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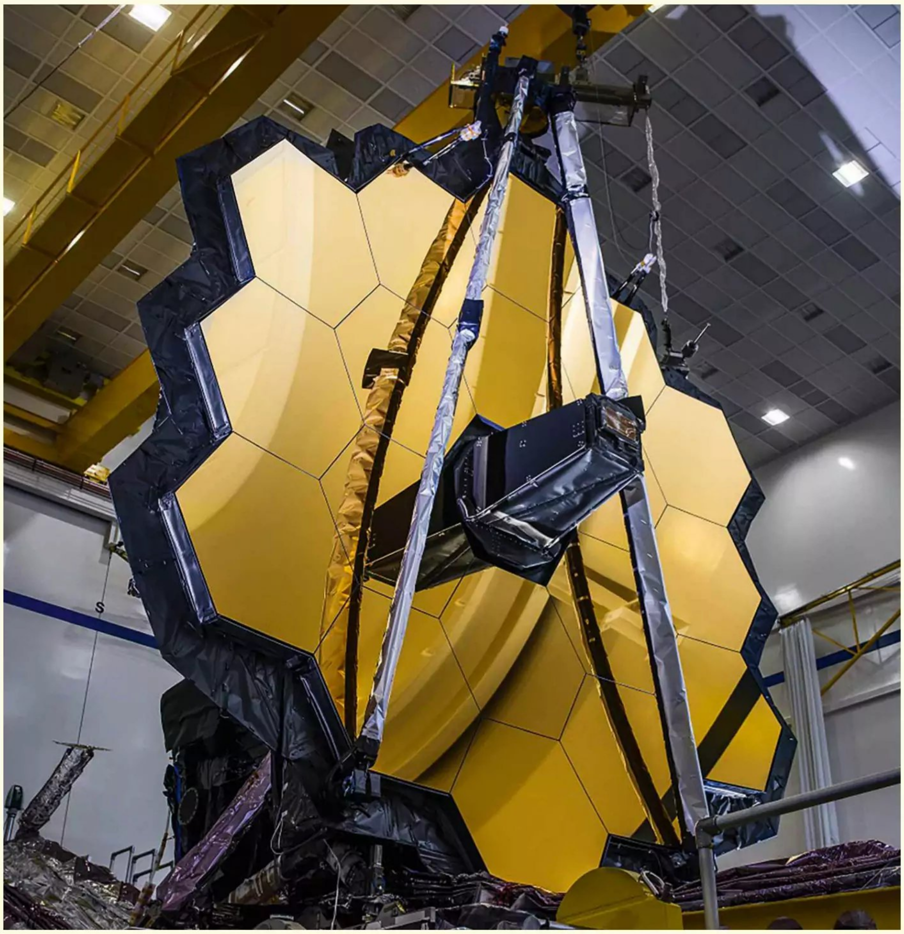
An artist's impression of the James Webb Space Telescope's initial deployment

NASA/JPL

ASTRONOMY

IT'S TIME TO GET EXCITED ABOUT THE JAMES WEBB SPACE TELESCOPE

NASA's most ambitious project yet will peer deep into space looking for clues about the birth of planets, stars and the evolution of the Universe itself



You might be tempted to think of the James Webb Space Telescope (JWST) as just another hyped-up space mission. Resist that temptation. The JWST is the most ambitious space telescope ever launched.

It's also the biggest gamble.

The JWST – or Webb, as NASA would like it to be known – is designed to reveal the evolution of the Universe, from its early phases to the modern era. It will do this by undertaking a thorough investigation of the Universe at infrared wavelengths.

To reveal the evolution of the Universe, Webb will target the origin of the various celestial objects that have emerged along the way. This begins in the distant, early Universe. Webb's cameras and instruments will focus on the first galaxies and the first stars to light up the Universe.

Today, the evidence suggests that there's probably a supermassive black hole at the centre of every galaxy. Yet how those black holes form is a mystery. Were they the gravitational seeds that catalysed galaxy formation, or did they form naturally at the centre of a gigantic gas cloud that was already coalescing to become a galaxy. Webb will investigate.

