NASA’s Hubble Space Telescope: New Views of the Universe
Experience the life and history of the Hubble Space Telescope through this interactive and stunning exhibit! The Hubble Space Telescope’s traveling exhibit is divided into eight fascinating sections. Each one highlights a different aspect of the Hubble Space Telescope, whether it is the satellite itself, one of its many discoveries, or what the future may hold.

Hubble imagery has both delighted and amazed people around the world. The exhibit contains images and data taken by Hubble of planets, black holes, and many other fascinating cosmic entities that have captivated the minds of scientists for centuries. Experience the life and history of the Hubble Space Telescope through this interactive and stunning exhibit. Also featured is an exhibit on the James Webb Space Telescope and what to look forward to from space telescopes in the future.

THE HUBBLE MODEL
The 1:15 model of the Hubble Space Telescope is the central focus of the traveling exhibit, and gives the observer a visual representation of the telescope as it is in space. The ring surrounding the model provides insight into the size, operations and capabilities of the Hubble telescope. The rear of the station provides a three-step explanation of why Hubble is above the atmosphere and what makes it different from ground observatories. Viewers of the exhibit learn how the space telescope manipulates light captured by its mirrors in order to obtain images of distant stars and galaxies, as well as the events leading up to the launch of the telescope.
SERVICING MISSIONS

The Hubble Space Telescope servicing missions station highlights each of the five Hubble repair missions, or expeditions by astronauts to repair the telescope and ensure that it’s working at its best.

The servicing missions station details what hurdles Hubble has faced and the innovative solutions that astronauts have made to overcome them. The station includes displays of some of the tools used by the astronauts on these servicing missions, many of these tools having actually flown into space.

Astronaut Jeffrey Hoffman removes the Wide Field and Planetary Camera 1 during the first Hubble servicing mission December 1993.

THE TUNNEL

The Tunnel is a path that surrounds and immerses visitors in a series of images from some of Hubble’s most fascinating discoveries. Wherever you look, there is a new image captured by the telescope, and as you traverse through the tunnel, you experience the entirety of the space telescope’s lighting sequence through a series of extended exposures of each photo. The images in the tunnel reflect recent science made possible with the Hubble Space Telescope. When exhibit space is limited, the back half of the tunnel is deployed, and images are subject to change.

The major elements of the Hubble Space Telescope (HST) are the Optical Telescope Assembly (OTA), the Support System Module (SSM), and the Scientific Instruments (SI). Wing-like solar arrays extend from each side, and dish-shaped antennas extend above and below the body of the telescope. The HST was deployed from the Space Shuttle Discovery into Earth orbit in April 1990. The Marshall Space Flight Center had responsibility for design, development, and construction. The Perkin-Elmer Corporation developed the optical system and guidance sensors. The Lockheed Missile and Space Company produced the protective outer shroud and spacecraft systems, and assembled and tested the finished telescope.

PLANETS

The Planets station of the traveling exhibit details some of Hubble’s most significant contributions to the observation of planets in our solar system and beyond. Hubble tackles the question of where these planets came from and how they formed. The satellite can watch these planets and how they change over time in order to answer important questions on their histories and their origin. The telescope can see storms as they sweep across Mars, a comet as it strikes Jupiter, or volcanic eruptions on Jupiter’s moon Io. The solar system is alive with change, and Hubble is watching.

The Hubble Space Telescope shows detail of two continent-sized storms erupting in Jupiter’s atmosphere showing the planet’s internal heat plays a significant role in generating atmospheric disturbances.
Galaxies are enormous systems of stars and gas that fill the universe by the billions. Astronomers have many ideas as to how these galaxies formed, although their great variety in shape and size suggest that they have vastly different histories. Hubble’s incredible views of these galaxies help astronomers to answer questions about the universe, whether they be about its age, its origin, or its fate. The galaxies wall of the exhibit features Hubble’s 15th anniversary image of the Whirlpool Galaxy (M51), while the information tower looks at interacting galaxies, determining the age of the universe, and at our neighbor the Andromeda Galaxy.

Violent gas collisions that produced supersonic shock fronts in a dying star are seen in a new, detailed image from NASA Hubble Space Telescope.

Planetary nebula PK 329-02.2 is located in the constellation of Norma in the southern sky. When stars that are around the mass of the sun reach their final stages of life, they shed their outer layers into space, which appear as glowing clouds of gas called planetary nebulae.

