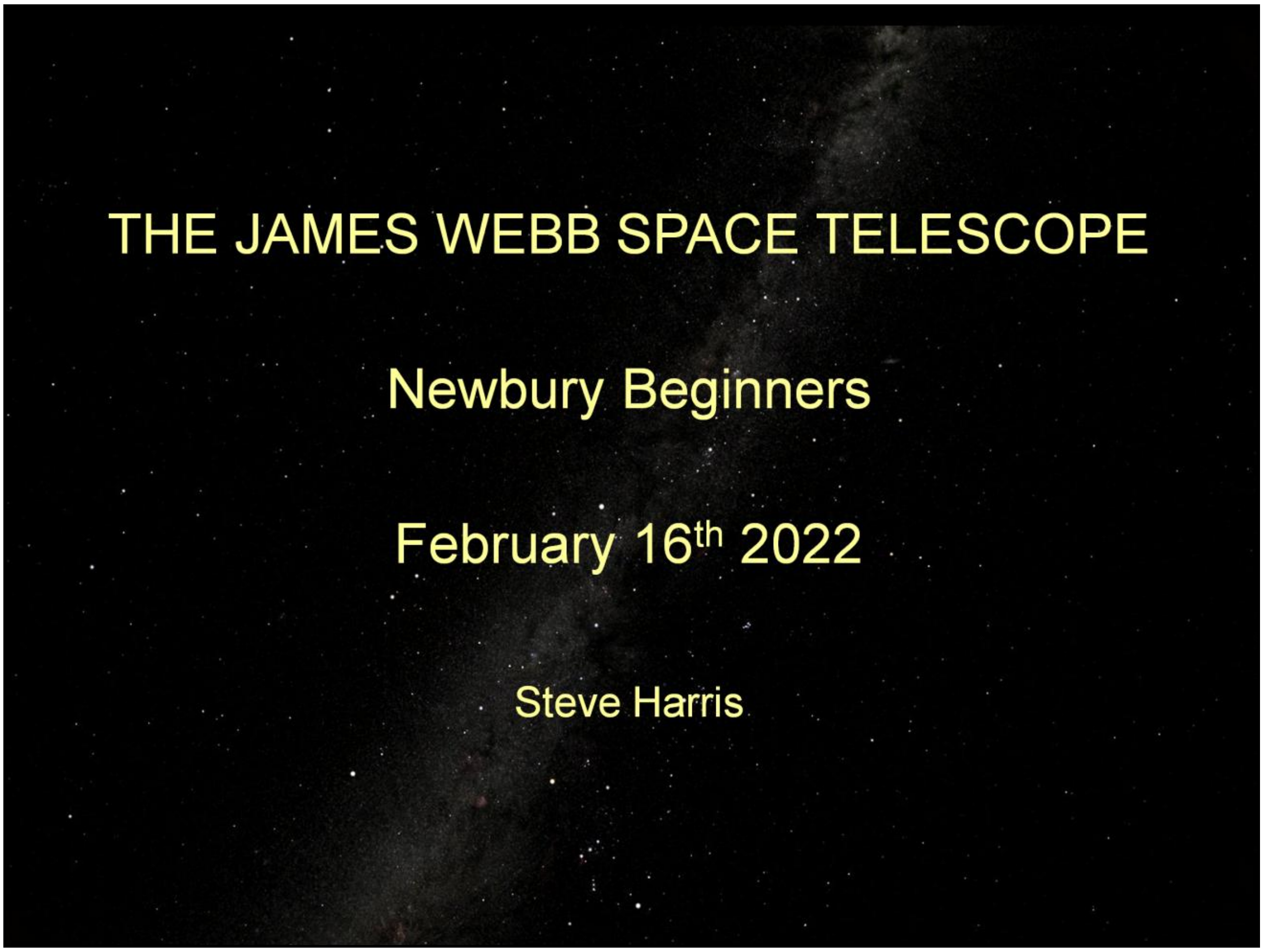
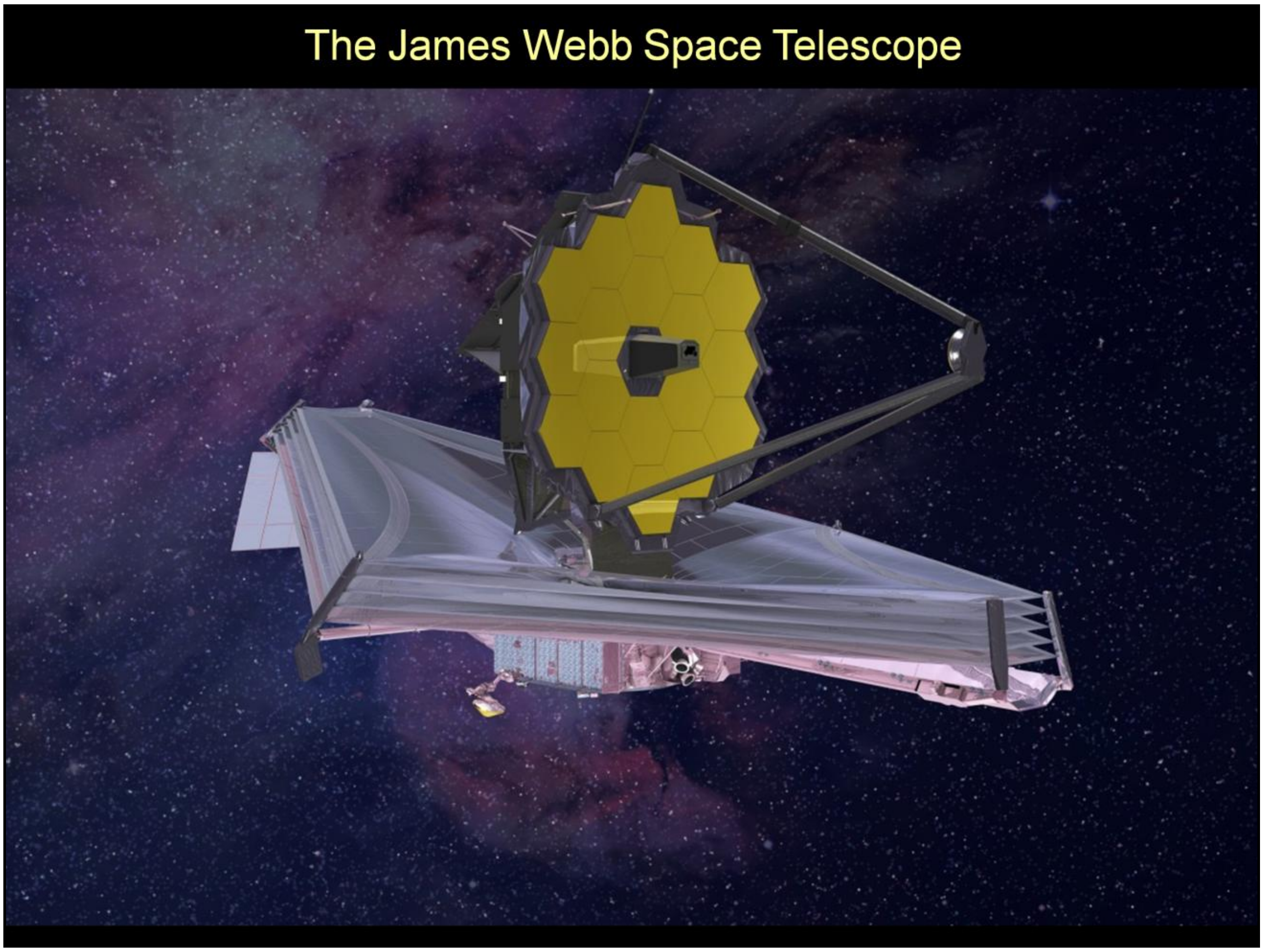

THE JAMES WEBB SPACE TELESCOPE
Newbury Beginners
February 16th 2022
Steve Harris




NASA's James Webb Space Telescope or JWST was launched on an Arianespace's Ariane 5 rocket on Saturday 25th December 2021.

It was lanched from the ELA-3 Launch Zone of Europe's Spaceport at the Guiana Space Centre in Kourou, French Guiana.

