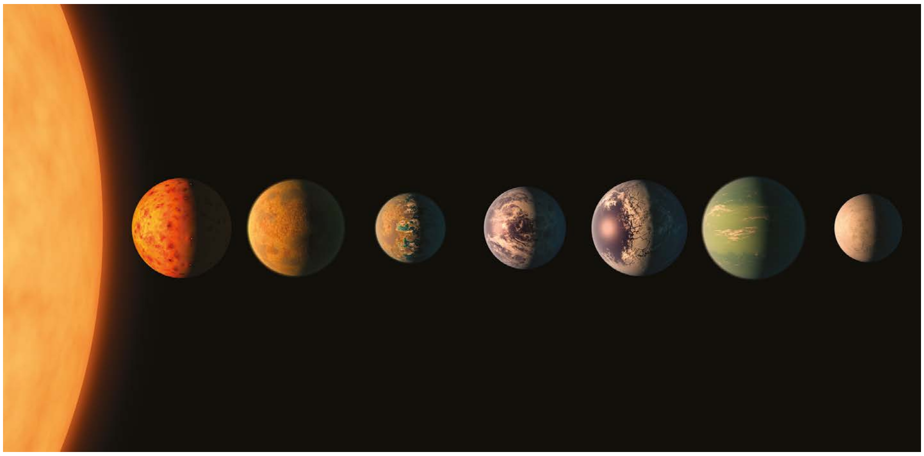


Approximations of the seven planets of the TRAPPIST-1 system (artist's rendering).

NASA/JPL-CALTECH

JWST GETS BEST VIEW YET OF PLANET IN HOTLY PURSUED STAR SYSTEM

No atmosphere was found on TRAPPIST-1b, but the findings have sparked a new era of planetary studies.

By Alexandra Witze

Using the James Webb Space Telescope (JWST), astronomers have confirmed that the planet TRAPPIST-1b probably has no atmosphere. Researchers have been excited to use the new telescope to explore the planet and its six siblings, which are all roughly the size of Earth and which orbit a star 12 parsecs (39 light years) from Earth. The system is a unique laboratory for studying how environmental conditions arise on planets – and how they might become suitable for life.

Last November and December, JWST searched for an atmosphere on TRAPPIST-1b by looking for heat radiating from it. With the telescope's ability to study infrared light, "you can actually measure the glow of the planet", says Thomas Greene, an astronomer at NASA's Ames Research Center in Mountain View, California. He and his colleagues reported their results on 27 March (T. P. Greene *et al. Nature* https://doi.org/grz99p; 2023).

Although the finding might sound disappointing to those hoping for an atmosphere, scientists say that the work showcases JWST's transformational power and opens the door for more results from the TRAPPIST-1 system.

Previous studies with the Hubble and Spitzer space telescopes, using a different technique, showed that TRAPPIST-1b – the innermost planet in the system – probably doesn't have a large puffy atmosphere made mostly of hydrogen (J. De Wit *et al. Nature* **537**, 69–72; 2016). But researchers couldn't rule out whether it has a dense atmosphere, as Earth might have had billions of years ago.

A planetary laboratory

JWST looked at TRAPPIST-1 in mid-infrared wavelengths of light – 20 times redder than the human eye can see – to see how that radiation changed as TRAPPIST-1b moved behind the star. By measuring the brightness of the star and planet together compared with that of the star alone, astronomers could calculate how much came from the planet. If TRAPPIST-1b had an atmosphere, it would have re-circulated the energy absorbed from the star and appeared less bright than Greene and his colleagues measured.

It's not surprising that TRAPPIST-1b has no atmosphere, because it is blasted by four times as much radiation as Earth receives from the Sun. TRAPPIST-1 is also wracked by stellar flares and other activity that sends radiation across its planets, potentially scouring away atmospheres. Still, understanding these conditions is crucial because M dwarf stars – cool, dim stars such as TRAPPIST-1 – often have Earth-sized planets orbiting them.

