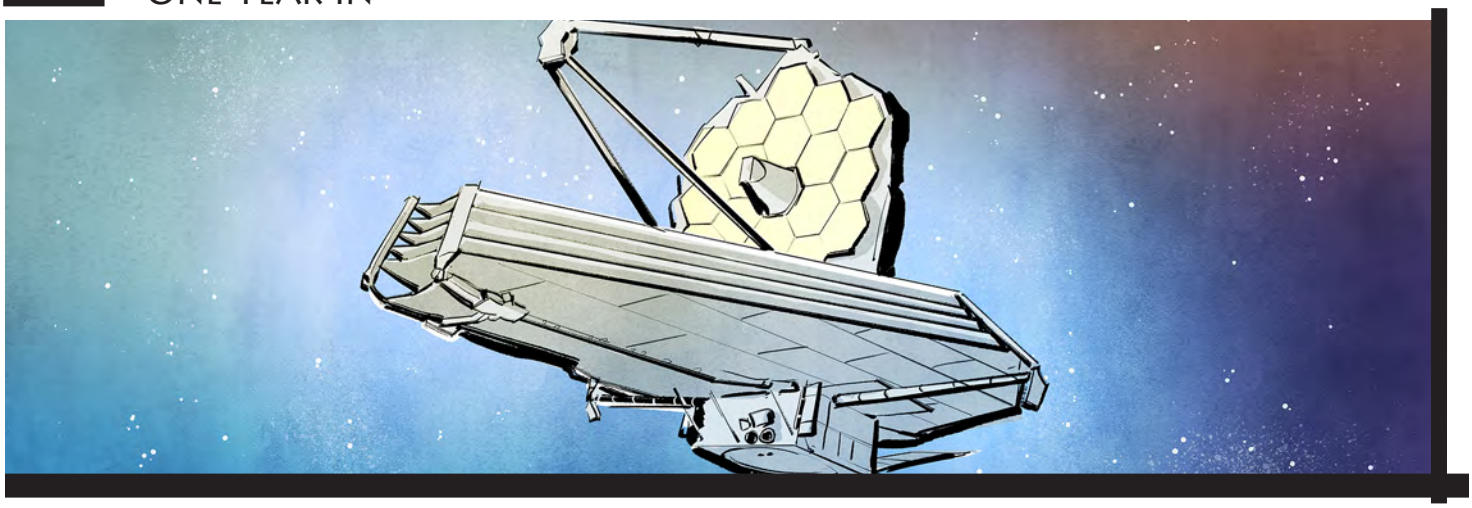
The James Webb Space Telescope – One Year In



On Christmas Day 2021, the **National Aeronautics and Space Agency (NASA)** launched the James Webb Space Telescope (JWST). The send-off took place in French Guiana, South America. The JWST is the largest, most powerful space telescope ever built. NASA, the European Space Agency (ESA), and the Canadian Space Agency (CSA) have spent $10 billion on the project.

In July 2022, the first image from JWST was released. It was a photo of a 4.6 billion-year-old **galaxy** called SMACS 0723. That was our first view of the distant galaxy. Then, in July 2023, JWST shared an image of the Rho Ophiuchi cloud complex – a star-forming region closest to Earth. It is 460 **light-years** away.

Ambitious Objectives

The Webb telescope has five objectives. It will observe farther into the **Universe** than ever before. It will search for the first stars and galaxies created after the **Big Bang**. It will help us understand how planets, stars, and galaxies evolve. It will explore distant worlds and study the Solar System. Finally, it will help us learn if there could be life on other planets.

Key to the Past

JWST can gaze deeply into **infrared** light. That will help it accomplish these goals. Here's why. Distant starlight stretches as the Universe expands. By the time it gets to our part of the Universe, it is in the infrared region of the light spectrum. Our eyes – and less powerful telescopes – can't see this light.

JWST, however, can. It detects infrared glow from the most distant objects in the Universe. By doing so, the telescope is looking back in time. It shows us how the Universe looked when it was new. So it could help us answer some Big Questions. What are the origins of the Universe? Where do we come from? How did we come to be?