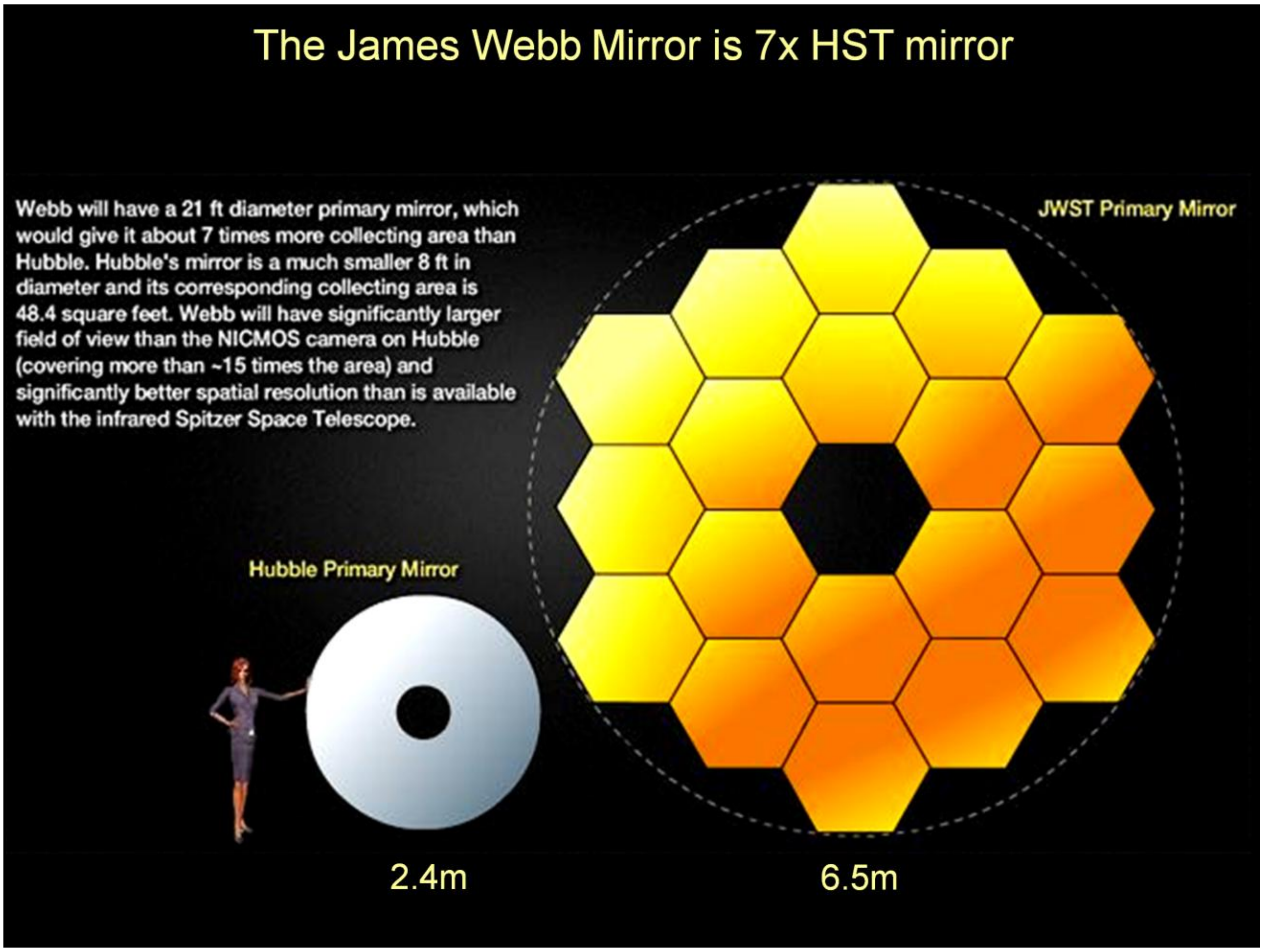
JWST is an infrared telescope with a 6.5 metre primary mirror.

The observatory will study every phase of cosmic history from within our solar system to the most distant observable galaxies in the early universe.

The James Webb Telescope is NASA's largest and most powerful space science telescope ever constructed.

JWST's enormous size and frigid operating temperature presented extraordinary engineering challenges.

After launching from French Guiana, the observatory will travel to an orbit about one million miles away from Earth and undergo six months of commissioning in space.



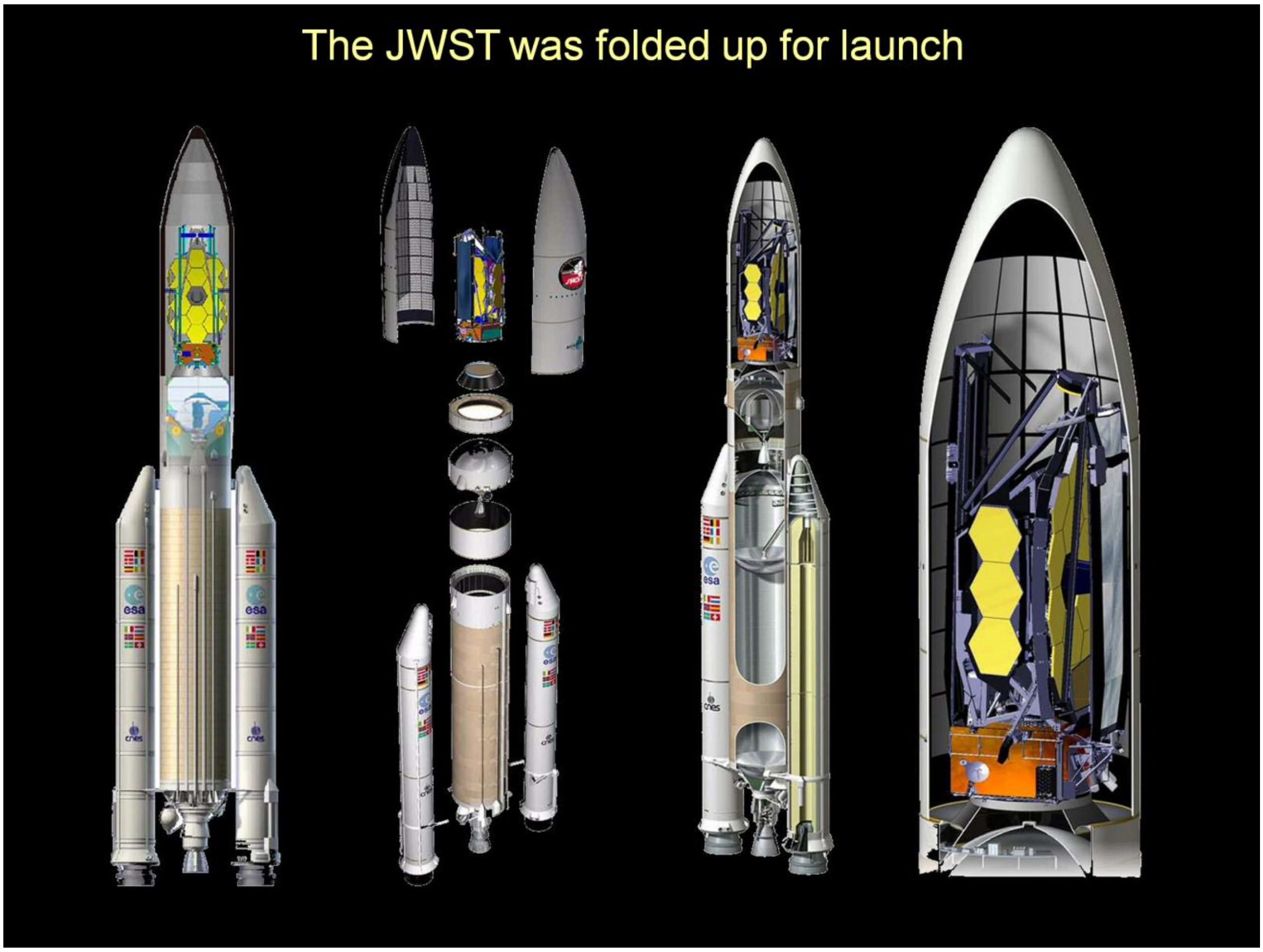

The diagram above shows the comparison of the HST and JWST main mirrors.

The main improvements over the HST are the increased telescope aperture and the ability to detect infrared light.

With a mirror almost three times wider, JWST will be able to see objects almost ten times fainter than HST allowing us to see objects ten times fainter.

This in conjunction with the ability to detect light further into the infrared.

Scientists will be able to peer even further to see the very first stars and galaxies as they were 13.6 billion years ago or just 200 million years after the Big Bang.



