ASU Knowledge Enterprise

Arizona State University

2022 **HIGHLIGHTS**

Changing the way
the world **solves** problems


THRIVING
PLANET
THRIVING
PEOPLE
THRIVING
SOCIETY

Advancing innovation and scientific discovery is more urgent now than ever before.

Together with local, national and international collaborators, we are reimagining a sustainable global future — working in new ways to build a healthy and **thriving planet**. We are developing solutions for human health and well-being that support **thriving people** and their communities. And we're leading efforts to advance crucial technology, such as microelectronics and quantum sciences, that will help promote economic strength and national security to maintain a **thriving society**. **At ASU, we are changing the way the world solves problems."**

Sally C. Morton
Executive vice president
ASU Knowledge Enterprise

Learn how we are finding new approaches to pressing challenges.

01 Exploring our universe

02 Protecting our planet

03 Saving lives, improving health

04 Advancing technology for a positive future

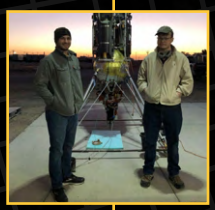
05 Leading the nation in research and innovation

01

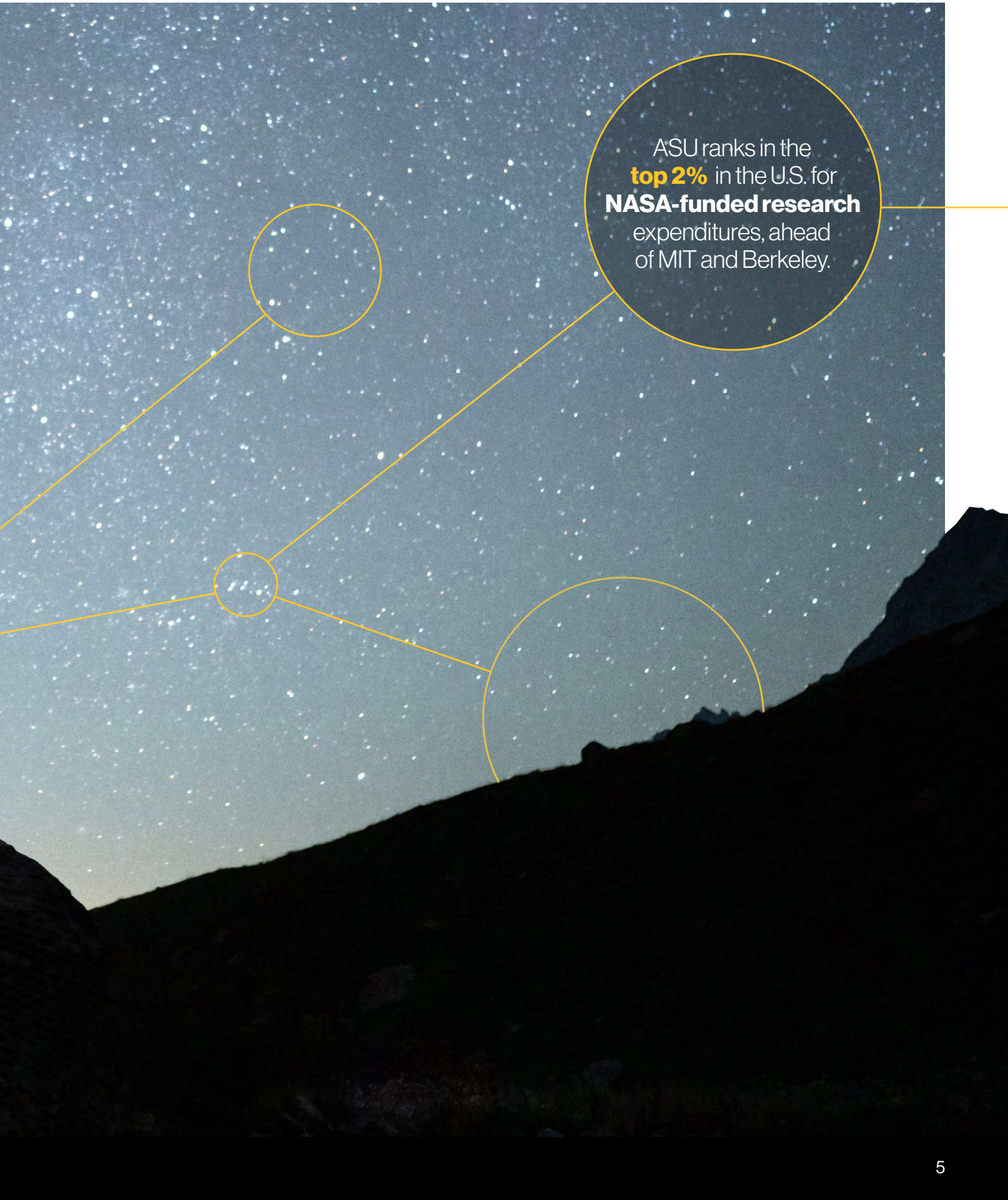
Exploring our universe

There's no 'I' in 'team,' but sometimes there is AI

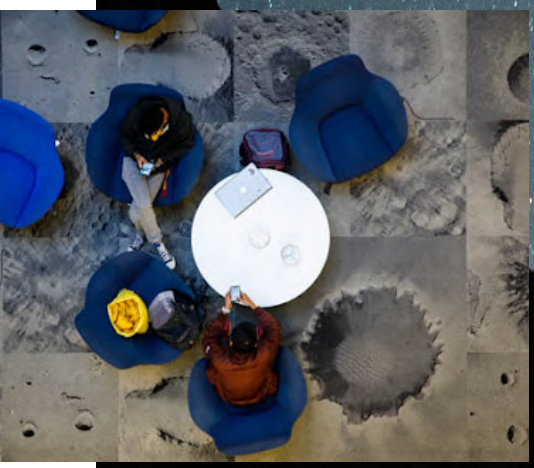
ASU space missions: Where are they now?



Spacewatch: Lifeguards help moon mission


ASU ranks in the
top 2% in the U.S. for
NASA-funded research
expenditures, ahead
of MIT and Berkeley.

CHARTing the future of space exploration



ASU's **Global Security Initiative** produces mission-relevant approaches and decision support tools to address some of the world's most vexing and complicated security challenges.

- **130+** affiliated faculty.
- **#3** in the nation for DARPA Young Faculty Awards.

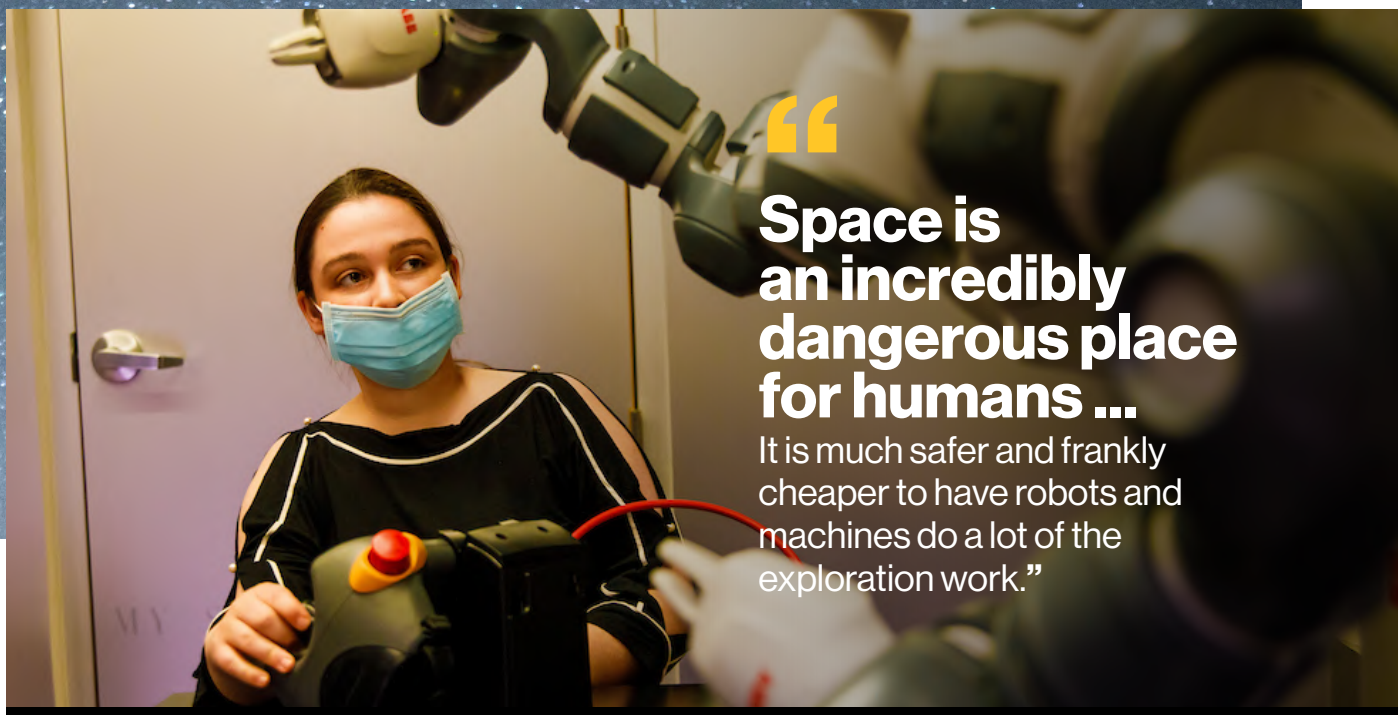
globalsecurity.asu.edu

Researchers at a new ASU testbed are helping people, robots and AI collaborate more safely and effectively.

