



THE JAMES WEBB TELESCOPE

– LOOKING BACK TO THE BEGINNING



On Christmas Day, the **National Aeronautics and Space Administration** (NASA) launched the James Webb Space Telescope. It headed into the beyond from French Guiana in South America. It is the largest and most powerful space telescope ever constructed. It's the result of a \$10 billion collaboration between NASA, the European Space Agency (ESA), and the Canadian Space Agency (CSA). And it will change how we see the **Universe**.

Pause for a moment, and think. What's 'out there', beyond the Earth and our solar system? What galaxies are there to explore beyond the Milky Way? What is it like deep in the vastness of space where the most distant stars are? These stars are so far away that any faint signals of light that the telescope

may detect have been traveling through space for more than 13.5 billion years. If we can see these stars, we will be looking billions of years back in time to the beginnings of the Universe. We'll learn more about that mysterious period after the Big Bang. That's when the first stars formed and grouped together into galaxies.

Observing the Universe in its infancy might help us answer Big Questions. What are the origins of the Universe? Where do we come from? How did we come to be?

That's the promise of the Webb Space Telescope.

THE VIEW IN INFRARED

Webb is the long-awaited successor to the **Hubble Space Telescope**. Hubble worked

with the visible part of the light spectrum – the part we see with our eyes. Webb is tuned to the longer waves of infrared light.

These infrared wavelengths are where the glow from the most distant objects in the Universe will show up. That's because distant starlight gets stretched by the expansion of the Universe. By the time it arrives in our part of the Universe, it has shifted into the infrared region of the light spectrum. Hubble couldn't reach far enough into the infrared to detect distant starlight. But Webb will.

"We think there should be stars, or galaxies, or black holes maybe beginning at 100 million years after the Big Bang," says senior project scientist John Mather. "If they're there, and we're lucky... they'll be just little red specks."

DEFINITIONS

HUBBLE SPACE TELESCOPE: a telescope launched into low-Earth orbit in 1990 to provide information about the universe in the visible, infrared, and ultraviolet ranges

NASA: U.S. government agency responsible for space travel and research

UNIVERSE: everything in space: stars, planets, galaxies, etc.



The telescope's camera will also peer through gas and dust to see objects in the nearby Universe. It will study planets in our solar system and compare them with exoplanets orbiting other stars. It will probe their atmospheres and look for water. It will study starlight filtered through these atmospheres to learn about their chemical composition.

“We are poised on the edge of a truly exciting time of discovery,” said NASA's Thomas Zurbuchen.

THE ORBIT

The observatory will orbit the Sun about 1.5 million kilometres further out from the Sun than the Earth. It will orbit for a year and have access to the entire sky. Throughout this orbit, it will stay on the night side of the Earth. That's the side looking out into deep space.

As an infrared observatory, Webb must be protected from all bright, hot sources. Otherwise, it won't be able to see the faint heat signals of distant objects in the Universe. So it will unfurl a large sunshield. This diamond-shaped structure is about the size of a tennis court. It will block the Sun's heat and light from the telescope's heat-sensitive optics.

Meanwhile, the observatory on the side facing the Sun will be bathed in sunshine. It will generate power via a solar array.

AN ENGINEERING FEAT

Webb is so big, it couldn't fit into the nose cone of a launch rocket. Instead, it was folded up into a package the size of a school bus for transport into space. Once there, it unfurled like a butterfly.

Webb needs six months to set up before it can receive data and deliver its first images. That will be a harrowing time. Thousands of parts and sequences have to work together perfectly over a million kilometres away.

Webb is the most complex operation ever tried in space. How complex? Take focussing the mirror. At Webb's core is a 6.5 metre-wide primary mirror coated with a thin layer of gold. Eighteen mirror segments are hinged together, with motors that adjust their curvature. They must align to about 1/10,000th the thickness of a human hair.

“When we first focus on a star in space, we'll actually see 18 different spots of light,” says NASA's Begoña Vila. “Then we'll adjust the mirror to bring the spots together into a single star.”

Webb must also operate at an extremely low temperature – minus 233 degrees Celsius. Materials shrink as they get cold, so engineers had to build the Webb mirror to shrink to just the right dimensions in space.

Thousands of scientists, engineers, and technicians from

A UNIVERSE IS BORN

The Big Bang is the scientific theory that explains the origins of the Universe. This Big Bang wasn't an explosion. Scientists believe that from a single point – and in a fraction of a second – the Universe stretched and expanded massively. The Universe is still expanding, but at a much slower rate.

Among the many things we don't know are: What caused the Big Bang? How can something come from nothing? Was there anything there before?

