

STEM

M A G A Z I N E

Can Humans Become Interplanetary and Interstellar Species?

Dr. Michaelyn Thomas

The Quiet Unraveling of America's STEM Pipeline

Shelly A Muñoz

Understanding Naloxone Use: A Lifesaving Tool

Dr. Talia Wall / Touro College of Pharmacy

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STEM Magazine strives to encourage curiosity, investigation, inspiration, creativity, and innovation; the foundations of every career passion.

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STEM Magazine
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STEM Magazine is a monthly non-profit education publication for educators, students, their parents and industry professionals.

Read monthly in 75 countries and 47 U.S. states, STEM Magazine strives to encourage the educator to better understand the importance of STEM skills, their use in every school subject, the need and ease of integration into curriculum and the urgency for students to embrace STEM through a more complete understanding of it.

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Sci-Fi or Science:

Can humans become interplanetary and interstellar species?

By **Dr. Michaelyn Thomas**

Space systems engineer

Humanity is well on their way to becoming an interplanetary and even potentially an interstellar species. Interplanetary means that humans would travel and live on a planet within our solar system, and interstellar means that humans would travel and live outside of our solar system.

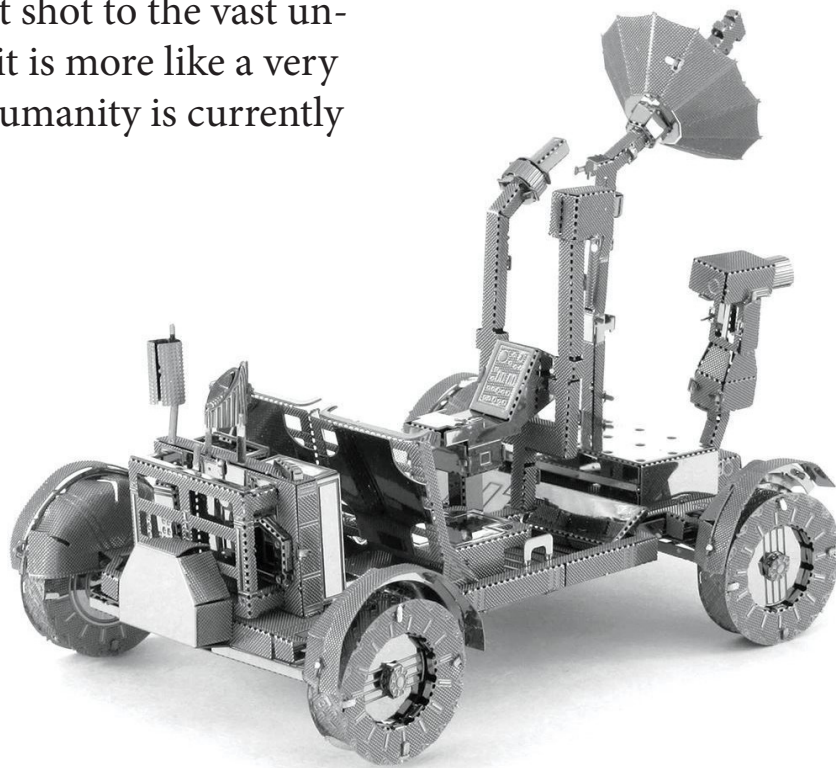
There are many breakthrough advancements that must be considered. Historical and current endeavors behind space exploration and scientific discovery must be at the forefront when meticulously planning future expeditions. Through existing space technology, scientists and engineers have found ways to orbit planet Earth as well as reach the Earth's Moon again through spaceships for human spaceflight and uncrewed—no humans on board—spacecraft missions.

Satellites, rovers, and telescopes have also reached other planets, orbit the Sun, and have even traveled beyond our solar system making space technology interstellar. These foundational building blocks are key to securing humanity's place in space. As humanity continues space exploration expeditions beyond Earth, it is not simple nor is it a straight shot to the vast unknown. Instead, it is more like a very tall ladder, and humanity is currently on the first rung.

First stop, Earth's Moon

Many world-wide governments are actively aiming to get humans back on the Moon. The Moon has a rich history of scientific discovery, and the Apollo Era first landed humans on the Moon on 20 July 1969. It was the Apollo 11 mission where National Aeronautics and Space Administration (NASA) astronauts, Neil Armstrong and Buzz Aldrin, walked the surface of the Moon with astronaut Michael Collins remaining in the command and service module in lunar orbit.

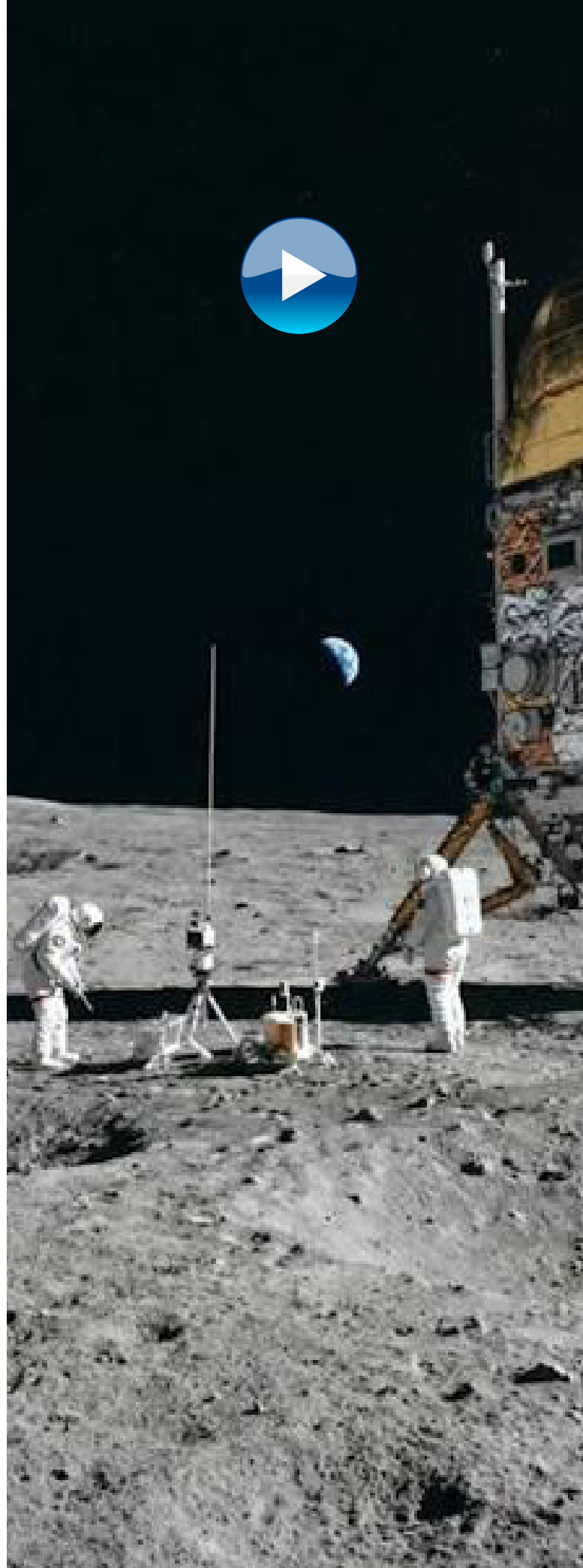
All three astronauts returned safely to Earth just four days after this historic space mission. After the successful landing with Apollo 11, five of six additional lunar landings were carried out, resulting in 10 additional astronauts stepping down on Earth's Moon.