Exploring the solar system and beyond will require robots to assist humans — and go where we cannot. Robots are built to accomplish things that would be impossible, dangerous or costly for humans to do. For example, they can survive in space for many years without a return trip and withstand harsh conditions that people cannot, like extreme temperatures or high radiation.

Researchers at a new Arizona State University testbed are helping people, robots and artificial intelligence collaborate more safely and effectively. At ASU's General Human Operation of Systems as Teams (GHOST) Lab, researchers examine people's ability to work with robots and AI in scenarios such as a life-threatening meteor strike on a lunar colony.

The lab is open to the community during public events such as ASU Open Door, as well as to visiting stakeholders. In addition to serving as a research testbed, the lab is also an art installation that encourages visitors to ponder our relationship with robots and AI.



An ASU researcher operates YuMi, *a robot that can skillfully manipulate objects, such as building things out of Lego bricks.*

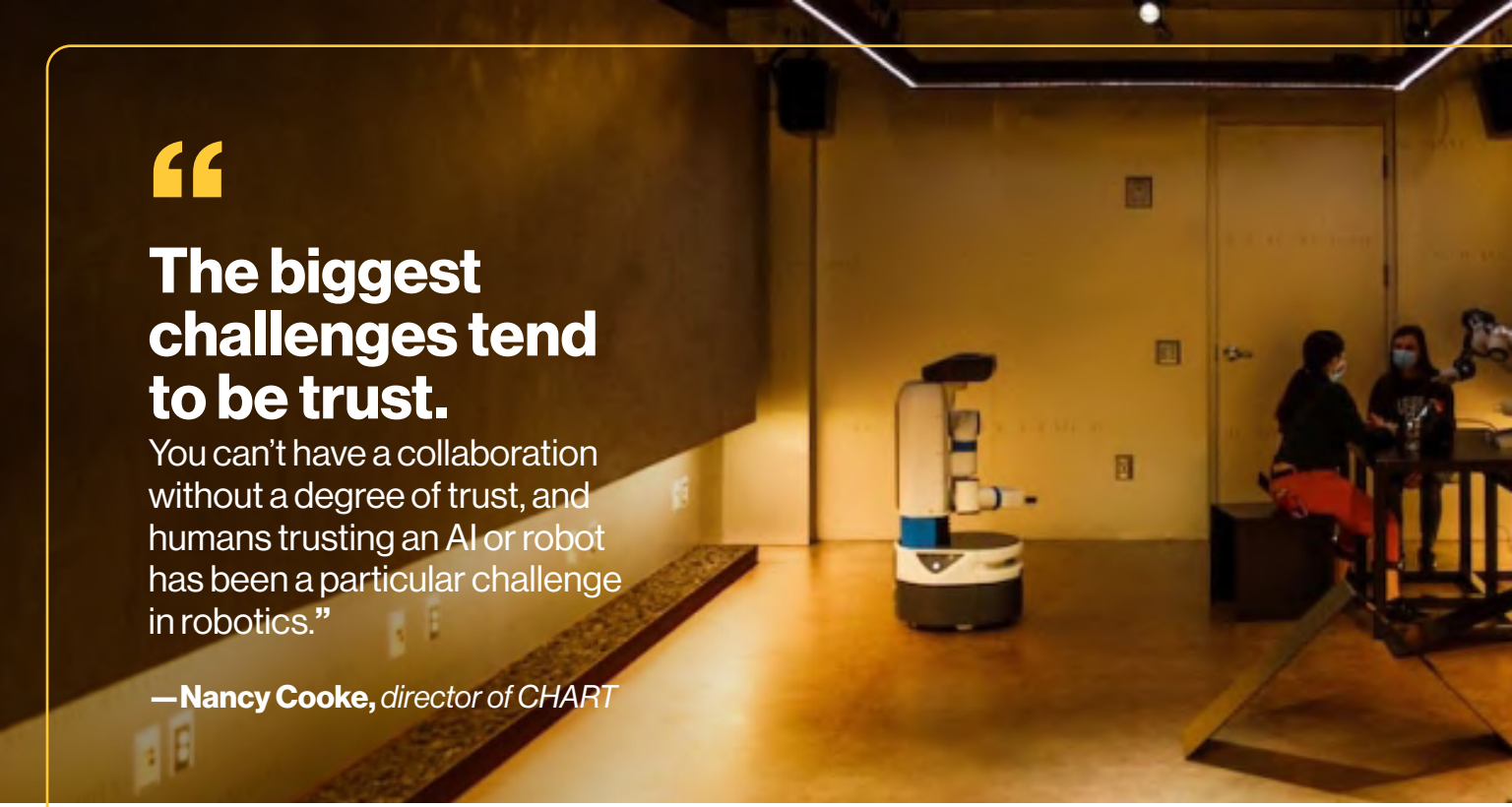
ASU's Center for Human, Artificial Intelligence and Robot Teaming (CHART) constructed the lab to conduct research on coordinating teams of humans, robots and AI. Human interaction with robots and AI is increasing exponentially in areas like health care, manufacturing, transportation, space exploration and defense technologies. But information about how humans and intelligent systems work within teams remains scarce.

