SPECIAL REPORT

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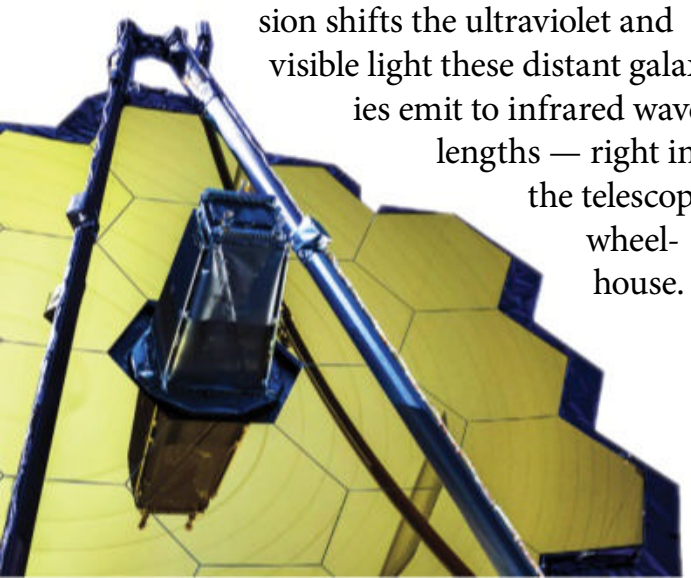
TOO BIG, TOO SOON

The James Webb Space Telescope's hunt for the earliest galaxies has turned up some massive surprises. BY RICHARD TALCOTT

WHEN THE JAMES WEBB Space Telescope (JWST) roared from the launch pad Dec. 25, 2021, astronomers expected it to revolutionize our view of the cosmos. Little did they realize just how prophetic they were.

Scientists released the first images from the 6.5-meter telescope in July 2022. Astronomers immediately started poring over the photos. Cosmologists paid particular attention to views of deep space, where they hoped to find galaxies that formed within the first billion years after the Big Bang. Only JWST can probe this far back because universal expansion shifts the ultraviolet and visible light these distant galaxies emit to infrared wavelengths — right in the telescope's wheelhouse.



Ivo Labbé of the Swinburne University of Technology in Melbourne, Australia, led a team that discovered six of these galaxies that existed just 500 million to 700 million years after the Big Bang. The light from these objects left their hosts more than 13 billion years ago.

Seeing the distant beacons wasn't the biggest surprise, however: These galaxies were spitting out an extraordinary amount of light, implying they must be truly massive. "These objects are way more massive than anyone expected," said team member Joel Leja of Penn State in a press release. Five tip the scales at more than 10 billion solar masses, while one appears to weigh 100 billion solar masses, or nearly as much as the Milky Way.

The prevailing attitude had been that early galaxies began as small clouds of gas, stars, and dust that grew gradually into the stately spirals and ellipticals we see in today's universe. Most galaxies convert at most 10 percent of their gas into stars, but these newly discovered island universes would need to be converting nearly 100 percent. The discovery "calls the whole picture of early galaxy formation into question," added Leja. The team published its results in the Feb. 22 issue of *Nature*.

