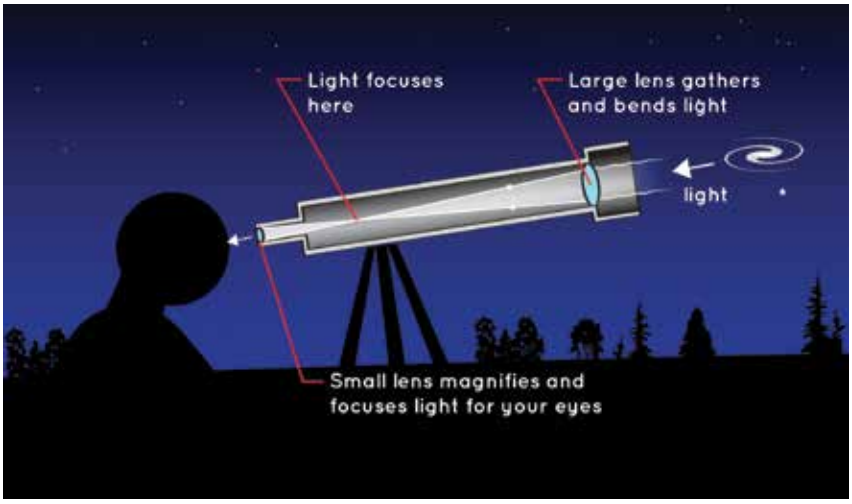
Activate Learning®

The James Webb Space Telescope

How can telescopes help us to see objects in space?

Telescopes are used by astronomers to see objects in space that are faraway. At first, telescopes used lenses made of pieces of clear, curved glass. Most telescopes now use curved mirrors since they are lighter and easier to make. They gather light from the night sky and then focus it. More light can be gathered from an area if the lenses are bigger.



Credit: NASA/JPL-Caltech

A simple refracting telescope uses lenses to make images bigger and more visible.

When telescopes are located on the surface of the earth, people are looking through the atmosphere which absorbs some types of waves. Stars twinkle because the atmosphere distorts and scatters the light from stars. This limits the ability of telescopes on Earth to "see" objects that are very dim, or to view fine details on objects in space. In addition, the atmosphere blocks light at certain wavelengths from reaching the ground. Telescopes that are above the Earth's atmosphere have an advantage since they do not have the atmosphere limiting their view.

The Hubble Space Telescope

The Hubble Space Telescope helped us find out much about our Universe. It is six separate instruments that can view the Universe in many different ways. It was placed in Earth's orbit during a space shuttle mission in 1990. The Hubble Space Telescope can look at stars without having to look through Earth's atmosphere. It orbits Earth at more than 550 km (342 mi) above Earth's surface, which is well outside the atmosphere. Astronomers are able to collect data and guide the telescope by remote control. The telescope sends data and images back to Earth using a radio antenna and other communication satellites.