CHART's work involves everything from how these teams communicate verbally and nonverbally, to how to coordinate swarms of robots, to the legal and ethical implications of increasingly autonomous technology. To accomplish this, robotics engineers and computer scientists work closely with researchers from social sciences, law and even the arts.

Lance Gharavi is associate director of ASU's Interplanetary Initiative and professor in the School of Music, Dance and Theatre. He is not a roboticist, but an experimental artist, scholar and early pioneer in the field of digital performance who works with the physical interactions between humans and robots. He leads the art installation portion of the GHOST Lab.

“Space is an incredibly dangerous place for humans,” he says. “It is not a place that is conducive to human life. It is much safer and frankly cheaper to have robots and machines do a lot of the exploration work. If we're going to have a base on the moon or Mars, we're going to want to send robots there in advance to do some of the prep work for us. And then once we get astronauts there, they'll need to be working with artificial intelligences and robots as collaborators to create habitats and help keep systems operative that will sustain human life.”

But first, humans, robots and AI need to collaborate well, and it's no easy feat due to people's inherent distrust of



> **The biggest challenges tend to be trust.**
> You can't have a collaboration without a degree of trust, and humans trusting an AI or robot has been a particular challenge in robotics."
>
> —**Nancy Cooke,** *director of CHART*

these technologies. GHOST Lab explores how humans can develop trust in robots and AI so they can work together seamlessly on space exploration missions.

The project is led by Nancy Cooke, a professor of human systems engineering at ASU's Polytechnic School and director of CHART, a unit of ASU's Global Security Initiative. A cognitive psychologist by training, she has spent years working to understand human teamwork and decision-making. She now applies this expertise to human-technology teams, including ones collaborating on space missions.

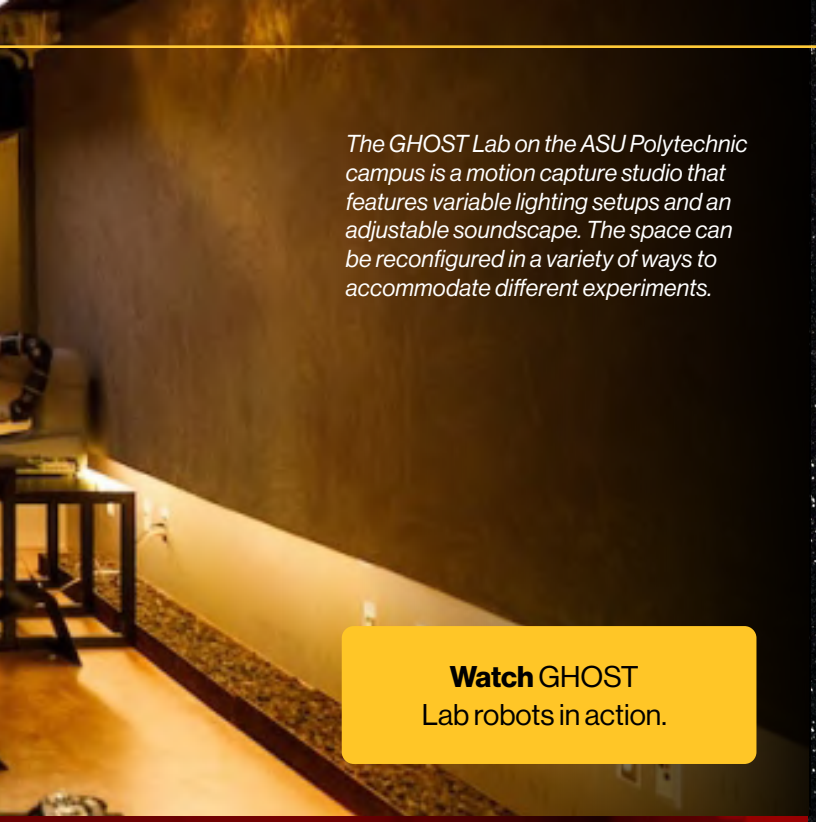
Her research received funding from the Defense University Research Instrumentation Program, allowing her to purchase members of a robotic dream team. CHART was also awarded an Air Force Office of Scientific Research seedling grant to conduct research at the GHOST Lab associated with Space Force, the space service branch of the U.S. armed forces.