What We're Learning

By April 2023, JWST had found the four oldest, most distant galaxies yet observed. Their light has taken 13.4 billion years to reach us. They date from 300 to 500 million years after the Big Bang. That's when the first stars are believed to have emerged.

Definitions

Big Bang: the scientific theory that explains the origins of the Universe. Scientists believe that from a single point, the Universe underwent a massive expansion and stretching that happened in a fraction of a second.
Galaxy: an extremely large group of stars and planets
Infrared: relating to or using a type of light that can be felt as heat but cannot be seen
Light-year: a unit of length equal to just under 10 trillion kilometres – the distance light travels in one calendar year
National Aeronautics and Space Agency (NASA): U.S. government agency responsible for space travel and research
Universe: everything in space: stars, planets, galaxies, etc.

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JWST has also given us detailed images of the 'Pillars of Creation.' These are three towers of **interstellar** gas and dust in the Eagle Nebula. Each one is a light-year tall. Stars form in the dense clouds of these pillars.

We've never seen inside these clouds before. But JWST's technology can penetrate them. The new images revealed young red stars sprinkled throughout the clouds. They are called 'protostars.' That means they are not yet big enough or hot enough to burn hydrogen in their cores.

JWST's images have also provided more precise counts of new stars. And they have revealed the quantities of gas and dust in each region. That's helping scientists learn more about how stars form.

Strange new worlds

JWST is showing us what planets outside our solar system look like, too. These planets are called exoplanets. In September 2022, the telescope took its first image of an exoplanet – HIP 65426 b. It's a gas giant 6-12 times the mass of Jupiter, nearly 400 light-years from Earth.

Images of a gas giant called WASP-39 b surprised analysts. The planet's atmosphere showed water vapour, sulfur dioxide, carbon monoxide, sodium, and potassium. Carbon dioxide could potentially support life.

The real revelation, though, was the sulfur dioxide. WASP-39 b is incredibly hot – 900 degrees Celsius. We thought that the processes that lead to the creation of sulfur dioxide couldn't occur at such high temperatures. So, less common chemical reactions must be responsible. One possibility? Photochemistry, such as when intense light hits water.

Proving us wrong

The JWST has shown us exciting things we didn't expect to see. For example, massive galaxies from 500-700 million years after the Big Bang are larger than we thought possible. And images from one of these galaxies, CEERS 1019, show the most distant active **black hole** we've found. Scientists can't yet explain how a black hole formed so soon after the Universe began.

Another image reveals a young cluster of stars, NGC 346. The picture indicates how the Universe looked during a period of intense star formation between 10 and 11 billion years ago. It showed stars and planets in cloud-like formations full of dust and hydrogen.

About JWST

JWST follows the Earth's orbit around the Sun, about 1.5 million kilometres further out from the Sun than the Earth. It stays on the Earth's night side. The telescope has a large, diamond-shaped sunshield about the size of a tennis court. It blocks the Sun's heat and light from its heat-sensitive optics. The part of the observatory on the side of the sunshield facing the Sun is always bathed in sunshine, generating power via a solar array.

At JWST's core is a 6.5 metre-wide primary mirror coated with a microscopically thin layer of gold. Eighteen mirror segments hinged together have motors on the back to adjust the curvature. They must be aligned to within nanometres – about 1/10,000th the thickness of a hair.

Thrilling discoveries

These revelations are exciting scientists, who say that the JWST has transformed their thinking.

"[It sees] light from faraway corners of the Universe for the very first time," said NASA's Bill Nelson. "Every image is a new discovery."

Expect more thrills to come! ★

Definitions

black hole: a region of space resulting from the collapse of a star, that has an extremely high gravitational field

interstellar: between the stars

THE JAMES WEBB SPACE TELESCOPE

– One Year In

COMPREHENSION QUESTIONS

1. Everything in space including stars, planets, galaxies, etc. is called the:

2. Explain what the **Big Bang** theory is.

3. Who built the James Webb Space Telescope? How much did it cost?

4. When and where was this telescope launched?

5. Where is the James Webb Telescope located?

6. Explain how the telescope is aligned.

7. How can the James Webb Telescope both block and make use of the Sun's heat and light?

8. Describe the mirror on the James Webb Telescope and explain how it works.

9. What can the James Webb Telescope detect that other telescopes cannot? Why is this important?

10. List at least three mission objectives of the James Webb Telescope.

THE JAMES WEBB SPACE TELESCOPE – One Year In

ORGANIZER

A. The article describes many of the photos that JWST has been able to capture and what they tell us about the Universe. Note the details of each photo and the significance of its discovery, where possible.