The Hubble Deep Field (HDF) is an image of a small region in the constellation Ursa Major constructed from a series of 342 separate exposures taken with the Wide Field and Planetary Camera between December 18-28, 1995. Several hundred never before seen galaxies are visible in this deepest-ever view of the universe, called the Hubble Deep Field, made with NASA Hubble Space Telescope.

The Stars section of the traveling exhibit deals with the stars in our home galaxy, the Milky Way. This section of the exhibit includes iconic imagery of the Eagle Nebula throughout Hubble’s lifetime as well as information on nebulae – clouds of dust and gases that are vigorous hotbeds for star formation. Interactive kiosks take viewers on a tour through the life and death of a star, while a time marker puts time and distances of stars in perspective.

Violent gas collisions that produced supersonic shock fronts in a dying star are seen in a new, detailed image from NASA Hubble Space Telescope.

STARS

GALAXIES

HUBBLE DEEP FIELD

What happens when you point human-kind’s most powerful telescope at the smallest, most-distant, darkest part of the sky?

In 1995, researchers selected a small target region (about 1/24-millionth of the sky) within the constellation Ursa Major. The composite image at right revealed nearly all of the 3000 objects detected are some of the youngest and most distant galaxies known.
THE UNIVERSE

The exhibits in this section deal with the distant universe. The faint light that Hubble detects from this far-away region has been traveling for billions of years and represents events that occurred when the universe was very young. Hubble’s deepest views are shedding light on some of the most profound questions of all. How does the universe work? Where did we come from? Are we alone? The Hubble Universe station’s wall extends cosmology to the farthest reaches of the universe with an image of the Hubble Ultra Deep Field, which contains an estimated 10,000 galaxies in the span of a single image. The information tower looks at gravitational lensing, a natural phenomena first predicted by Einstein that uses the warping of space and time itself in order to gain insight into the earliest formations in our universe. The multi-spectral station of the Universe station gives viewers a hands-on experience with the infrared, visible, and ultraviolet capabilities of the telescope. When the observer puts their hand into the interactive display, they see their hand as Hubble would in each of the three wavelengths of light discernible by the space telescope.

THE WEBB TELESCOPE

The James Webb Space Telescope exhibit gives the observer a peek into the creation and development of the Webb telescope, and it tells a tale of two telescopes: what Hubble can accomplish and what the James Webb Space Telescope has to offer. The exhibit compares the two telescopes and highlights some of the key differences between the two satellites. The Webb telescope will focus primarily in the infrared light spectrum and will provide us with insight into the early universe, while Hubble, which is more versatile in its views of the ultraviolet spectrum, will continue to operate into the 2020s and provide us with new scientific observations and discoveries. Working together, these two telescopes will allow us to see the universe as we never have before.

Ball Aerospace engineers guide an array of six gold-plated James Webb Space Telescope mirrors after final acceptance testing at Marshall’s x-ray and cryogenic facility.

The primary mirror of NASA’s James Webb Space Telescope consisting of 18 hexagonal mirrors looks like a giant puzzle piece standing in the massive clean room of NASA’s Goddard Space Flight Center in Greenbelt, Maryland. Appropriately, combined with the rest of the observatory, the mirrors will help piece together puzzles scientists have been trying to solve throughout the cosmos. In the photo, two technicians stand before the giant primary mirror.
Hubble Space Telescope – An Overview

NASA’s Hubble Space Telescope was the first astronomical observatory to be placed into orbit around Earth with the ability to record images in wavelengths of light spanning from ultraviolet to near-infrared. Launched on April 24, 1990, aboard the Space Shuttle Discovery, Hubble is currently located about 340 miles above Earth’s surface where it completes 15 orbits per day—approximately one every 95 minutes. The satellite moves at the speed of about 5 miles (8 km) per second, fast enough to travel across the United States in about 10 minutes.

The Telescope
Hubble is classified as a Cassegrain reflector, named after a 15th century French cleric who was among the first to suggest this basic optical design. Light hitting the telescope’s main, or primary, mirror is reflected to a smaller, secondary mirror suspended above the primary. The secondary, in turn, reflects the light back through a hole in the primary where it enters Hubble’s instruments (cameras and spectrographs) for final focus before it hits their detectors.

Hubble’s primary mirror is not only exquisitely polished, but at 94.5 inches (2.4 m) in diameter, collects an immense amount of light. Hubble can detect objects that are 10 billion times fainter than the unaided eye can see. High above the blurring effects of Earth’s atmosphere, Hubble also gets a much clearer view of the cosmos than do telescopes located on the ground. The space telescope can distinguish astronomical objects with an angular diameter of a mere 0.05 arcsecond—the equivalent to discerning the width of a dime from a distance of 86 miles. This resolution is about 10 times better than the best typically attained by even larger, ground-based telescopes. High resolution enables Hubble to locate such objects as dust disks around stars or the glowing nuclei of extremely distant galaxies.