The use of autonomous machines to explore space is on the rise. It took 24 years for five NASA planetary rovers to land on Mars — Sojourner in 1997, Spirit in 2004, Opportunity in 2004, Curiosity in 2012 and Perseverance in 2021. Now the pace is accelerating, with up to eight planetary rovers expected to land on the moon over the next two years: Lunar Outpost's MAPP, Carnegie Mellon University's MoonRanger and NASA's VIPER in 2023, and Lunar Outpost's Lunar Vertex and up to four of NASA's CADRE rovers in 2024.

GHOST Lab researchers are exploring the challenges that teams of humans, robots and AI could confront during space exploration by simulating potential scenarios and testing responses to them.

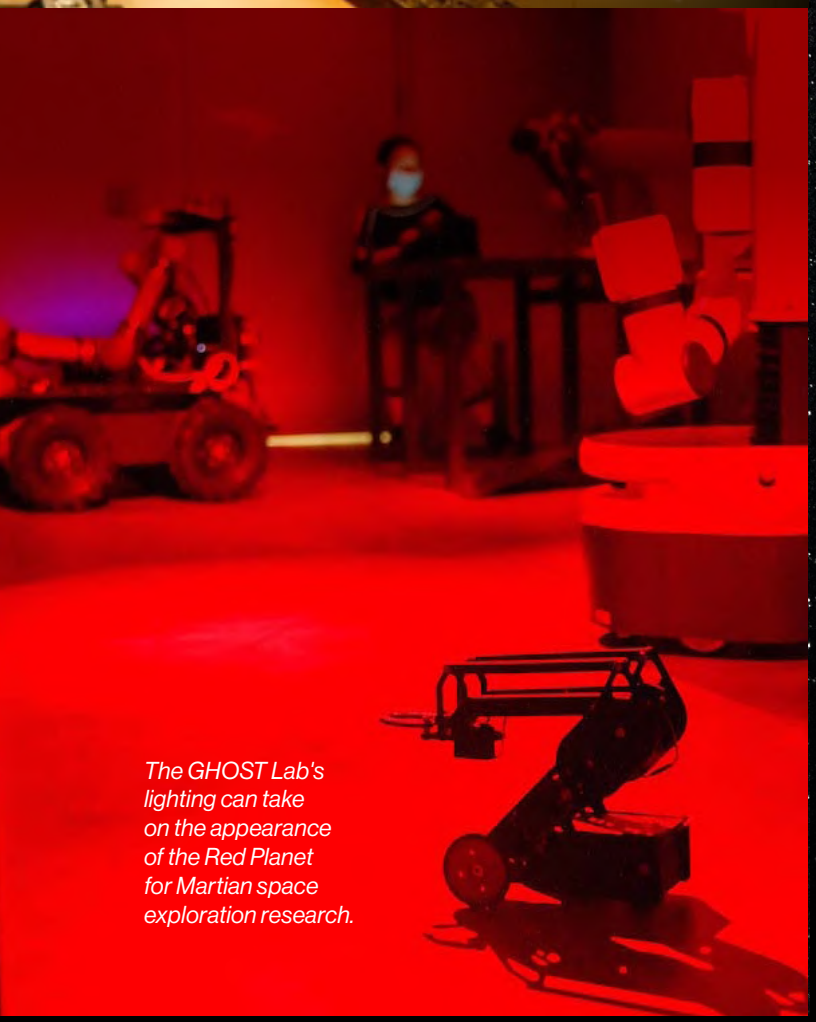
Will the result be mission accomplished or mission impossible? Cooke says the answer lies in successful teamwork among humans, robots and AI.