A key early step in studying the TRAPPIST-1 system is to take advantage of JWST's power to understand the star itself, says Julien de Wit, an exoplanet researcher at the Massachusetts Institute of Technology in Cambridge: "know thy star" should come before "know thy planets". Astronomers should work together to study TRAPPIST-1 with JWST using multiple techniques, to understand the star as fully as possible, he says. Otherwise, researchers will struggle to interpret what they are seeing in planetary observations, because the star's activity could be contaminating those measurements.

More discoveries are sure to come. Other research teams have been using JWST to study TRAPPIST-1b, as well as other planets in the system. That includes TRAPPIST-1b's neighbour, TRAPPIST-1c, a planet that is close enough to its star for JWST to study its glow. Publications on all of these are expected soon.

MOLECULAR SYRINGE FERRIES PROTEINS INTO HUMAN CELLS

Technique borrowed from nature could spur the development of better drug-delivery systems.

By Heidi Ledford

Researchers have hijacked a molecular 'syringe' that some viruses and bacteria use to infect their hosts, and put it to work delivering potentially therapeutic proteins into human cells.

"It's astonishing," says Feng Jiang, a microbiologist at the Chinese Academy of Medical Sciences Institute of Pathogen Biology in Beijing. "It is a huge breakthrough."

The technique, published in *Nature* on 29 March, could offer a new way to administer protein-based drugs, but will need more testing before it can be used in people (J. Kreitz *et al. Nature* https://doi.org/gr2nxw; 2023). The approach might also be useful for delivering the components needed for CRISPR–Cas9 genome editing.

The medical applications of CRISPR are currently limited by the challenges of getting the reagents – the DNA-cutting Cas9 enzyme and a short piece of RNA that guides Cas9 to a specific region in the genome — into cells.

"One of the major bottlenecks for gene editing is delivery," says study co-author Feng Zhang, a molecular biologist at the Broad Institute of MIT and Harvard in Cambridge, Massachusetts.

While Zhang and his collaborators searched for ways of transporting proteins into human cells, microbiologists were learning about an unusual group of bacteria that use molecular spikes to pierce a hole in the membranes of host cells. The bacteria then transport proteins through the perforation and into the cell.

Last year, Jiang and his colleagues reported that they could manipulate this syringe-like system in the bioluminescent bacterium *Photorhabdus asymbiotica*, loading proteins from mammals, plants and fungi into the syringe (F. Jiang *et al. Sci. Adv.* **8**, eabm2343; 2022). Normally, the bacterium lives inside nematodes and uses its syringe to transport a toxin into the cells of insects infected by the nematode. The toxin kills the insect, and the nematode eats the remains. "The bacterium can be viewed as a hired gun," says co-author Joseph Kreitz, a molecular biologist at the Massachusetts Institute of Technology in Cambridge.

In Zhang's lab, Kreitz and his collaborators were working on ways to engineer the *P. asymbiotica* syringe so that it would recognize human cells. They focused on a region called the tail fibre, which normally binds to an insect-cell protein. Using the artificial-intelligence program AlphaFold, which predicts protein structures, the team designed ways to modify the tail fibre so that it would recognize mouse or human cells instead. "Once we had the image, it was very easy to modify it for our uses," says Kreitz. "That was the moment when it all came together."

The researchers loaded the syringes with various proteins, including Cas9 and toxins that can kill cancer cells, and delivered them into human cells grown in the lab, and into the brains of mice.

Flexible system

The system was unable to transport the mRNA guide needed for CRISPR–Cas9 genome editing, but the team is developing ways to do this, says Kreitz. The fact that it was able to ferry Cas9 into cells speaks to the technique's flexibility, he adds, because Cas9 protein is about five times larger than the syringes' usual cargo.

The syringe story is reminiscent of the way that researchers developed CRISPR–Cas9 — a system that many microorganisms rely on in nature to defend against viruses and other pathogens — for use as a genome-editing technique, says Asaf Levy, a computational microbiologist at the Hebrew University of Jerusalem. The work could have a transformational effect on medicine, he adds. "The evolution of this thing is quite amazing."

