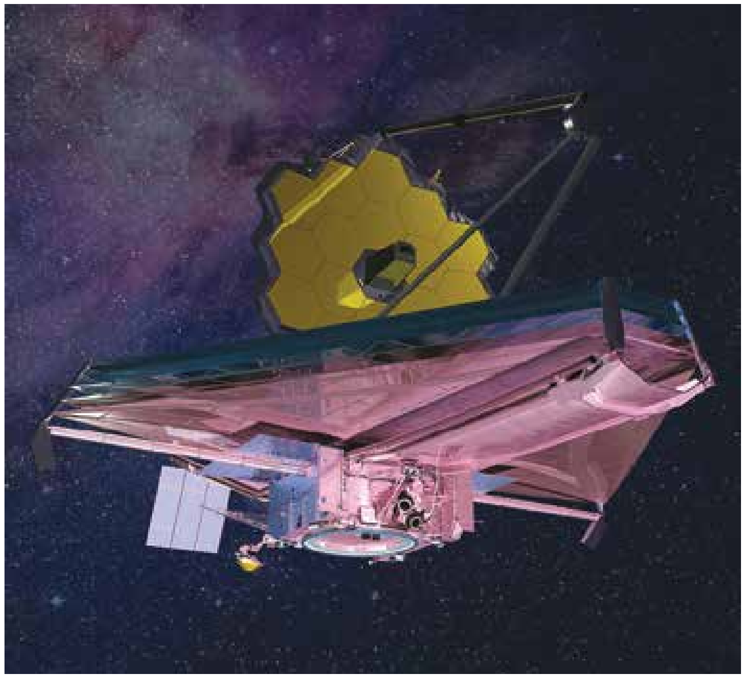
The James Webb Space Telescope: A Common Mission for All Mankind

by Janet G. West

> Ah! But a man's reach should exceed his grasp, or what's a Heaven for?
> —Robert Browning

July 14—On July 12, 2022, a concert of agencies composed of NASA, the European Space Agency (ESA), the Canadian Space Agency (CSA), and the Jet Propulsion Laboratory (JPL) presented to the world via live online feed the first "gifts" from the James Webb Space Telescope ("Webb," or JWST). These were five literally breathtaking images of a deep-field view of galaxies; a dying star; a grouping of five galaxies; spectroscopic data of an exoplanet more than a thousand light years away, and a star "nursery" of awesome proportions.

There were groups of thousands of enthusiastic supporters represented on the live presentation, with video connections to Canada, Europe, various cities and towns across America (as well as the Goddard Space Center and JPL), several other locales, and a group of excited and giggling schoolchildren waving to the camera from Bangalore, India. At times, the scientists themselves became visibly moved and teary-eyed; the detail depicted in the images is far beyond that of the Hubble Space Telescope, due to Webb's much larger mirror and its capabilities for seeing into the mid- and near-infrared range. The astronomers and other researchers were unified in a common message: "Webb belongs to all of humanity! This is *your* telescope!"



NASA

The James Webb Space Telescope, about 100 times more powerful than the Hubble Space Telescope. Its composite, 6.5 meter mirror sits atop its multi-layer sunshield and other components. The telescope is named for NASA's leader in the 1960s.

The marvelous images are available for download on the NASA website (www.nasa.gov) as well as on social media, and it is well worth it to view these images in their full-color glory. It is important to note that these images were produced in *five days*; Hubble took two weeks to produce one image with less detail.

How Webb 'Sees' the Universe

The Webb Telescope is about one hundred times more powerful than the Hubble Space Telescope, not only because of the size of its mirror (6.5 meter diameter to Hubble's 2.4, or seven times the surface area), but because of the wavelengths at which it primarily "sees," that of the infrared part of the spectrum. While the Hubble has a Near Infrared Camera, its field of view is very limited, as if one were looking through a soda straw.