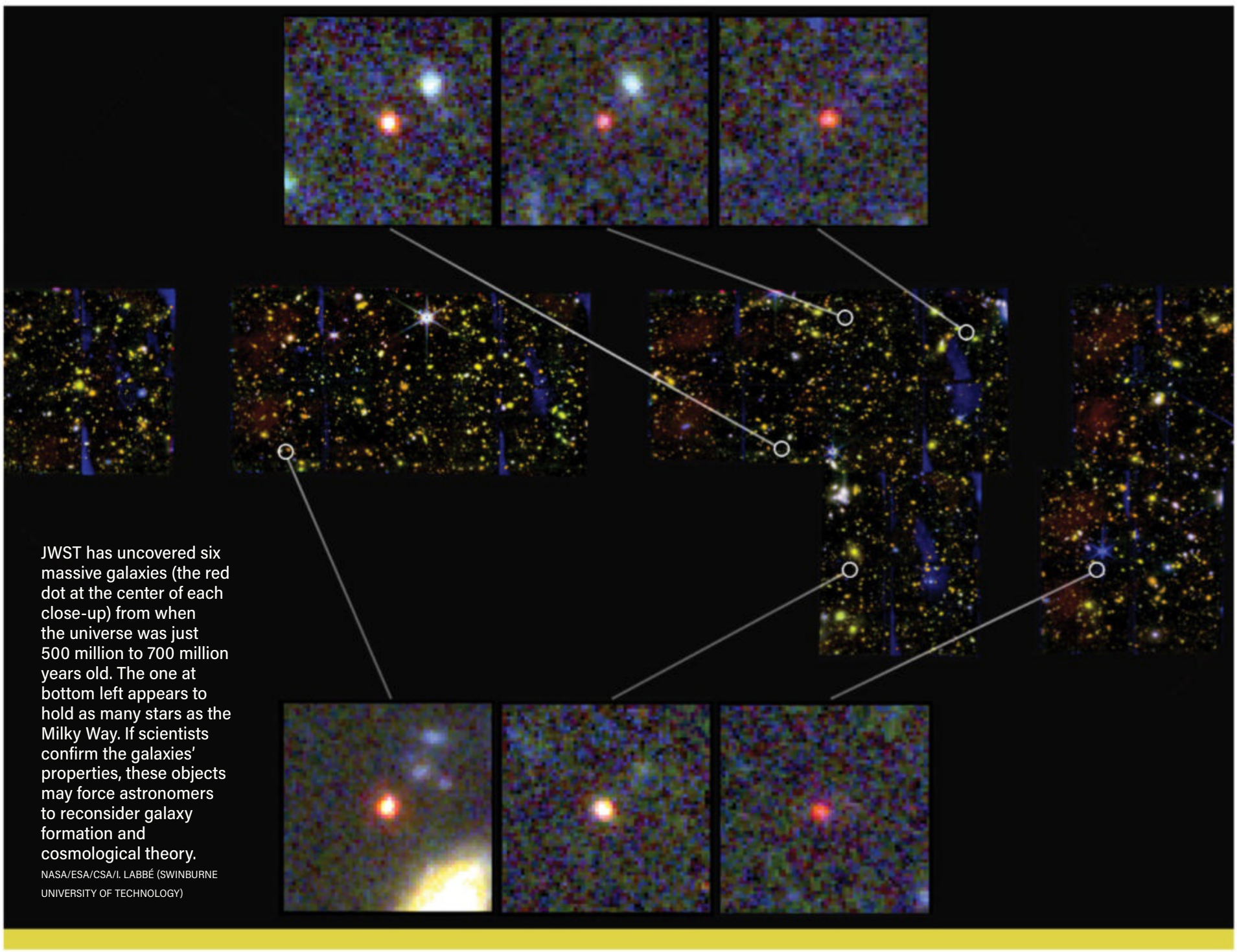
A SECOND PROBLEM

If the question of how big galaxies could form so early was the extent of the theoretical challenge, that would be one thing. But the new findings also raise major concerns about cosmologists' leading theory of how the cosmos evolved, which combines dark energy with cold dark matter.

Michael Boylan-Kolchin of the University of Texas at Austin crunched the numbers and found that if the estimated masses of these galaxies are right, "we'll require something very new about galaxy formation or a modification to cosmology," he said. One possibility for the latter would be a period of enhanced cosmic expansion shortly

FAR LEFT: ARCHANGEL80889/DREAMSTIME.COM

The Hubble Space Telescope's Extended Groth Strip offers a template for current and future JWST observations. NASA/ESA/M. DAVIS (UC, BERKELEY)



JWST has uncovered six massive galaxies (the red dot at the center of each close-up) from when the universe was just 500 million to 700 million years old. The one at bottom left appears to hold as many stars as the Milky Way. If scientists confirm the galaxies' properties, these objects may force astronomers to reconsider galaxy formation and cosmological theory. NASA/ESA/CSA/I. LABBÉ (SWINBURNE UNIVERSITY OF TECHNOLOGY)

after the Big Bang, which might require looking into new forces and particles. Boylan-Kolchin published his analysis in the April 13 *Nature Astronomy*.

All the researchers emphasize the preliminary nature of these studies. Both the galaxies' ages and masses are estimates and could be revised once JWST takes spectra of the objects to nail down their distances and compositions. Such observations would rule out the presence of central supermassive black holes making the galaxies appear more massive, or abundant dust causing them to appear redder and thus farther away. The scientists hope JWST delivers these results within the next year or so. (The telescope has lots of competing priorities, after all.)

The observations came as part of the Cosmic Evolution Early Release Science Survey, a program to focus JWST's full imaging and spectroscopic power on a small slice of sky known as the Extended Groth Strip. The Hubble Space Telescope imaged this 70' by 10' region in Ursa Major in 2004 and 2005. Hubble captured more than 50,000 galaxies in the strip. Now JWST has probed even deeper, opening a window into the universe's first billion years.

Contributing Editor **Richard Talcott** *can't wait for every new JWST revelation.*