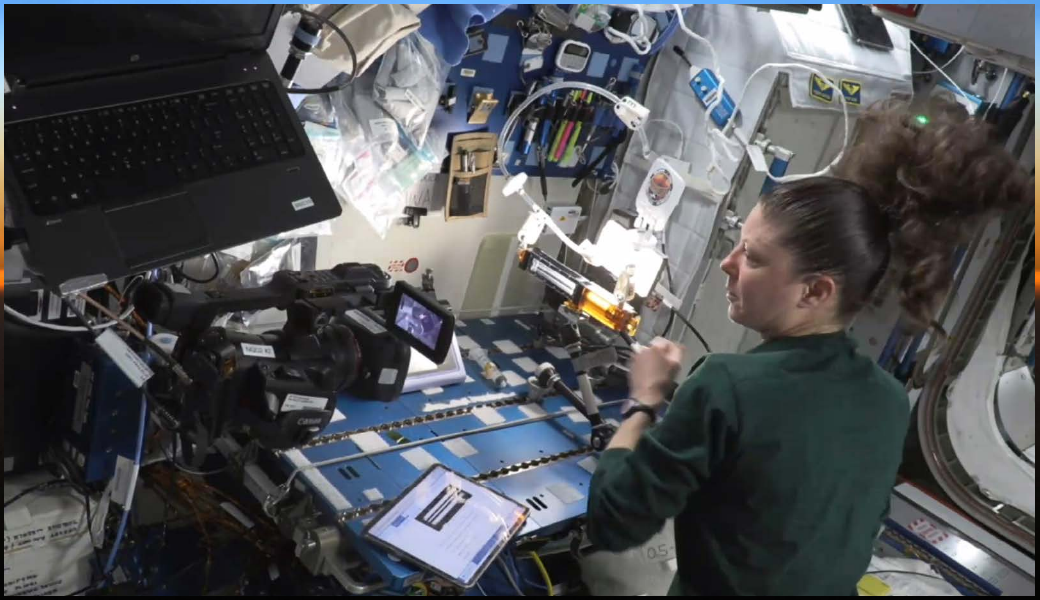
Studying Respiratory Distress Syndrome in Space



"Whoa" moment: astronaut Tracy Dyson conducts one of the nine experiments Dressaire sent to the ISS.

At night, far from any city, it's possible to spot the lights of the International Space Station (ISS) in its orbit 250 miles above Earth. Earlier this year, **Emilie Dressaire,** an assistant professor in the UC Santa Barbara Mechanical Engineering Department, had a much more intimate look at the 356-foot-long spacecraft, spending time *inside* it via Zoom as she worked with an astronaut to fix a problem with one of nine onboard experiments she had sent to the ISS last November.

"You're at home, and it's the middle of the night, because they work on European time," she recalls of the interaction. "You set your alarm for one AM, turn on Zoom, and start watching the experiment. You're talking to somebody who is in a crowded control room in Colorado, and they're talking to the astronaut in space. In one experiment, fluid was moving too quickly in a tube, so we were trying to fix it. My six-year-old daughter climbed into bed with me, saw this astronaut Tracy Dyson with her hair floating around, and said, 'Whoa.'"

Definitely not your average wilderness ISS sighting.

For Dressaire, the idea to send experiments into space had its roots in the Covid pandemic, when tens of thousands of people suffered — and many died — from respiratory distress syndrome (RDS). Dressaire, an expert in fluid dynamics who had been interested for some time in how fluids interact with gels, saw RDS as an expression of such dynamics.

"That's kind of the lens we looked through when we heard about this respiratory problem," she says. "There were lots of conversations about people, especially adults, who weren't getting a lot of relief from the traditional approach, called surfactant replacement therapy (SRT), in which liquid medication is administered through the trachea."

The treatments for RDS involve introducing a surfactant — a slippery medication that gets distributed throughout the respiratory system and is intended to provide relief by making things move. The liquid medication is the "fluid" in the fluid-gel interaction that interests Dressaire, while the "gel" is the mucus lining of the upper respiratory tract.

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Emilie Dressaire

Reading up, Hatching a Plan

As Dressaire and her lab group started digging into the literature, it appeared that a lot of work had been done to see if the difference between the efficacy of SRT in infants and adults could be due to the difference in size of the respiratory system.

The researchers read papers in which scientists concluded that the more extensive branching of the adult respiratory system compared to that of an infant played a role in how well surfactant replacement therapy worked. They also looked at the effect of gravity, which is greater in adults, because their lungs are bigger than those of babies, which leads to the surfactant ending up in the bottom of the lungs. They thought, however, that there was more to it, and that gravity probably did not account for the adults' reduced responsiveness to SRT.

The researchers found, too, that some of the surfactant gets stuck in the upper respiratory tract, where it isn't needed. "At that point, nobody had considered the role of mucus," Dressaire explains, "but we thought that maybe the more mucus is present, the more the medication accumulates in the upper respiratory tract. We thought that the mucus was probably affecting how, and how much of, a drug is being delivered to the respiratory system, where it needs to go."

