



## Risk and Reward: The James Webb Telescope By Beth Frede



(Source: <https://sciences.ncsu.edu/news/james-webb-space-telescope-qa-with-astrophysicist-bordoloi/>)

On December 25, 2021, the JAMES WEBB SPACE TELESCOPE was launched from Europe's Spaceport in FRENCH GUIANA, South America. After decades of work, billions of dollars, and numerous delays, JWST, or Webb as it's also called, became the largest space OBSERVATORY (a structure housing an astronomical telescope or other scientific equipment) that was ever created and successfully launched. As a result of this FEAT (achievement), on July 12, 2022, the world was able to see farther into the universe than ever before.... But it almost didn't happen.

**SPELL:** LAUNCHED                      FEAT                      UNIVERSE

What is the name of the space telescope we're talking about today?

JAMES WEBB

The James Webb Space Telescope was launched from a spaceport in \_\_\_\_\_, South America. FRENCH GUIANA

Sometimes the James Webb Space Telescope is referred to as Webb or \_\_\_\_\_. JWST

JWST is the largest (what) that was ever created and successfully launched. SPACE OBSERVATORY

The word feat means? ACHIEVEMENT

A space observatory is a structure that houses what? ASTRONOMICAL TELESCOPE; OTHER SCIENTIFIC EQUIPMENT

What's another word for feat or achievement? ACCOMPLISHMENT, TRIUMPH, etc.

What is something that either gives you or would give you, a feeling of accomplishment?



Emerging stellar nurseries and individual stars in the Carina Nebula taken from NASA's James Webb Space Telescope.

<https://www.nasa.gov>

The NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, or NASA, began planning for Webb even before its PREDECESSOR (forerunner) the HUBBLE SPACE TELESCOPE was launched in 1990. Getting a large operational ASTRONOMY lab into space is no easy task, and Webb was going to be bigger than anything humans had ever sent into space before. Now completed, JWST is about the size of a tennis court!

**SPELL:** PREDECESSOR      ASTRONOMY      ADMINISTRATION

What is the name of the space telescope that came before Webb that was mentioned in the lesson? HUBBLE

NASA stands for the National \_\_\_\_\_ and Space Administration.

AERONAUTICS

James Webb Space Telescope is the size of a \_\_\_\_\_? TENNIS COURT

In what year was Hubble launched? 1990

When did Webb launch? 2021

How many years after Hubble's launch was Webb's? Please show your work.  $2021 - 1990 = 31$  YEARS

What are two words that rhyme with Hubble? BUBBLE, DOUBLE, RUBBLE, STUBBLE, TROUBLE

Name another sport that's played on a court. BASKETBALL, BADMINTON, SQUASH, PICKLEBALL

Initial designs for Webb began in 1996 with a projected BUDGET of one billion dollars. The original goal was for Webb to launch in 2007. But the project was more difficult than expected. Many UNANTICIPATED costs and technical delays led scientists, engineers, and the media to wonder if JWST would ever come to FRUITION (completion).

SPELL: BUDGET                      FRUITION                      INITIAL  
Scientists, engineers, and \_\_\_\_ \_\_\_\_ wondered if JWST would come to fruition. THE MEDIA

When did engineers begin designing Webb? 1996

The original goal was to launch Webb in what year? 2007

If Webb was started in 1996 and finished in 2007, write an equation to show how many years the project took.

$2007 - 1996 = 11$  YEARS

What is one reason the Webb project was harder than expected?  
UNANTICIPATED COSTS, TECHNICAL DELAYS