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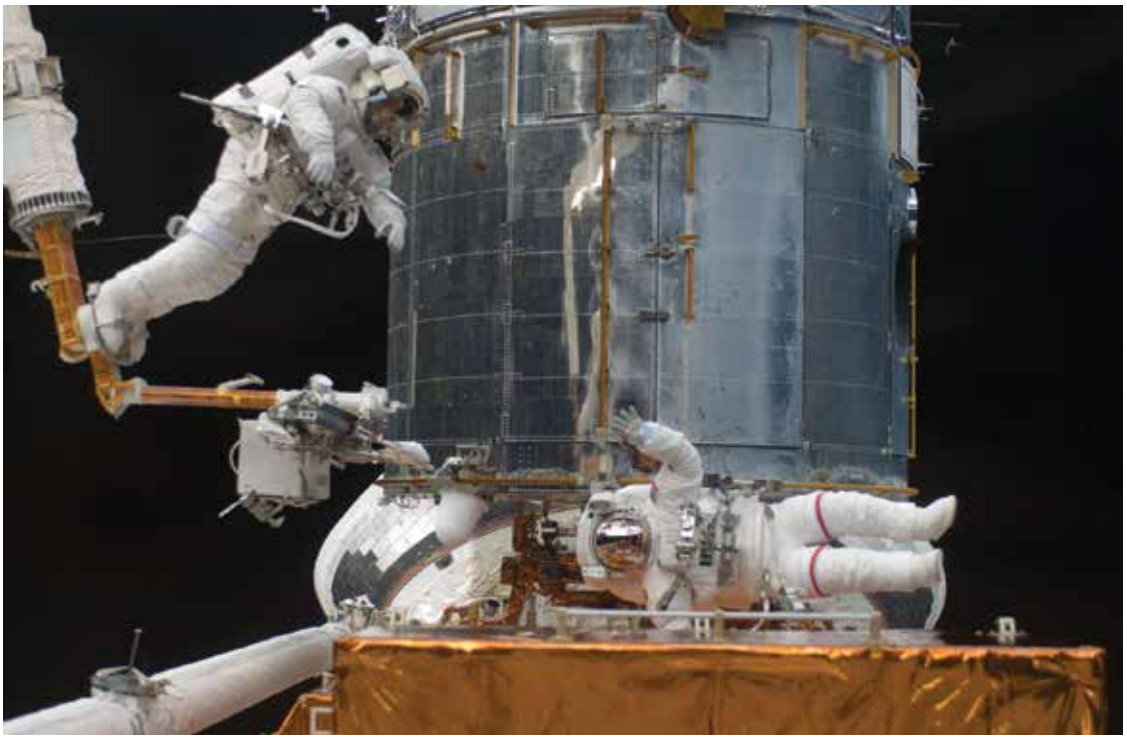
It was designed so that astronauts could repair the telescope in space if necessary. Five space shuttle missions between 1993 and 2009 have been launched to repair or increase the capabilities of the Hubble.



Astronauts repair the massive Hubble Space Telescope

The James Webb Space Telescope

The James Webb Space Telescope is the successor to the Hubble telescope and is now the most powerful and largest space telescope. Scientists can now look at what our Universe was like about 200 million years after the Universe was formed. The telescope can see some of the first galaxies ever formed and can look inside dust clouds to see where new stars and planets are forming.

1. What are two advantages to having a big telescope that is far out in space?

   Telescopes in space do not have to look through the Earth's atmosphere in order to view stars. They are able to see new stars and planets forming.

2. Why was it important for the Hubble Space Telescope to be fairly close to Earth?

   With the Hubble Space Telescope fairly close to Earth, Astronauts are able to make needed repairs and improvements. Scientists are able to collect data and guide the telescope by remote control.

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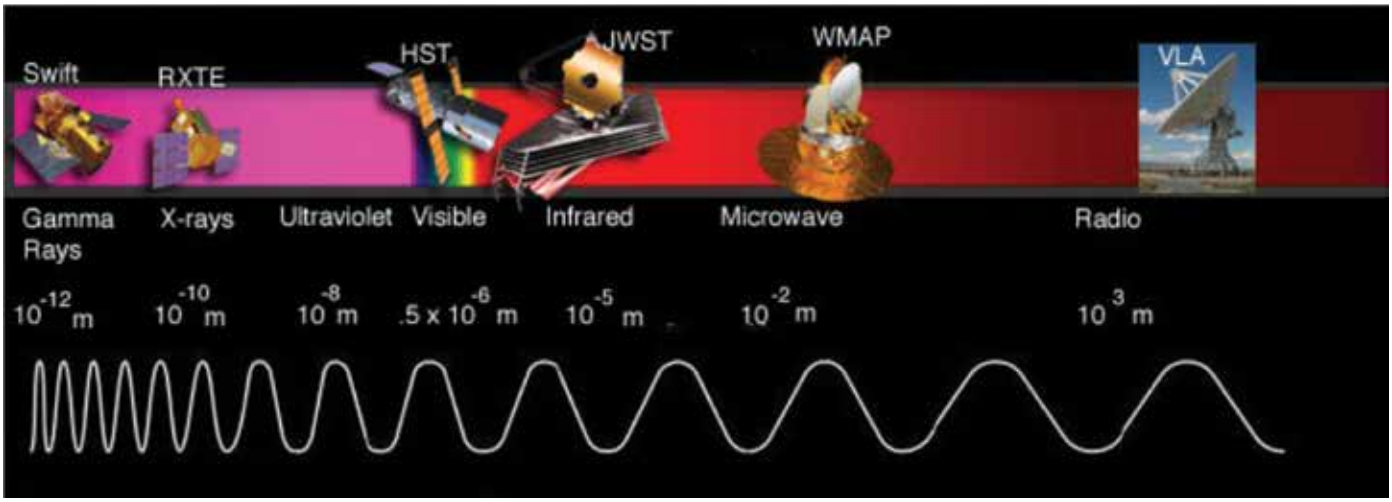
How do the two telescopes compare?