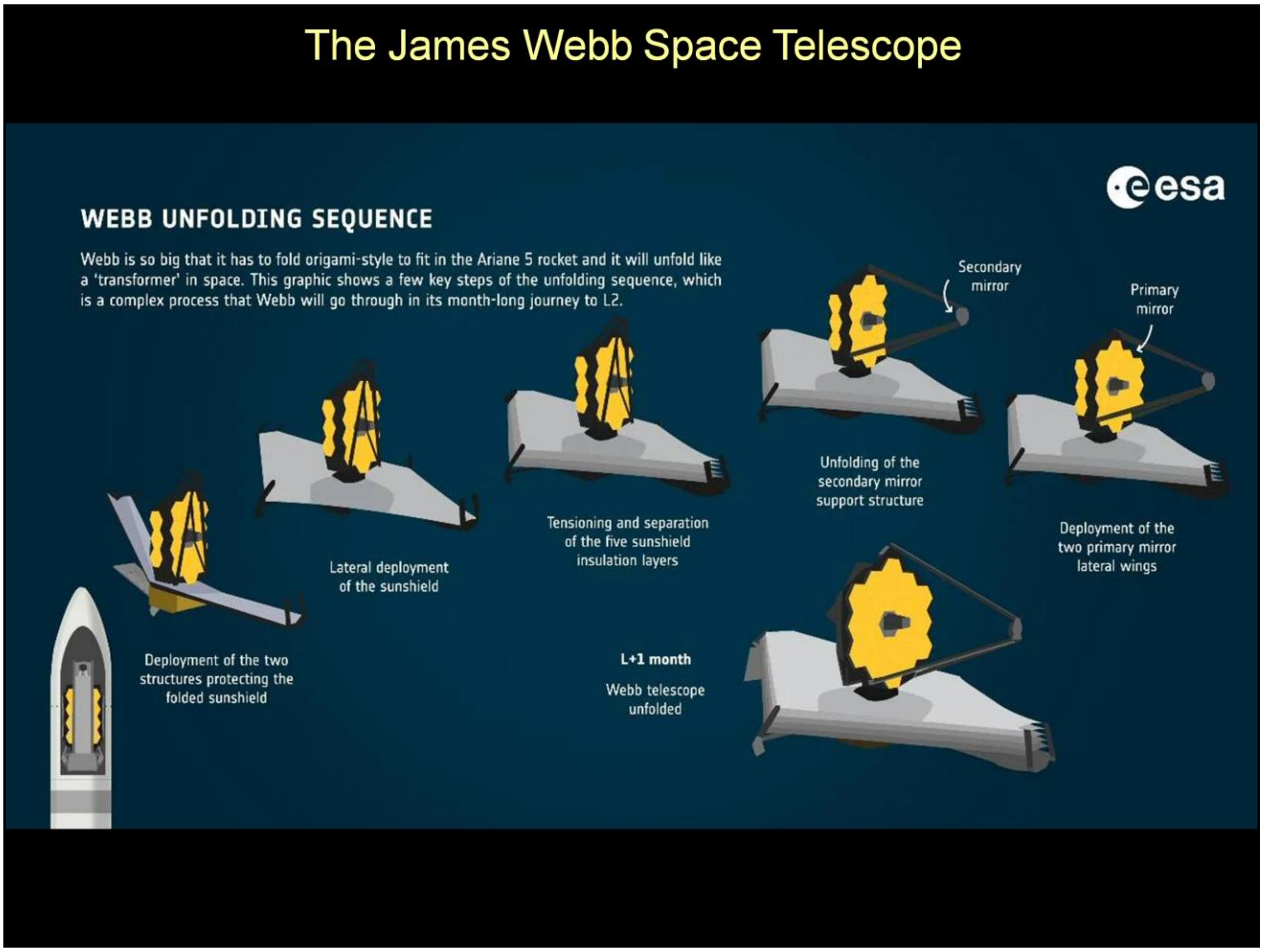

The JWST mirror is made as eighteen hexagon shaped segments that were folded to fit into the Ariane 5 rocket that carried it into space.

One of the most noticeable features of the JWST is the enormous and complicated heat shield that will protect the telescope from unwanted heat.

The detectors for observing in inferred must be kept very cold because these rays are what we recognise as radiated heat.

To enable these rays to be studied any other sources of heat must be kept away from the telescope.

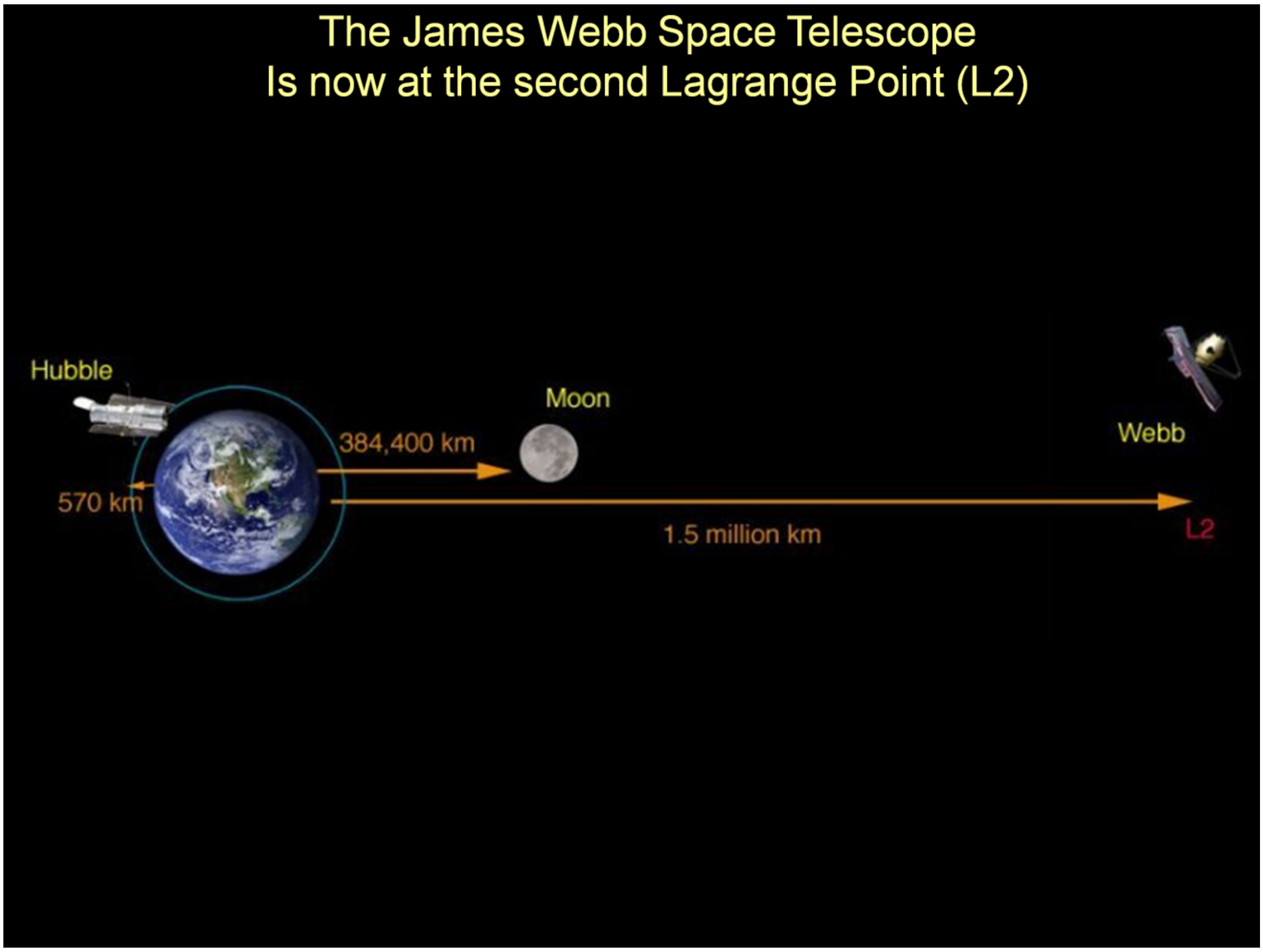
The Heat Shield was folded to fit into the rocket it had to be folded up then assembled during it journey through space to its observing location.




Once the folded up Telescope assembly had separated from its launch vehicle it started to prepare itself for its mission.

It started its mission by unfolding its mirrors and sunshield.

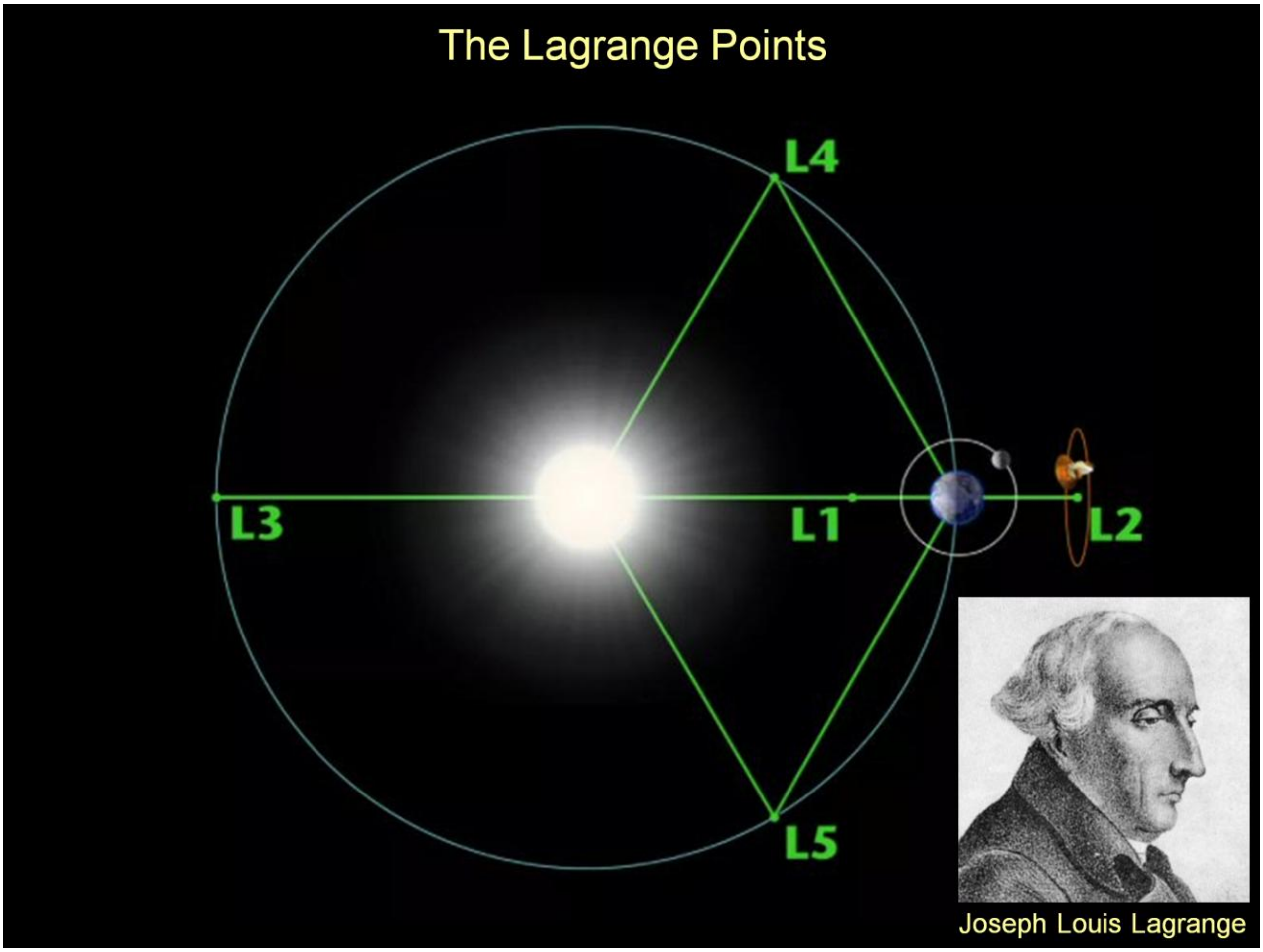
It then initiated other smaller systems such as cooling system; aligning; and calibrating systems.




