Space Tales

A boom in space-based science is under way. Private companies ferry people and cargo to and from the International Space Station, where astronauts run increasingly automated experiments. While one UCSB team reviews data from a recent mission, another prepares for one ahead. Meanwhile, Netflix plans a movie about UCSB College of Engineering graduate and NASA astronaut José Hernández.

Photograph courtesy of NASA

The SpaceX Crew Dragon Endeavour is pictured high above Earth during its approach to the International Space Station.

Photograph courtesy of Allan Hancock College

Netflix Movie to Tell the Story of UCSB Alumnus Astronaut's Path to Space

Former astronaut José Hernández has shared his inspirational story with students across the country, including (shown) at a community event in Santa Maria in 2017.

The inspirational story of former NASA astronaut José Hernández, a graduate of UC Santa Barbara's Electrical and Computer Engineering Department who went from California's migrant farmworker community to orbiting the Earth, will be the subject of a Netflix original movie set to begin production this summer. The working title of the film is "*A Million Miles Away*."

Hernández spent fourteen days in space in 2009 as a flight engineer on board STS-128, a NASA Space Shuttle mission to the International Space Station (ISS). But his flight path to space, where he became the first person to send a tweet in Spanish from space, was not easy.

"The film shows my life as a migrant farmer who went from working in the fields with his parents to becoming an astronaut," said Hernández, who described his nomadic childhood of moving each year with his family to various locations throughout California and Mexico. "I think this film is going to inspire a lot of people, not just kids, to believe that anything is possible if you put your mind to it."

Hernández said that a few years ago he was approached

Photographs on this page courtesy of NASA

Discovery crew members gather on the 225-foot level of Launch Pad39A (from left): commander Rick Sturckow, mission specialists Danny Olivas and Christer Fuglesang, pilot Kevin Ford, and mission specialists Nicole Stott, Patrick Forrester, and José Hernández.

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by Select Films, a production company that had produced such hit films as *Secretariat, The Rookie*, and *McFarland, USA*, the last of which highlights a high school cross-country team that won a state championship.

"I had been approached by film companies before, but Select Films had a proven track record of telling feel-good motivational stories," said Hernández, adding that he and Select Films pitched their idea to six studios in a two-day period. "Four of the studios wanted to pick it up. We went with Netflix, because we felt it would be viewed by a larger audience."

The company hired Bettina Gilois, an Emmy-nominated writer who wrote the script for *McFarland, USA*, to write the screenplay, and Alejandra Márquez Abella to direct the film. Márquez Abella's breakout film, "*Las Ninas Bien*," received fourteen nominations and won four awards at the Ariels, Mexico's Oscar-equivalent, .

The movie will tell the story of how his second-grade teacher convinced his parents to stay in one place to provide stability for their children. It continues by depicting his life as a teenager growing up in Stockton, including the pivotal moment in 1976 when he was inspired to become an astronaut, watching Gene Cernan walk on the moon during the Apollo 17 mission. The film will also portray his struggles while majoring in engineering at the University of the Pacific.

"A movie always has to have a villain. The villain in this case is not a person; it's the self-doubt and inner struggle of believing in myself," said Hernández. "A lot of minority children suffer from impostor syndrome (see article on page 30), feeling they don't belong and aren't as competent as they should be while they start to succeed. The film addresses this head on, so hopefully people will see it and be able to better deal with their own struggles and rejection."

Hernández knows all about rejection. He was turned down eleven times by NASA's astronaut program, finally getting accepted on his twelfth attempt, in May 2004.

"I would always convince myself it's not a bad consolation prize to be where I am, and I'd think about all the things I had accomplished. It helped me realize that I belonged," recalled Hernández. "My dream of becoming an astronaut motivated me to get an engineering degree from Pacific and a graduate degree from UCSB. It motivated me to work at a premier research facility like the Lawrence Livermore National Laboratory, get a job that I love that paid me well, become a pilot and a scuba diver, and learn a third language, Russian."