The Apollo program effectively ended on 19 December 1972, and no human has touched down on the Moon since the Apollo 17 mission.

With this success came catastrophe and sacrifice before them—on 27 January 1967, Apollo 1 was set to be the first crewed mission. Tragically, it resulted in a devastating cabin fire during a pre-launch test, killing NASA astronauts Virgil “Gus” Grissom, Edward White, and Roger Chaffee. NASA took strict measures, working tirelessly to improve human and mission safety for space exploration. Further, the Apollo 13 mission landing was unsuccessful due to an oxygen tank explosion while Astronauts Jim Lovell, Jack Swigert, and Fred Haise Jr. were en route to the Moon. This explosion crippled the service module’s ability to provide electrical power to the spacecraft, destroying the propulsion and life support systems. Fortunately, the entire crew made it safely back to Earth, but regrettably, they were unable to take those historic steps on the lunar surface.

The Apollo era set the strong, historical foundation needed for current human spaceflight today. Now, there is a laser-focus on returning humans to the surface of the Moon and beyond, thanks to the current lunar efforts of the Artemis program, Apollo’s twin sister.



The Artemis program is also led by NASA, and the series of missions will extend what the Apollo program started—humans will learn how to live and work on the Moon in preparation for the first human spaceflight mission to planet Mars. The building of the lunar infrastructure is actively underway for more scientific discovery and more technological advancement in space. It will take the international community to establish this sustained presence on the Moon.

On 16 November 2022, Artemis I was the first of the Artemis missions, and it was an uncrewed lunar flight test that lasted just shy of 26 days. It was a very successful test flight that contributed to additional knowledge for future Artemis missions. The next Artemis mission, Artemis II, consists of the first crewed mission with humans on board, and it is planned to be a lunar flyby lasting 10 days with astronauts Reid Wideman, Victor Glover, Christina Koch, and Jeremy Hansen.

This lunar flyby mission launched on 01 April 2026 and demonstrated a wide range of capabilities needed for deep space missions. At the writing of this article, Artemis II is on day six of this mission! Astronaut Reid Wiseman is the Commander, and he is a former United States Navy test pilot. Astronaut Victor Glover is the Pilot, and he is the first Black astronaut to travel to the

Moon. Astronaut Christina Koch is the Mission Specialist, and she is the first Woman to travel to the Moon. Astronaut Jeremy Hansen is also a Mission Specialist for Artemis II and is the first Canadian to travel beyond Low Earth Orbit. This historic Artemis II mission consists of many firsts and truly represents space exploration and innovation at its finest.

The remaining series of Artemis missions have gone through a great deal of change under the newly appointed NASA Administrator, Jared Isaacman. Previously, Artemis III was scheduled to land humans on the lunar surface in 2028. However, Artemis III will now launch a crew in the Orion spacecraft on top of the Space Launch System (SLS) rocket in efforts to test rendezvous and docking capabilities in low Earth orbit (LEO) in advance of landing humans on the Moon. This mission is now slated for 2027.

The Artemis IV mission is now slated for early 2028, some 56 years after the last NASA astronauts, Eugene Cernan and Harrison “Jack” Schmitt, stepped foot on planet Earth’s Moon in 1972. This mission will aim to land humans back on the lunar surface. This will undoubtedly be the most complex to date, but with humanity’s ingenuity and innovation, the selected astronauts will deepen our understanding of planet Earth, our solar system, and how

humanity will proactively become an interplanetary, and perhaps interstellar, species. This Artemis mission will be approximately 30 days of exploring the lunar South Pole region.

After humans step foot on the Moon in 2028, it is anticipated that the next series of Artemis missions will be focused on building the first space station for humans to live and work on Earth's Moon. With the collective Artemis missions, NASA will establish a long-term presence on the Moon in preparation for human spaceflight to Mars. Therefore, Artemis IV will be the first mission to bring together a complexity of multiple launches and spacecraft dockings in the lunar orbit for humans to live and work on the Moon.

The Apollo program truly paved the way for the Artemis program, scientific discovery, and future interplanetary and interstellar space travel. It starts with extending what the Apollo missions started in efforts to demonstrate a sustained lunar presence. The Artemis program will primarily teach humans how to live and work off planet Earth in preparation for sustained human spaceflight beyond Earth's orbit.



Next stop, Mars

Planet Mars is the fourth rock from the Sun, and its average distance from Earth is approximately 225 million kilometers. Mars is a very strategic destination for humanity's first interplanetary human spaceflight mission because of its proximity to the Sun and conditions on its surface. The first human spaceflight mission to Mars is targeted for the early 2030s with a sustained work and life presence by the 2050s. Mars is ripe for exploration as humanity continues to push the bounds of what we know about our universe.

Engineers and scientists are working tirelessly around the globe to research and develop technological advances that space explorers will use to live and to work on Mars, while traveling safely to and from Earth. Robotic space rovers are also pathfinding the way to get humans to the rocky red planet—Mars is nicknamed the rocky red planet because of its finely grained ferric oxide dust, making it reddish in color due to its rocky planet soil. There are many scientific and strategic reasons to further explore Mars including: 1) it is currently the most accessible planet to reach in our solar system; 2) it could unlock the origins of life as we know it; and 3) it could be the first future destination to relocate humankind for evolutionary survival.

When the solar system took shape about four and a half billion years ago, Mars formed when gravity pulled in swirling gas and dust, and like Earth, Mars has a central core, a rocky mantle, and a stable crust. Mars is one of Earth's neighbors, and the planet is the furthest terrestrial planet from the Sun, taking 687 days to orbit the Sun as opposed to Earth's 365 days. The typical Martian day is slightly longer than Earth, at 24 hours and 39 minutes as opposed to Earth's 24-hour day. Mars is just about half of the diameter of Earth at 6,779 kilometers and is less dense than Earth having approximately 15 percent of Earth's volume and 11 percent of Earth's mass. This means that the gravity on Mars is approximately 3.7 meters per second squared, which is 38 percent of Earth's gravity. If you weigh 100 pounds on Earth, you would only weigh 38 pounds on Mars because the surface gravity on Mars is 62 percent less than the surface gravity on Earth.