The JWST will be located near the second Lagrange point (L2) of the Earth-Sun system which is 1,500,000 km (930,000 miles) from Earth, directly opposite to the Sun.

Normally an object circling the Sun further out than Earth would take longer than one year to complete its orbit.

Near the L2 point the combined gravitational pull of the Earth and the Sun allow a spacecraft to orbit the Sun in the same time it takes Earth to orbit the Sun.



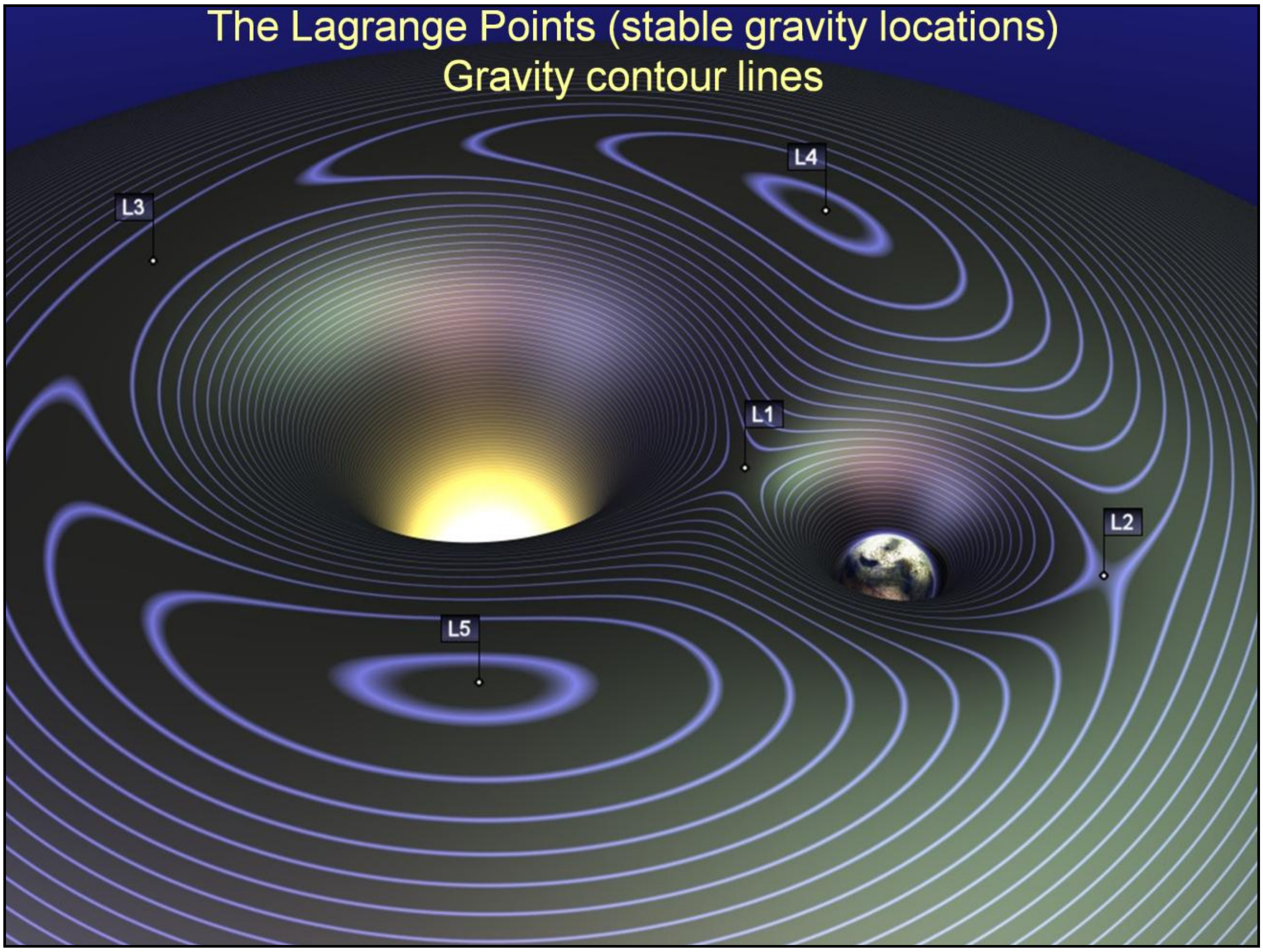

The telescope will circle around the L2 point in a halo orbit which will be inclined with respect to the ecliptic.

It will have an orbital radius (around L2) of approximately 800,000 km and take about half a year to complete.

The JWST will loop around the L2 point as shown in the diagram above.

This looping around the L2 point helps the telescope maintain its stable position as it effectively orbits the Sun with the assistance of Earth.

Unfortunately JWST cannot hide in Earth’s shadow because it needs to remain in sunshine to provide power through its Solar Panel Array.



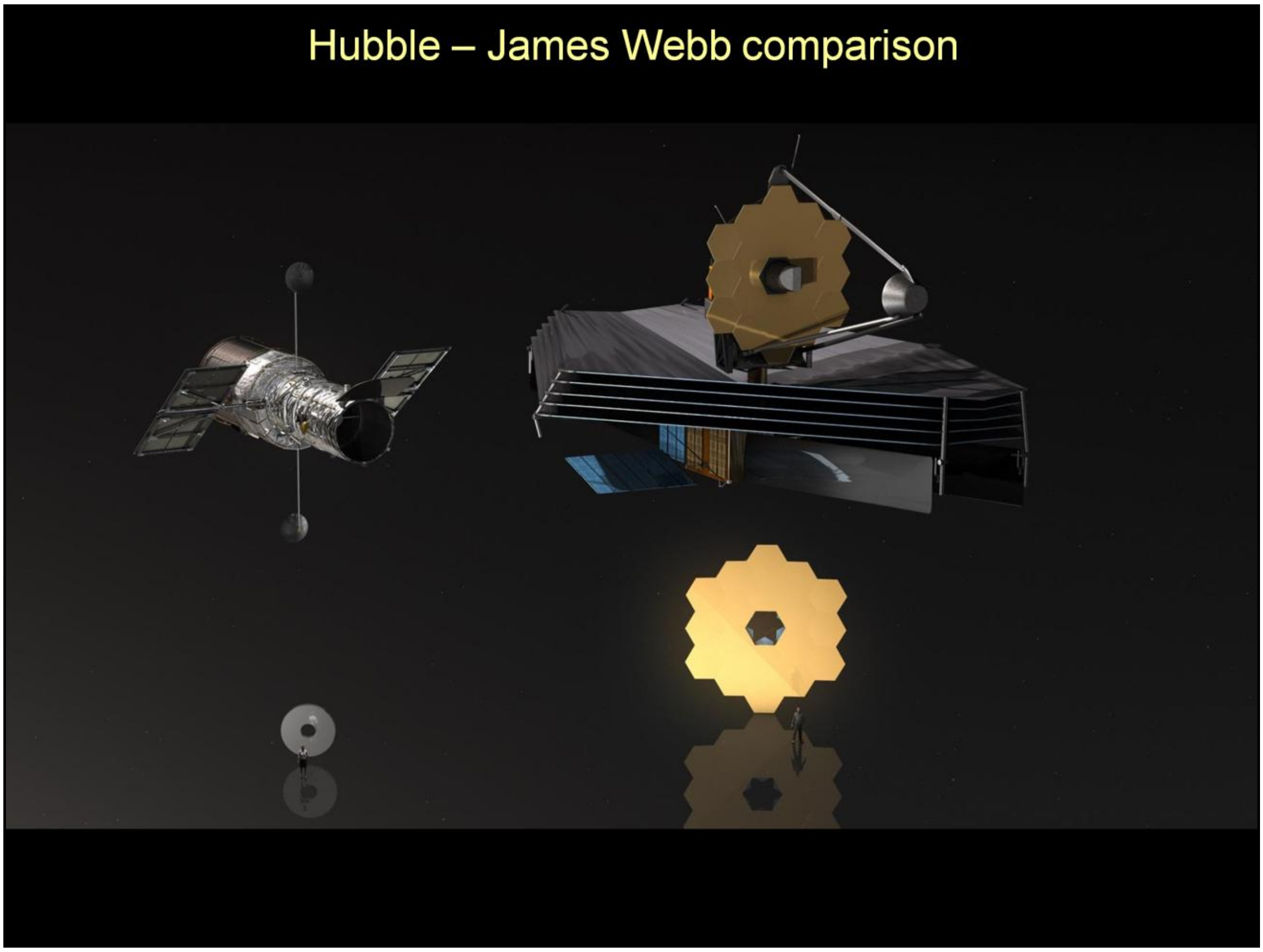

As L2 is just an equilibrium point with no gravitational pull, a halo orbit at L2 is not an orbit in the usual sense.

The spacecraft is actually in orbit around the Sun and the halo orbit can be thought of as controlled drifting to remain in the vicinity of the L2 point.

This requires some station-keeping: around 2–4 m/s per year from the total budget of 150 m/s.

Two sets of thrusters on the JWST constitute the observatory's propulsion and manoeuvring system.

So the JWST will effectively be dragged around the Sun by Earth.