Also because it circles above the atmosphere, Hubble can view astronomical objects across a wider range of the electromagnetic spectrum than ground-based telescopes, which are limited by atmospheric absorption at various wavelengths. This gives astronomers using Hubble a fuller view into the energetic processes that create the radiation seen and measured.
Hubble Space Telescope – Mission Operations

NASA’s Goddard Space Flight Center (GSFC) is home to the Hubble Space Telescope Operations Project, the government’s team of technical managers and scientists who oversee all aspects of the Hubble mission. Under its direction, an integrated group of civil servants and contractors at GSFC collectively known as the operations team is responsible for Hubble’s mission operations—those functions of the mission that operate together to assure the health, safety, and performance of the spacecraft. Examples include monitoring and adjusting the spacecraft’s subsystems (e.g., power, thermal, data management, pointing control, science instruments, etc.), flight software development, sustaining engineering of the control center hardware and software, and systems administration of the network and ground system components.

A separate contractor team at the Space Telescope Science Institute (STScI) in Baltimore, Maryland, is similarly responsible for science operations—the functions necessary to award telescope time, schedule observations, create command timelines, calibrate the received data, and archive the datasets. Working closely together, GSFC and the STScI operate Hubble 24 hours a day, 7 days a week, though most of the commanding to the telescope and receipt of its science data is accomplished by computers via automated operations.

The Space Telescope Operations Control Center (STOCC) is located at GSFC. It consists of a Mission Operations Room (MOR) and an Operations Support Room (OSR). The MOR is Hubble’s primary command and control room; both manual and automated operations are performed from this location.

Prior to the implementation of automated operations in May 2011, a team of console operators staffed the MOR around the clock. They executed the required procedures to acquire communications with the telescope, manage Hubble’s science and engineering data recorders, and load Hubble’s computers with command sequences. They also monitored telemetry from the spacecraft and reported any problems or concerns to the appropriate subsystem engineers.

Hubble transmits its data using the TDRSS spacecraft.
The Hubble Space Telescope, the iconic astronomical observatory of our times, has spectacularly extended our understanding of the Universe – from nearby planets to the most distant galaxies. As often happens in science, discoveries raise new questions that are sometimes tantalizingly beyond present capabilities. The James Webb Space Telescope is designed to continue - and expand - the legacy of scientific discovery from Hubble.

Both telescopes share similar goals: to explore the Universe and improve our understanding of processes such as the assembly and evolution of galaxies, star birth, and the formation of planets. This shared purpose is reflected in their common features: mirrors to collect light from distant stars and galaxies and sensors that convert that light into digital images and spectra. They both work in the vacuum of outer space, and use radio signals to transmit their images to Earth. Both also have solar panels that collect energy to power the telescope, and pointing control systems that keep the telescope extremely stable while taking data.

Despite their similarities, these two telescopes are very different. Webb will be optimized for infrared light, unlike Hubble, which observes in ultraviolet and visible light and has only limited near-infrared capabilities. Webb will also have a much larger primary mirror that will enable it to collect more light than Hubble. Seeing in the infrared is essential for viewing objects at the edge of the Universe, since the light from these far-away objects is red-shifted from the visible into the infrared wavelengths by the expansion of our Universe. Observing far into the infrared also allows Webb to see deep into the dusty cocoons where stars and planets form.

Size Matters

The primary mirror of a telescope collects the light from the objects that the telescope observes. The larger the primary mirror, the more light the telescope collects. The area of Webb’s mirror is about six times larger than Hubble’s, which will enable it to see objects that are fainter and farther away. This will allow Webb to peer back to a time when galaxies were just forming!

Webb is cool

Since all objects (including telescopes) emit infrared light, the telescope and its instruments must be very cold. Webb has a large sunshield that blocks the light...
from the Sun, Earth, and Moon, which otherwise would heat up the telescope, and swamp the astronomical signals. For this to work, Webb must be in an orbit where all three of these objects are in about the same direction. This is achieved by putting Webb in an orbit that is a million miles away at the second Earth-Sun Lagrange point (L2). This is in contrast to Hubble that orbits just 350 miles above the Earth.