Mars has a relatively thin atmosphere, and it is primarily made up of carbon dioxide with traces of nitrogen, argon, oxygen, methane, and other gases, which means that without an Earth-like engineered habitat, a spacesuit is required. Because the atmosphere is so thin, heat and light from the Sun can easily escape the planet. The temperature on Mars can be as high as 20 degrees Celsius and as low as negative



153 degrees Celsius. It could feel as nice as Spring weather, or more chilling than Antarctica. Mars can sometimes have very strong winds causing massive dust storms that cover the entire planet. The severity of such storms could take several months for all the dust to finally settle. Mars also has two small, potato-shaped moons, or natural satellites, named Phobos and Deimos.

The goal of landing humans on the surface of Mars has been on the horizons for many nations and private space companies for decades, and it is requiring many space exploration advances to get humans there. To date, the United States has successfully landed nine landers and rovers, and two remain active—Curiosity and Perseverance.

However, Mars exploration endeavors started in 1965 with Mariner 4 passing Mars within 9,650 kilometers while taking the first close-up photos of the surface. These critical technologies aid engineers and scientists to learn as much as possible about the planet, which is the next critical step for humans to become an interplanetary species. It is imperative to understand what it takes to survive on Mars for sustained periods of time. Rovers and other spacecraft orbiting the red planet collect samples and scan the atmosphere to inform researchers about potential human habitability.

Like Earth's Moon, Mars is an optimal destination for even more scientific discovery which will enable humanity to travel, explore, work, and live far beyond Earth.

Is it possible to terraform Mars?

Topics of terraforming Mars have emerged and whether science can support it. Terraforming is possible but would certainly require technology that does not exist today. Furthermore, it would be incredibly expensive. Essentially, Mars has a very thin atmosphere, and the atmospheric pressure is less than one percent of the atmospheric pressure on Earth. Therefore, any liquid water on the surface of Mars would either evaporate or freeze.

Terraforming Mars would require warming the thin atmosphere, and oxygen would need to be created through engineered microbes leveraging photosynthesis—when plants convert energy from the Sun by combining water and carbon dioxide to create oxygen—in efforts to support life. While the Martian atmosphere does consist of carbon dioxide—the molecule that regulates Earth's temperature and ensures all life is possible by serving as a major source of energy to fuel our daily lives—on Mars, it is way too thin and too cold to support liquid water for humans to survive without a



proper spacesuit and engineered habitat. Humans on Mars without terraforming must stay in a sealed, pressurized, and radiation-shielded habitat that produces artificial oxygen, water, and sources for food.

Beyond Mars and our solar system

Mars is currently the most favorable destination for humankind to become interplanetary. When thinking about becoming interstellar, there are other Milky Way Galaxy destinations that could be considered for this futuristic space travel. There are six exoplanets—Proxima Centauri b, TRAPPIST-1e, LHS 1140b, Gliese 12b, K2-18b, and Kepler-186f—that could potentially support life beyond our solar system. Astronomers and planetary scientists have used data from powerful telescopes like the James Webb Space Telescope (JWST) to detect Earth-like

exoplanets while evaluating if their star systems would allow for a stable environment. An exoplanet is a planet outside of our solar system that orbits another star instead of our Sun.

It would take many generations and perhaps many centuries for humankind to step foot on some of these exoplanets due to:

- 1) distance in which the travel time exceeds current human expectancy of life;
- 2) extensive interstellar human space travel transcending harsh and unknown conditions; and
- 3) the extremely audacious technological breakthroughs needed in propulsion systems and rocketry that would bend the rules of space and time as we know it today.

Current space travel technology would not allow humans to reach any interstellar destination that could potentially sustain life within a reasonable human timeframe. These six exoplanets are several to hundreds of light years away, and a light year is a unit of length used by planetary scientists and astronomers to measure vast distances across the universe, denoting the distance that light travels in one Earth year. One light year equates to approximately 9.46 trillion kilometers, and it would take 35,000 to 40,000 years with current rocket technology just to travel one light year. This is because humanity has not developed a way to travel at the speed of light or faster than the speed of light.

Exoplanet Proxima Centauri b is approximately 4.24 light years away from Earth, and it is the closest known exoplanet to our solar system. Proxima Centauri b orbits the habitable zone of the relatively low luminous and small red star, Proxima Centauri, and it is believed to have a rocky surface that would be ripe to support liquid water. However, Proxima Centauri b has extreme ultraviolet radiation from its star which would deplete the atmosphere making it difficult to sustain human life.

Exoplanet TRAPPIST-1e is approximately 41 light years away from Earth, and it orbits the relatively low lumi-

nous and small star, TRAPPIST-1.

This exoplanet is also believed to have a rocky surface with many similarities to Earth. Further, TRAPPIST-1e could possibly maintain a stable climate due to the red star's mild energy with possibilities of containing even more water than Earth.



Exoplanet LHS 1140b is approximately 49 light years away from Earth. This exoplanet is thought to have a very thick atmosphere which is very promising for heat retention, stable temperatures, and water sustainment. Further, LHS 1140b is thought to be a water world with extensive oceans, and it orbits a relatively low luminous and small red star.

Exoplanet Gliese 12b is approximately 40 light years away and orbits a low luminous and small red star. Little is known about its atmosphere, but Gliese 12b's estimated surface temperature is approximately 42 degrees Celsius. Therefore, it lies in a promising habitable zone.

Exoplanet K2-18b is approximately 124 light years away from Earth, and like LHS 1140b, it also is believed to have a very thick hydrogen rich atmosphere which is critical for heat retention, stable temperatures, and water sustainment. It is also believed to have water vapor in its atmosphere and methane and carbon dioxide which would suggest hydrogen oceans.

Exoplanet Kepler-186f is approximately 579 light years away from Earth, and it is the first identified exoplanet that is similar in size to Earth. This exoplanet only receives about a third of the energy that Earth receives from the Sun, from its relatively low luminous and small

red star, but this is an indicator that it could still have liquid water. Researchers believe that the surface may be rocky, and its potential for enhanced human habitability would seem promising.

What lies ahead for interplanetary and interstellar space exploration?

While humanity needs to be focused on the advanced technology needed to survive beyond Earth, humans are social complex systems themselves, and one of the biggest challenges will not be a technical one. Humanity is governed by different rules, norms, and laws, and the political climate must be inclusive and cooperative for establishing a sustained presence beyond Earth. Replicating the divisions we face on Earth—borders and ideologies—would make interplanetary and interstellar space exploration very difficult due to potential civil unrest and wars. This could hinder reaching these audacious objectives for humanity's survival.