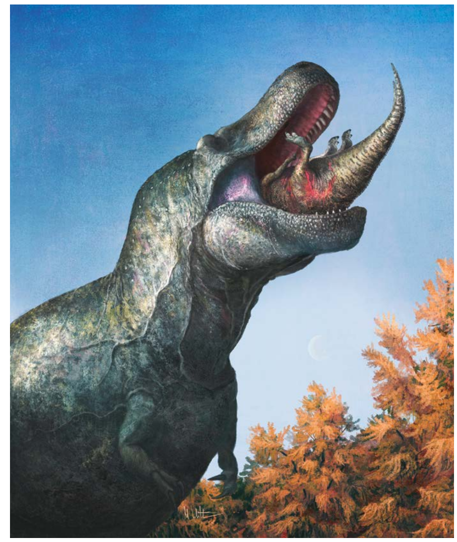
FACELIFT FOR *T. REX*: ANALYSIS SUGGESTS IT HAD LIPS

Evidence from living reptiles supports the idea of a scaly cover over some dinosaurs' teeth.

By Dyani Lewis

The fearsome maw of the iconic *Tyrannosaurus rex* has had a makeover. According to a study published in *Science*, the dagger-like teeth of theropod dinosaurs such as *T. rex* would not have been visible when their mouths were closed. Instead, they would have been concealed behind thin, scaly lips (T. M. Cullen *et al. Science* **379**, 1348–1352; 2023).

Reconstructions of large theropods — whether in Hollywood films or scientific texts — often depict the prehistoric predators as having jaws full of exposed teeth, even when their mouths are shut. Palaeontologists had reasoned that theropod teeth were probably exposed because the teeth are so big, and because the living relatives of theropods, alligators and crocodiles, have toothy grins.


MARK P. WITTON

In having lips, *T. rex* resembled lizards.

But when Kirstin Brink was a graduate student at the University of Toronto, Canada, in the 2010s, she and fellow students Thomas Cullen and Derek Larson got talking about whether that depiction was accurate. "It just looks so weird when the *T. rex* mouth is closed, and you can see the teeth," she says.

Brink, now a vertebrate palaeontologist at the University of Manitoba in Winnipeg, Canada, notes that modern-day lizards, such as iguanas and Komodo dragons, have lips that hide their teeth.

Other palaeontologists have also wondered whether extinct theropods smiled like a crocodile or had lips like lizards. But Brink, Cullen, Larson and their colleagues are the first team to examine the skulls and teeth of theropods and their living relatives to settle the debate.

Brink says that the tooth enamel in theropods points to them having lips that cover the teeth. "Enamel needs to stay hydrated," she says, otherwise it is prone to cracking.

In crocodiles, the enamel is thick and stays hydrated because they live in the water. Even so, crocodile teeth bear the signs of cracks and damage on their outer surfaces. That's not the case in theropods, she says. Theropod teeth are covered by just a thin layer of enamel, indicating that these dinosaurs probably had lips to keep the teeth protected and coated in saliva when their mouths were closed.

Brink and her colleagues also compared theropods with Komodo dragons (*Varanus komodoensis*), one of the few living reptiles with teeth shaped like those of theropods. "Komodo dragons are weird though, because they have these gigantic gums," says Brink. There's no evidence that theropods had such gummy mouths, but it's possible, she says.

"These authors have given *T. rex* a facelift," says Steve Brusatte, a vertebrate palaeontologist at the University of Edinburgh, UK. The work is "the single strongest case for lippy tyrannosaurs yet", he says.

Soichiro Kawabe, a vertebrate palaeontologist at Fukui Prefectural University in Eiheiji, Japan, says he has long suspected that theropod enamel was too thin for the teeth to have been exposed. "So I am happy that the scientific data has now been presented," he says. "It looks less monstrous and more natural," he adds. Kawabe would like to see similar work to be done in other prehistoric creatures, such as toothy pterosaurs, for which the facial morphology is less known than for the well-studied *T. rex*.

But *T. rex* wouldn't have been able to purse its lips as humans do, because it wouldn't have had the necessary muscles. "Dinosaur lips would have been scales and keratin, and some soft bits covering the teeth from the outside, not the big fleshy and pouty lips of humans," says Brusatte.

"I doubt it will be the final word in this contentious debate," he says. "Ultimately, we need to find a fossil *T. rex* mummy with skin and muscles and scales still preserved on the head."