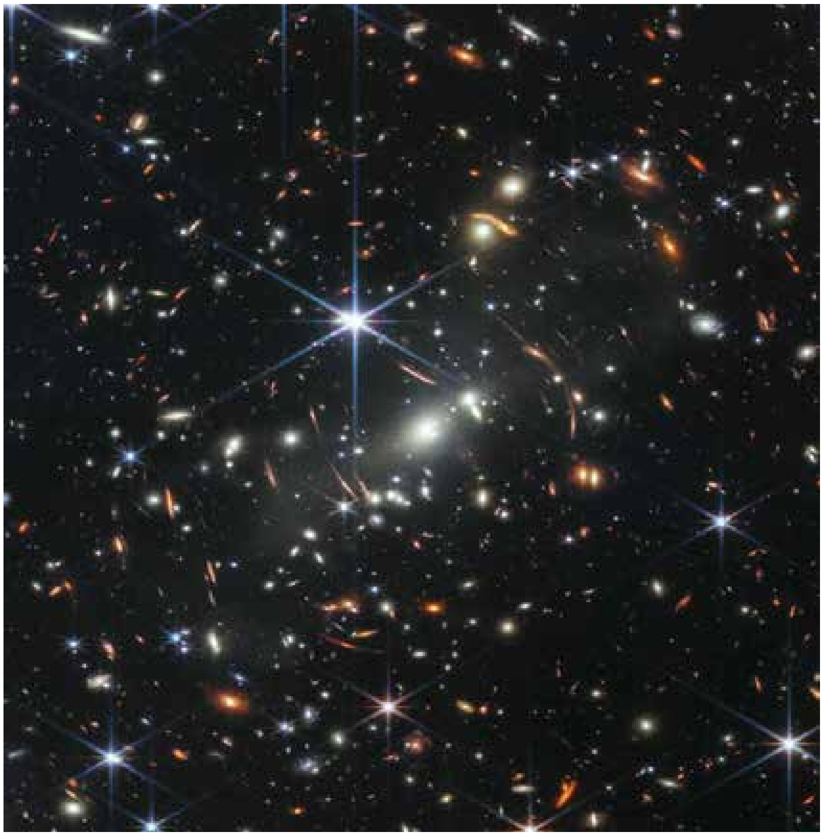
The electro-magnetic spectrum is a continuum of wavelengths, from the very long (such as radio waves, which can be 100 kilometers and more in length) to the very short (such as visible light, measured in billionths of a meter, nanometers), to the microscopic (such as gamma rays, measured at 100 picometers or less (a picometer is a trillionth of a meter). We humans see a very narrow range of this spectrum (about 400-700 nanometers) which we call visible light. Anything much past either side of that is invisible to us.

For example, if you've ever glanced at a black light (ultraviolet range: about 10-400 nanometers), you may notice that it's difficult to focus on it and it will appear fuzzy (and you shouldn't try to focus if you don't want to fry your retinas). It is fuzzy because the wavelength is too short for our eyes to handle. Deep red light is at the other, longer wavelength end of the visible spectrum. Then the infrared range of light is itself sub-divided into near, middle and far (wavelength from about 700 nanometers to 1 millimeter). Once the wavelengths go into the near range of infrared, it is invisible to the human eye.

Webb's instruments and cameras, described below, can show the same object in different wavelengths, and because of that, different astronomical structures will appear in different images of the same object.

Seeing in the infrared range allows Webb to do a number of things that Hubble can't—it allows it to pierce the gas and dust clouds that normally hide whole fields of stars; and due to the redshift, it allows the telescope to see further back in time.

FIGURE 1
Deep Field Image



NASA/ESA/CSA/STScI

The Magnificent First Images

The first image presented was Webb's first Deep Field (**Figure 1**), which was released by President Biden during the evening of July 11, and represents a galaxy cluster known as SMACS 0723. NASA's website describes it with increasing detail:

> Thousands of galaxies—including the faintest objects ever observed in the infrared—have appeared in Webb's view for the first time. *This slice of the vast universe covers a patch of sky approximately the size of a grain of sand held at arm's length by someone on the ground.*
>
> The combined mass of this galaxy cluster acts as a gravitational lens [causing the apparent smeared curvature of some objects], magnifying more distant galaxies, including some seen *when the universe was less than a billion years old.* This deep field, taken by Webb's Near-Infrared Camera (NIRCam), is a composite made from images at different wavelengths, totaling 12.5 hours [of telescope time]—achieving depths at infrared wavelengths beyond the Hubble Space Telescope's deepest fields, which took weeks. And this is only the beginning. Researchers will continue to use Webb to take longer exposures, revealing more of our vast universe. [emphasis added]

Part of Webb's mission is to locate potentially inhabitable exoplanets; the second image shows spectroscopic data from a hot gas-giant exoplanet called WASP-96 b (**Figure 2**), which is approximately 1,150 light-years away in the constellation Phoenix in the southern sky. WASP-96 b is one of more than 5,000 confirmed exoplanets in the Milky Way, and is 2.5 times larger than Jupiter, but less than half its mass.