The first phase, the next 50 years, is continuing to expand what humanity is doing with the Artemis program. It is about establishing a permanent presence on Earth's Moon by learning how to use the Moon's resources for working and living, while developing and improving upon life support systems. The Moon is humanity's training ground for Mars, and it is critical that we build out the lunar infrastructure

while traveling to and from Mars over the next 50 years. Once Mars is reached, this will be humanity's first interplanetary destination. During this time, surface habitats must be created to shield humans from radiation; crops must be harvested for food sources and sustainability must be learned; and multi-generational living must be practiced including births to take place off planet Earth.

The second phase, 30 to 200 years, consists of industrializing Earth's Moon and Mars. This assumes that both the Moon and Mars are relatively stable, and economic expansion can be the focus. Essentially, advanced asteroid mining with construction and water depots will exist in space, and space-based manufacturing facilities could potentially focus on technology like solar-powered satellites providing energy back to Earth. Further, orbital habitats would be constructed, providing many with artificial gravity for favorable living conditions.

The third phase, 100 to 1,000 years, will be more interstellar breakthroughs with robots and probes, as well as leveraging potential laser technology for advanced propulsion systems. Robots and probes will reach exoplanets well before humans, and that timeline is very hard to estimate due to the amount time, money, and societal

influence it would take to achieve. Interstellar human space travel will most likely require transportable artificial gravity habitats that could survive very harsh and extensive space travel; life expectancy extensions and cryogenic discoveries; and artificial intelligence caretakers that could sustain and aid human life, particularly in transit.

Conclusion

Humanity has their work cut out for them to achieve interplanetary and interstellar status. However, it is possible and could be backed by science. Space exploration continues to push the bounds of what we know about our universe, and as humanity learns more about the cosmos, the quicker and safer we can achieve what is currently deemed impossible.

About the author

Dr. Michaelyn L. Thomas is a successful space systems engineer and founder of Spaced Out Doc, a consulting firm. She is also a part-time engineering professor for graduate students, and Dr. Thomas spent most of her professional career working in the private space industry, which included launching a start-up rocket company (pun-intended) founded by Sir Richard Branson, as a c-suite executive.

Scholastically, Dr. Thomas has four degrees and one minor degree in five distinctly different academic disciplines. She also belongs to Tau Beta Pi, the engineering honor society. Dr. Thomas holds a doctor of education degree in organizational leadership from University of La Verne; a master of science degree in space systems engineering from Johns Hopkins University; a master of business administration degree from University of Redlands; and a bachelor of arts degree in political science with an emphasis in public law and a minor degree in Russian language from California State University, Long Beach.

Professionally, Dr. Thomas' career trajectory reflects a constellation as opposed to a traditional ladder to success. From her entry-level beginnings to where she is today, Dr. Thomas has held executive leadership roles in the

space industry ranging from financial management to system-of-systems engineering and integration.

Dr. Thomas' consulting company, www.spacedoutdoc.com, provides affordable and equitable consulting services for individuals and organizations ready for lift-off. Her career constellation and academia have uniquely positioned her to be an effective leader in both the private and public sectors of the space industry.

Dr. Thomas authored the children's book, **Pearl the Space Girl: The A to Z Adventure of Exploring Space Careers**, depicting a heroine for all kids. This children's book is meant for teachers, parents, legal guardians, caregivers, foster parents, and loved ones alike to read this with the children in their lives to encourage them to pursue education and careers in space.



What Happens When We Stop Investing in the People Who Build the Future?

By Shelly A Muñoz

“The Quiet Unraveling of America’s STEM Pipeline”

Over the past two years, I have watched something happen in STEM education that I never expected to see. Friends and colleagues—exceptional educators who built STEM programs, supported science teachers, developed curriculum, connected schools with industry and higher education, wrote grants, created robotics and engineering opportunities, and helped students see possibilities beyond the walls of their classrooms—have watched their positions disappear. Then my own STEM leadership position was eliminated.

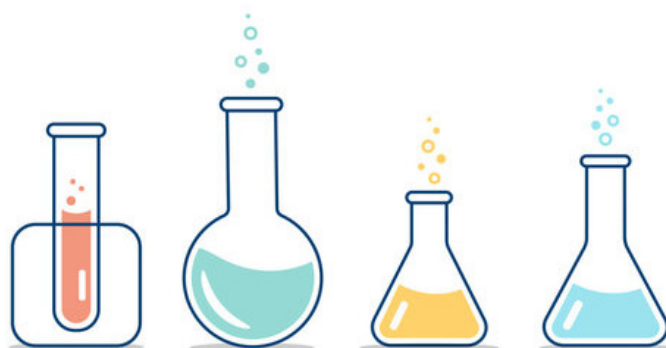
At first, these losses can look like isolated local decisions. A district restructures. A position is absorbed. A grant ends. A budget tightens. A university laboratory loses funding. A research project is suspended. But when you pull the lens back, a much more troubling picture begins to emerge.

Across the country, uncertainty surrounding federal education funding is now colliding with major disruptions to education research and scientific

research. Education organizations are currently fighting for access to nearly \$2 billion in congressionally appropriated education-research funding they say has been withheld. At the same time, schools and states are trying to plan amid continuing uncertainty about federal support.¹ The instability reaches far beyond the Department of Education.

The question we should be asking is no longer simply, What programs will be cut? We need to ask something much bigger:

What happens to the future of American STEM when we begin dismantling the infrastructure that creates it?



STEM Is Not Four Subjects - it Is an Ecosystem.

We have spent years describing STEM as science, technology, engineering, and mathematics. But STEM is not simply four subjects. It is an ecosystem. A curious elementary student becomes fascinated with the night sky. A teacher recognizes that curiosity and gives her opportunities to investigate it. A STEM coordinator brings an engineering challenge into her classroom. A grant provides equipment her school could never otherwise afford. A university partnership connects her teacher with current research. A summer STEM experience introduces her to an engineer. Years later, an undergraduate research opportunity allows her to work alongside scientists.

Eventually, that child might become the engineer designing our infrastructure, the researcher developing a cancer treatment, the scientist studying our changing planet, the computer scientist developing the next generation of artificial intelligence—or the teacher who inspires another child to begin the cycle again.

That is the STEM pipeline, and every part depends upon another. Remove enough pieces, and eventually the pipeline stops functioning.

The Numbers Should Concern Every STEM Educator.

Consider what has been proposed for the National Science Foundation. NSF describes its STEM Education Directorate as responsible for helping develop a capable STEM workforce and scientifically informed citizenry. Its investments reach across educational levels through research, scholarships, fellowships, curriculum development, networks, institutional capacity building, and programs connecting research with practice.²

The administration's FY2026 NSF budget request proposed reducing the Directorate for STEM Education from approximately \$1.17 billion to \$288 million—a 75% reduction from the FY2024 current plan. Within that request, STEM education research would decline approximately 78.5%, while other STEM education investments would decline approximately **73%.**³ Those numbers are extraordinary.