Type of light detected

The instruments on Hubble can see some of the infrared spectrum, but it mostly sees ultraviolet and visible parts of the spectrum. Webb's instruments work mostly in the infrared range of the electromagnetic spectrum, with a bit in the visible range. When stars and planets are forming, there are clouds of dust around them that absorb visible light, so we can't see them with most telescopes. Infrared light that is given off by these areas can go through the dust and can be detected by the Webb telescope.



EM Spectrum and satellites

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These are two Hubble images of the "Pillars of Creation" in the Eagle Nebula. The left image captures a visible light view, showing an opaque cloud of gas and dust. On the right, near-infrared light penetrates much of the gas and dust, revealing stars behind the nebula and hidden away inside the pillars. The image on the right provides an example of the types of images the Webb is capable of taking. The Webb telescope has not taken any images of the "Pillars of Creation" yet, but will be able to take these kinds of infrared images in greater detail and clarity in the future.
https://webbtelescope.org/contents/media/images/4178-Image

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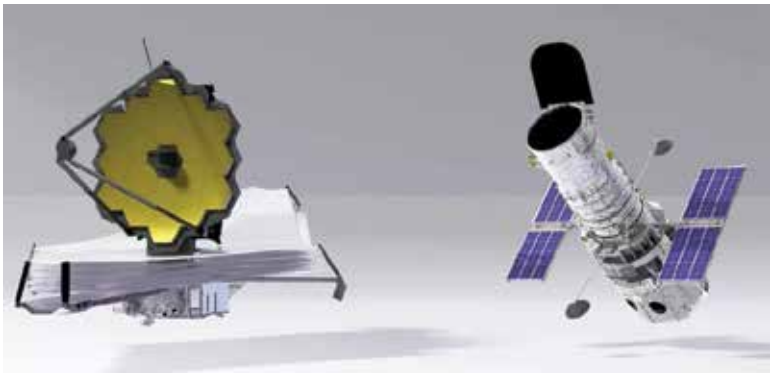
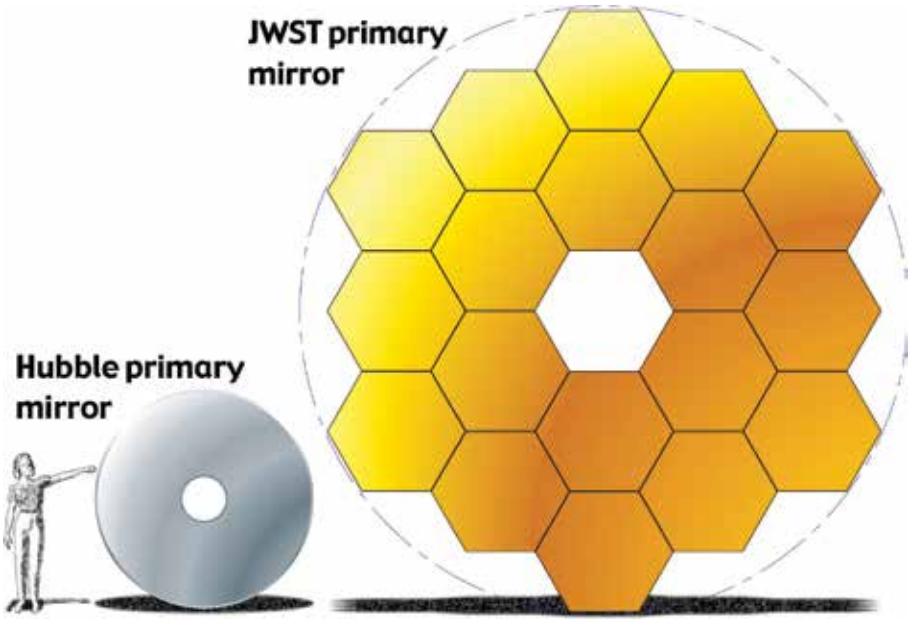
Size

