3	50	54	52	50	54	
E8	214	210	210	210	214	
F6	148	135	missing	missing	130	
H10	73	83	missing	80	81	
I5	58	69	54	missing	65	

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 key. Remind them how previously, fewer photons meant darker areas, and that this should guide their colors or shading in the color key.

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.

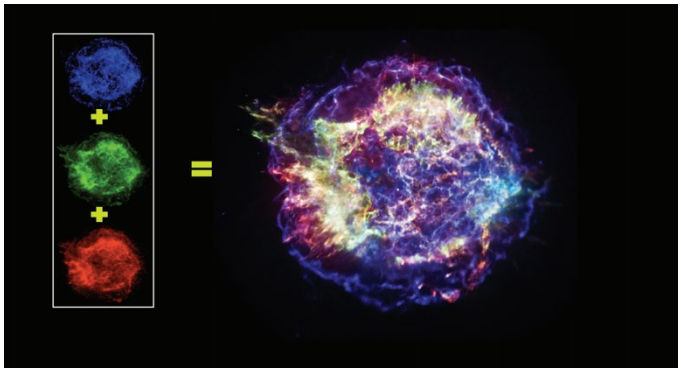
ACCESSIBILITY TIP

In place of the Decoding Starlight activity, learners can label a printout of an existing astronomical image 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.

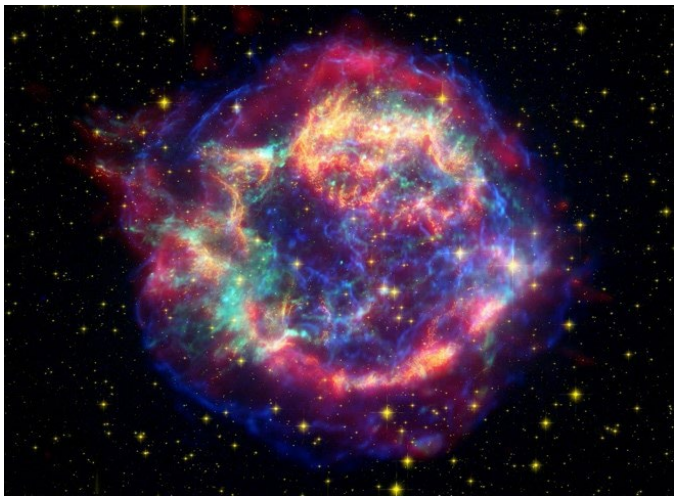
5 WRAP-UP

Put 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 Cha ndra, 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 different 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 300 kelvins (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 kelvins (18,000 degrees Fahrenheit).
- Chandra data, shown in blue and green, probes unimaginably hot gases, up to about 10 million kelvins (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 resources that they can do on their own.

TIPS & ADAPTATIONS

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, or triangle. 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 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 or as handouts.