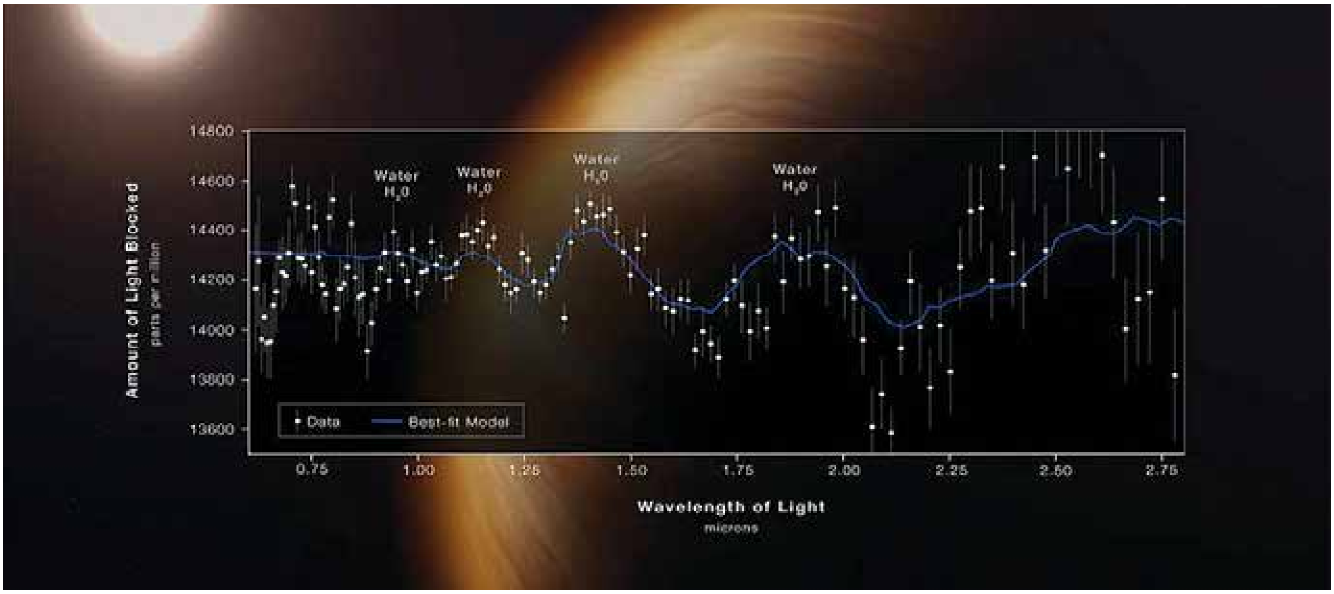
The powerful instruments of Webb were able to detect water vapor in the atmosphere of this hot, massive planet, and to detect evidence of haze and clouds that previous studies of this planet did not find.

During the presentation of the next image, that of

FIGURE 2

Hot Gas Giant Exoplanet WASP-96 b and Its Atmospheric Composition

NIRISS Single-Object Slitless Spectroscopy



NASA/ESA/CSA/STScI

This exoplanet has water in its atmosphere, a major plus for human habitation. But this one is mainly gas and much too hot for us. The superimposed spectrogram shows data points of light absorption at wavelengths associated with water vapor.

the Southern Ring Nebula, the two scientists, Drs. Alex Lockwood and Karl Gordon of the Space Telescope Science Institute in Baltimore, MD, became visibly emotional, and enthusiastically described the details of the images (**Figure 3**). These were captured by two different instruments operating at different wavelength ranges within the infrared, each showing different colors in the image, representing a variety of elements, such as hydrogen and helium. These instruments were the Webb's NIRCam (image at left), while the image from Webb's Mid-Infrared Instrument (MIRI) on the right shows for the first time a second star at the center, which had been obscured by dust in previous images.

Astronomers could detect that the nebula was a binary star system, but had never actually been able to view the two stars. The image from the MIRI clearly resolved the two stars at the very center of the nebula, due to the infrared wavelengths at which it was viewing.