Photo	Details/Significance
SMACS 0723	
Rho Ophiuchi cloud complex	
The four oldest, most distant galaxies yet observed	
Pillars of Creation	
HIP 65426 b	
WASP-39 b	
CEERS 1019	
NGC 346	

B. After gathering and considering the information in the above table, which of these photos, in your opinion, may have the ***most significant impact*** on the scientific understanding of the origins of the Universe? Give reasons to support your response.

THE JAMES WEBB SPACE TELESCOPE – One Year In

QUESTIONS FOR FURTHER THOUGHT

1. "***In just one year, the James Webb Space Telescope has transformed humanity's view of the cosmos, peering into dust clouds and seeing light from faraway corners of the Universe for the very first time. Every image is a new discovery, empowering scientists around the globe to ask and answer questions they once could never dream of.***" - NASA Administrator Bill Nelson

As you see it, why is it important to learn the answers to these questions? Support your ideas with examples.

2. Which of JWST's five mission objectives, according to the Canadian Space Agency (CSA), do you believe will have the biggest impact on science and scientific exploration in the future? Give reasons to support your opinion.

QUESTIONS FOR ONLINE EXPLORATION

Note: The links below are listed at **www.lesplan.com/links** for easy access.

1. Visit NASA's official James Webb Space Telescope site to learn more about the mission:
https://www.nasa.gov/mission_pages/webb/main/index.html

List 3 facts that you learned from the site:

_____

_____

2. Watch the construction of the James Webb Telescope:
https://www.yout-ube.com/watch?v=QNY6DPZNZII [3:35]

What impressed you the most about this engineering feat? Explain.

_____

_____

3. Explore the JWST photo albums to find the photos described in the article:
2022: https://www.flickr.com/photos/nasawebbtelescope/albums/72177720301006030
2023: https://www.flickr.com/photos/nasawebbtelescope/albums/72177720305127361

Which of these images do you find the most interesting? Why?

_____

_____

4. Learn more about Canada's role in the James Webb Space Telescope and its Near-Infrared Imager and Slitless Spectrograph (NIRISS):
https://www.asc-csa.gc.ca/eng/satellites/jwst/canada-role.asp
https://asc-csa.gc.ca/eng/search/video/watch.asp?v=1_zc7mdlng [1:32]

What three facts stand out to you as important? Why?

_____

_____

_____

5. Check out these lesson plans, activities, and programs, developed by NASA and the Canadian Space Agency, that relate to the James Webb Space Telescope:
https://jwst.nasa.gov/content/forEducators/formal.html
https://www.asc-csa.gc.ca/eng/youth-educators/

THE JAMES WEBB SPACE TELESCOPE – ONE YEAR IN

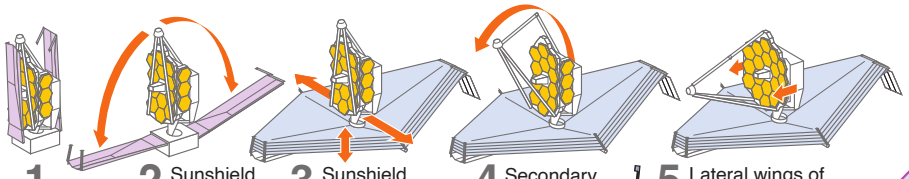
INFOGRAPHIC

James Webb Space Telescope

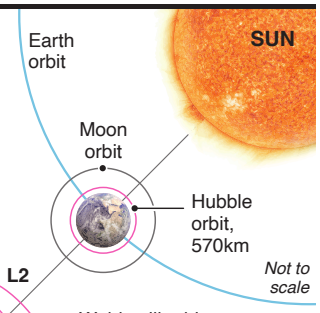
Conceived more than 30 years ago as the successor to the Hubble Space Telescope, Webb is the largest and most powerful observatory ever built. Once in orbit, it will allow astronomers to peer into the farthest reaches of the universe