Today it is clear that exploring new frontiers beyond Earth will require successful teamwork with AI and robot partners boldly going by our sides. ■



The GHOST Lab on the ASU Polytechnic campus is a motion capture studio that features variable lighting setups and an adjustable soundscape. The space can be reconfigured in a variety of ways to accommodate different experiments.

Watch GHOST Lab robots in action.



The GHOST Lab's lighting can take on the appearance of the Red Planet for Martian space exploration research.

Space at ASU

300+
space investigators

120+
space industry partners

40+
instrument facilities and laboratories supporting space research and innovation

30+
relationships with international space agencies

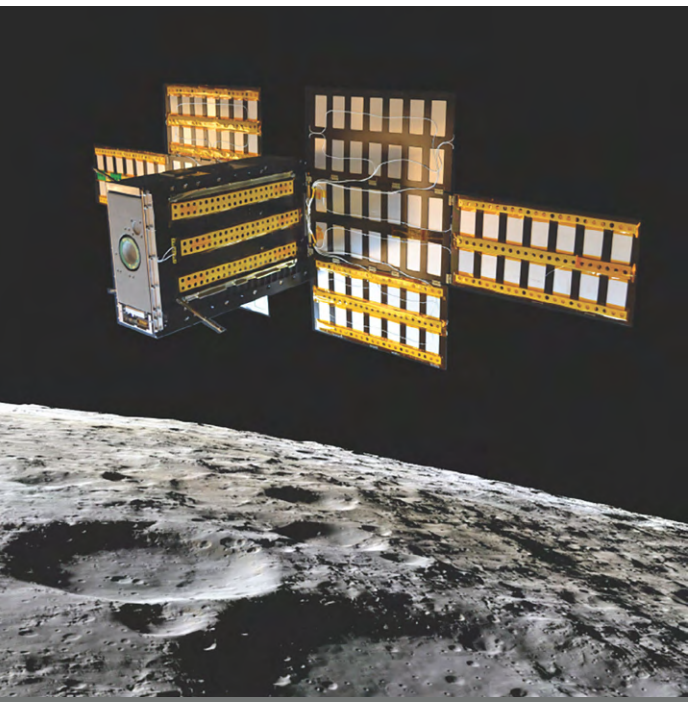
25+
active space missions

Learn more about how ASU is powering the human drive to explore our universe:
space.asu.edu

Space mission updates

Webb images reveal interstellar discovery

ASU astronomers combined data from NASA's James Webb Space Telescope and Hubble Space Telescope to produce a beautiful image of a galaxy pair about 700 million light-years away from Earth. The scientists were able to trace the light emitted by the bright white elliptical galaxy through the winding spiral galaxy in front of it, allowing astronomers to identify the effects of interstellar dust in the spiral galaxy. This dust plays a key role in the evolution of galaxies and the formation of new stars and planets. The team got another surprising result from the image — light from a distant galaxy within the first few billion years of the Big Bang, which is gravitationally distorted by the enormous mass of the elliptical galaxy. ■



The LunaH-Map CubeSat was designed, assembled, integrated and tested at ASU, in collaboration with multiple space industry partners.

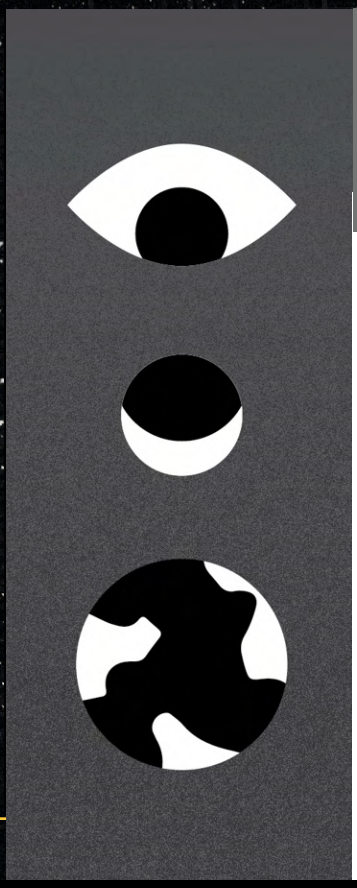
LunaH-Map flies to the moon

In November, a shoebox-sized spacecraft designed and built at ASU entered orbit around the moon. The Lunar Polar Hydrogen Mapper (LunaH-Map) CubeSat launched Nov. 16 on NASA's Space Launch System rocket as part of the Artemis I mission. Its goal is to measure the amount of water ice on the permanently shadowed craters on the moon's south pole using a miniature neutron spectrometer. This powerful technology has been used on many NASA missions for identifying water on planetary surfaces. By flying over the south pole at a very low altitude, LunaH-Map will be able to resolve ice enrichments that previous spacecraft could not. This will help us understand the origins of water on the moon and how it has been redistributed since the moon's formation. The maps will also be used to plan future missions and landing sites for robotic and human water-ice prospecting. ■