The size of each telescope is similar, but the James Webb Space Telescope primary mirror is much bigger than Hubble's, giving it 6.25 times more collecting area. It also has a 15 times larger field of view. The mirror of the James Webb Space Telescope is also much lighter since it is made of beryllium which is a very strong substance that makes the mirror very durable. The mirror of James Webb Space Telescope folds up so that it can easily be stored. A thin gold coating is put on the mirror to make it reflect infrared light better.



Credit: GSFC

Overall size comparison of Webb and Hubble https://www.jwst.nasa.gov/



Mirror size comparison of Webb and Hubble
https://www.jwst.nasa.gov/comparisonWebbVsHubble.html

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3. How does the mirror of the James Webb Space Telescope compare to that of the Hubble Telescope? Discuss at least three ways they are different.

The James Webb primary mirror is much bigger than the Hubble and has a 15 times larger field of view. It is much lighter than the Hubble mirror and was able to be folded to launch on the spaceship

4. Draw diagrams with labels to compare the Hubble telescope with the James Webb Space Telescope.

The Hubble telescope mainly detects visible light and ultraviolet light. Images from the Hubble telescope show stars and planets forming in clouds of dust. The clouds of dust absorb most of the visible light which reduces the amount of details we are able see. The James Webb telescope mostly works with the infrared range. Infrared light that is given off by newly forming stars and planets can go through the dust and can be detected by the Webb telescope, thus we will be able to see many more details.

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Location

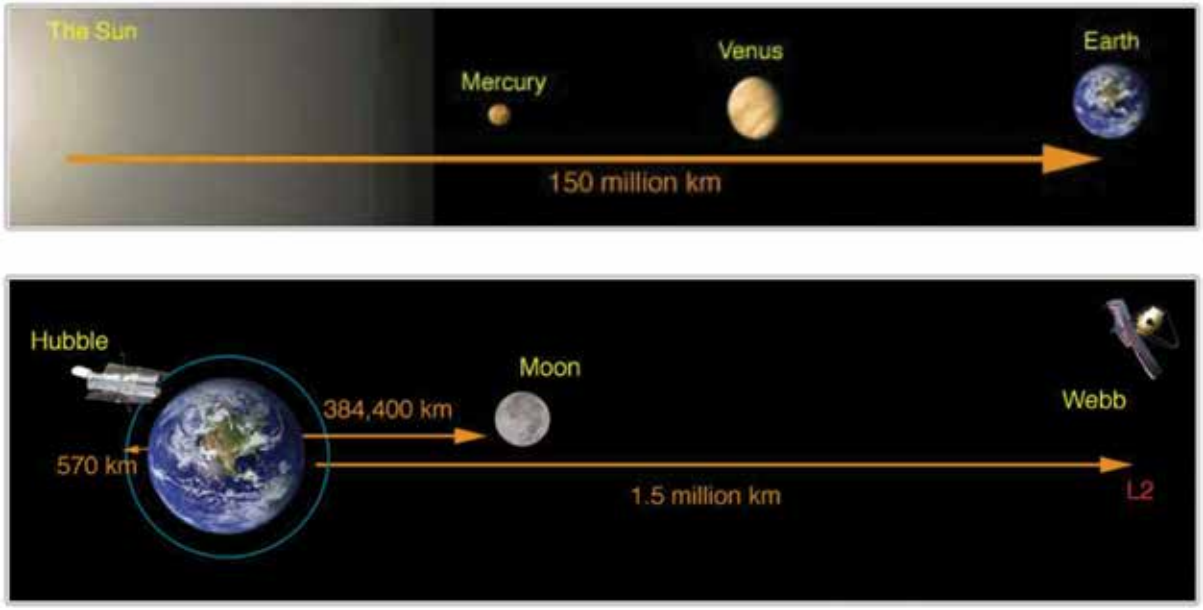
The Hubble Space Telescope orbits around the Earth at an altitude of ~570 km (354 miles) above it. Compare this to the 150 million km (93 million miles) that the Earth is from the Sun or the 384,400 km (238600 miles) the Earth is from the Moon. The James Webb Space Telescope does not orbit the Earth like the Hubble Space Telescope does, but is located at the Earth-Sun L2 Lagrange point, which is 1.5 million km from the Earth.