It is important to be precise: a presidential budget request is not the same thing as a final congressional appropriation. Congress ultimately determines federal spending, and proposed reductions do not automatically become enacted cuts. But proposed budgets tell us something important about priorities, and the effects of funding disruptions



What Does Federal Research Funding Have to Do With a Fifth-Grade Classroom?

Everything. This is where I believe we have failed to tell the STEM story effectively. When people hear “federal research funding,” they may imagine scientists in white coats working in distant laboratories. That is part of the picture. But federal STEM investment also helps us understand how children learn science and mathematics, how teachers develop expertise, how students develop STEM identities, which instructional approaches work, how informal STEM experiences influence young people, and how we expand participation in STEM careers.

NSF’s STEM K–12 program, for example, supports fundamental, applied, and translational research designed to advance STEM teaching and learning across formal and informal educational environments.⁵ Research becomes curriculum. Research becomes teacher professional learning. Research becomes classroom practice. Research becomes technology, an internship, or a scholarship. Sometimes, research becomes the moment a child realizes, I could do this.

That is why separating “research cuts” from “education cuts” misunderstands the system. *They are connected.*

are not theoretical. Education organizations have already gone to court seeking access to nearly \$2 billion in congressionally appropriated research funding they say has been withheld.⁴ That distinction matters. We should neither exaggerate what has occurred nor minimize what is at stake.



What We Lose Today May Not Be Visible for a Decade

This may be the most dangerous part. The consequences of reducing STEM investment do not necessarily appear tomorrow morning. A fourth grader who loses access to an engineering program does not appear on next year's federal budget. A teacher who loses specialized STEM support still reports to work Monday morning. A university laboratory that takes fewer graduate students does not immediately create a national workforce crisis. A promising researcher who decides to pursue a career somewhere else does not generate a line item labeled "American innovation lost."

The consequences accumulate quietly. Then, years later, we wonder why we cannot find enough engineers, why fewer students are pursuing certain scientific fields, why rural communities struggle to recruit technical workers,

why teachers lack access to current STEM research, why fewer young people see themselves belonging in science, or why another country leads the breakthrough technology we wish had been developed here.

This is what makes STEM investment different from many other expenditures. We are investing in capacity we may not need for ten or twenty years.

The Students With the Least Access Will Feel It First

We also need to be honest about who loses when STEM opportunities disappear. Families with resources will find alternatives. They can purchase robotics kits, pay for coding camps, travel to science museums, hire tutors, and enroll their children in enrichment programs. Communities located near major universities and technology centers may continue to provide extraordinary STEM opportunities.

But what about the student attending a small rural school whose only engineering experience came through a grant-funded program? What about the student whose teacher depended upon professional development funded through a university partnership? What about the first-generation college student whose introduction to scientific research came through a federally supported program?

What about schools that cannot simply replace federal dollars with local fundraising?

Opportunity gaps in STEM do not begin when students apply to engineering school. They begin years earlier, when some children repeatedly have opportunities to build, investigate, code, design, experiment, fail, revise, meet scientists and engineers, and imagine themselves belonging in STEM—while other children do not. Every opportunity we remove narrows that doorway.

We Are Doing This at the Exact Moment We Need More STEM Capacity

Perhaps the greatest contradiction is the timing. Artificial intelligence is transforming nearly every industry. Quantum computing is moving from theory toward application. Biotechnology is changing medicine. Cybersecurity threats are growing. Advanced manufacturing is becoming increasingly sophisticated. Energy challenges require new scientific and engineering solutions. Space exploration is entering another remarkable era.

We are simultaneously telling young people that the future belongs to those who can think scientifically, mathematically, computationally, and creatively. Employers are asking for those skills. Policymakers are talking about global technological competitiveness. Schools



are being asked to prepare students for careers that do not yet exist.

Yet we are creating instability within parts of the very research and educational infrastructure responsible for developing that workforce. Those two realities cannot coexist indefinitely. We cannot demand a world-leading STEM workforce while weakening the pathways that create one.

STEM Education Is Infrastructure

Perhaps we have been using the wrong language all along. STEM education is not simply a collection of programs. It is national infrastructure. Roads move people. Electrical grids move energy. Digital networks move information. America's STEM ecosystem moves ideas—from curiosity to investigation, from investigation to research, from research to discovery, from discovery to innovation, from innovation to industry, and eventually from one generation to the next.

Teachers are part of that infrastructure. STEM coordinators are part of it. Universities are part of it. Federal research agencies are part of it. Scientists are part of it. Museums, laboratories, after-school programs, professional organizations, nonprofits, and industry partners are part of it. Our students are not simply beneficiaries of the system; they are the next generation responsible for carrying it forward.

The Losses We Will Never Be Able to Count

Years from now, we may be able to calculate how much money was reduced, redirected, delayed, or ultimately restored. We can count grants. We can count positions. We can count programs. But I worry most about what we will never be able to count.

We will never know about the experiment that was never conducted, the teacher who had an extraordinary idea but no longer had the support to develop it, the research career that never began, or the rural student who never discovered engineering.

We may never know about the graduate student who chose another career because the laboratory could no longer support another researcher, the scientist who took her ideas somewhere else, the breakthrough that occurred somewhere else because we stopped investing in the people who might have discovered it here, or the child who never discovered that STEM belonged to them.

Those losses will never appear on a spreadsheet. But they may ultimately be the most expensive losses of all. I have spent more than two decades working in STEM education. I have watched children light up when they



realize they can solve a problem no one has solved for them. I have watched teachers transform classrooms when they are given the tools, time, research, and professional support to innovate. And I have watched extraordinary STEM educators lose the very positions created to make those experiences possible.

So when I see uncertainty surrounding federal education funding and enormous proposed reductions to scientific and STEM education research, I do not simply see numbers. I see the people behind them: teachers, scientists, researchers, rural schools, laboratories, and most importantly, children whose futures are still being written.

America's scientific strength has never begun in a laboratory. It begins much earlier. It begins the moment a child looks at the world and asks, Why? And it grows when a teacher has the knowledge, resources, and opportunity to respond, Let's find out.

Before we make decisions that weaken America's STEM ecosystem, we should ask ourselves one final question:

*When the next generation asks "Why?"
will we have invested enough to help
them discover the answer?*

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About the Author



Shelly A. Muñoz is a Culturally Responsive Instructional Leadership Lead supporting Minnesota educators through MDE’s COMPASS initiative, a nationally recognized STEM educator, author, and presenter with 30 years of experience in science and STEM education. Throughout her career, she has served as a classroom educator, STEM curriculum coordinator, education consultant, and systems-level leader, building programs, partnerships, and

learning experiences that expand opportunities for students and strengthen STEM teaching and learning.