In particular, the image from the NIRCam revealed textures, dimensions and depth heretofore unseen in any previous space image. Ripples of dust and gas encircle the star like foamy waves, shown as hues of oranges and tans; at the center is a bluish hue around the dying star, like an opalescent gem set into the heavens.

NASA noted that observations taken with NIRCam also revealed extremely fine rays of light fanning out around the outer part of the nebula. Starlight from the central stars streams out where there are holes in the gas and dust—like sunlight through gaps in a cloud.

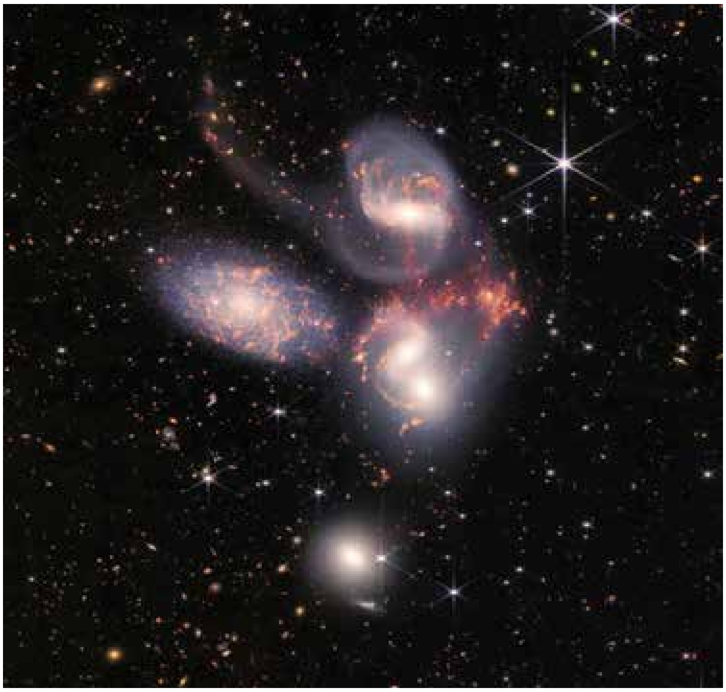
FIGURE 3

The Southern Ring Nebula, Two Webb Views

NASA/ESA/CSA/STScI

FIGURE 4

Stephan's Quintet, Webb



NASA/ESA/CSA/STScI

FIGURE 5

Stephan's Quintet, Hubble (with slight rotation)

NASA/ESA/CSA/Hubble SM4 ERO Team

Comparison Shows the Technological Leap

The fourth image presented was that of Stephan's Quintet, a visual grouping of five galaxies (**Figure 4**). Two of the five, forming a reverse "s," are intersecting. By contrast, **Figure 5** is the image as captured by the Hubble Telescope (with a slight rotation).

NASA describes the Webb image:

> This enormous mosaic is Webb's largest image to date, covering about one-fifth of the Moon's diameter. It contains over 150 million pixels and is constructed from almost 1,000 separate image files. The information from Webb provides new insights into how galactic interactions may have driven galaxy evolution in the early universe.
>
> With its powerful, infrared vision and extremely high spatial resolution, Webb shows never-before-seen details in this galaxy group. Sparkling clusters of millions of young stars and starburst regions of fresh star birth grace the image. Sweeping tails of gas, dust and stars are being pulled from several of the galaxies due to gravitational interactions. Most dramatically, Webb captures huge shock waves as one of the galaxies, NGC 7318B, smashes through the cluster.

The "finale" was the Webb image of a star-producing region called the "Cosmic Cliffs," as described on NASA's website (**Figure 6**):

> This landscape of "mountains" and "valleys" speckled with glittering stars is actually the edge of a nearby, young, star-forming region called NGC 3324 in the Carina Nebula. Captured in infrared light by NASA's new James Webb Space Telescope, this image reveals for the first time previously invisible areas of star birth.
>
> Called the "Cosmic Cliffs," Webb's seemingly three-dimensional picture looks like craggy mountains on a moonlit evening. In reality, it is the edge of the giant, gaseous cavity within NGC 3324, and the tallest "peaks" in this image are about 7 light-years high. The cavernous area has been carved from the nebula by the intense ultraviolet radiation and stellar winds from extremely massive, hot, young stars located in the center of the bubble, above the area shown in this image.

