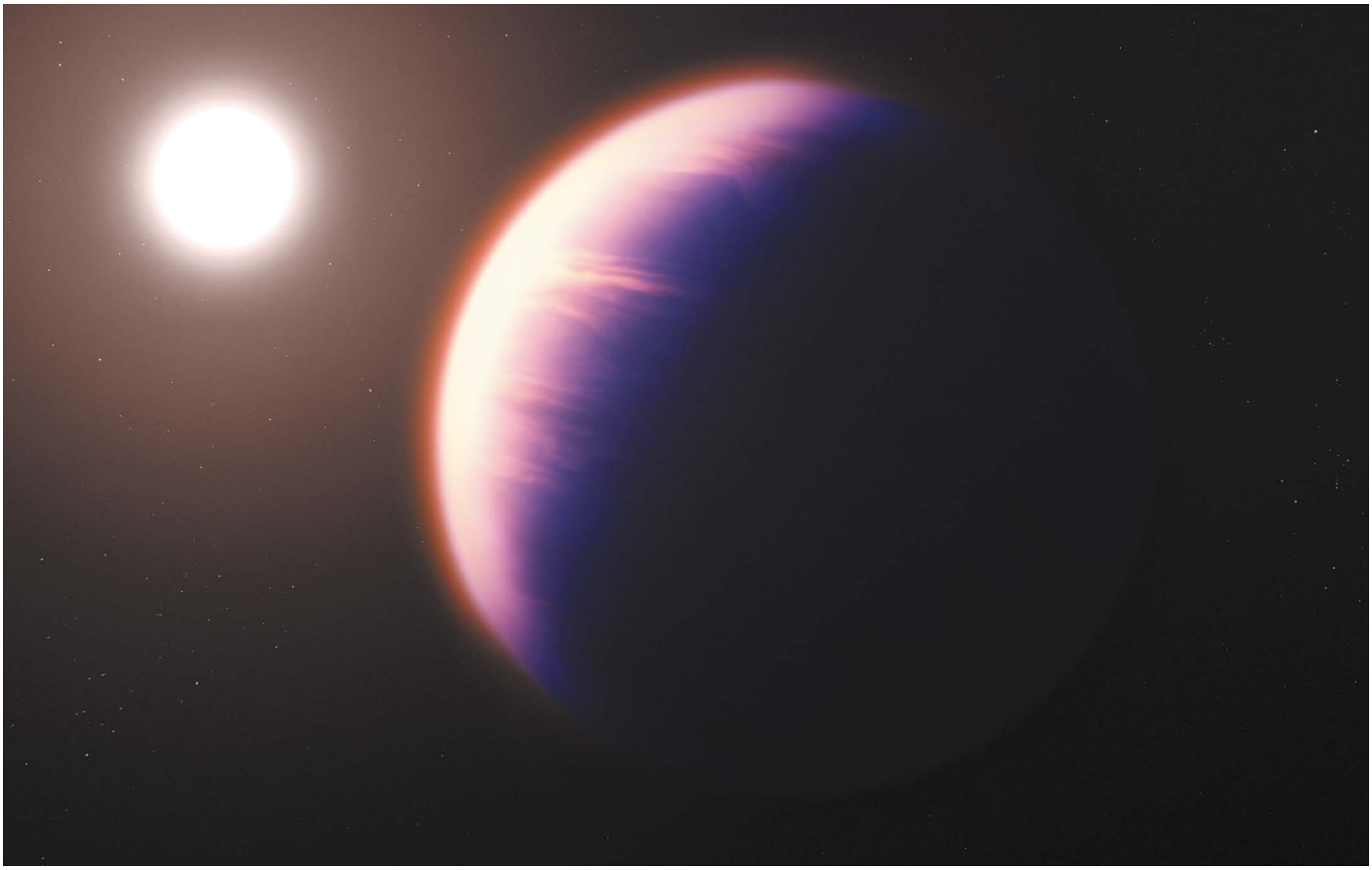
News in focus



NASA/ESA/CSA/JOSEPH OLMSTED (STSCI)

WASP-39b orbits close to its star, making it a hot exoplanet (artist's rendering).