She is the author of *Architects of Cognitive Resilience: Reimagining Learning in the Age of Artificial Intelligence*, which challenges educators to consider what it means to prepare young people not simply to use emerging technologies, but to remain curious, adaptive, innovative, and deeply human in a rapidly changing world.

Her work sits at the intersection of STEM, instructional leadership, educational systems, policy, and the future of learning, with a particular commitment to ensuring that rural and historically underserved students have access to the opportunities, experiences, and intellectual belonging necessary to see themselves as scientists, engineers, innovators, and problem-solvers.

After 30 years dedicated to science and STEM education, Muñoz continues to champion the educators, research, programs, and systems that make America’s future in STEM possible.



How Soap Works

By Ferris Jabr



It probably began with an accident thousands of years ago. According to one legend, rain washed the fat and ash from frequent animal sacrifices into a nearby river, where they formed a lather with a remarkable ability to clean skin and clothes. Perhaps the inspiration had a vegetal origin in the frothy solutions produced by boiling or mashing certain plants. However it happened, the ancient discovery of soap altered human history. Although our ancestors could not have foreseen it, soap would ultimately become one of our most effective defenses against invisible pathogens.

People typically think of soap as gentle and soothing, but from the perspective of microorganisms, it is often extremely destructive. A drop of ordinary soap diluted in water is sufficient to rupture

and kill many types of bacteria and viruses, including the new strains of coronavirus that continue to circle the globe. The secret to soap's impressive might is its hybrid structure.

Soap is made of pin-shaped molecules, each of which has a hydrophilic head — it readily bonds with water — and a hydrophobic tail, which shuns water and prefers to link up with oils and fats. These molecules, when suspended in water, alternately float about as solitary units, interact with other molecules in the solution and assemble themselves into little bubbles called micelles, with heads pointing outward and tails tucked inside.

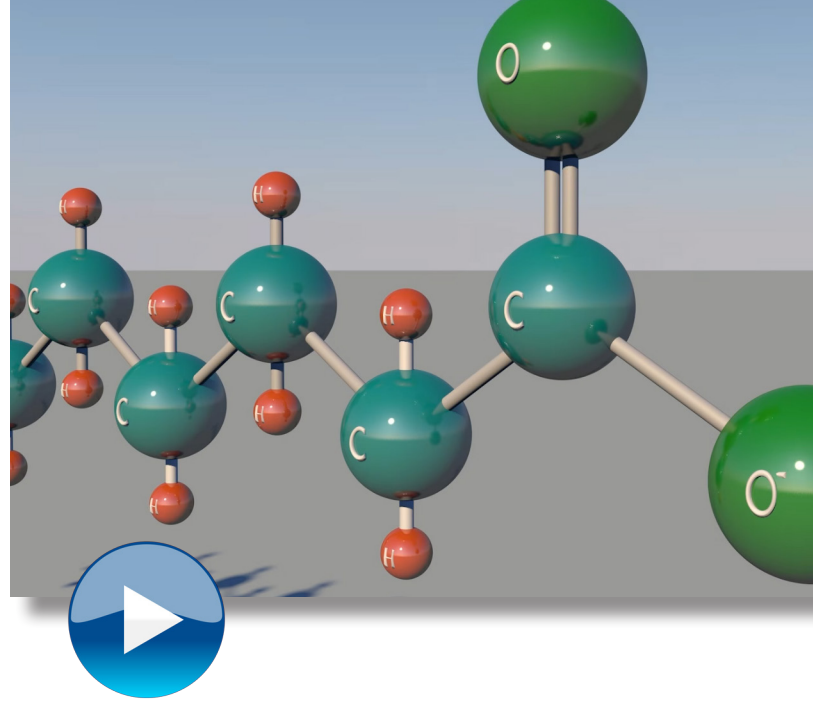
Some bacteria and viruses have lipid membranes that resemble double-layered micelles with two bands of hydrophobic tails sandwiched between two rings of hydrophilic heads. These membranes are studded with important proteins that allow viruses to infect cells and perform vital tasks that keep bacteria alive. Pathogens wrapped in lipid membranes include coronaviruses, H.I.V., the viruses that cause hepatitis B and C, herpes, Ebola, Zika, dengue, and numerous bacteria that attack the intestines and respiratory tract.

When you wash your hands with soap and water, you surround any microorganisms on your skin with soap molecules. The hydrophobic tails of the free-floating soap molecules attempt to evade water; in the process, they wedge themselves into the lipid envelopes of certain microbes and viruses, prying them apart.

“They act like crowbars and destabilize the whole system,” said Prof. Pall Thordarson, acting head of chemistry at the University of New South Wales. Essential proteins spill from the ruptured membranes into the surrounding water, killing the bacteria and rendering the viruses useless.

In tandem, some soap molecules disrupt the chemical bonds that allow bacteria, viruses and grime to stick to surfaces, lifting them off the skin. Micelles can also form around particles of dirt and fragments of viruses and bacteria, suspending them in floating cages. When you rinse your hands, all the microorganisms that have been damaged, trapped and killed by soap molecules are washed away.

On the whole, hand sanitizers are not as reliable as soap. Sanitizers with at least 60 percent ethanol do act similarly, defeating bacteria and viruses by destabilizing their lipid membranes. But they cannot easily remove microorganisms from the skin. There are



also viruses that do not depend on lipid membranes to infect cells, as well as bacteria that protect their delicate membranes with sturdy shields of protein and sugar. Examples include bacteria that can cause meningitis, pneumonia, diarrhea and skin infections, as well as the hepatitis A virus, poliovirus, rhinoviruses and adenoviruses (frequent causes of the common cold).

These more resilient microbes are generally less susceptible to the chemical onslaught of ethanol and soap. But vigorous scrubbing with soap and water can still expunge these microbes from the skin, which is partly why hand-washing is more effective than sanitizer. Alcohol-based sanitizer is a good backup when soap and water are not accessible.

In an age of robotic surgery and gene therapy, it is all the more wondrous that a bit of soap in water, an ancient



and fundamentally unaltered recipe, remains one of our most valuable medical interventions. Throughout the course of a day, we pick up all sorts of viruses and microorganisms from the objects and people in the environment. When we absentmindedly touch our eyes, nose and mouth — a habit, one study suggests, that recurs as often as every two and a half minutes — we offer potentially dangerous microbes a portal to our internal organs.

As a foundation of everyday hygiene, hand-washing was broadly adopted relatively recently. In the 1840s Dr. Ignaz Semmelweis, a Hungarian physician, discovered that if doctors washed their hands, far fewer women died after childbirth. At the time, microbes were not widely recognized as vectors of disease, and many doctors ridiculed the notion that a lack of personal cleanliness could be responsible for their patients' deaths. Ostracized by his colleagues, Dr. Semmelweis was eventually committed to an asylum, where he was severely beaten by guards and died from infected wounds.