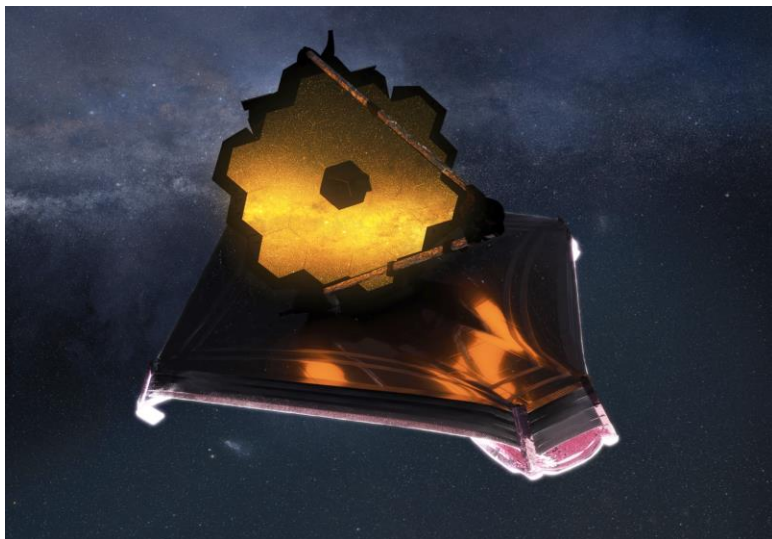


Illustration of James Webb Telescope fully deployed. Credits: NASA/Adriana Manrique Gutierrez

Scientists and engineers designed Webb to help us see objects in space that were too old, too far, or too dim for the Hubble Space Telescope to capture. This would require constructing the largest OPTICAL TELESCOPE ever built for space. An optical telescope uses a mirror to gather and focus light to create magnified images or collect data. Webb's telescope mirror would have to be massive: over 21 feet high, as compared to Hubble's 8-foot mirror. But the enormous mirror would give Webb a field view 15 times larger than Hubble's!

**SPELL:** MIRROR                      MAGNIFIED                      FIELD

What uses a mirror to gather and focus light to create magnified images?  
AN OPTICAL TELESCOPE

An optical telescope creates magnified images or does what? COLLECTS DATA

Webb's telescope needed a massive mirror that is over how many feet tall?  
21 FEET

How much taller is Webb's mirror than Hubble's?  $21 - 8 = 13$  FEET

How tall in feet would you be if the height of Webb's telescope mirror equaled three of you?  $21 \div 3 = 7$  FEET

The Webb Telescope's field view is how many times larger than Hubble's?  
15 TIMES

Scientists wanted Webb to help them see objects that were too \_\_\_\_\_ for Hubble to capture. OLD, FAR, DIM

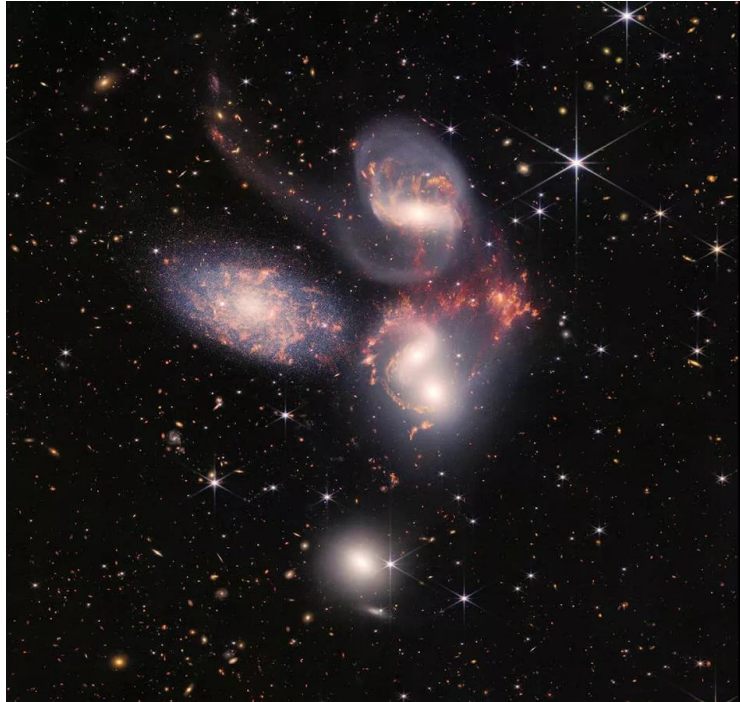
What is an antonym for "enormous"? WEE, MINISCULE, etc.

Besides a telescope, name another device people use to see things more clearly. GLASSES, MICROSCOPE, BINOCULARS, etc.

VAKT: Stephan's Quintet is a compact grouping of five galaxies, pictured below. Point to each of the five galaxies in the image. (Note- there are two galaxies very close together in the middle of the quintet.)