Hernández hopes the film will feature a few scenes shot on the UCSB campus, where he earned a master's degree in electrical and computer engineering in 1986. He describes his time at UCSB as pivotal.

"Because I had received a Graduate Engineering Minority Fellowship, for the first time, I didn't have to work. I could focus solely on my studies and work with the great professors, like **Sanjit Mitra** in digital signal processing," said Hernández, whose daughter, **Marisol,** graduated from UCSB last June with a BA in statistics and data. "UCSB prepared me very well for my job at the Lawrence Livermore National Laboratory. I am certain that without that training from UCSB, there is no way I would have become an astronaut."

While working at the Lawrence Livermore National Laboratory, Hernández co-developed the first full-field digital mammography imaging system for early detection of breast cancer. He left in 2004, when he was selected for astronaut training.

José Hernández takes a break from prepping for Space Shuttle mission STS-128, which launched in 2009.

More than a decade after his mission to the ISS, Hernández is still involved with NASA, primarily performing educational outreach. He runs his own aerospace company, Tierra Luna Engineering, which has worked with Boeing to provide communication satellites to Mexico, and has launched satellites for Lockheed Martin. He also runs the Reaching for the Stars Foundation, a non-profit in Stockton aimed at inspiring youth to follow their dreams and find passion in STEM fields. Through the foundation, he has told his story of defying the odds to students across the nation, including stops at UCSB, where he was the commencement speaker in 2014, and at Allan Hancock College in Santa Maria, a major UCSB feeder school for minority students.

"Students see someone who looks and talks like them, and they see how I defied the odds to become an astronaut. I want them to know that if I can do it, so can they," said Hernández, who also wrote a book, *Reaching for the Stars*. "You can only reach so many people in person or in a book. A movie, I think, is the ultimate medium for reaching millions of people. Hopefully, we can inspire lots of children and adults."

"I think this film is going to inspire a lot of people, not just kids, to believe that anything is possible if you put your mind to it."

Hernández said that the production team has not selected a cast yet, but he would like to see his role played by Michael Peña. "He looks short and stocky, and is not particularly good-looking, just like me," Hernández laughed. "He plays down-to-earth characters, and even played an astronaut before in *The Martian*. He makes the most sense to me."

Asked if he will make a cameo appearance, Hernández, who will be a technical consultant on the film, said he planted the seed with this production company. "I even told them the scene," he joked, "but it will be up to the director, so we will see. At least I'll be on location during the film, so I will be ready to go."

Netflix plans to release the movie in 2022. Hernández hopes to return to UCSB to host a screening and a question-and-answer session at that time.

The International Astronomical Union named Asteroid (122554), Joséhernández, in honor of the UCSB graduate this spring. It was one of twenty-seven asteroids recently discovered in a belt between Mars and Jupiter that were named in honor of African American, Hispanic, and Native American astronauts who inspire the next generation.

Photographs courtesy of NASA

The Heart of Space

Space travel has interesting effects on the human body. For instance, the microgravity environment causes the heart to undergo morphological changes similar to those seen in many cardiac diseases. The molecular mechanism behind these changes is unknown. In order to understand the phenomenon, a team of biologists, bioengineers, and aerospace engineers shipped biological samples aboard a SpaceX Falcon 9 rocket to the International Space Station (ISS).

Beth Pruitt, a UC Santa Barbara mechanical engineer and director of the Center for BioEngineering, collaborated with Joseph Wu from Stanford University and Bioserve Space Technologies on a project to send live engineered heart tissues (EHTs) to space. At the ISS, astronaut Kathleen Rubins maintained the EHTs and performed experiments intended to shed more light on how microgravity affects heart tissues.