Florence Nightingale, the English nurse and statistician, also promoted hand-washing in the mid-1800s, but it was not until the 1980s that the Centers for Disease Control and Prevention issued the world's first nationally endorsed hand hygiene guidelines.

Washing with soap and water is one of the key public health practices that can significantly slow the rate of a pandemic and limit the number of infections, preventing a disastrous overburdening of hospitals and clinics.

But the technique works only if everyone washes their hands frequently and thoroughly: Work up a good lather, scrub your palms and the back of your hands, interlace your fingers, rub your fingertips against your palms, and twist a soapy fist around your thumbs.

Or as the Canadian health officer Bonnie Henry said recently, “Wash your hands like you’ve been chopping jalapeños and you need to change your contacts.” Even people who are relatively young and healthy should regularly wash their hands, especially during an illness, because they can spread the disease to those who are more vulnerable. Soap is more than a personal protectant; when used properly, it becomes part of a communal safety net.

At the molecular level, soap works by breaking things apart, but at the level of society, it helps hold everything together. Remember this the next time you have the impulse to bypass the sink: Other people’s lives are in your hands.





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Naloxone

Understanding Naloxone Use: A Lifesaving Tool to Reverse Opioid Overdose

By Talia Wall, PharmD, BCPS

Assistant Professor of Pharmacy Practice, Touro College of Pharmacy



*A*n overdose occurs when a person takes more of a substance than their body can safely handle. Although overdoses can result from alcohol or other drugs, prescription pain medications as well as illegal intake of opioids are among the most common causes.

According to the U.S. Food and Drug Administration (FDA), nearly 2 million Americans were living with a prescription pain reliever use disorder in 2018, highlighting the ongoing need for overdose prevention and education¹.

Who Is at Risk for an Opioid Overdose?

Many people assume that only those who misuse drugs are at risk for an opioid overdose. In reality, anyone taking an opioid medication can be at risk under certain circumstances. Patients prescribed an opioid are at increased risk if they are also taking another medication that depresses the central nervous system, such as a benzodiazepine, which is commonly prescribed to treat anxiety.

A patient who has previously experienced an opioid overdose or has a history of opioid use disorder is at particularly elevated risk. Young children are also vulnerable, as accidental ingestion of opioid medications or other substances can quickly become life-threatening¹.

Recognizing the Signs of an Overdose

Recognizing an opioid overdose quickly can save a life. Common signs and symptoms include problems breathing, small pupils, choking, unresponsiveness or loss of consciousness. A victim's skin may also begin to appear blueish in color or become clammy^{1,2}.

Naloxone: A Lifesaving Medication

Naloxone is considered the standard of care for rapidly reversing an opioid overdose, a situation where every moment counts. Importantly, no medical training is required to administer naloxone, making it an invaluable resource for family members, caregivers, friends, and bystanders.

To further promote awareness, the FDA recommends that healthcare providers discuss overdose prevention and reversal with patients who are prescribed opioid medications. For patients considered at high risk for overdose, the FDA also recommends prescribing naloxone alongside an opioid prescription¹.

It is safe to administer naloxone even if one is not completely certain that an opioid overdose is causing the presenting symptoms in a patient. If opioids are not present, naloxone will not produce harmful effects related to opioid reversal. Naloxone can also be safely administered to people of any age, including children.



How Does Naloxone Work?

Opioids produce their dangerous effects by attaching to opioid receptors in the brain. When too many opioid molecules attach to these receptors, breathing slows and may eventually stop. Naloxone works as a competitive opioid antagonist.

It competes with opioid molecules for the same receptors in the brain. Since naloxone has stronger attraction to the receptors, it essentially pushes the opioid molecules away and prevents their effect on the body. Naloxone's only effect on the receptors is to lock them up, which allows breathing to return to normal. An observable reversal of the overdose can be realized within minutes of naloxone administration. However, it is only active for roughly an hour, whereas opioids may last longer in the body, so additional doses may be needed, and further emergency medical care is always necessary³.

Expanding Access to Continue the Battle

Naloxone was first approved as an injection to reverse opioid overdoses back in 1971⁴. It wasn't until 2015 that the more user friendly nasal spray version was approved under the brand name Narcan[®], signifying crucial progress in making the medication more accessible. Still, a barrier existed in that

a prescription was required to obtain the medication⁵.

Recognizing the growing need for broader public access, the FDA approved the first over-the-counter naloxone nasal sprays in 2023⁵. According to the Centers for Disease Control and Prevention (CDC), drug overdose deaths have declined by almost 40% since 2023, due in large part to increased naloxone availability⁶. Higher-dose nasal sprays and injectable formulations of naloxone remain available by prescription, and patients at high risk of overdose may be discharged from the hospital with either a prescription or a take-home naloxone kit.

Today, over-the-counter naloxone is widely available and typically costs \$35- \$50 for a two-pack, while generic or store-brand versions can often be purchased for under \$30 for a two-pack. In June 2026, the FDA approved an additional over-the-counter naloxone nasal spray to further improve public access⁷. Three over-the-counter brands are now available: Narcan[®], RiVive[®], and Rextovy[®]. Naloxone is easy to use, and the medications come with step-by-step directions for use.

Proper knowledge can save a life. Recognizing the signs of an opioid overdose and knowing how to use naloxone can empower people to act during an emergency. As access to naloxone con-

tinues to expand, more families, caregivers, and community members have the opportunity to help prevent overdose deaths.

About the author:

Dr. Talia Wall is the Assistant Director of Practice Experience and Assistant Professor of Pharmacy Practice at Touro College of Pharmacy. This article is for informational purposes only and is not a substitute for professional medical advice.



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MARS

The next generation of robots for Mars

By Dr. Sophia Gad-Nasr

NASA has awarded seven companies contracts to help develop the next generation of robots for Mars. This is a really big deal; not just because of the robots, but because we're beginning to see private companies take larger roles in space exploration, with NASA buying commercial capabilities rather than owning entire missions.

The awards are part of the Mars STRIDE program (Science Transport and Robotic Innovation for Deployment and Exploration). NASA's investing about \$17 million total for the early phase concept studies and prototypes of robots. The goal is to develop aerial and surface systems that can access areas that rovers like Perseverance and Curiosity simply cannot reach.

With these systems, we could access difficult areas like steep slopes, caves, lava tubes. Caves are really interesting because they're protected from radiation and extreme temperatures at the surface, so they could be better places to preserve organics or evidence of ancient life. The work starts this fall.





