WEBB will:

- Bring us ever closer to the point when the first supermassive stars burst into life. From these ancient cosmic origins, Webb will chart the growth of galaxies from amorphous masses of perhaps millions of stars to the giant spiral shapes, home to hundreds of billions of stars we see today.
- Reveal the chaotic and turbulent regions in which gravity has bound enough material to ignite fusion, marking a new star.
- Uncover the swirling disks that surround young stars, and study new planets in the making.
- Sample, with its sophisticated instruments, the light from planets around distant stars, looking for traces of water and the chemistry of life.

Webb’s exploration of the universe begins where the most powerful modern observatories reach their limits.
THE NEED FOR INFRARED VISION

In 1994, just four years after the launch of the Hubble Space Telescope, astronomers began imagining what the next great space observatory would be. Though remarkable strides were being made by Hubble in unlocking the mysteries of the universe, a compelling science case for a new kind of telescope was emerging, one that would operate far from Earth, larger than any launched into space, and optimized to see in the infrared.

In astronomy, the infrared portion of the electromagnetic spectrum is prized for its wealth of scientific data. And, as the Hubble Space Telescope revolutionized optical astronomy, a next-generation observatory would do the same for the infrared, which holds the key to the very ancient, very distant universe.

As starlight travels billions of light-years across space it succumbs to the effects of the expansion of the universe. Over the course of their cosmic journey, as space itself expands, light waves become stretched, or shifted, to longer and redder wavelengths of energy. Eventually, visible light from the most distant stars becomes stretched to the point that it is now only detected in the infrared. So the earliest stars and the first galaxies fade from view, in part from extreme cosmic distances and in part because space itself continues its break-neck expansion begun by the Big Bang.

To extend their vision farther into space, astronomers will need the power to detect fainter objects and the capability to look farther down the spectrum into the shadowy realm of infrared light.

With its longer wavelengths, infrared radiation passes much more readily through dense molecular clouds, which are impenetrable to visible light. These light-year-spanning collections of dust and gas are stellar nurseries, where new stars burst into life and planets coalesce from dusty debris rings.

The Orion Nebula: Infrared vs. optical view. A nearby star-forming region, the Orion nebula looks markedly different in infrared (left) and visible light (right) photographs. The infrared view penetrates deep into the dust structure of the hydrogen molecular cloud.
THE NEXT PHASE of infrared astronomy would do more than simply build on these remarkable pioneering instruments. The Webb telescope would be in every way a superior instrument, utilizing both innovations in optical engineering and mechanical engineering to create the largest mirror ever launched into space.

The size of Webb’s primary mirror is unprecedented for a space telescope and is essential to bring infrared astronomy to a new level of exploration. For all wavelengths, a larger mirror means greater sensitivity and the ability to see fine detail. For an infrared telescope, this is especially important because of a fundamental property of light: the longer the wavelength, the lower the resolution.

To achieve this size, Webb follows a proven technology path now used on the largest telescopes on Earth — build large by building in segments. Pioneered on the 32.8-foot (10-meter) Keck telescopes in Hawaii, this technology is enabling Webb’s mirror to surpass all previous space telescopes in size and power. Comprising 18 hexagonal segments, each 4.27 feet (1.3 meters) across, Webb’s mirror segments will achieve the same performance as a single 6.5-meter mirror.
Webb’s mirror will be 6.5 meters (21.3 feet) across. It will have seven times the collecting area of the Hubble Space Telescope and 50 times the area of the Spitzer Space Telescope’s mirror.

The Webb telescope’s primary mirror is too large to be monolithic like Hubble’s mirror. The mirror is divided into 18 precisely ground and polished hexagonal segments.
**Underside of the James Webb Space Telescope**

- **Segmented primary mirror**: 18 hexagonal segments made of the metal beryllium and coated with gold to capture infrared light.
- **Multi-layer sunshield**: Five layers shield the observatory from the light and heat from the Sun and Earth.
- **Trim flap**: Helps stabilize the satellite.
- **Star trackers**: Small telescopes that use star patterns to target the observatory.
- **Spacecraft bus**: Contains most of the spacecraft steering and control machinery, including the computer and the reaction wheels.
- **Solar power array**: Always facing the Sun, panels convert sunlight into electricity to power the observatory.
- **Earth-pointing antenna**: Sends science data back to Earth and receives commands from NASA’s Deep Space Network.
- **Cold side of telescope**: ~40 K (~−388°F).