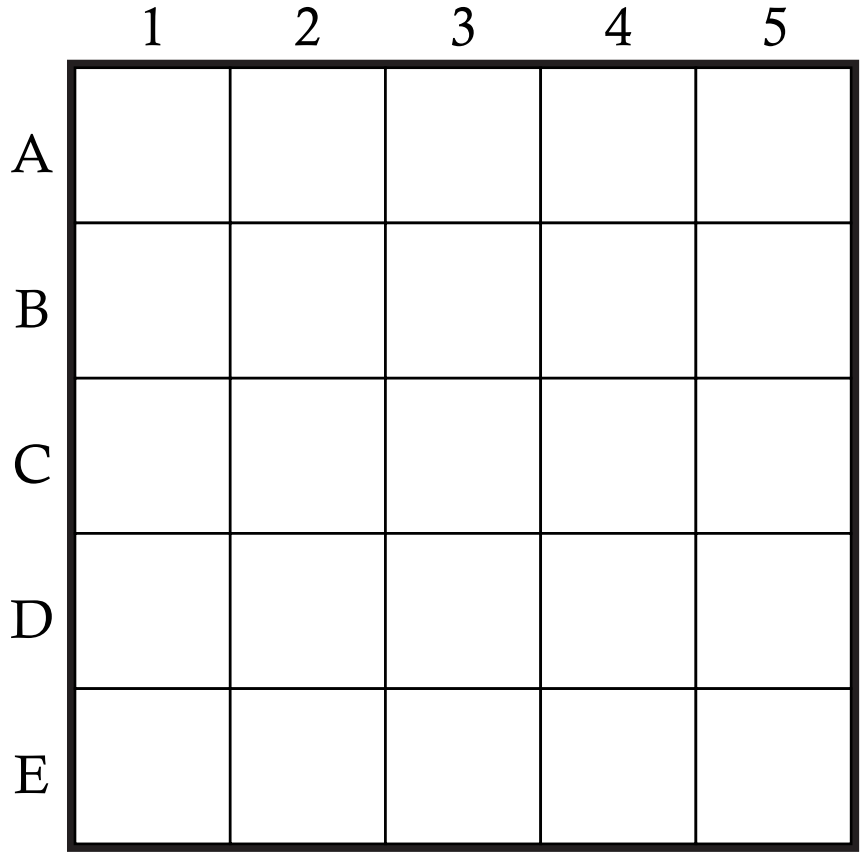
90-MINUTE OPTIONS

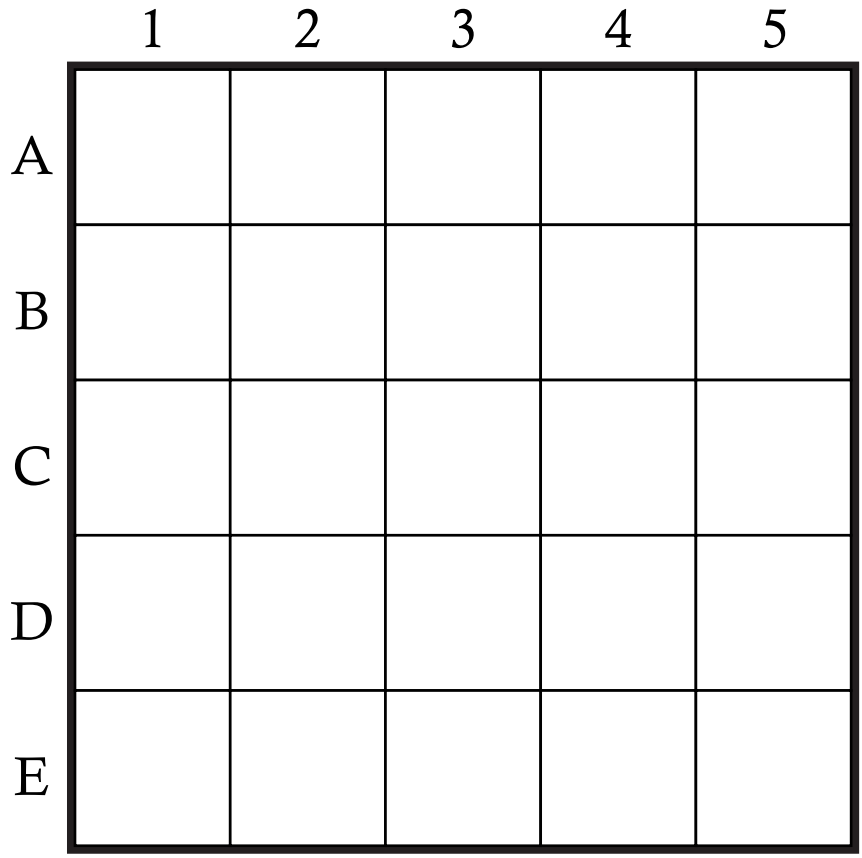
This activity can be extended with the following options:

- 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.