WEBB TELESCOPE DETECTS CARBON DIOXIDE ON EXOPLANET

Report heralds what's to come from the landmark observatory, which is set to explore 76 worlds during its first year.

By Shannon Hall

The James Webb Space Telescope — already famous for its mesmerizing images of the cosmos — has done it again. The telescope has captured the first unambiguous evidence of carbon dioxide in the atmosphere of a planet outside the Solar System.

The finding not only provides tantalizing hints about how the exoplanet formed, but is also a harbinger for what's to come as Webb studies more and more alien worlds. It is the first result from Webb to be published in a peer-reviewed journal[1].

The discovery is presented in a data plot with none of the lustre of Webb's previous images — which showed galaxies locked in a cosmic dance and radiant clouds in a stellar nursery. But Jessie Christiansen, an astronomer at the NASA Exoplanet Science Institute at the California Institute of Technology in Pasadena, describes the data as "gorgeous".

The plot, or spectrum, reveals detailed information about the atmosphere of the exoplanet WASP-39b, called a hot Jupiter by scientists because it has a diameter similar to Jupiter's but orbits its star much more closely than Mercury orbits the Sun, making it incredibly hot. The planet, which is more than 200 parsecs from Earth, was initially discovered during ground-based observations[2] and later detected by NASA's Spitzer Space Telescope, which operated between 2003 and 2020. Data from the latter suggested[3] that WASP-39b's atmosphere might contain carbon dioxide, but the results were inconclusive.

Then came Webb. For a little more than eight hours on 10 July, the infrared telescope observed the planet moving across the face of its star. In this time, starlight shone through the planet's atmosphere, where various molecules absorbed specific wavelengths of infrared light. Astronomers wondered whether carbon dioxide would show up as a telltale blip in the spectrum. "And there it was – just jumping off of the computer screen," says study co-author Natalie Batalha, an astronomer at the University of California, Santa Cruz (UCSC), who leads Webb's Transiting Exoplanet Early Release Science team.

"This is the first time it's really been a 'punch in the face' kind of detection."

Batalha wasn't alone. When Christiansen, who is not part of the team, saw the data, she gasped. "I was like, 'Oh, there it is,'" she says. "We've had hints of it before, but this is the first time it's really been a 'punch in the face' kind of detection."

Mysterious origins

The result has bolstered confidence that Webb is going to be revolutionary for exoplanet research. In its first year of operation alone, the telescope is commissioned to observe 76 exoplanets; the final tally could be in the hundreds over its lifetime. It will gaze through the atmospheres of gas giants and small, rocky worlds that could be similar to Earth. "My very first thought when I saw that signal was, 'Wow, this is going to work,'" Batalha says.

But finding carbon dioxide is also impressive on its own. "From a science standpoint, it's extremely exciting," says Jonathan Fortney, director of the Other Worlds Laboratory at UCSC and a co-author of the paper. It would be reasonable to expect that a planet similar to Jupiter, which formed from the same disk of material as its star, would have roughly the same chemical make-up as that star. But that isn't the case in our Solar System; nor is it true for WASP-39b. The exoplanet's strong carbon dioxide signal suggests that it is enriched with elements heavier than the hydrogen and helium that typically constitute stars. The question is, why?

"That's where the story starts to get interesting," Batalha says. It's possible that when WASP-39b was young, it was bombarded with comets and asteroids, which could have delivered heavier elements such as carbon and oxygen. Interestingly, the exoplanet seems to have the same amounts of heavy elements as Saturn, which astronomers also think endured a violent youth.