Image of Stephan's Quintet taken by James Webb Space Telescope

<https://www.space.com/stephans-quintet-its-a-wonderful-life>



Another issue for NASA engineers was where to place the Webb Telescope so it would work properly. The goal was for Webb to allow mankind to see events in space that took place as long ago as possible in order to learn more about the universe and its beginnings. Scientists do this by observing light and gasses left behind from COSMIC EVENTS, even those that occurred millions or billions of years ago. Webb needed to be located somewhere extremely cold to protect its UNIQUE data and image-capturing TECHNOLOGY.

**SPELL:** EXTREMELY      MANKIND      OCCURRED

How many zeros are in one million? 6 ZEROS

How many zeros are in one billion? 9 ZEROS

To look back in space and learn more about the universe and its start, scientists observe light and gasses left behind from what? COSMIC EVENTS

To look back in space and learn more about the universe and its start, scientists observe what two things? LIGHT, GASSES

Webb uses INFRARED light to capture images that would allow us to see farther and more clearly into space than ever before. The infrared WAVELENGTHS are longer than visible light and can pierce through all but

the densest areas of dust. However, infrared images are SUSCEPTIBLE to being distorted by the slightest heat. So, scientists concluded that to keep it sufficiently cool, they would build the telescope a giant SUNSHIELD, and send Webb a million miles from Earth where the temperature would be a frigid -370° FAHRENHEIT. Brrrrrrrr!

**SPELL:** SUSCEPTIBLE                      SUFFICIENTLY                      CONCLUDED  
Infrared \_\_\_ are longer than those of visible light and let us see farther into space than ever before.

**WAVELENGTHS**

Infrared light can pierce through all but the densest areas of what? DUST  
We said that the Webb telescope needs to be somewhere extremely cold.  
What was that temperature?

-370 DEGREES FAHRENHEIT

What are two things that scientists decided to do to prevent the Webb telescope's images from being distorted? BUILD A SUNSHIELD; SEND WEBB A MILLION MILES FROM EARTH, etc.

What is the other commonly used temperature scale that's associated with the metric system? CELSIUS

VAKT: cross your arms over your chest, rub your arms, lift your shoulders, and make a face as if you were very cold.

VAKT: Trace the wavelengths below with your finger or a pencil.

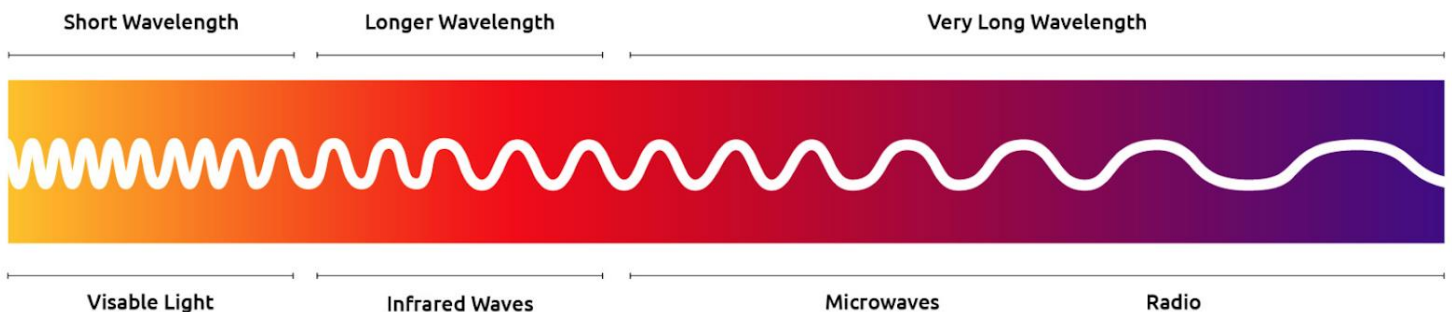


Image from <https://www.suryaheating.co.uk/what-is-infrared/>

Creating Webb's ENORMOUS mirror and sunshield was one challenge.... Sending them into space was another. There was no rocket big enough to take them into outer space fully ASSEMBLED. Instead, the sunshield would be folded up, the mirror would be divided into HEXAGONAL sections and stacked in special canisters to be sent to their location. Then these parts

would have to reassemble themselves in outer space... perfectly.... The first time they DEPLOYED (moved into position)!