Right after the Big Bang, the Universe was a dark place. It contained only hydrogen, helium, and some lithium. All other elements were created in the nuclear reactions that resulted in the first stars. That includes the carbon that makes up living things, the nitrogen in Earth's atmosphere, and silicon in rocks.

“It's absolutely amazing to me that we could observe that process,” says Rebecca Bowler, an astronomer on the Webb team.

14 countries worked decades to launch Webb. Now, they are watching with huge excitement.

“The promise of Webb is not what we know we will discover; it's what we don't yet understand or can't yet fathom about our Universe,” says NASA's Bill Nelson. “I can't wait to see what it uncovers.” ★



COMPREHENSION QUESTIONS

1. What is the **Universe**?

2. What is the name of the scientific theory that explains the origins of the Universe.?

3. Explain how scientists believe the Universe was created.

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

5. When and where was this telescope launched?

6. Explain how the telescope was packaged for its journey into space.

7. Explain where this telescope will be positioned in space.

8. What will the Webb telescope be able to detect that the Hubble Telescope could not? Explain.

9. What other tasks will the Webb telescope perform?



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QUESTIONS FOR FURTHER THOUGHT

1. The article tells us that the promise of the Webb Space Telescope is that it might help us answer questions such as: "What are the origins of the Universe? Where do we come from? How did we come to be?" As you see it, why is it important to learn the answers to these questions? Support your ideas with examples.

2. The article describes a number of technological and engineering marvels that have been incorporated into the James Webb Telescope. Which of these do you find the most interesting? What connections can you make between Webb's capabilities and more basic experiments that you may have performed in Science class? Explain.

3. Stephen Hawking, a theoretical physicist and author of *A Brief History of Time*, said, "**To confine our attention to terrestrial matters would be to limit the human spirit.**" What do you think he meant by this? Give examples to support your ideas.



SCIENCE, TECHNOLOGY, AND THE ENVIRONMENT

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QUESTIONS FOR ONLINE EXPLORATION

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

1. Watch the launch of the James Webb Telescope:

Full launch: <https://www.youtube.com/watch?v=7nT7JGZMbtM> [2:17:30]

Countdown and launch: <https://www.youtube.com/watch?v=9tXlqWldVVk> [1:25]

Launch animation: <https://www.youtube.com/watch?v=n9MxqFfBTzQ> [2:46]

2. Visit NASA's official James Webb Telescope site to learn more about the mission:

<https://jwst.nasa.gov/>

3. Watch the construction of the James Webb Telescope: <https://www.youtube.com/watch?v=-MVAm89KBfE> [4:21] What impressed you the most about this construction?

4. The JWST (James Webb Space Telescope) has its own YouTube channel. Learn more at this link:

https://www.youtube.com/channel/UCfi4_aCc2nEhtUMSGqaim_Q

5. “29 Days on the Edge” describes the key processes that the James Webb Telescope will need to complete in the first 29 days following its launch in order to be successful in its mission:

<https://www.youtube.com/watch?v=uUAvXYW5bmI> [8:02]

6. Watch the James Webb Telescope Mirror Movement Tracker streaming live:

<https://www.youtube.com/watch?v=SN74VERcd2M>

7. Watch an animation of Webb’s orbit: <https://www.youtube.com/watch?v=524fcGyki5c> [2:00]

8. Find out more about how the James Webb and Hubble Space telescopes compare:

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

<https://www.asc-csa.gc.ca/eng/satellites/jwst/webb-hubble-successor.asp>

Identify 3 key differences in their capabilities.