E-THEMIS embarks for Europa mission

In May, an ASU designed and built instrument to measure the surface temperature of Jupiter's ice-shrouded moon Europa arrived at NASA's Jet Propulsion Laboratory in Southern California. The Europa Thermal Emission Imaging System (E-THEMIS) is an infrared camera designed to map temperatures across Europa's surface, which will fly aboard NASA's Europa Clipper spacecraft. It is planned to launch on a SpaceX Falcon Heavy rocket in October 2024 and arrive at Jupiter in April 2030. After entering Jupiter's orbit, the spacecraft will make about 50 flybys of Europa to investigate whether the moon could harbor conditions suitable for life. E-THEMIS images, taken in three heat-sensitive bands, will help scientists find clues about Europa's geological activity, including regions where the moon's presumed ocean may lie near the surface. Although Europa is slightly smaller than Earth's moon, scientists think its ocean may hold twice the volume of Earth's oceans. ■

E-THEMIS lead scientist Philip Christensen stands next to the box-like "tent" that surrounds both E-THEMIS and its optical test equipment.

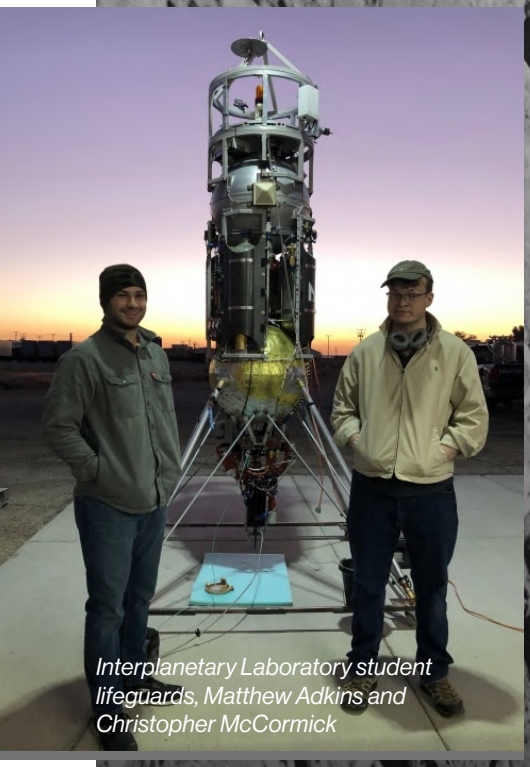


ShadowCam peers into moon's darkest secrets

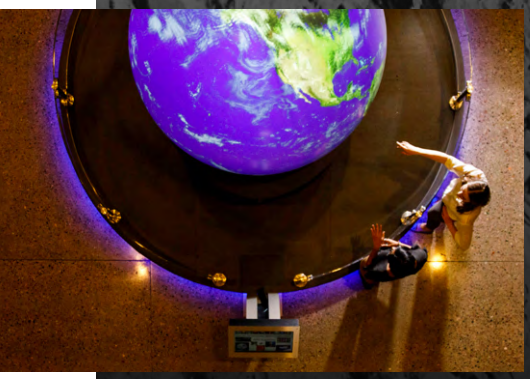
A powerful science camera is heading to the moon to look inside places we've never seen before.

The ASU designed and led ShadowCam will peer into permanently shadowed craters scattered around the poles of the moon. Because the moon does not have the tilted spin axis of the Earth, these dark spaces never receive the sun's light. Some scientists think there may be deposits of water, or even methane and ammonia, in these mysterious craters. Such materials would potentially be useful for future human presence on the moon. They may also provide important clues to the past billion years of our solar system. ShadowCam is a NASA-funded instrument and is part of a collaboration between NASA and the Korea Aerospace Research Institute. ShadowCam is an instrument on the Korean Pathfinder Lunar Orbiter, which launched aboard a SpaceX Falcon 9 rocket on Aug. 5. Images are expected in early 2023. ■

Students gain NASA mission experience



Interplanetary Laboratory student lifeguards, Matthew Adkins and Christopher McCormick



ASU's **Interplanetary Initiative** works across disciplines and sectors to shape an inclusive and sustainable pathway into space.

interplanetary.asu.edu

ASU students working at the Interplanetary Laboratory, nicknamed "lifeguards" for their essential role in managing the lab, contributed to a NASA mission whose goal is to provide ground footage of NASA vehicles landing on the moon and to capture rocket exhaust plume data, which allows scientists to study the geology of the surface where the rocket lands.