**Technology improves with the passage of time**

Webb employs many technologies developed in the years since Hubble was launched. These advanced technologies, also described on our website (www.jwst.nasa.gov), include ultra-lightweight beryllium mirrors; a deployable multilayer sunshield; a super-cold mechanical helium cryocooler; tiny microshutters used to select specific fields of view; new communications networks to transmit and store large quantities of data; and larger ultra-sensitive infrared detectors to record extremely faint signals.

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<thead>
<tr>
<th></th>
<th>Hubble</th>
<th>Webb</th>
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<tbody>
<tr>
<td><strong>Mirror Diameter</strong></td>
<td>7.9 ft (2.4 m)</td>
<td>21.3 ft (6.5 m)</td>
</tr>
<tr>
<td><strong>Length</strong></td>
<td>44 feet (13.2 m)</td>
<td>72 feet (22 m)</td>
</tr>
<tr>
<td><strong>Wavelengths</strong></td>
<td>Ultraviolet, Visible, and Near Infrared: 0.1-2.5 micrometers</td>
<td>Visible, Near Infrared and Mid Infrared: 0.6-29 micrometers</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td>Orbiting Earth, about 350 miles (570 km) above the surface</td>
<td>Orbiting L2, about 940,000 miles (1,500,000 km) from Earth</td>
</tr>
<tr>
<td><strong>Temperature</strong></td>
<td>70 F (21 C)</td>
<td>-370 F (-230 C)</td>
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**Current status of the mission**

Webb is in the detailed design phase of its development. All necessary technology developments have been completed, and long-lead items, such as the beryllium mirror segments and science instruments, are now under construction. Launch is planned for 2014 on an Ariane 5 rocket.

The James Webb Space Telescope is an international collaboration between NASA, the European Space Agency, and the Canadian Space Agency.

www.nasa.gov
TEACHER RESOURCES

Below you’ll find links to various websites that will give you more information about space and the Hubble telescope. These resources can help you prepare before you come on your tour, as well as give you some ideas for post-tour lessons and activities that you can do with your class.

Lesson Plans
NASA's Website for Educators - Find space-themed lesson plans and resources for you to use in your classroom. Here you can find materials for any grade level!
https://www.nasa.gov/audience/foreducators/5-8/index.html

The European Space Agency's Website for Educators - Find detailed lesson plans and activities to use in your classroom to address a range of topics, including what a solar system is and how you would grow plants in space.
https://www.esa.int/Education/Teachers_Corner/Primary_classroom_resources

Websites & Videos
Hubble - Learn more about what the Hubble Space Telescope is and see what the telescope is looking at right now!

Solar System Exploration - View and interact with the different components of our solar system, including the Sun, asteroids, and the planets and their moons.
https://solarsystem.nasa.gov/solar-system/our-solar-system/overview/

SpacePlace - This website contains easily-understandable space explanations for kids, with answers to questions like “What is a black hole?” or “What causes the seasons?“. With pictures, videos, and games, this website is great for kids to explore and learn about space.
https://spaceplace.nasa.gov/

International Space Station - Learn more about what it’s like to live and work in space on the International Space Station
https://www.nasa.gov/audience/foreducators/stem-on-station/dayinthelife

Hubble & Going Forward to the Moon Video - Watch this video to learn how Hubble has helped NASA with their plans to establish a colony on the Moon by 2024
https://www.youtube.com/watch?v=rUvDf-DB_is

Nat Geo Kids Hubble Videos - These two videos from National Geographic explain what Hubble is and how it works.
https://www.youtube.com/watch?v=FEIqDEPsBHQ
https://www.youtube.com/watch?v=MqrcuWOKeno
NASA’s Hubble Space Telescope Exhibit

First California Exhibition
October 1, 2019 - March 29, 2020

NASA’s Hubble Space Telescope Exhibit is a 2,200 square-foot experience that immerses visitors in the magnificence and mystery of the Hubble mission.

★ This amazing exhibit features a 1:15 scale model of the Hubble Space Telescope

★ Students will enjoy a hands-on experience using the same technology that allows Hubble to gaze at distant galaxies

★ Students will learn about Hubble’s contributions to the exploration of planets, stars, galaxies, and the universe

Your class will explore the life and history of the Hubble Space Telescope and experience the splendor of Hubble’s many discoveries through this stunning, interactive exhibit.

EXHIBIT STATIONS:
★ The Hubble Model
★ Servicing Missions
★ The Tunnel
★ Planets
★ Stars
★ Galaxies
★ The Universe
★ The James Webb Space Telescope

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