During the live presentation online, one of the NASA astronomers excitedly pointed to many of the

FIGURE 6

The Cosmic Cliffs

NASA/ESA/CSA/STScI

structures in this image, exclaiming, "We don't even know what these are yet! Or what they're doing there!"

The NASA representatives emphasized again and again that Webb truly represents "the dawn of a new era" for space exploration; that these images are "just the beginning" of Webb's capabilities, and now the hard scientific research can begin.

What Are the Instruments Webb Is Using?

The instruments are located within the Integrated Science Instrument Module (ISIM) which in turn, is one of three major elements that make up the JWST Observatory flight system. The second is the Optical Telescope Element (OTE), which includes the 6.5 meter mirror and feeds the gathered light to the ISIM; and the third, the Spacecraft Element, which comprises the Spacecraft Bus and Sunshield.

The ISIM includes the cryogenic instrument module. Here, various detectors must be brought down to extremely cold temperatures—in the range of 39 Kelvin (–389°F)—so that the sensitive instruments will pick up interstellar radiation, and not an accidental infrared "selfie" of its own heat signature.

The four main instruments within the ISIM are described on the Webb Space Telescope website as follows:

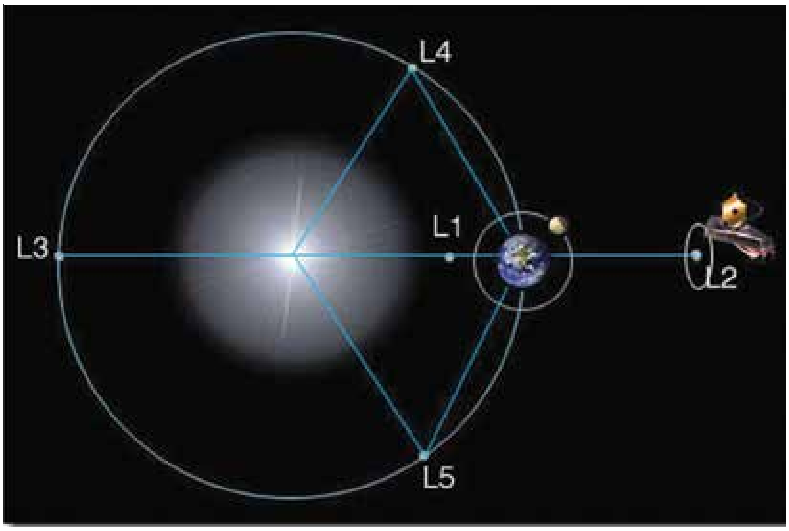
- Near-Infrared Camera (NIRCam), provided by the University of Arizona. NIRCam is Webb's primary near-infrared imager, providing high-resolution imaging and spectroscopy for a wide variety of investigations. Because NIRCam is the only near-infrared instrument with coronagraphic and time-series imaging capabilities, it is crucial for many exoplanet studies.
- Near-Infrared Spectrograph (NIRSpec), provided by the ESA, with components provided by NASA/Goddard Flight Space Center. NIRSpec is one of Webb's versatile tools for near-infrared spectroscopy. In addition to standard single-slit spectroscopy to gather spectra of specific objects, NIRSpec also has an integral field unit to investigate spatial variations in spectra and a microshutter array to capture individual spectra of dozens of objects at once. This highly efficient design is part of what makes Webb ideal for studying extremely distant, faint galaxies.
- Mid-Infrared Instrument (MIRI), provided by the consortium of the ESA and the NASA Jet Propulsion Laboratory (JPL). This instrument provides imaging and spectroscopy capabilities in the mid-infrared. As the only mid-infrared in-

strument, astronomers rely on MIRI to study cooler objects like debris disks, which emit most of their light in the mid-infrared, and extremely distant galaxies whose light has been shifted into the mid-infrared over time.

- Fine Guidance Sensor/Near Infrared Imager and Slitless Spectrograph (FGS/NIRISS), provided by the Canadian Space Agency (CSA). NIRISS provides near-infrared imaging and spectroscopic capabilities. As the only instrument capable of aperture mask interferometry, NIRISS has the unique ability to capture images of bright objects at a resolution greater than the other imagers.