Folding / unfolding

Too big to fit inside any rocket, Webb will be folded up for launch, and unfolded gradually over its first month in space



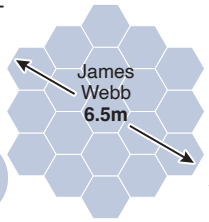
1 Folded
2 Sunshield structure unfolds
3 Sunshield layers extend and separate
4 Secondary mirror deployed
5 Lateral wings of primary mirror deployed



Secondary mirror: Reflects light from primary mirror into science instruments

Webb will orbit ***Lagrange point 2*** – spot 1.5 million km from Earth where gravitational pull from Earth and sun balance out – allowing observatory to remain in stable position

Primary mirror
Almost three times bigger than Hubble's. 18 gold-plated beryllium hexagons give much greater light-gathering capability



Sunshield
Five tennis court-sized layers block light from sun, moon and Earth to keep telescope at -223C, essential to see faint infrared light without interference

Integrated Science Instrument Module (ISIM): Houses four main instruments

Trim flap Helps stabilize satellite

Solar power array

Earth-pointing antenna

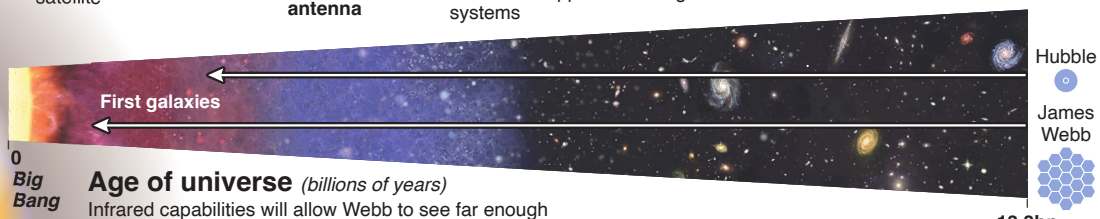
Spacecraft bus Control, power and other support systems

Star trackers Help to keep telescope pointed at target

Hubble
James Webb

Seeing infrared

Webb will focus on infrared range of electromagnetic spectrum, allowing it to observe objects too old and too distant for Hubble to see