Dressaire wanted to study that phenomenon, but doing so on Earth comes with big challenges. "If you want to look at small-scale effects that are most important deep in the lungs, then you have to make gel-coated channels in the micrometer range," she notes, "and it's really hard for us to make the gel-coated tube and then image the deformation caused by the motion of the fluid. Eventually, we thought, *What if we go into space, where we can have big tubes and not worry about gravity, making it possible to isolate the effects of surface tension?"*

They had a plan. To prepare to execute it, Dressaire hired an implementation partner, BioServe, based at the University of Colorado, Boulder, because, she says, "We had never built an experiment for space, and NASA has a lot of rules to make sure everybody is safe and things work right, and that we can communicate with astronauts and so on." BioServe worked with **Trinh Huynh,** a fourth-year PhD student in Dressaire's lab, to design the experiments and were in the communication loop when astronauts were working on them.

Experiments in Space

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One of the astronauts her team worked with was flight commander Butch Wilmore. He and mission pilot Sunita "Suni" Williams were launched into space June 5 as the first astronauts aboard the Boeing Starliner rocket, which would later return to Earth without them, when, following detection of helium leaks and other problems , it was deemed unsafe for human flight. While unfortunate for the crew, who now are expected to be back on Earth early in 2025, Dressaire says, "It also meant that we had more time with Butch, which was awesome. By the end of our experiments, he was saying, 'Oh, this is fun. If there's one more sample, sign me up.'" (Wilmore got his wish when he was scheduled to run the final experiment on October 17.)

While Dressaire sent nine samples for nine experiments to the ISS last November, with the intention of determining whether the mucus lining could slow down, speed up, or trap some of the liquid medication used in SRT, it wasn't until January that the first of them was run. They had to wait behind a collection of biological experiments that involved living cells or mice that had to be taken care of first. "Our gels are really stable, so we knew we would not be at the top of the pile," Dressaire says.

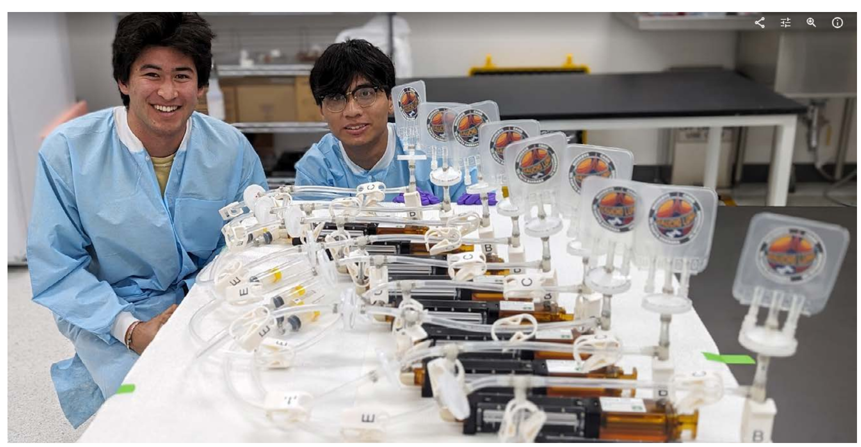
Each of the nine experiments was slightly different in terms of such variables as the thickness of the gel layer, the viscosity of the liquid, and the size of the tube. "If we were to run those experiments on Earth, we could have used water-based liquids and gel, but because they were going to space and wouldn't be run immediately, everything had to be oil-based so that it wouldn't dry out. We needed an analog for water, and oil was close enough."

When astronaut Loral O'Hara started conducting the first experiments, things didn't go quite as planned, with some of the oil flowing in the wrong direction. "We had considered that something might go wrong, and it turned out that a solution was kind of built in," Dressaire explains. "We had the astronaut slightly blow up a little bag that was part of the experimental setup, and then just squeeze it to redirect the oil if she saw it going the wrong way again. It worked."

Throughout the interactions around the experiments, Dressaire was impressed with the astronauts' commitment to doing everything they could to get the science right. "They were always asking, 'Can I do something else' or 'Is this where I should be?'"

In July, Dressaire and the team were starting to see results, via video recordings of each experiment that they received from NASA. "We're looking at the plug or the fluid moving faster or slower. Initially we could see that when we have a thick mucus-like layer, more fluid appears to stick to it, which is what we hypothesized."

The next step will be to compare the results from the experiments conducted aboard the ISS with those previously done in the lab to quantify the difference gravity makes and solidify whether or not their hypothesis is true. If, at the end of it all, they do realize that thick mucus makes the treatment less effective, Dressaire notes, "Then maybe they can use a medicine to try to make the mucus thinner and more fluid. Once we've quantified the effect, that's something that other scientists could also put in their numerical simulations to combine different effects and study the transport in patient-specific lung geometries."



Undergraduate student researcher JP Raimondi (left) and fourth-year PhD student Trinh Huynh pause in the Dressaire lab while preparing the nine experiments for their journey to the International Space Station.