5. How are they alike and different? Include the type of light detected, size, location and what they can see.

The atmospheres of exoplanets may contain chemicals that are important to developing life which could indicate life on those planets.

6. Why would it be important for the mirror of the James Webb Space Telescope to be light?

The James Webb Space Telescope would need to be light and foldable so that it could be loaded on to a rocket and delivered deep into space.



Webb will orbit the sun 1.5 million kilometers (1 million miles) away from Earth at what is called the second Lagrange point or L2. (Note that these graphics are not to scale.)

https://www.jwst.nasa.gov/content/about/comparisonWebbVsHubble.html

The James Webb Space Telescope's solar shield will block the light from the Sun, Earth, and Moon. The James Webb Space Telescope then stays cooler since this is very important for an infrared telescope.

As the Earth orbits the Sun, Webb orbits with it. So it stays fixed in the same spot in relation to the Earth and the Sun, but is moving around in space. Satellites also orbit around the L2 point.

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What can the James Webb Space Telescope see?

The James Webb Space Telescope will study the atmospheres of exoplanets. These atmospheres may contain chemicals that are the building blocks of life. So it could give us evidence of life on other planets!

Here is a picture of the Cartwheel Galaxy taken by the James Webb Space Telescope. It gives us new details about how stars form and about the galaxy's black hole. There are two other large galaxies on the left of the picture and many other smaller ones in the background. The Cartwheel Galaxy is about 500 million light years away. An inner and outer ring were produced during a high-speed collision between a large spiral galaxy and a smaller galaxy that you cannot see in this picture. The inner ring is where there are very large young star clusters. The outer ring has star formations and supernovas.

Credits: NASA, ESA, CSA, STScI

A large pink, speckled galaxy resembling a wheel with a small, inner oval, with dusty blue in between on the right, with two smaller spiral galaxies about the same size to the left against a black background.

This is an image of the Cartwheel Galaxy taken with the NASA/ESA (European Space Agency) Hubble Space Telescope. The Hubble Space Telescope also took pictures of the Cartwheel Galaxy, but dust was in the way and the pictures do not show as much detail.

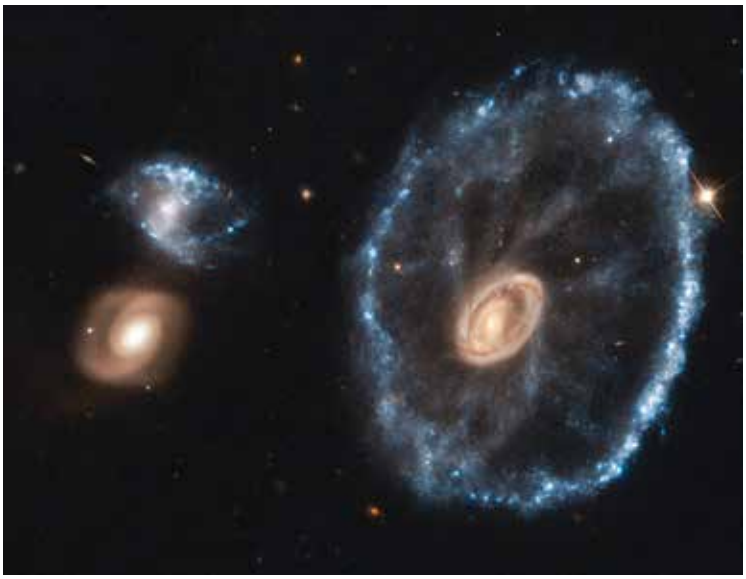

Image credit: ESA/Hubble & NASA Text credit: ESA

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