**SPELL:** CANISTER                      ASSEMBLED                      DEPLOYED

There was no \_\_\_ big enough to take the mirror and sunshield into space fully assembled? ROCKET

What shaped sections would the mirror be divided into? HEXAGONAL

Name is a synonym for enormous. HUGE, TREMENDOUS

**VAKT:** Shape a lump of playdough or clay into a hexagon. Use the one at the end of the lesson as a guideline or make your own. OR draw a hexagon within the hexagon. Draw another inside of that hexagon. Continue to draw as many within the first one as you can.



Test of the sunshield. Photo by By Chris Gunn - NASA Goddard Space Flight Center

If Webb MALFUNCTIONED in space, it would be impossible to repair since it would be stationed a million miles from Earth. So, the engineers and scientists at NASA had to make sure that every measurement was right, and that everything was tested and retested multiple times to ENSURE (make certain) that it would all work correctly, in SEQUENCE (order) once Webb was launched.

**SPELL:** SEQUENCE                      MULTIPLE                      STATIONED

The word in the lesson that means “to make certain” is? ENSURE

Since Webb would be stationed a million miles from Earth, it would be impossible to repair if it did what out in space? MALFUNCTIONED

Who at NASA had to make sure every measurement was right?

ENGINEERS, SCIENTISTS

VAKT: Watch the Webb's deployment sequence here:

<https://en.wikipedia.org/wiki/File:James-Webb-Space-Telescope-Deployment-Sequence-Nominal.webm>

Testing, adjusting, and retesting Webb took years longer and even more money than was expected. Each time NASA asked for a budget increase, the U.S. CONGRESS had to approve it. In 2011, the project came close to being shut down. Some senators and state representatives were so frustrated with Webb's ever-increasing BOTTOM LINE (final cost) that they wrote a bill to propose no longer funding the project.

SPELL: SENATOR APPROVE ADJUSTING

Who had to approve NASA's budget increases? CONGRESS

In what year did the Webb project come close to being shut down? 2011

How many years ago was 2011?  $2023 - 2011 = 12$  YEARS

What is another phrase that means final cost? BOTTOM LINE

What piece of legislation did the frustrated senators and state reps write to propose shutting down the Webb project? BILL

Who was frustrated with Webb's increasing bottom line? SENATORS, STATE REPRESENTATIVES

Name another type of legislation. LAW, RESOLUTION

Meanwhile, PROPONENTS (advocates) of the Webb Telescope fiercely defended it, CITING (recognizing) the years of work and resources that had already gone into it. They were PASSIONATE about the new information and inspiration that a successful Webb space station could provide.

SPELL: CITING PASSIONATE ADVOCATE

Another word for an advocate is? PROPONENT

The word that means "citing" is? RECOGNIZING

Those who advocated for Webb were passionate about the information and \_\_\_ that Webb could provide. INSPIRATION



Proponents of Webb fiercely defended it because of all that had been invested in the project already. Name one of the things that was mentioned in the text. YEARS OF WORK, RESOURCES

What is something that inspires you?

Ultimately, the science COMMUNITY won, and Congress agreed to continue funding the project. In 2021, Webb successfully launched, and its EQUIPMENT deployed nearly perfectly. Today we have the most detailed photos of outer space ever taken, including images of a galaxy from so far away that its light took 13 billion years to reach us. To give you an idea of how old that galaxy is scientists estimate that our UNIVERSE is 13.8 billion years old!

SPELL: EQUIPMENT                      COMMUNITY                      UNIVERSE  
How old do scientists estimate our universe is? 13.8 BILLION YEARS OLD

Ultimately, who won Congress's approval to continue funding Webb?

SCIENCE COMMUNITY; SCIENTISTS

What is an antonym for "perfect"? IMPERFECT, FLAWED, etc.

VAKT: Which number represents 13.8 billion? Point to it.

**138,000,000**

**13,800,000,000**

**138,000,000,000**

While there have been 12 space stations launched since 1971, no other has delivered such sharp images and PENETRATIVE (insightful) data from so deep into the universe. NASA Administrator BILL NELSON summed up what he feels is Webb's biggest gift to astronomers and space enthusiasts alike. "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. I can't wait to see what it uncovers!"