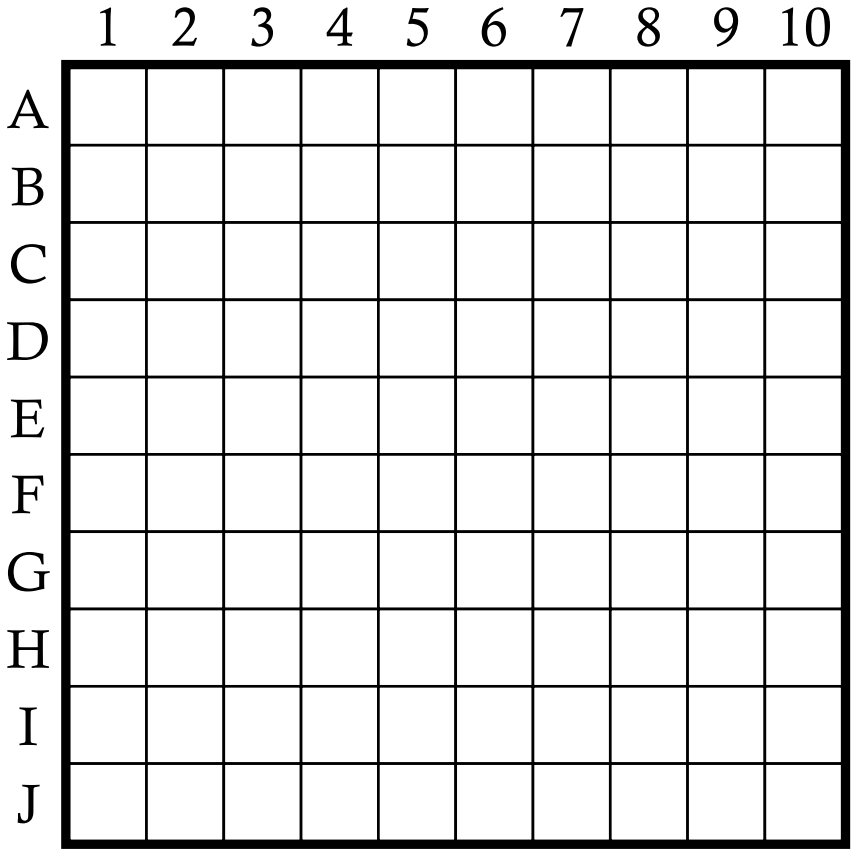
- Participants can further analyze the multiwavelength image of Cassiopeia A by labeling its structures on a printout of the image: warm dust, hot gases, extremely hot gases, neutron star.
- Participants can learn about sonification, a method of translating data from celestial objects into sound, by listening to a sonification of data obtained from Cassiopeia A.

5x5 PIXEL GRID WORKSHEET



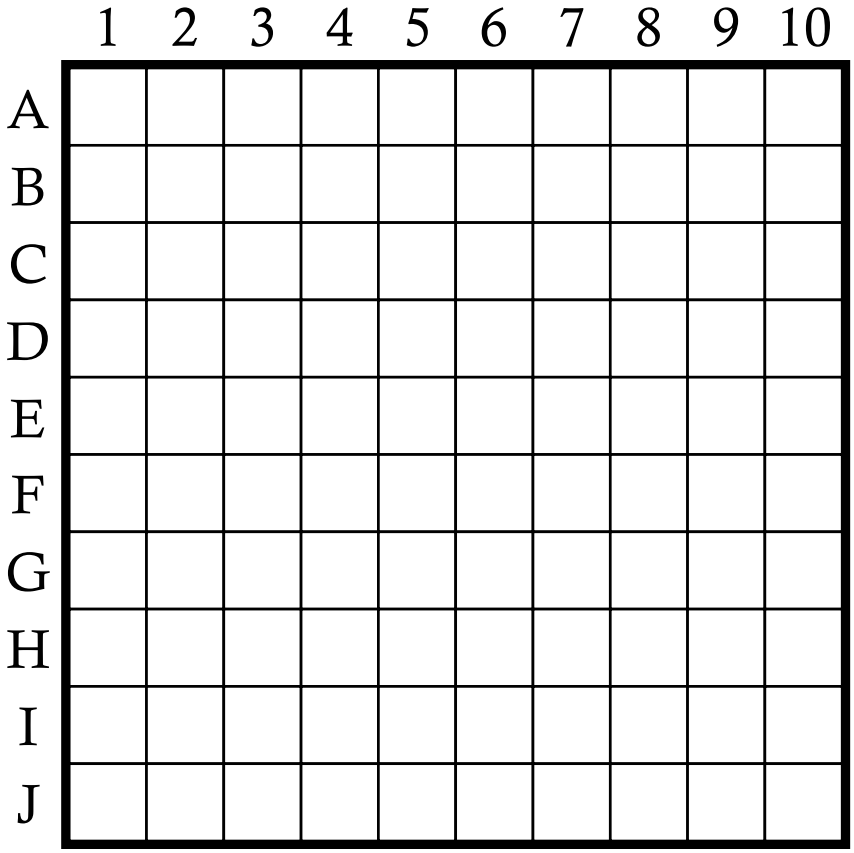


10x10 PIXEL GRID WORKSHEET



Shading Values:

0 1 2 3



Shading Values:

0 1 2 3



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 activities

OPTIONAL MATERIALS

- Coloring the Universe with False-Color Images, Create Images with Raw Data, or Observing with NASA

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 & Adaptations section for a 90-minute version.

TARGET AUDIENCE

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

1 ENGAGEMENT

Play a ViewSpace video or display a variety of space images from AstroPix.

5 MIN. Engage participants by asking if they recognize the objects in the images. Explain that astronomers study these objects by images like these. ASK: How do you think these images are made? Today, we'll answer that!

Alternative if attendees have participated in Scenario 2-2, STATE: 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 captions. For images, verbally describe objects for blind or low-vision learners. At in-person events, provide multiple copies of images for closer viewing.

2 INTRODUCE THE CONTENT

Use the Coloring the Universe with False-Color Images tutorial, or use the Data and Image Processing facilitator slide deck.

5 MIN. Provide participants with printouts of the Background section from the Coloring the Universe with False-Color Images tutorial. Allow time for participants to read and discuss this material. It provides an explanation for how colors are asigned to black and white astronomical images to represent different wavelengths of light, or reveal specific information that scientists want to see and study. It also provides background on filters.


Coloring the Universe with False-Color Images

In this lesson, we will learn how to create colorful pictures from black and white astronomical images.

Background

Every picture of space starts out as a black and white scientific image. Raw scientific images from a telescope contain a lot of information about the astronomical object that was observed. Scientists use a process to color the pictures called false color imaging to essentially color-code the information they want to look at, as well as make the more pleasing to the eye.

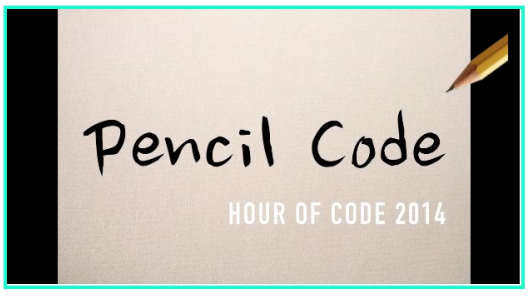
VOCABULARY TIP

Introduce new vocabulary at events by bolding terms on slides. You can also display and define new words around the event space.

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.