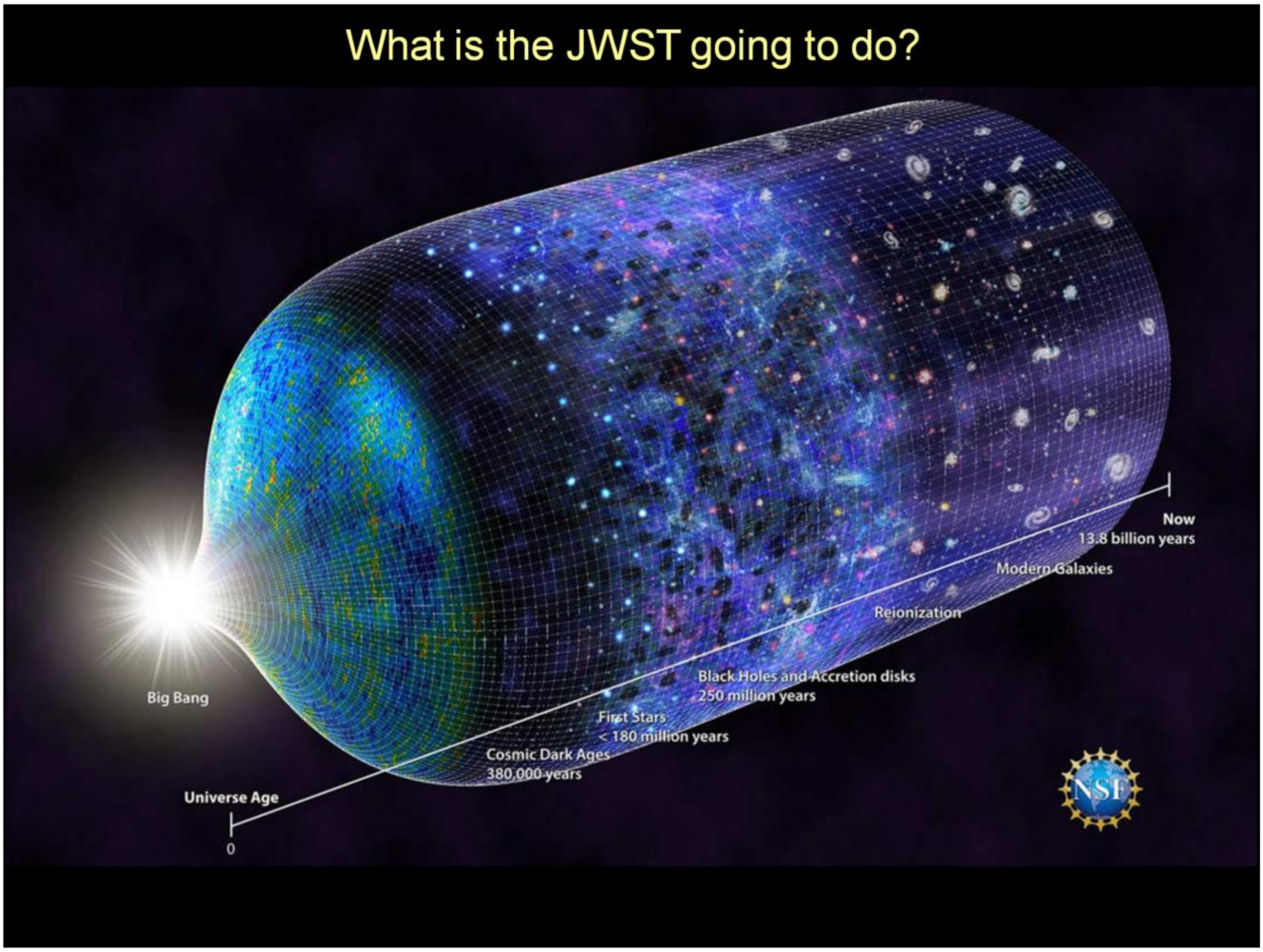



With a mirror that is almost three times the aperture (diameter) of Hubble the JWST will have nearly 10 times the light grasp.

JWST will be able to see objects almost ten times fainter than HST.

The mirror is coated with pure Gold to improve its ability to reflect infrared light.

This is in conjunction with the ability to detect light further into the infrared wave lengths.




The diagram above shows how the Universe developed after the Big Bang 13.8 billion years ago.

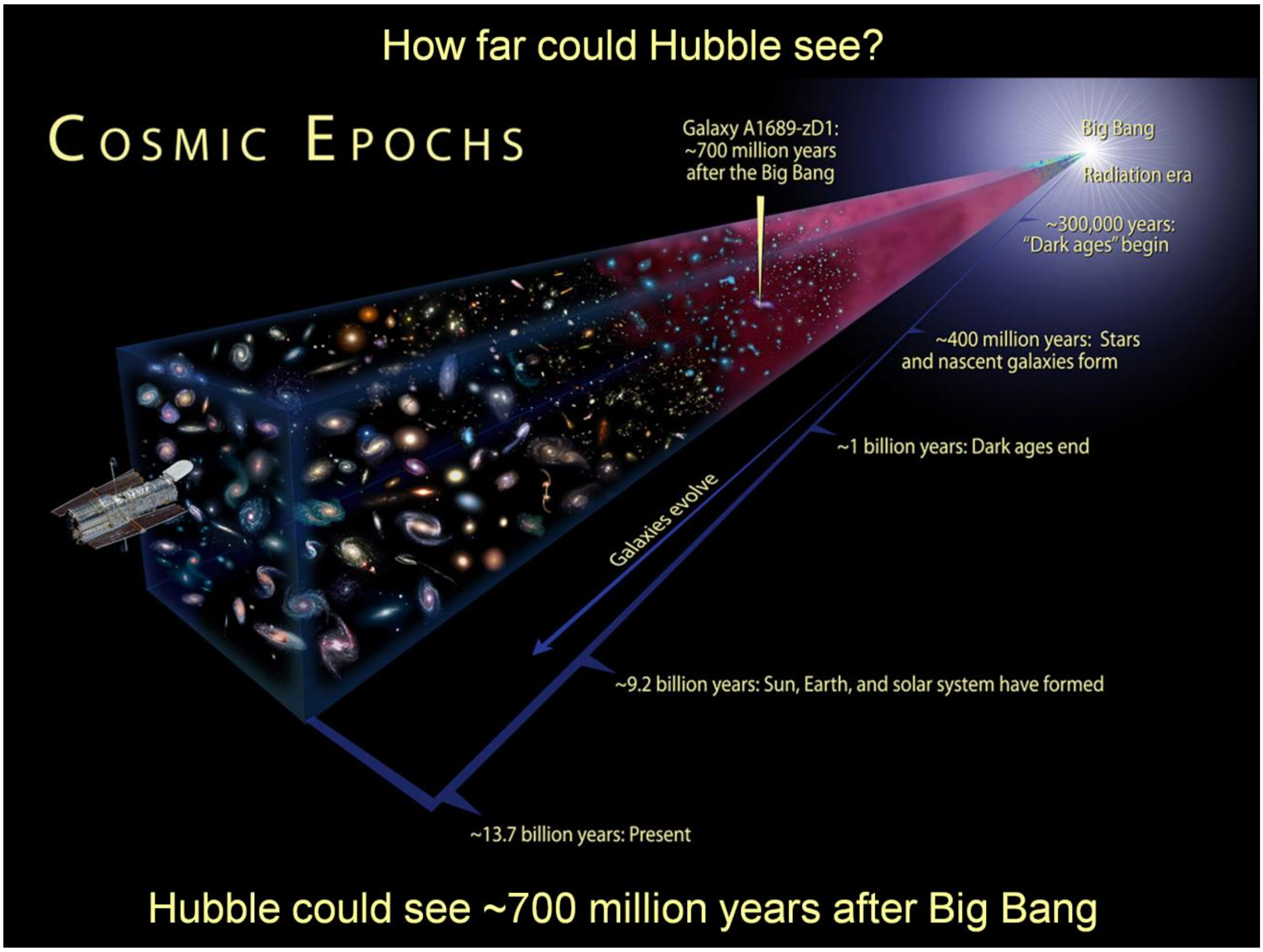
Things began to develop very fast immediately after the Big Bang.

Everything was much closer together and very hot but as the Universe continued to expand it started to cool.

As the atoms cooled they were able to group together due to their gravity.

So the first stars were created from pure Hydrogen and Helium gas.

The conditions in these early galaxies allowed the forming stars to be Super Giants.




The diagram above shows a slice of the Universe.