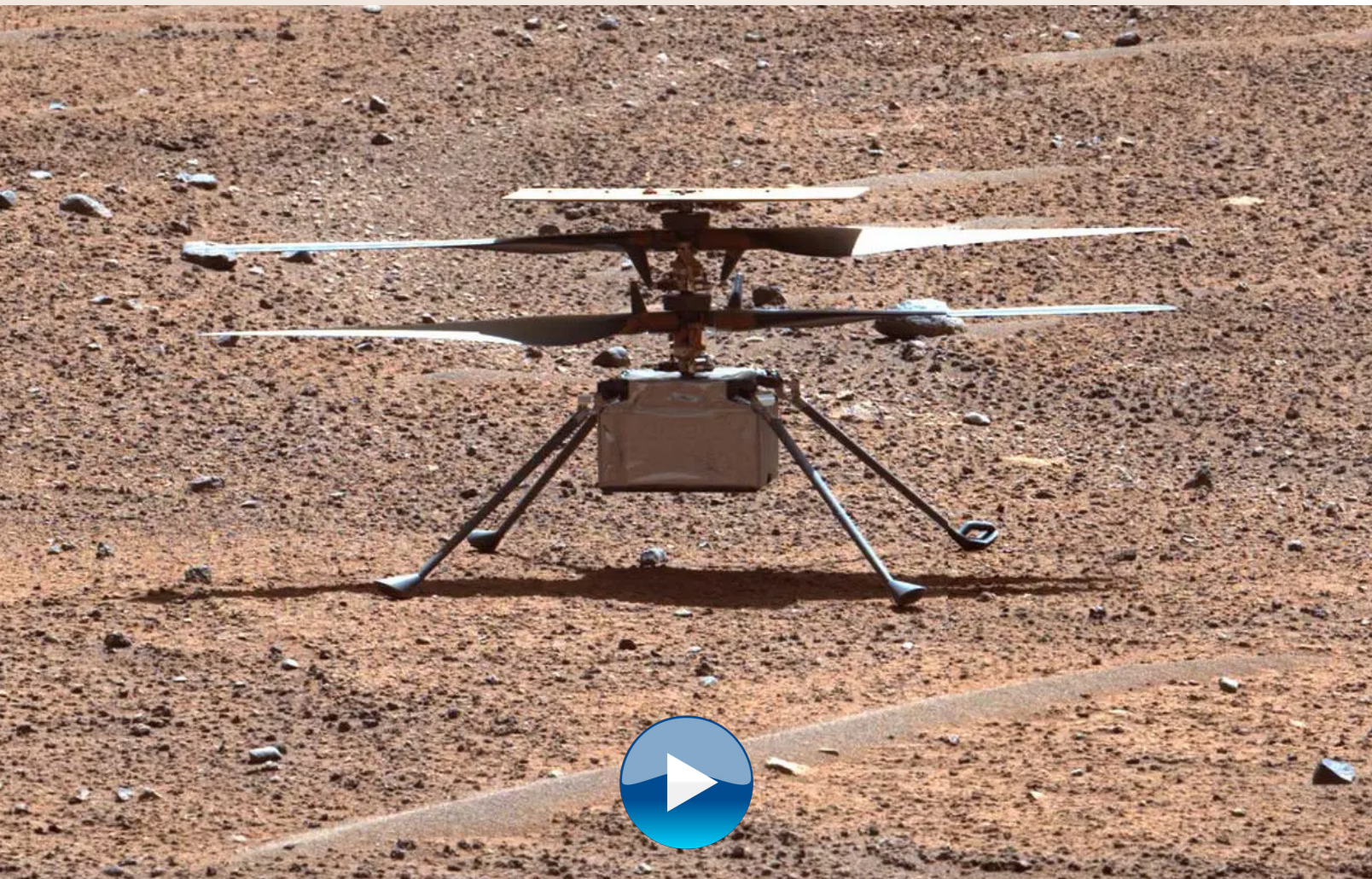
Designed from the ground up with multiplanetary applications in mind, FLEX poses substantial benefits to NASA for Mars exploration. Under STRIDE, Astrolab will study adapting its core FLEX rover architecture, which features unparalleled payload handling and traverse capabilities, to handle the unique requirements of Mars.

The companies are AeroVironment, Astrobotic, Venturi Astrolab, Ground Control Robotics, Honeybee Robotics, Intuitive Machines, and MEI Technologies. To be clear, these aren't booked missions. It's early development work that could potentially support missions to Mars. And the call specifically asked what it would take for robots and systems built for Earth and the Moon to work on Mars.

So it makes sense that some of the companies selected work on lunar missions, like Astrolab with its lunar terrain vehicles, Intuitive Machines who landed on the Moon twice, as well as Astrobotic and Honeybee who build lunar landers and drills.

AeroVironment is one I loved seeing here, because they participated in developing NASA Jet Propulsion Lab-

oratory's Ingenuity, the little Martian helicopter that was supposed to make 5 flights, and gave us 72! The company has already proposed a next-generation helicopter called Skyfall. I don't know if this is what the STRIDE awards are funding, but it would make a lot of sense if it was!



A separate mission was announced by NASA a few weeks ago: a public-private partnership with Relativity Space for Aeolus, a Mars atmospheric-science mission that'll map Martian weather systems. It's targeted for 2028. NASA will provide instruments, while Relativity provides the spacecraft, rocket,

and cruise operations. The mission data will help reduce risk for future robotic and human landings.

The reason I mention Aeolus is because they, along with STRIDE, is the Moon-to-Mars path taking shape, and private space companies are at the center of it! Commercial space is extending all the way to Mars, private space companies are taking on larger roles in spacecraft, launch, mobility, and mission operations, NASA is increasingly acting as the customer and science partner.

The Moon-to-Mars path centers around commercial space, and it has already begun.

Sophia Gad-Nasr, PhD

Ph.D. Astrophysicist | Strategic & Technical Communications for Aerospace, Defense & Deep Tech | Founder, Astropartigirl | I don't simplify; I translate.



To understand STEM...

...you must DEFINE STEM. You cannot define an acronym without defining each of the words the letters stand for.

Universities and organizations around the world continue to debate what a STEM career is, but there is no doubt that “every career” uses STEM skills and this observation remains the focus of STEM Magazine.

Science: “The systematic accumulation of knowledge” (all subjects and careers fields)

Technology: “The practical application of science” (all subjects and careers)

Engineering: “The engineering method: a step by step process of solving problems and making decisions” (every subject and career)

Math: “The science of numbers and their operations, interrelations, combinations, generalizations, and abstractions” (every career will use some form[s])

For a moment, set aside any preconceived notions of what you think a STEM career is and use the above dictionary definitions to determine the skills used in any career field you choose.

These definitions are the “real” meaning of STEM and STEM careers.

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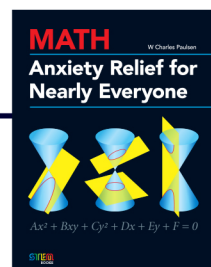
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