As for the first stars, no one knows what these were like, but theory suggests that they could be gigantic megastars, burning more brightly and hotter than anything in the Universe today. Webb will search for them.

It will also scrutinise the birth of stars and planets in the more recent Universe by peering inside the dusty nebulae that cocoon these nascent celestial objects.

Infrared light is uniquely suited to these investigations. In the case of the first stars and galaxies, they're so far away that the Universe has expanded greatly since their light began its journey. This expansion has caused that light to stretch, transforming what was once visible light into infrared light. And when it comes to looking inside the nebulae where stars and planets and born, infrared light is more penetrating than visible light. So observing at infrared wavelengths will allow astronomers to see deeper inside these dusty clouds.

Another reason for using infrared is that molecules are particularly interactive at those wavelengths. Therefore, studying the infrared light reflected or emitted by celestial objects allows the molecular composition of those objects to be studied. While the chemistry of a celestial object is interesting in its own right, these studies can also be used to gauge the habitability of planets. This is because chemistry is the essential stepping stone from physics to biology.

ON TARGET

Particular targets for Webb's molecular analysis include some of the thousands of exoplanets that have been discovered orbiting stars other than our own. Webb will also be a powerful tool for analysing the ices on the distant bodies in our Solar System, which may hold secrets relating to its formation.

Webb's science goals have been determined by the questions that the Hubble Space Telescope raised. This is why Webb is often said to be Hubble's successor, even though it operates at different wavelengths.

> **"We could be on the verge of a great watershed in our understanding of the Universe"**

Hubble revolutionised our view of the Universe and changed our understanding of celestial objects. It is hoped that Webb will do the same. This new observatory will be stationed 1.5 million kilometres away in space. It'll take a month to reach its final orbit at the second Lagrange point (Lagrange

ABOVE LEFT The James Webb Space Telescope's primary mirror measures 6.5m in diameter when fully deployed

ABOVE Here, Webb is folded up for launch in a clean room at the launch site in French Guiana

NASA/CHRIS GUNN X2

points are particular locations in space where launched objects tend to stay put) and has been designed to last for at least 10 years.

But Webb's launch is a massive gamble, because it can't be launched in its final configuration. When operational, Webb is the size of a tennis court, with most of that being made up of the sunshield. This huge sunshield is necessary because in order to work at the infrared wavelengths that astronomers are targeting, the telescope must be protected from the Sun's heat. This sunshield is made up of five layers of high-tech material that must be rolled together and folded away during launch, then pulled out with a complex system of moving platforms and arms.

Then there's the telescope mirror itself. Webb's primary mirror is 6.5m in diameter (Hubble's was a 'mere' 2.4m) and it's too large to fit in the fairing of a rocket. So, like the sunshield, it has to be folded up for launch. How do you fold a mirror? Simple, you make it out of gold hexagonal segments and fit them with motors so that they be tucked out of the way.

It sounds impressive – indeed, it is impressive. But only if it works. The engineering challenge of building an unfolding telescope is unparalleled. This is one of the reasons that the telescope has taken a quarter of a century to develop and cost roughly $10bn to build.

That investment is what makes it all such a gamble. This telescope has absorbed so much time, effort and money that it's 'too big to fail'. In fact, it crossed that line years ago, which is how it unlocked more and more cash to overcome the substantial technological hurdles that it continued to encounter. And as more money was invested, so the pressure to get it right increased, which led to more tests, more delays, more money, more pressure and so on. Now comes the moment of truth.

On 22 December, Webb will be launched aboard a European Ariane 5 rocket. Once en route to its destination, ground operators will deploy each part of the telescope in a series of steps. It will take weeks, and at each step something could go wrong. That's not to say something will go wrong, but that potential is probably the biggest fear in the minds of everyone associated with the project.

When you watch it launch, wish Webb well, but remember that the launch is not the end of the story. As Han Solo said following a similarly dicey lift off from the planet Tatooine, "Here's where the fun begins."

So check in regularly in the days and weeks following the launch to find out how the deployment is going. By the end of January, Webb should be fully deployed and in its operating orbit. Then, in your best Han Solo voice, you can say, "Here's where the science begins."