SPELL: ENTHUSIAST                      FATHOM                      INSIGHTFUL

What word means insightful? PENETRATIVE

Who is the NASA Administrator quoted in the lesson? BILL NELSON

How many space stations have been launched since 1971? 12

Bill Nelson says that discovering what we don't yet understand or can't fathom is Webb's biggest gift to whom? ASTRONOMERS, SPACE ENTHUSIASTS

How do you think learning about outer space could help people here on Earth?

In the end, the James Webb Space Telescope cost \$10 billion and took 25 years from design to launch. Do you think the resources invested in Webb were worth it? Briefly explain.

Imagine that scientists come up with a way to remove all of the pollution from Earth's air, water, and land, contain it in a giant bubble, and send it off into space. They claim it's safe, but the technology is unproven. Should we do it? Why or why not?



Images of the "Pillars of Creation" from Hubble (left) and Webb (right). <https://bigthink.com/starts-with-a-bang/jwst-first-science-images/>

*Beth Frede is an S2C Practitioner based in New Hampshire where she lives with her husband and dog. She loves painting, putting in the kitchen, and learning about new things while writing lessons.*

## RESOURCES:

[https://www.nytimes.com/2022/07/15/podcasts/the-daily/webb.html?action=click&module=audio-series-](https://www.nytimes.com/2022/07/15/podcasts/the-daily/webb.html?action=click&module=audio-series-bar&region=header&pgtype=Article)

[bar&region=header&pgtype=Article](https://www.nytimes.com/2022/07/15/podcasts/the-daily/webb.html?action=click&module=audio-series-bar&region=header&pgtype=Article)

[https://www.nytimes.com/2022/07/15/podcasts/the-daily/webb.html?action=click&module=audio-series-](https://www.nytimes.com/2022/07/15/podcasts/the-daily/webb.html?action=click&module=audio-series-bar&region=header&pgtype=Article)

[bar&region=header&pgtype=Article](https://www.nytimes.com/2022/07/15/podcasts/the-daily/webb.html?action=click&module=audio-series-bar&region=header&pgtype=Article)

<https://webb.nasa.gov/content/news/index.html#archives>

<https://www.nasa.gov/image-feature/goddard/2022/nasa-s-webb-reveals-cosmic-cliffs-glittering-landscape-of-star-birth>

<https://webb.nasa.gov/content/about/faqs/facts.html>

[https://en.wikipedia.org/wiki/Timeline\\_of\\_the\\_James\\_Webb\\_Space\\_Telescope](https://en.wikipedia.org/wiki/Timeline_of_the_James_Webb_Space_Telescope)

[https://en.wikipedia.org/wiki/James\\_Webb\\_Space\\_Telescope](https://en.wikipedia.org/wiki/James_Webb_Space_Telescope)

<https://www.azooptics.com/Article.aspx?ArticleID=81>

[https://www.washingtonpost.com/national/health-science/budget-fight-rages-over-james-webb-space-](https://www.washingtonpost.com/national/health-science/budget-fight-rages-over-james-webb-space-telescope/2011/10/13/gIQALjYLM_story.html)

[telescope/2011/10/13/gIQALjYLM\\_story.html](https://www.washingtonpost.com/national/health-science/budget-fight-rages-over-james-webb-space-telescope/2011/10/13/gIQALjYLM_story.html)

<https://www.theguardian.com/science/blog/2011/jul/11/james-webb-space-telescope>

<https://www.science.org/content/article/congress-keep-funding-nasas-webb-telescope>

<https://en.wikipedia.org/wiki/File:James-Webb-Space-Telescope-Deployment-Sequence-Nominal.webm>

[https://en.wikipedia.org/wiki/James\\_Webb\\_Space\\_Telescope#/media/File:James\\_Webb\\_telescope\\_sunshield.jpg](https://en.wikipedia.org/wiki/James_Webb_Space_Telescope#/media/File:James_Webb_telescope_sunshield.jpg)

<https://bigthink.com/starts-with-a-bang/jwst-first-science-images/>

<https://www.space.com/stephans-quintet-its-a-wonderful-life>