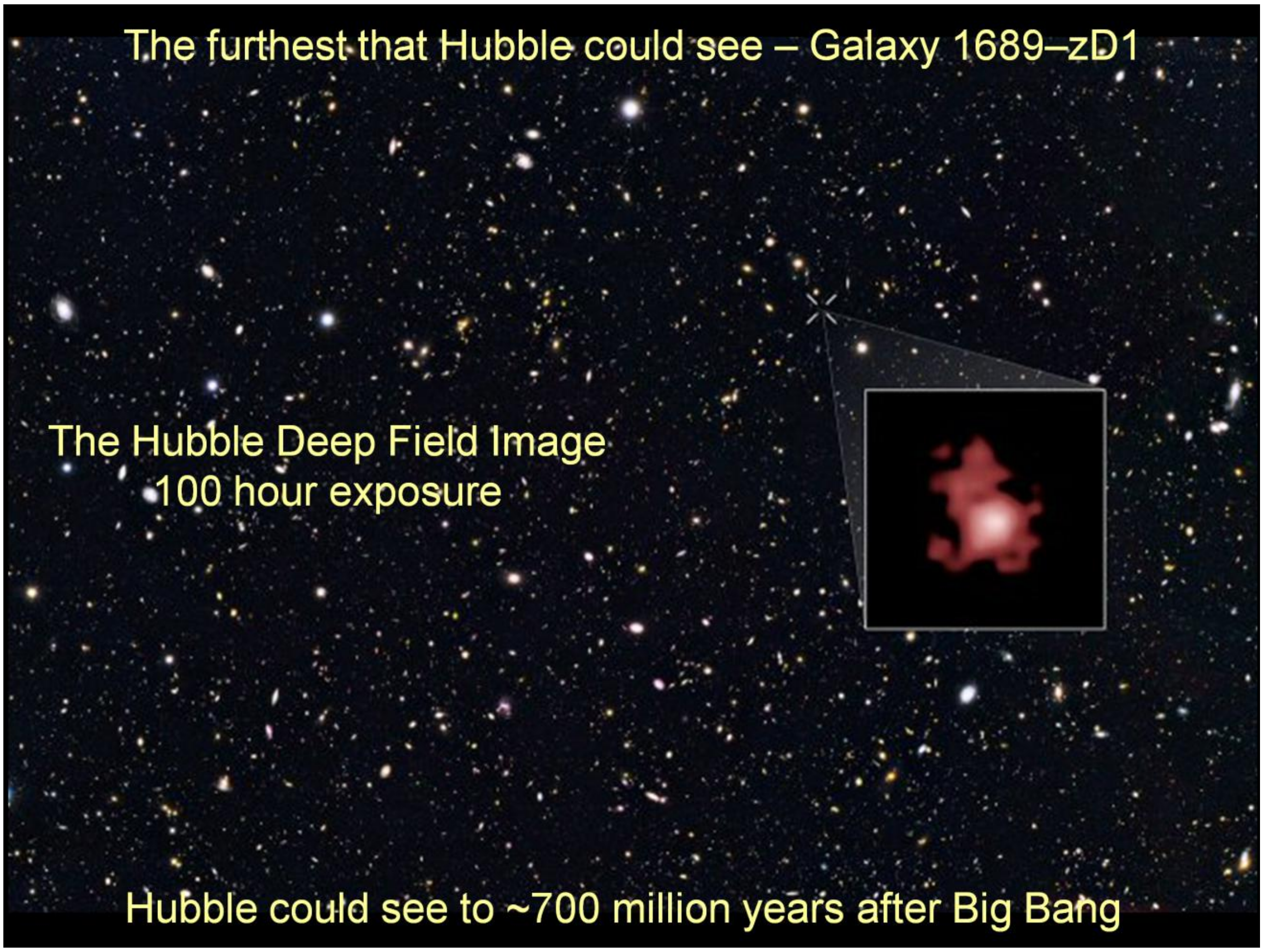
The Hubble space telescope is shown looking back towards the big Bang.

This is when time began for us and everything in our Universe was created.

For us anything that happened or was there before the Big Bang has no meaning to us because we can never see out beyond our Universe.

Hubble was able to see Galaxies forming just ~700 million years after the Big Bang.

However Hubble could not see the very first stars and galaxies that formed earlier than this.




The most distant Galaxy that Hubble detected was Galaxy 1689-zD1 shown above.

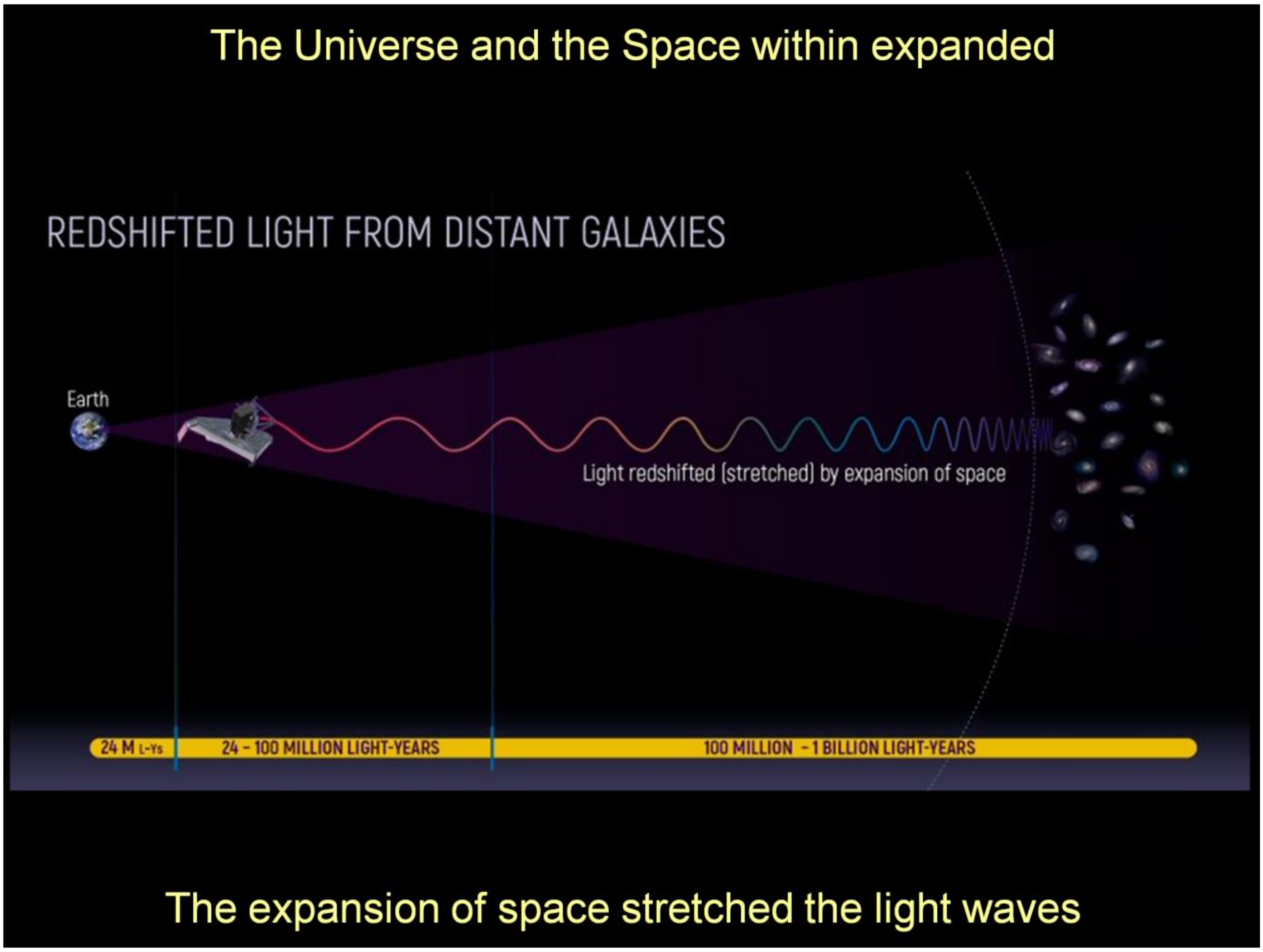
Hubble could not see beyond 700 billion light years because the light waves had been stretched.

We need to think about the expansion of the universe in a rather weird way.

The galaxies are not just moving away from the Big Bang, the space of the Universe is also expanding.

Light that emitted from the first galaxies has been stretched so its wavelength has also been stretched.

Blue light from the first stars has been stretched so it is now seen as longer infrared wavelength light.

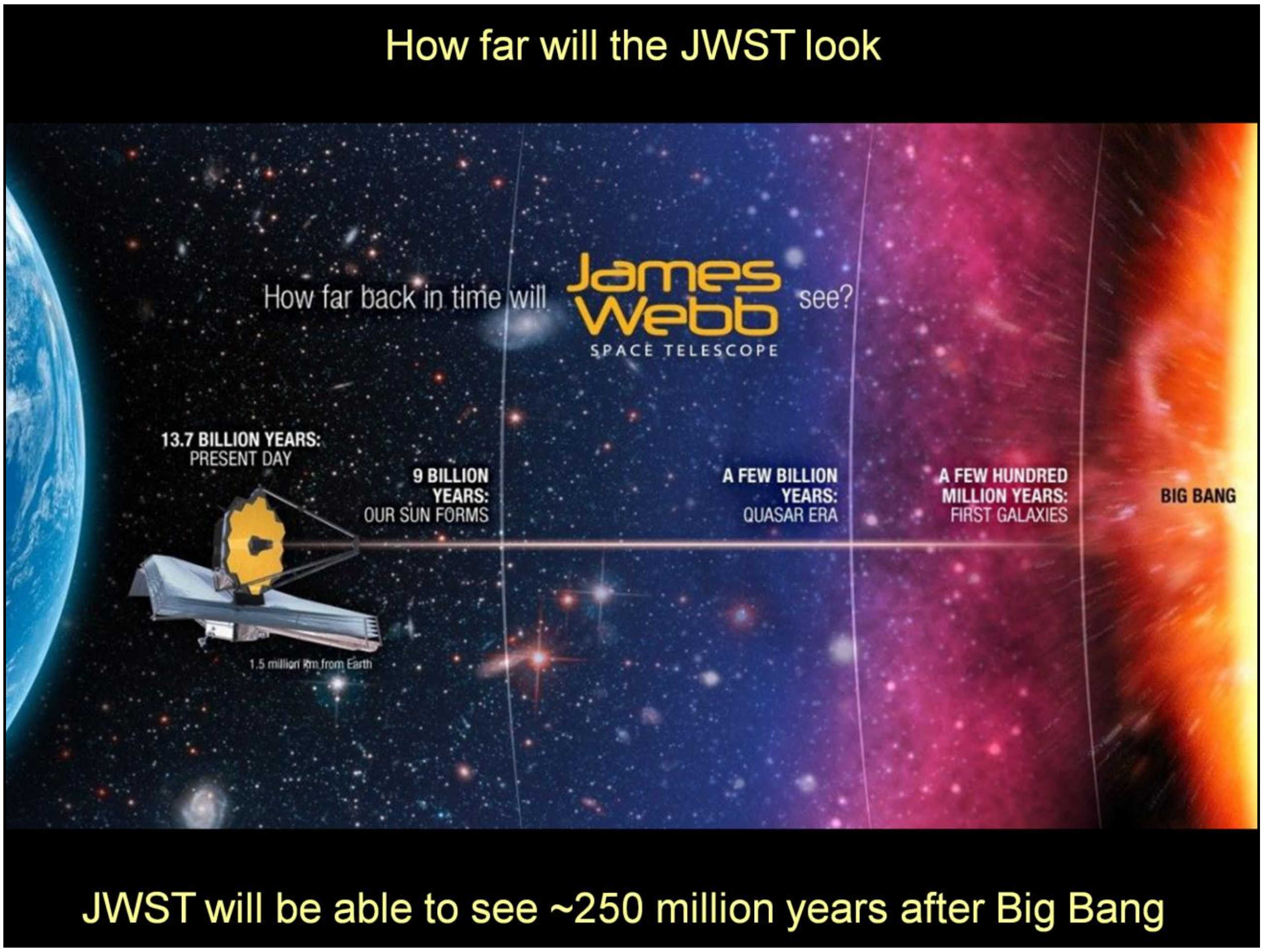



Since the Big Bang the Universe has been expanding.