Or the answer might be that WASP-39b formed from materials in the cold outer reaches of its planetary system, then migrated inwards. At its final resting spot, it snuggled up to its host star, which could have blasted away some of the hydrogen in the exoplanet's atmosphere – causing the heavier elements to become more concentrated, and making it richer in carbon dioxide than it was originally. Fortney, Batalha and their colleagues are working on four papers that will analyse the planet's spectrum in considerably more detail, and probe these possibilities.

"It's like archaeology," Batalha says. "You're trying to build up a big story – and you're using the molecules themselves as tracers of that story."

The building blocks of life

Spotting carbon dioxide in a planet's atmosphere is a stepping stone towards detecting life beyond Earth. Astronomers don't expect WASP-39b to be capable of hosting life – it is much too close to its star. They don't even expect the Webb telescope to find definitive signs of life on another planet. But using Webb to detect carbon dioxide helps to lay the foundation for future discoveries.

Astronomers think that a mixture of carbon dioxide and methane in a planet's atmosphere could be an indicator of life – what's known as a biosignature. WASP-39b's signal is "halfway to a good biosignature", says Christiansen. Batalha's team has built a model predicting that the planet's atmosphere also contains water, carbon monoxide and hydrogen sulfide – but little methane.

Ultimately, the detection of life will probably require an observatory even more advanced than Webb. But, Batalha says, "this is a really important phase that we need to pass through to be ready for that technology in the future".

1. JWST Transiting Exoplanet Community Early Release Science Team. *Nature* https://doi.org/10.1038/s41586-022-05269-w (2022).
2. Faedi, F. *et al. Astron. Astrophys.* **531**, A40 (2011).
3. Wakeford, H. R. *et al. Astron. J.* **155**, 29 (2018).

MOUSE EMBRYOS GROWN WITHOUT EGGS OR SPERM: WHY, AND WHAT'S NEXT?

Two research teams produced synthetic embryos from stem cells, for long enough to see organs develop.

By Cassandra Willyard

The recipe for mammalian life is simple: take an egg, add sperm and wait. But two papers now demonstrate that there's another way. Under the right conditions, stem cells can divide and self-organize into an embryo. In studies published in *Cell*[1] and *Nature*[2], two groups report that they have grown synthetic mouse embryos for 8.5 days, longer than ever before. The embryos developed distinct organs – a beating heart, a gut tube and even neural folds.

The process is far from perfect. Just a tiny fraction of the cells develop these features, and those that do don't entirely mimic a natural embryo. But the work still represents a major advance that will help scientists to see organ development in unprecedented detail. "This is very, very exciting," says Jianping Fu, a bioengineer at the University of Michigan in Ann Arbor. "The next milestone in this field very likely will be a synthetic stem-cell-based human embryo," he says.

The two research teams achieved the feat using similar techniques. Magdalena Zernicka-Goetz, a developmental and stem-cell biologist with laboratories at the University of Cambridge, UK, and the California Institute of Technology in Pasadena, has been working on this problem for a decade. "We started with only embryonic stem cells," she says. "They can mimic early stages of development, but we couldn't take it any further." Then, a few years ago, she and her team discovered[3] that, when they added stem cells that give rise to the placenta and yolk sac, their embryos developed further. Last year, they demonstrated[4] that they could use this technique to culture embryos until day 7. In their latest paper, published in *Nature*, Zernicka-Goetz and her team describe how they grew embryos for another 1.5 days.

Embryos in glass

The group used a technique developed by Jacob Hanna, a stem-cell biologist at the Weizmann Institute of Science in Rehovot, Israel, who has also been working on this problem for years. Last year, Hanna's team reported[5] that it had developed a device for culturing natural mouse embryos for an unprecedented length of time outside the uterus. This incubator, which kept the embryos going from day 5 to day 11, takes aspects of a previous technology – in which the embryos reside in glass vials that rotate on a Ferris-wheel-like system – and adds ventilation. The ventilation system controls the pressure and the mixture of oxygen and carbon dioxide entering the vials.