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INFOGRAPHIC

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**

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

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

Secondary mirror: Reflects light from primary mirror into science instruments

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

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

Star trackers
Help to keep telescope pointed at target

Spacecraft bus
Control, power and other support systems

Earth-pointing antenna

Solar power array

Trim flap
Helps stabilize satellite

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

Earth orbit
Moon orbit
Hubble orbit, 570km
L2
SUN

Not to scale

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

0 Big Bang
13.8bn Today

First galaxies

Radio waves
Infrared
Visible
Ultraviolet
X-rays

Hubble
James Webb

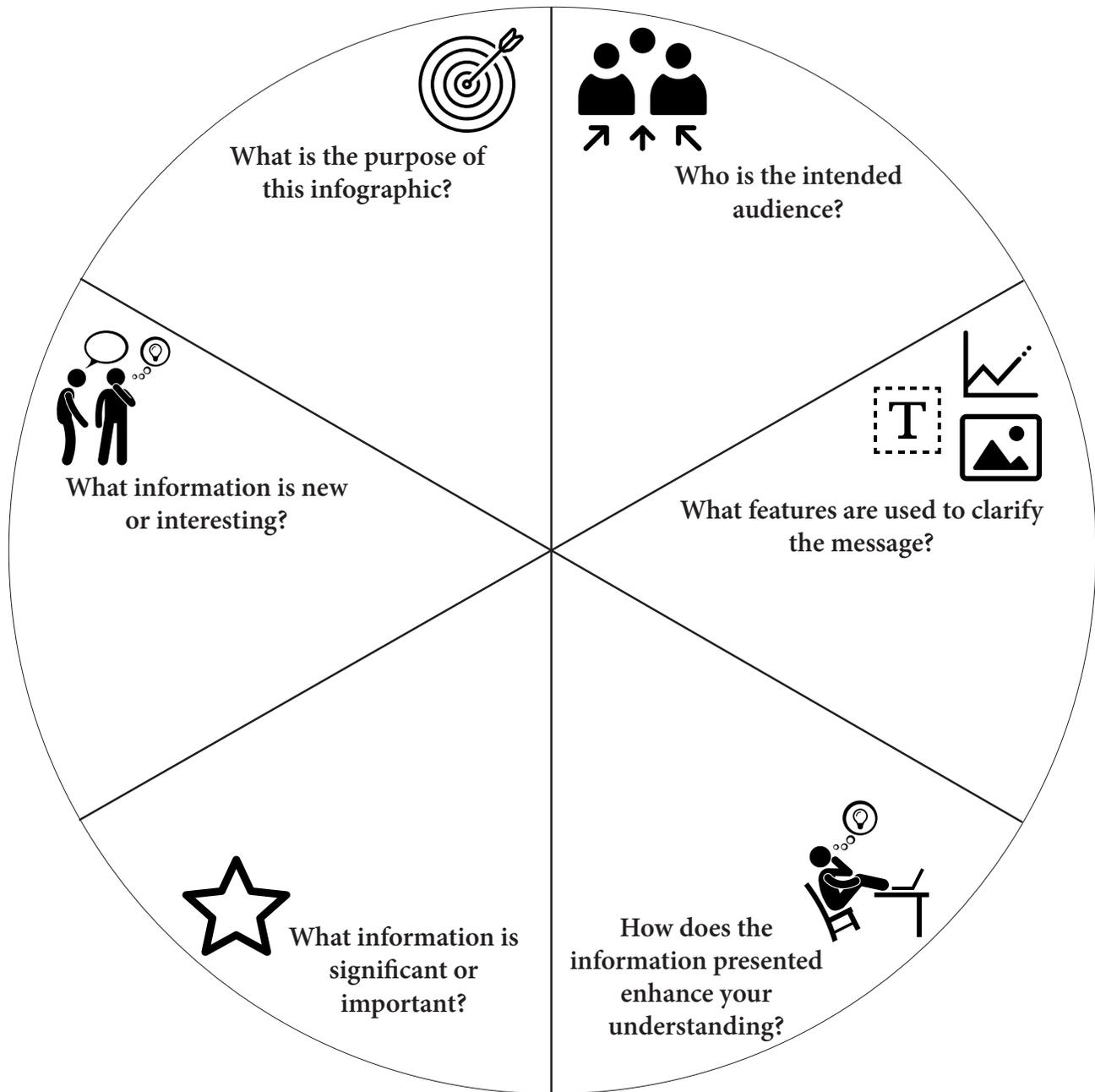
Ariane 5 will launch from Europe's Kourou spaceport in French Guiana

Sources: NASA, ESA, CSA

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ANALYZING AN INFOGRAPHIC



What questions do you still have about the topic presented?



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 the origins of:**

- a) the Milky Way Galaxy
- b) the Universe
- c) the solar system
- d) black holes

_____ 2. **The James Webb Telescope can see:**

- a) infrared waves
- b) microwaves
- c) electromagnetic waves
- d) X rays

_____ 3. **The James Webb Telescope will orbit:**

- a) the Earth
- b) Neptune
- c) the Moon
- d) the Sun

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?** Early on, the Universe only contained hydrogen, helium, and lithium.

_____ 5. **True or False?** The Webb Telescope is an international project between six space agencies.

_____ 6. **True or False?** The Webb Telescope will orbit near the sun and operate at a hot temperature.

C. Fill in the blanks to complete each sentence.

7. The Universe is still _____ .

8. NASA = National Aeronautics and _____ Administration

9. The James Webb Telescope was launched from _____ Guiana in South America.

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

10. *What do you hope that the James Webb Telescope mission will discover?* Give reasons to support your response.