The is not just expanding, the space within the Universe is also expanding.

Light that emitted from the first stars has been stretched so its wavelength has also been stretched.

Blue light from the first stars has been stretched so it is now seen as longer infrared wavelength light.




The original matter created in the big Bang was very dense and hot.

As atoms were very close together they were able to create Blue Giant Stars.

These blue stars could be up to and perhaps more than 300 times the mass of our Sun.

However due to the expansion of the Universe these light waves have been stretched.

Their light has been stretched so much it has become longer wavelength infrared light.

Galaxy 1689-zD1 appeared red to Hubble and it was just about visible for the telescope.


The diagram above demonstrated the capabilities of the James Webb Space Telescope.

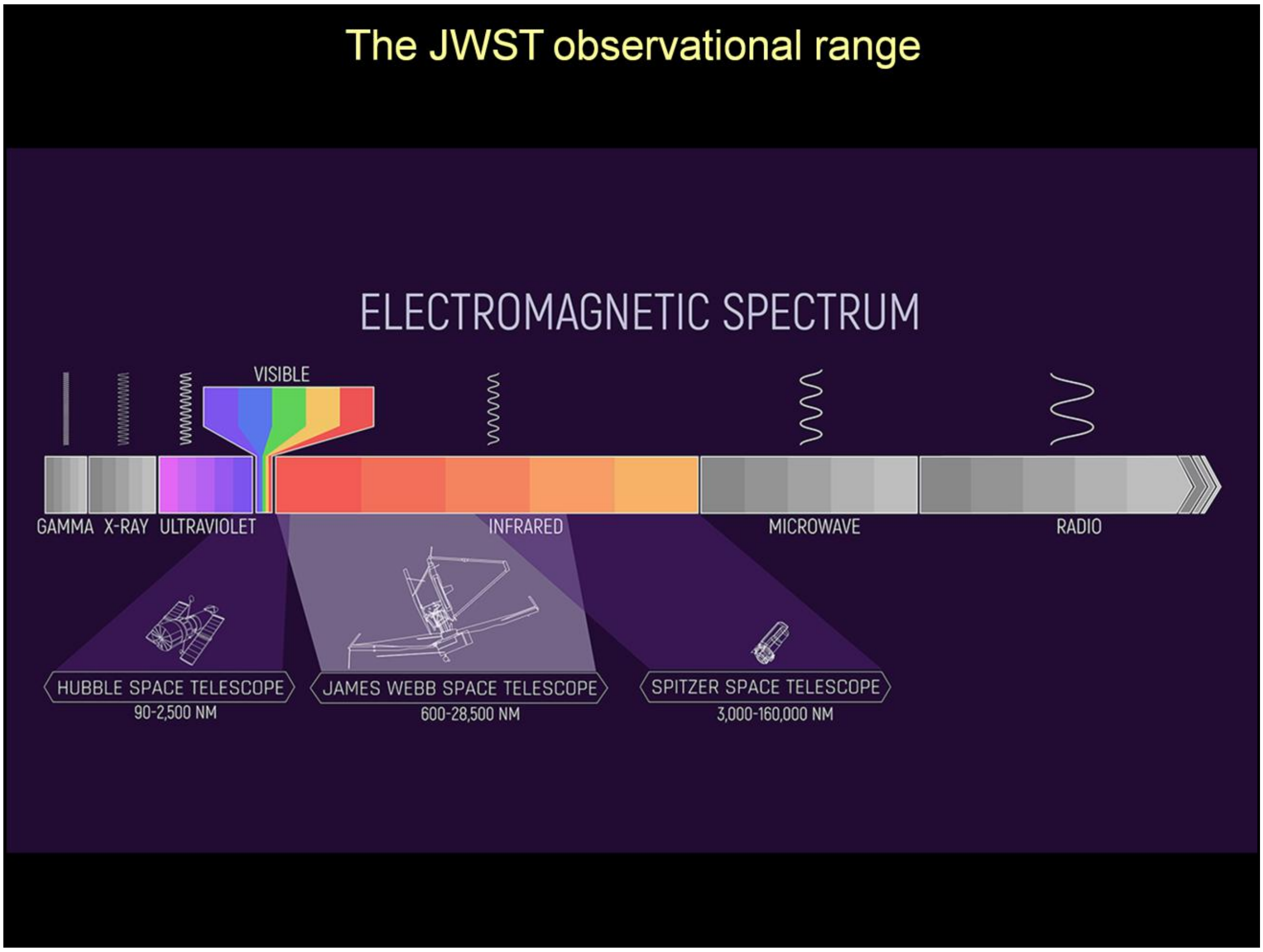
The JWST mirror has a light gathering capability 9 times greater than Hubble.

It has also been designed to be sensitive to infrared light beyond Hubble’s capability.

Hubble was able to see just into the very shortest wavelengths of infrared light.

James Webb can detect most of the infrared range of light.

This means the JWST can see light that was created earlier and closer to the Big Bang.



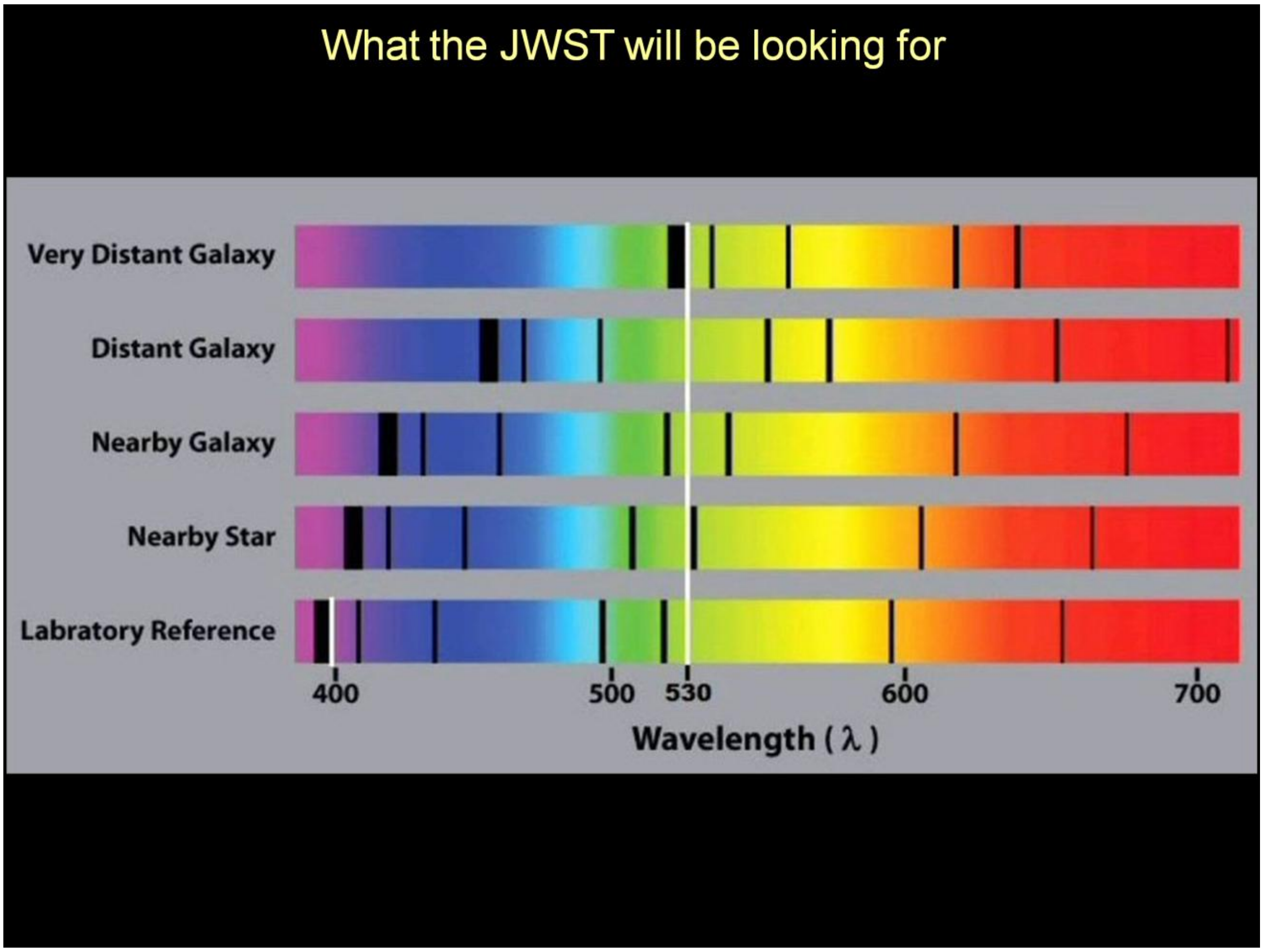

The diagram above shows the wavelengths of light that can be observed by the Space Telescopes.