"This project started three years ago as part of the Chips in Space program [funded by the National Institute of Health's National Center for Advancing Translation Sciences Tissue], which is aimed at enabling scientists to learn more about the effects of space flight on human physiology," says Pruitt. A tissue chip, also referred to as "organs on chips," is a small device about the size of a thumb drive that contains human cells in a 3D matrix. First used in 2018, the system represents a giant leap in scientists' ability to test how cells respond

Unweighted heart: Carefully packaged synthesized heart tissues (below) were sent to the International Space Station, where astronaut Kathleen Rubins (left) performed experiments intended to shed light on how they are affeced by microgravity.

to stresses, drugs, and genetic changes.

"Hopefully," Pruitt adds, "this will not only make it possible for astronauts to spend longer periods of time in space, but will also lead to fundamental knowledge about mechanobiology in the heart."

The scientific payload contained live EHTs comprising the three major cell types found in human heart tissue — cardiomyocytes, cardiac fibroblasts, and endothelial cells — which were derived from human induced pluripotent stem cells (IPSC) and embedded in an extracellular fibrinogen matrix. Some of those tissues returned to Earth on Jan. 14 and are currently being examined at UCSB and Stanford to determine the molecular changes that may have occurred as a result of the space flight.

"We are hoping not only to understand the effects of microgravity on these tissues, but also to use these functional and morphological changes to model known cardiovascular diseases here on Earth," says **Orlando Chirikian,** a third-year graduate student in the Pruitt lab who attended the Dec. 6 launch at NASA's Kennedy Space Center in Florida.

The researchers are especially interested in characterizing cardiac atrophy, a phenomenon observed in microgravity. Many experts believe that it is induced by mechanical unloading of the ventricles and a number of metabolic changes within the cells of the heart, but the mechanism behind the process has not been identified.

In previous space-flight studies, Wu, director of the Stanford Cardiovascular Institute, began investigating this phenomenon by using conventional cell-culturing platforms. This study builds upon that work by using a three-dimensional platform, in the form of the EHTs, complete with the three major cell types of the heart to better represent the multicellular environment.

"These tissues resemble cardiac tissue, making it possible for us to better assess changes that result from exposure to the microgravity of space," Chirikian notes. "The experiments are intended to characterize alterations in tissue morphology [size and weight], contractile function [force production], calcium-handling, cellular metabolism, and the transcriptome [the sum total of all the messenger RNA molecules expressed from the genes of an organism]."

Bubbling up Experiments for the International Space Station

Photographs courtesy of Space Tango

Boiling water for tea or coffee is among the simplest of all kitchen tasks. In the microgravity of space, however, it is beyond difficult. It is, in fact, impossible.

Boiling is a gravity-dependent phenomenon. As water boils on Earth, vapor bubbles form, which are less dense than water. This density difference generates buoyancy, which causes the bubbles to rise to the top surface and dissipate into the air. Bubble departure is important as it allows the substrate to generate new bubbles for continuous boiling heat transfer.

In space, none of that happens. A bubble formed in a liquid boiling in microgravity would simply expand continuously, because gravity-dependent buoyancy does not exist.

A group of UC Santa Barbara researchers is currently planning a series of experiments to be conducted two years from now aboard the International Space Station (ISS). They intend to study ways of enabling boiling, and the closely related process of condensation, under conditions of microgravity.

"It's an intriguing question," says **Yangying Zhu,** assistant professor of mechanical engineering and a principal investigator on the project, along with mechanical engineering assistant professor **Paolo Luzzatto-Fegiz** and chemistry professor **Javier Read de Alaniz.** They have received National Science Foundation funding in collaboration with the Center for the Advancemnt of Science in Space (CASIS), aka the ISS National Lab, to study phase changes in space.

"The question has applications both in space and here on Earth, where boiling is used to generate electrical power and condensation is used to harvest water," says Zhu. "On Earth, you can use a condenser to collect water droplets. The droplets are then shed as a a result of gravity, and you can collect them. In microgravity, however, the droplets will just stay on the surface, making it very hard to collect them."