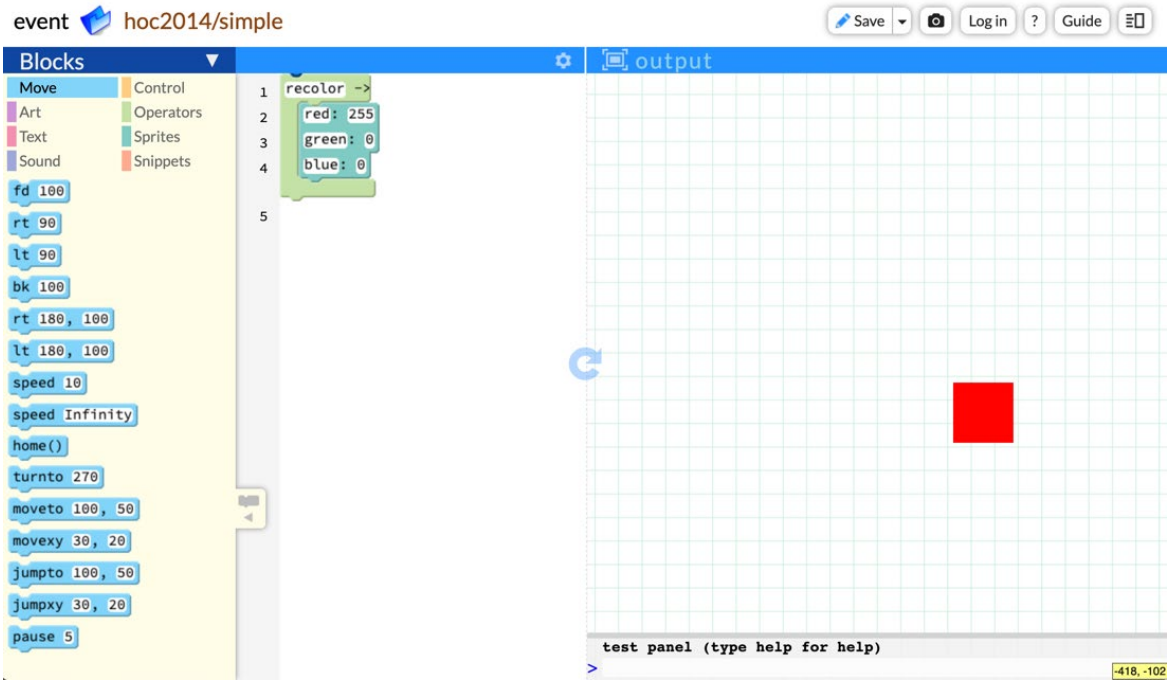


Lesson 1: Recoloring the Universe Intro

3 WARM-UP

State the outcome and model the activity.

15 MIN. 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.

4 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 a 3D printer is available, you can replace this activity with 3D Printing the X-Ray Universe.

5 WRAP-UP

Put 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.

TIPS & ADAPTATIONS

Beginners/Young Learners
This scenario can be simplified by focusing more on Lessons 1 to 3 of the Recoloring the Universe activity. Participants can explore colorizing the flower images in Lessons 4 to 5. Lessons 6 to 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
Using the web-based astronomical image analysis software called JS-9, participants can complete additional image-processing activities 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 participants who have internet-connected computers at home. Because Recoloring the Universe is packaged into separate lessons with accompanying videos, it can be used as a self-guided activity for at-home learners. Depending on the presentation platform being used, participants can 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.

90-MINUTE OPTIONS

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 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.

NASA'S UNIVERSE OF LEARNING

Event Planning Sheet & Checklist

This is a good starting point for organizations that have never organized STEM events before

Organization Name:

EVENT OVERVIEW

Event Name:

Event Date & Time:

Event Location (venue) and capacity *(e.g. Library lobby / 50 people max):*

Target Audience *(e.g. After-school program youth):*

Event objectives *(e.g. Participants will learn about how stars evolve over time):*

Expected number of attendees:

- ☐ Less than 20
- ☐ 20-50
- ☐ 50-100
- ☐ More than 100

Do you expect any participants with alternative learning needs?

- ☐ Yes
- ☐ No
- ☐ I don't know

Marketing and recruitment plan:

- ☐ Download Media & Event Resources (photo releases, press release templates...)
- ☐ Create flyers, promote on social media (see sample content for your posts section in Tips to Engage Your Audience)
- ☐ Partner with community organizations
- ☐ Add to Science Near Me
- ☐ Other

Possible Risks and Contingency Plan *(e.g. Plan an inside location if it rains):*

EVENT ACTIVITIES

Which topics will your event feature?

- ☐ Program Theme: Electromagnetic Spectrum
- ☐ Program Theme: Data and Imaging Processing
- ☐ Program Theme: Stars
- ☐ Program Theme: Finding Exoplanets
- ☐ Other:

If you are planning to incorporate other NASA's Universe of Learning Resources, select from below:

- ☐ ViewSpace
- ☐ MicroObservatory
- ☐ Data Manipulation
- ☐ Universe Unplugged
- ☐ Accessible Learning Resources
- ☐ NASA's Astrophoto Challenge
- ☐ DIY Planet Search

Additional resources are found in the NASA's Universe of Learning Resource Catalog.