Hubble was designed primarily to observe in ‘visible’ light but just into Ultraviolet and infrared.

James Webb was designed to detect ‘near’ (shortest) infrared and ‘mid’ (middle) wavelengths.

This means James Webb can see light that has been stretched by travelling furthest.

In other words it can see further back into the earlier development of the Universe.




The diagram above shows dark bands that appear on the spectrum of starlight.

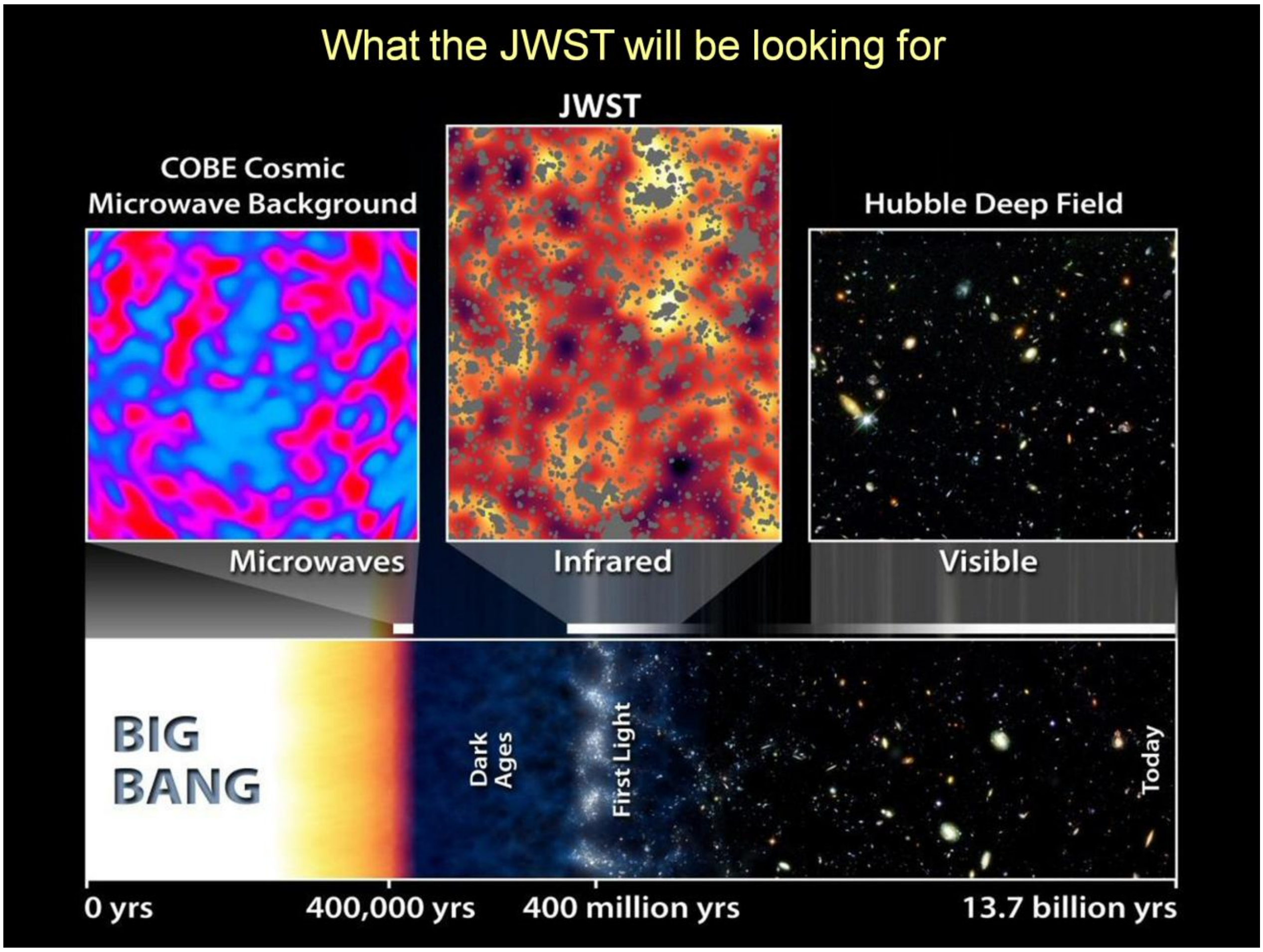
These bands are caused by various elements absorbing certain wavelengths of light.

Every element will block a unique pattern of bands on the light from a distant object.

When light waves are stretched these bands are moved along the spectrum with its original wavelength of light.

So the further the light has travelled the further it will be shifted along the spectrum (called Red Shift).

The 500 and 530 nanometre wavelengths are shown moved progressively to the red with increased distance.



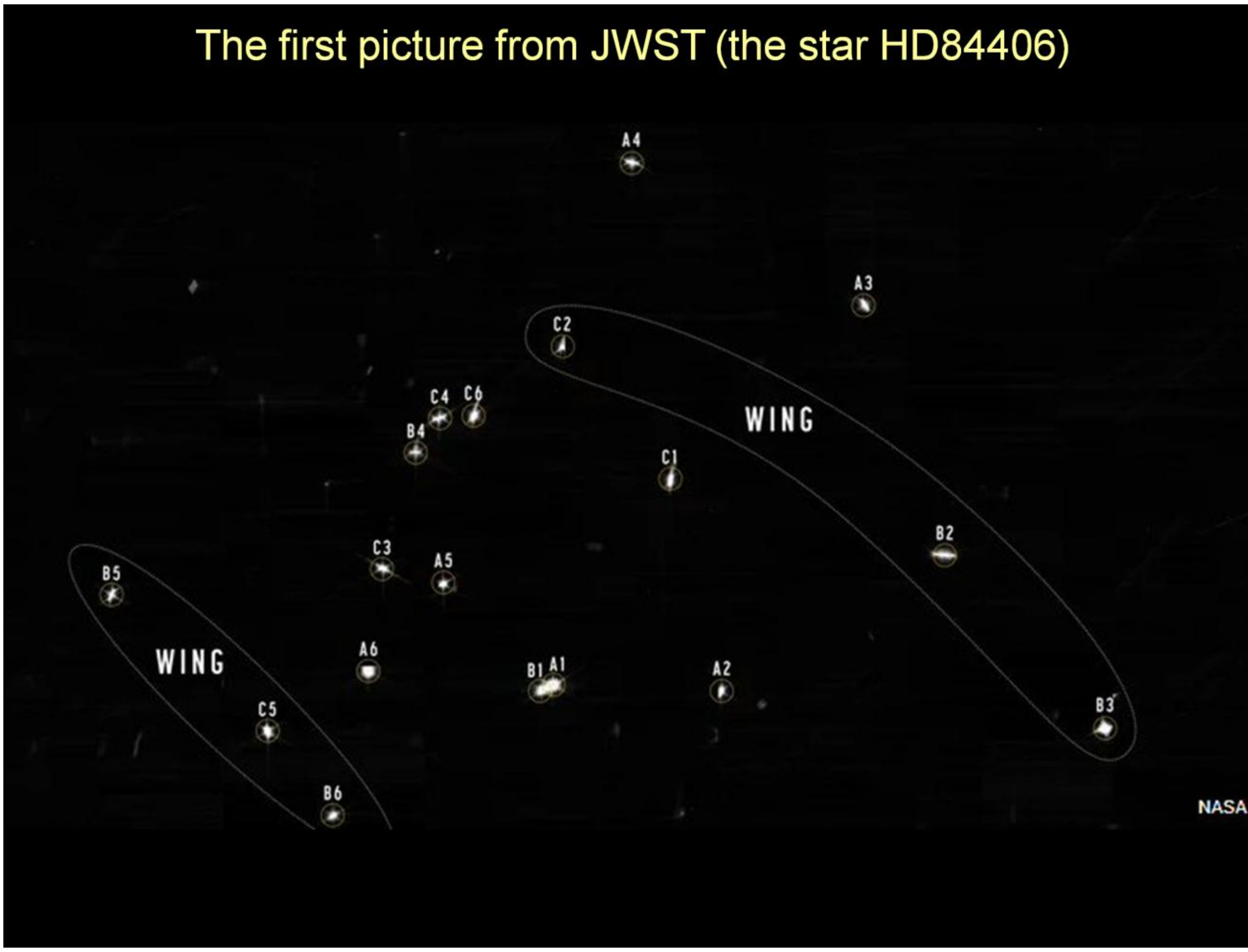

On the diagram above we can see the effect of the expansion of the Universe.

The first light produced in the Big Bang were very short waves of X-Rays that appear to us as Microwaves.

Light from the first stars was blue but now appear to us as infrared waves.

Light from mature galaxies closer to us has not been stretched so much and appears as visible light.

So we can see that light from the first galaxies and stars will be visible to the James Webb Space Telescope.




The image above was a big surprise to everyone who was eagerly waiting for the first image from the JWST.

This was because the first image was not expected until around June 2022.

The image may look a bit odd but NASA has said all is ok.

What we can see is 18 images of the same star that is called HD 84406.

There is a separate image from each mirror of the main composite mirror.

All this is just proving the whole system is working.


Beginner’s Website:
naasbeginners.co.uk