Ariane 5 will launch from Europe's Kourou spaceport *in* French Guiana

Age of universe *(billions of years)*

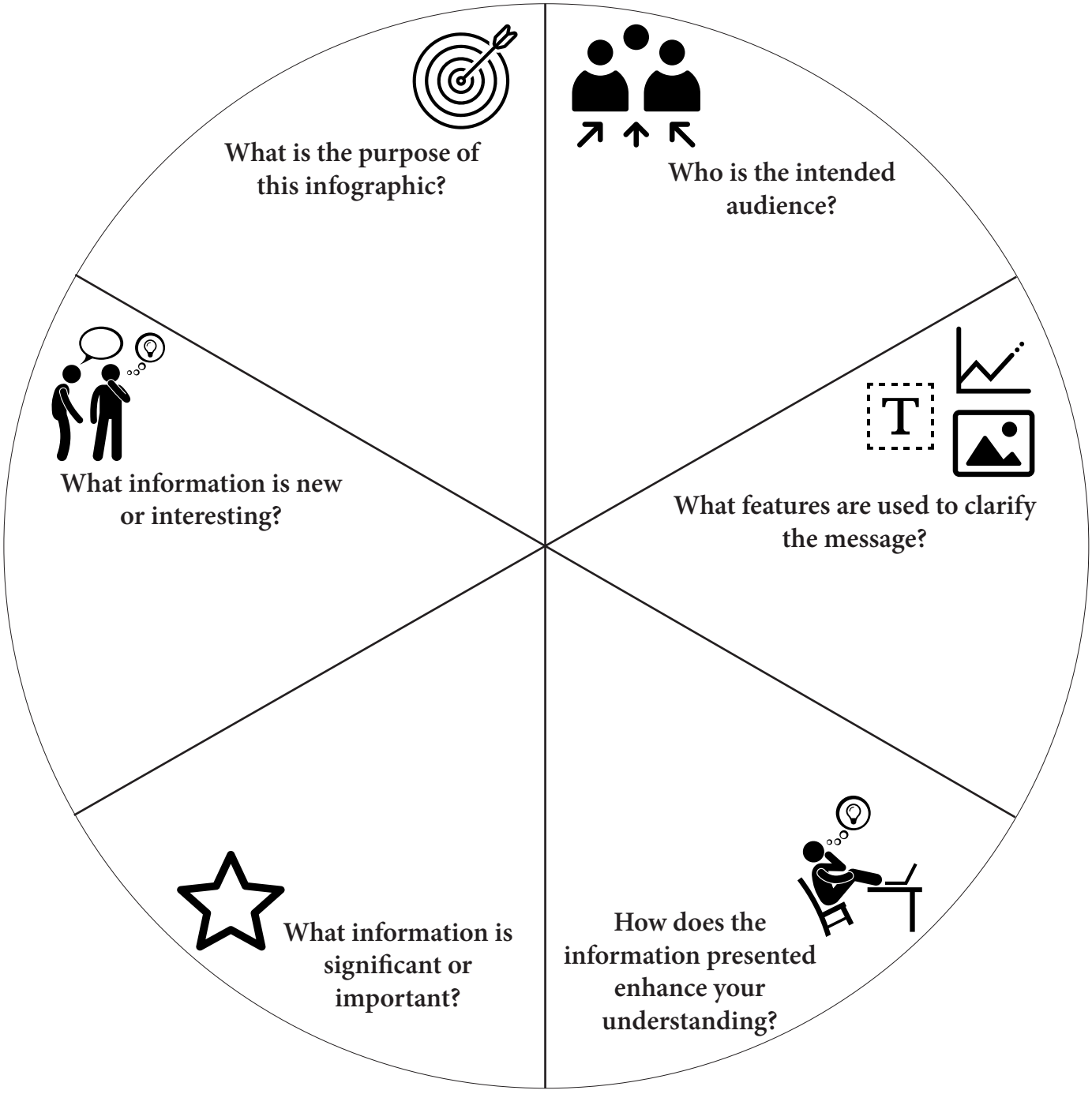
Infrared capabilities will allow Webb to see far enough to explore what universe looked like around 100 to 250 million years after Big Bang, when first stars and galaxies began to form

Sources: NASA, ESA, CSA

THE JAMES WEBB SPACE TELESCOPE

– One Year In

ANALYZING AN INFOGRAPHIC



What questions do you still have about the topic presented?

THE JAMES WEBB SPACE TELESCOPE – One Year In

PUTTING IT ALL TOGETHER

A. Write the letter that corresponds to the best answer on the line beside each question:

_____ 1. **The Big Bang is a scientific theory that explains how _____ was created.**
a) the Solar System b) a black hole
c) the Sun d) the Universe

_____ 2. **Which part of the James Webb Space Telescope is covered in a very thin layer of gold?**
a) the battery pack b) the antennas
c) the sunshield d) the main mirror

_____ 3. **The James Webb Space Telescope orbits:**
a) the Solar System b) Jupiter
c) the Sun d) the Earth

B. Mark the statements T (True) or F (False). If a statement is True, write one important fact to support it on the line below. If a statement is False, write the words that make it true on the line below.

_____ 4. **True** or **False?** A planet that exists outside of our Solar System is called a dwarf planet.

_____

_____ 5. **True** or **False?** The James Webb Space Telescope was built by three space agencies.

_____

_____ 6. **True** or **False?** The James Webb Space Telescope rotates as it travels through space.

_____

C. Fill in the blanks to complete each sentence.

7. A black _____ is a part of space with a very high gravitational field that is created when a star collapses.

8. An extremely large group of stars and planets is called a _____ .

9. NASA = National Aeronautics and _____ Agency.

D. Respond to the following question in paragraph form. ***(Use a separate sheet of paper if necessary.)***

10. As you see it, is the money spent on the JWST justified? Give reasons to support your response.

_____

_____

_____

_____

_____