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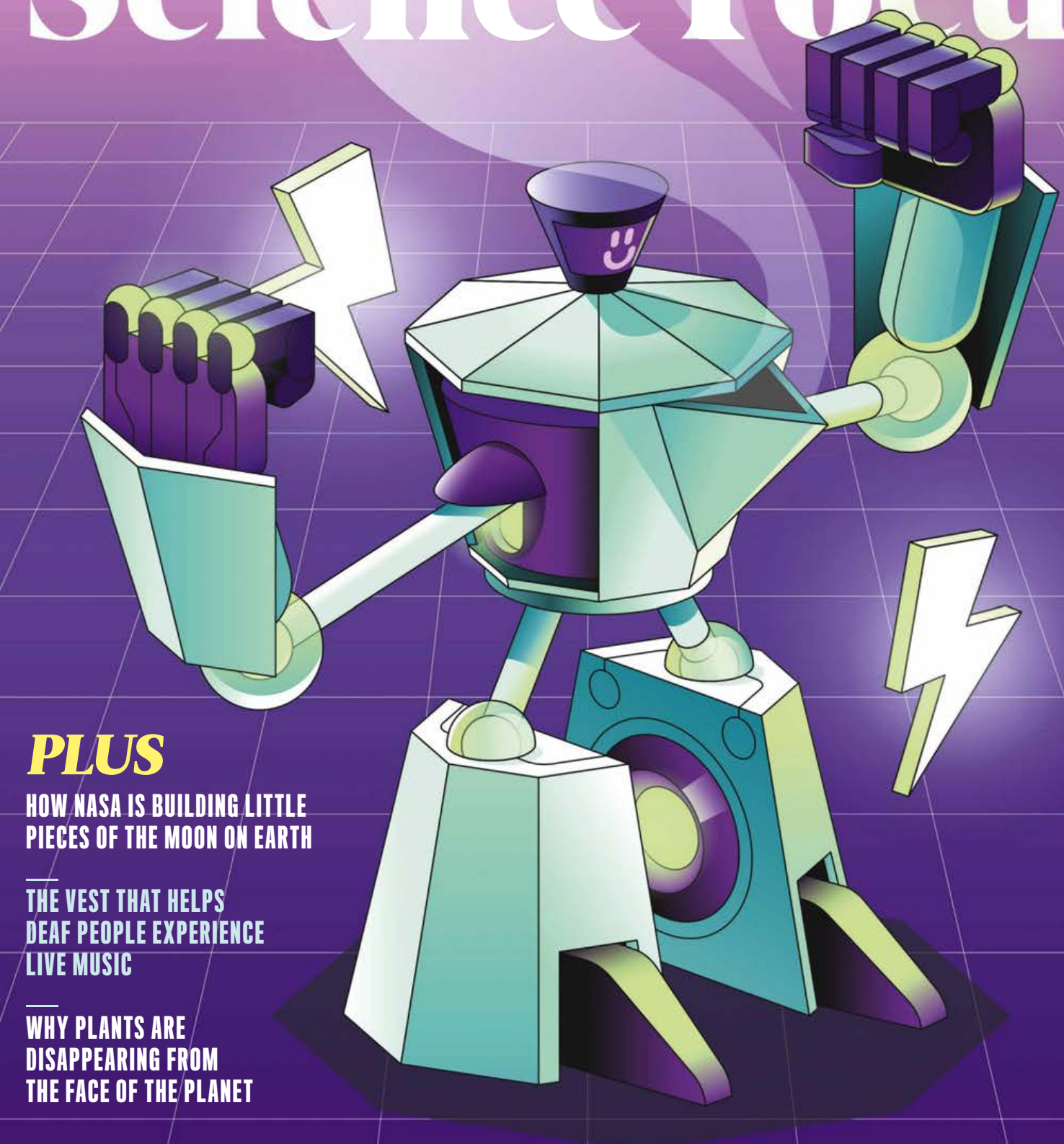

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COMMENT

DID THE JAMES WEBB SPACE TELESCOPE JUST SPOT GALAXIES THAT SHOULDN'T EXIST?

Given the age of the Universe, the galaxies we've just been shown appear to be too old. So, what's gone wrong?

If you've ever looked over at a shockingly productive colleague and asked, "How do you find the time?", then you'll know how cosmologists are currently feeling about the early Universe.

Since it started sending back data in mid-2022, the internationally funded, state-of-the-art James Webb Space Telescope (JWST) has been giving us images of distant galaxies that appear to have formed and matured far earlier than our models predicted.

Researchers have likened the situation to flipping through someone's family photo album expecting to find baby pictures and seeing a full-grown adult instead. With a person, you might just conclude that they're older than you thought. But with early galaxies, you quickly run into a problem with the age of the Universe.

JWST is looking at galaxies that are so distant that their light has taken more than 13 billion years to reach us. If the Universe is, as we currently think, 13.7 billion years old, there wouldn't have been enough time for such massive galaxies to have formed.

Headlines have been calling this a crisis for cosmology and a threat to the Big Bang theory. But before we throw out all our cosmology textbooks, let's dig a little deeper into the data.

As amazing as JWST is, the information it provides about the earliest galaxies isn't completely straightforward. While it has shown us spectacularly breathtaking views of nearby nebulae, star clusters and galaxies, its images of the most distant galaxies look, in general, like fuzzy little dots.

For the most part, the useful information we get from these images is actually from the spectrum of light they show – specifically, how much light is arriving at different colours (or wavelengths).

DR KATIE MACK

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"That would mean we have to completely rethink cosmic evolution"

There are two ways that JWST can examine a light source. It can take a spectrum by spreading out the light with a spectrograph (which works a bit like a prism) and examining the brightness at each colour, or it can use filters that block all but a select range of colours.

In both cases, to determine properties such as the galaxy's age or the total mass of its stars, we compare the data to simulations of the spectrum we expect for a galaxy with those properties.

These measurements are also how we determine the galaxy's 'redshift', which tells us what moment in the Universe's history we're looking at. The galaxies we've seen with the highest redshift values are sending us their light from within the first 400 million years after the Big Bang.

It's here that we run into a problem. Based on model spectrum comparisons, many of these galaxies seem to have too many stars, or stars that are too old, for the time in which they've existed. But there are several ways we could be mistaken – some observational and some theoretical.

On the observational side of things, photometric measurements can sometimes be inaccurate; a few apparently high-redshift galaxies turned out to be much closer to us when we took spectra. There have also been telescope calibration issues (although they're likely all settled now).

Then there's the fact that we're only seeing very small patches of the sky: we could have stumbled onto a clump of galaxies that simply aren't representative of the norm.

On the theory side, there's even more uncertainty. Our models of galaxy spectra are based on much closer galaxies. What if the early galaxies had different populations of stars (more massive stars and fewer small ones, for instance)?

What if star formation happened more rapidly in the past due to different physical conditions, or varied substantially over time? We're already seeing hints that our models need adjusting based on weird balances of chemicals in the spectra.

The most exciting conclusion, of course, is that those galaxies really are super massive and couldn't have formed in the time allotted. That would mean we have to completely rethink cosmic evolution.

But the more conservative position is that both the theory and observations are too uncertain for solid conclusions just yet. Perhaps when we figure out which knobs to turn in our galaxy formation models, we'll find new insights into the formation of structure in the Universe.

Based on what we know now, it's plausible that the Universe formed its galaxies as soon as it could, but still within physical feasibility. Just like your amazingly productive officemate – what looks impossible to us might be less about altering the laws of physics and more about using the time we have more efficiently.

ILLUSTRATION: MATTHEW HOLLAND