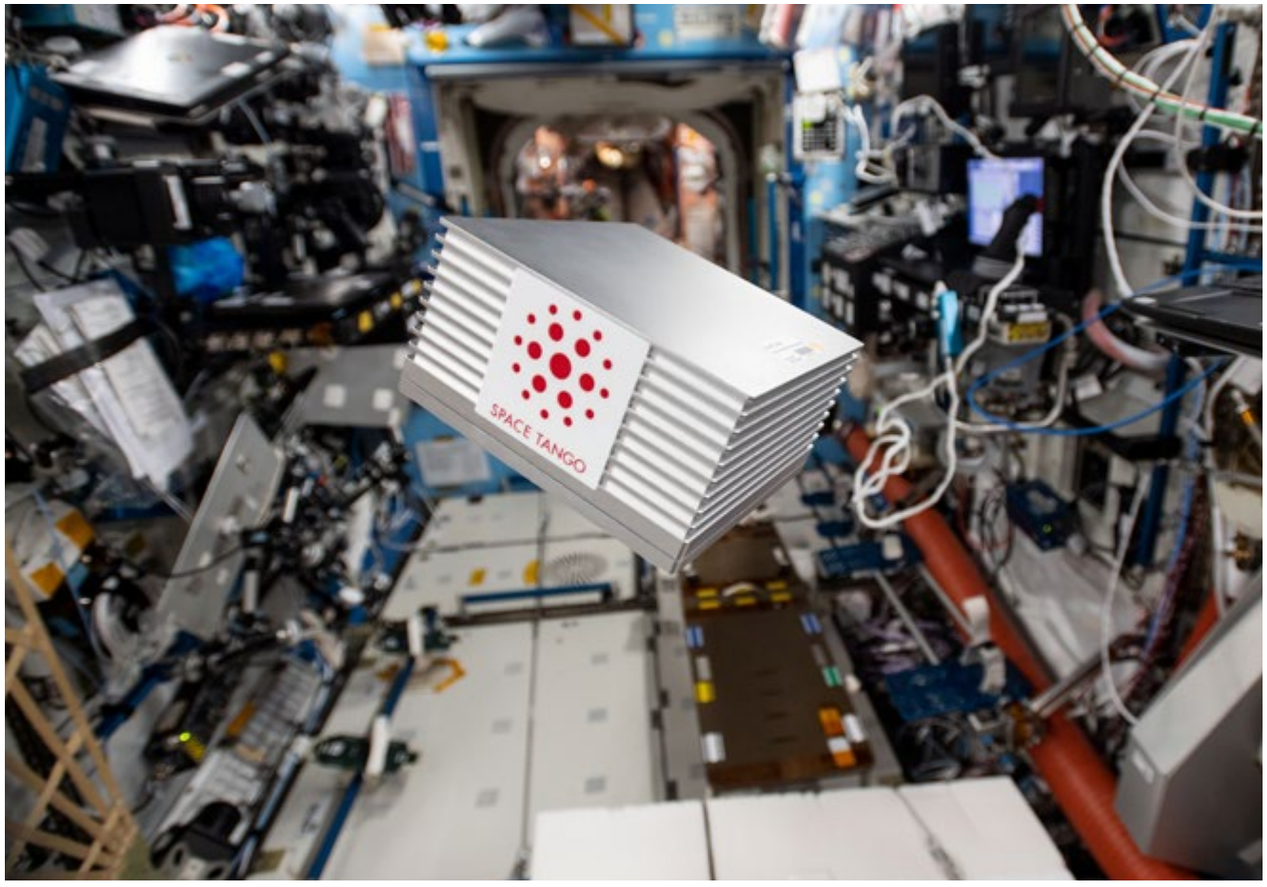
For this project, the researchers are investigating how to manipulate droplets (condensation) and bubbles (boiling) in space. Specifically, Zhu explains, "If we can come up with a method to remove a bubble from a boiling surface or remove a droplet from a condensation surface, we will be able to achieve very high boiling and condensation heat transfer rates in microgravity. That would be valuable in space for using boiling to cool electronics, and for thermal management in general, but also for such Earth-bound applications as power generation, water desalination, and HVAC in buildings. The key idea is how do you generate a buoyancy-like force on a bubble in a liquid in microgravity? That's where Javier and Paolo come in. Their expertise made it possible."