Single Day Event - List the order of your activities below. (If you're hosting multiple events, use the Multi-Day Event Activities table)

Time: *(e.g. 5 mins)*	Activity: *(e.g. Welcoming participants)*	Who: *(e.g. Volunteer 1)*	Material: *(e.g. Photo Release)*

MULTI-DAY EVENT ACTIVITIES

Week or Day:

Time: *(e.g. 5 mins)*	Activity: *(e.g. Welcoming participants)*	Who: *(e.g. Volunteer 1)*	Material: *(e.g. Consent forms)*

Week or Day:

Time: *(e.g. 5 mins)*	Activity: *(e.g. Welcoming participants)*	Who: *(e.g. Volunteer 1)*	Material: *(e.g. Consent forms)*

Week or Day:

Time: *(e.g. 5 mins)*	Activity: *(e.g. Welcoming participants)*	Who: *(e.g. Volunteer 1)*	Material: *(e.g. Consent forms)*

Week or Day:

Time: *(e.g. 5 mins)*	Activity: *(e.g. Welcoming participants)*	Who: *(e.g. Volunteer 1)*	Material: *(e.g. Consent forms)*

PLANNING TIMELINE

2+ Months before the event:

- ☐ Identify a NASA's Universe of Learning theme for your event
- ☐ Identify which activities you will feature
- ☐ Make sure you have activities to support alternative learning needs
- ☐ Purchase materials
- ☐ Create event advertising materials
- ☐ Publish/distribute event advertising materials
- ☐ Request a Subject Matter Expert (optional)
- ☐ Reach out to your Subject Matter Expert and set expectations (discuss the name of the talk if any, etc.)

1 Month - 2 weeks before the event:

- ☐ Recruit event volunteers
- ☐ Get your material ready (e.g. cut, laminate material, install software, print consent forms and youth surveys, etc.)
- ☐ Practice facilitating activities
- ☐ Promote the event (e.g., social media, flyers, etc.)
- ☐ Confirm the time and location of the event (or video call link) with your Subject Matter Expert

1 week - 1 day before the event:

- ☐ Test a video call with your virtual speaker

Day of the event:

- ☐ Set up banner or direction signs
- ☐ Hand out consent forms
- ☐ Hand out event evaluation forms
- ☐ Take pictures of your event
- ☐ Welcome your Subject Matter Expert or make sure the URLs work fine

After the event:

- ☐ Analyze your evaluation forms
- ☐ If you reached out to the NASA's Universe of Learning team, send the facilitator and participant evaluation forms, as well as the event pictures and consent forms

AUDIO/VISUAL NEEDS

- ☐ Projector
- ☐ Laptop(s)
- ☐ Screen(s)
- ☐ Microphone
- ☐ Speaker(s)
- ☐ Extensions

BUDGET

Available budget: $

Item:	Cost:

NOTES

PARTICIPANT SURVEY

The survey on the next page is designed to provide information about:

- How attendees responded to the event
- How successful the event was at enhancing learning, interest, and engagement
- What attendees might like to see in future events
- Who came to the event

You can also use the "About You" information to see if some groups responded better to the event than others (e.g., was the event better suited to those who already knew something about astronomy, or to those who were brand-new to it).

Feel free to adapt this survey in order to make it most useful to you!

For online events, you can create a survey using a free online tool.

WHAT DID YOU THINK ABOUT THE EVENT?

How much do you agree with these statements about the event?	Agree a lot	Agree a little	Disagree a little	Disagree a lot
I learned about astronomy and space science at this event.	◯	◯	◯	◯
I was interested in this event.	◯	◯	◯	◯
I enjoyed this event.	◯	◯	◯	◯
I became more interested in astronomy and space science at this event.	◯	◯	◯	◯
I will look for more information about astronomy and space science.	◯	◯	◯	◯
I would like to come to another event like this.	◯	◯	◯	◯
I would recommend this event to a friend.	◯	◯	◯	◯

What was the most important thing you learned about astronomy or space science at this event?

What else would you like to learn about astronomy or space science?

ABOUT YOU

Before this event, how much did you know about astronomy or space science?

- ◯ Nothing
- ◯ Only a little
- ◯ Some
- ◯ A lot

Before this event, how interested were you in astronomy or space science?

- ◯ Not at all
- ◯ Only a little interested
- ◯ Somewhat interested
- ◯ Very interested

Are you…? ◯ A girl ◯ A boy

How old are you? _____

PRINT

NASA's Universe of Learning materials are based upon work supported by NASA under award number NNX-16AC65A to the Space Telescope Science Institute, working in partnership with Caltech/IPAC, Center for Astrophysics | Harvard & Smithsonian, and Jet Propulsion Laboratory. 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.