FIGURE 7

The Webb Has a Home at Lagrange Point 2



NASA

The five Lagrange points are points of gravitational equilibrium in space for objects of small mass under the influence of two orbiting bodies of large mass, such as the Sun and Earth. The points lie in the orbital plane of the two large bodies. The Webb makes its own small orbit around L2, 1.5 million km from us. As the Earth orbits the Sun, L2 and the Webb move with it.

Housed in the same assembly as NIRISS is Webb's Fine Guidance Sensor (FGS). The FGS is a camera system designed to make sure Webb is stable and pointing in exactly the right direction throughout an observation. The FGS detects and identifies guide stars and ensures that Webb is locked onto those stars for the entire observation.

The NIRSpec, in particular, possesses a unique capability that enables it to obtain 100 simultaneous spectra in a micro-electromechanical system called a "microshutter array." NIRSpec's microshutter cells, each approximately as wide as a human hair, have lids that open and close when a magnetic field is applied. Each cell can be controlled individually, allowing it to be opened or closed to view or block a portion of the sky. In this way, it can take multiple "slices" of the same image at different wavelengths at the same time.

It is this adjustability that allows the instrument to do spectroscopy on so many objects simultaneously. Because the objects NIRSpec will be looking at are so far away and so faint, the instrument needs a way to block out the light of nearer bright objects. Microshutters operate similarly to people squinting to focus on an object by blocking out interfering light.

'Miracles' Are 99% Perspiration

It is difficult to say what is impossible, for the dream of yesterday is the hope of today and the reality of tomorrow.

—Robert H. Goddard

That Light whose smile kindles the Universe,
That Beauty in which all things work and move,
That Benediction which the eclipsing Curse
Of birth can quench not, that sustaining Love
Which through the web of being blindly wove
By man and beast and earth and air and sea,
Burns bright or dim, as each are mirrors of
The fire for which all thirst; now beams on me,
Consuming the last clouds of cold mortality.

—*from Adonais: An Elegy on the Death of John Keats, by Percy Bysshe Shelley*

The Webb Telescope is now orbiting the Sun at the second Lagrange point (L2), 1.5 million kilometers or nearly 1 million miles from Earth (**Figure 7**). It had over 300 single points of failure, 50 major deployments, and 178 release mechanisms, and every one of them had to work perfectly. The main mirror is made up of 18 separate hexagonal mirrors, each of which has seven actuators which can move in seven degrees of freedom, to make the entire surface a perfect mirror. The sunshield has five different layers, spanning almost 827 square meters. It had 140 release mechanisms, 70 hinge assemblies, eight deployment motors, 400 pulleys, 90 cables (totaling 400 meters in length), and all of the bearings, springs and gears that went with that. When the sunshield was being unfurled, 107 release mechanisms had to fire on cue.

Everything worked *perfectly*.

Now, with just the first images of Webb, all of these accomplishments can make one believe that this mission could be called a "mission impossible" or "miraculous"—and yes, it is! It is a miracle of human creativity, scientific discovery, and many years of dedicated and impassioned hard work from individuals spanning the globe.

Although we live mortal lives, the human heart and spirit can radiate to infinity through the expression of *agapē*—love for all mankind—for a common bright future for all of humanity. This can be accomplished if a sufficient number of people of good will join with the mission of the Schiller Institute to not only pull mankind back from the brink of the precipice of nuclear annihilation, but to also implement a new, just world economic system, as called for by the institute's founder Helga Zepp-LaRouche.

Do we in America have the passion to bring America back to her founding principles, to generously extend the principles of the Declaration of Independence to all mankind, to be a true beacon of hope, for the development of sovereign republics, and to vanquish the notion of "empire" forever?

The Creator conceived mankind in His own image and likeness; now, mankind has developed the technology by which we can countenance the Creation in all its glory. The Webb Telescope now opens a vista to look billions of years into the past; do we have the courage to become people of vision? Do we have the fortitude to dare to hold the image of the brilliant stars of mankind's future before us—millions of generations of children as yet unborn? To use our reason and educate our emotions as Schiller said, to foster unbounded human creativity?

It is for us, the living, to fight to shift the arc of history away from a dim world of the violent and pessimistic culture which characterizes today's youth, and rather move it in the direction of an optimistic future for those who come after us; those who sparkle invitingly in our mind's eye like far-off galaxies, daring each of us to become a woman or man of Providence.