Read de Alaniz's lab synthesizes unique surfactants — surface-active agents that can be added to a liquid to reduce surface tension — that are stable and soluble and have reversible responses to different wavelengths of light. The idea is to dissolve the surfactants in water and then hit them with light of a precise wavelength, which causes the surfactants to change form. Since surfactants like to stay at the interface of the bubble and the liquid, changing their form can in turn change the surface tension of the bubble.

"And if you can apply light to only one side of the bubble, surface tension will change on that side but remain unchanged on the other side," says Zhu. "This asymmetric surface tension distribution creates a force, called a Marangoni flow, in the liquid around the bubble, and

NASA Astronaut Drew Feustel prepares to install CubeLabs aboard the International Space Station.

A standardized Space Tango CubeLab, containing all the components for one or more automated "plug and play" experiments, floats aboard the ISS.



this liquid flow creates a net force on the bubble that can push it away from the surface."

Luzzatto-Fegiz is an expert in Marangoni effects and recently received an National Science Foundation CAREER award (see page 9) to study and model them in the context of super-hydrophobic surfaces, such as paints that might be used to reduce drag on ships. "From a fluid dynamics perspective, this is a really interesting question where everything affects everything else in complicated ways," he says. "We often work on these problems where, if you don't have a model, it's very hard to know if something will work or how fast a process will occur. We have expertise on the theory and on doing simulations for surfactant problems, which makes it exciting to be able to establish a framework for many of these processes."

The team hopes to be able to move a bubble away from the surface in microgravity, and to discover its maximum velocity. They also want to use light-enabled surfactants to realize complex fluid behavior, such as having two bubbles merge or having one bubble split into two and then four.

"We really get the benefit of the ISS in observing complex merging and splitting fluid behaviors," says Zhu, who has expertise in relating bubble dynamics to heat transfer. "On Earth, there is buoyancy and gravity in everything, and if we make bubbles, they reach only two to three millimeters in diameter before buoyancy causes them to detach from the surface. That limits the size of bubbles we can observe before that moment when buoyancy dominates everything.

"But in microgravity," she continues, "we have no buoyancy and no convection, which is a density-driven flow, so we can focus only on the effect of the photo surfactant. We know that any behavior we observe will be due to the Marangoni effect [made possible by the presence of the surfactants] and not buoyancy. That will allow us to build a very nice model to understand them."

For Read de Alaniz, the project has twofold benefits. "This helps us to understand fundamental properties of these new materials that we've been developing, while trying to accomplish something in space," he says. "It is an elegant way for us to enhance our fundamental understanding of changes in surface tension, and to use what we find to design new photo surfactants that have a bigger light-induced change, so that we can get the bubble departure to occur on a time scale that's relevant."

The project is occurring at a time when it is becoming easier and cheaper to conduct experiments aboard the ISS. Multiple private companies contracted by CASIS offer services to make experiments space ready. Automated experiments are placed inside modular, stackable cubes that measure four inches on a side. "You design your cube, and they plug it in on the ISS, and it will run the experiment," says Zhu.

The UCSB team's six cubes of cargo will include sealed containers that hold liquid and micro-heaters, which the team will engineer to generate bubbles and also to serve as temperature sensors; an array of small LEDs to transform the photo surfactants and activate the Marangoni effect; and a camera to record the activity.

Currently, astronauts aboard the ISS can make tea and espresso in an exotic made-for-space device called ISSpresso. Who knows, though, maybe soon they'll be able to do it the old-fashioned way, by boiling some water.