Interplanetary Initiative associate director Daniel Jacobs posed a challenge to the lifeguards: To design sensors for a novel experiment for a colleague with a flight test only a few months away.

While we've all seen a rocket landing from above, this project aimed to capture one from the ground perspective. An undergraduate student and graduate student — both with the lab since 2020 — took up the challenge.

The short turnaround time pushed them to their limits, working late into the night in the lab. They designed ExoCam, a prototype sensor that is dropped from a rocket as it lands. Once on the ground, it captures footage of the landing from the ground and measures impacts of particles kicked up by the lander.

The Interplanetary Laboratory team traveled to Pasadena, California, for the breathtaking moment of truth: the flight test.

The prototype was integrated into the mechanical system built by Honeybee Robotics, which was then tested in a dress-rehearsal drop from a bridge. After some minor revisions, the completed system was integrated onto a rocket-lander test vehicle built by Masten Space Systems in Mojave, California.

The rocket was flown to a height of 75 feet, where it ejected the ExoCam, dropping it to the desert floor, where it successfully recorded the landing in audio, video and particle impacts. ■

The Interplanetary Laboratory

ASU welcomed its first cohort of 12 Space at ASU student ambassadors from seven different academic units during the fall 2022 semester. The ambassadors built professional relationships through unique networking opportunities, developed leadership skills, and gained visibility and career-building exposure to the broader space sector.

NASA Administrator Bill Nelson and U.S. Sen. Mark Kelly from Arizona took a test drive in Tycho, a lunar rover prototype built by a team of ASU students and researchers during a recent visit to ASU's School of Earth and Space Exploration. The pair saw details of the university's more than 20 space missions. ASU is leading the NASA space missions Psyche and LunaH-Map while also developing instruments for scientific missions to the moon, asteroids and planets. Students take part in work both supporting and inspired by these missions.

02
Protecting our planet

Critters and cacti, snakes and lakes: 25 years of Phoenix ecosystem discoveries

Sea turtles pull ahead in the race against poaching

Bridging humanities and sustainability

Turning the tide for water security


ASU ranks
No. 1 in the U.S. and No. 2 globally for advancing **UN Sustainable Development Goals** in the Times Higher Education Impact Rankings.

Life in the city: ASU a powerhouse of urban ecology research

CAP LTER is a unit of the **Julie Ann Wrigley Global Futures Laboratory™**. The laboratory seeks to reshape our relationship with the Earth and design a future in which life thrives on a healthy planet.

globalfutures.asu.edu

With renewed funding, ASU scientists build on 25 years of discoveries about the Phoenix ecosystem.

More than half of all humans worldwide — and over 80% in the U.S. — live in cities. Yet when we think about studying the environment, we often think about everywhere but cities. For the past 25 years, scientists at Arizona State University have been studying the Phoenix metropolitan area as an ecosystem of its own — complete with critters and cacti, snakes and lakes, pavement and, of course, people.

"Cities are ecosystems. And they're different because they have a built environment and they have a very, very dominant species — people — that operate by different rules. We have culture and institutions and things that other species don't," says Nancy Grimm, a Regents Professor in the School of Life Sciences at ASU.

Grimm is a founding director of the Central Arizona-Phoenix Long Term Ecological Research (CAP LTER) project. CAP LTER is part of the National Science Foundation's Long Term Ecological Research (LTER) Network, started in 1980. LTER sites advance our understanding of the nation's ecosystems and inform scientists, policymakers and the public with the knowledge needed to conserve and protect them.

CAP LTER has been funded continuously since 1997. In November 2022, the NSF announced that it will provide nearly $8 million to support the program for another six years.

> **Cities are ecosystems.**
> And they're different because they have a built environment and they have a very, very dominant species — **people."**

Nancy Grimm *is a stream ecologist who led CAP LTER for nearly 20 years.*

There are 28 active LTER sites around the country, but only two are located in cities. ASU's is one.

"*Homo sapiens* is an urban species," says Dan Childers, current director of CAP LTER and a professor in the School of Sustainability. "So understanding the social, ecological and technological dynamics that are at work in urban ecosystems is critical."

Phoenix's location is important, too. The desert southwest includes many of the fastest-growing cities in the U.S. Globally, arid and semi-arid environments cover over 30% of the world's land surface and are home to a third of the world's population.

"When we study urban ecology here, we're studying Phoenix, but it's essentially a microcosm of the way cities can, should and should not function in a fairly broad part of the globe," says Childers.

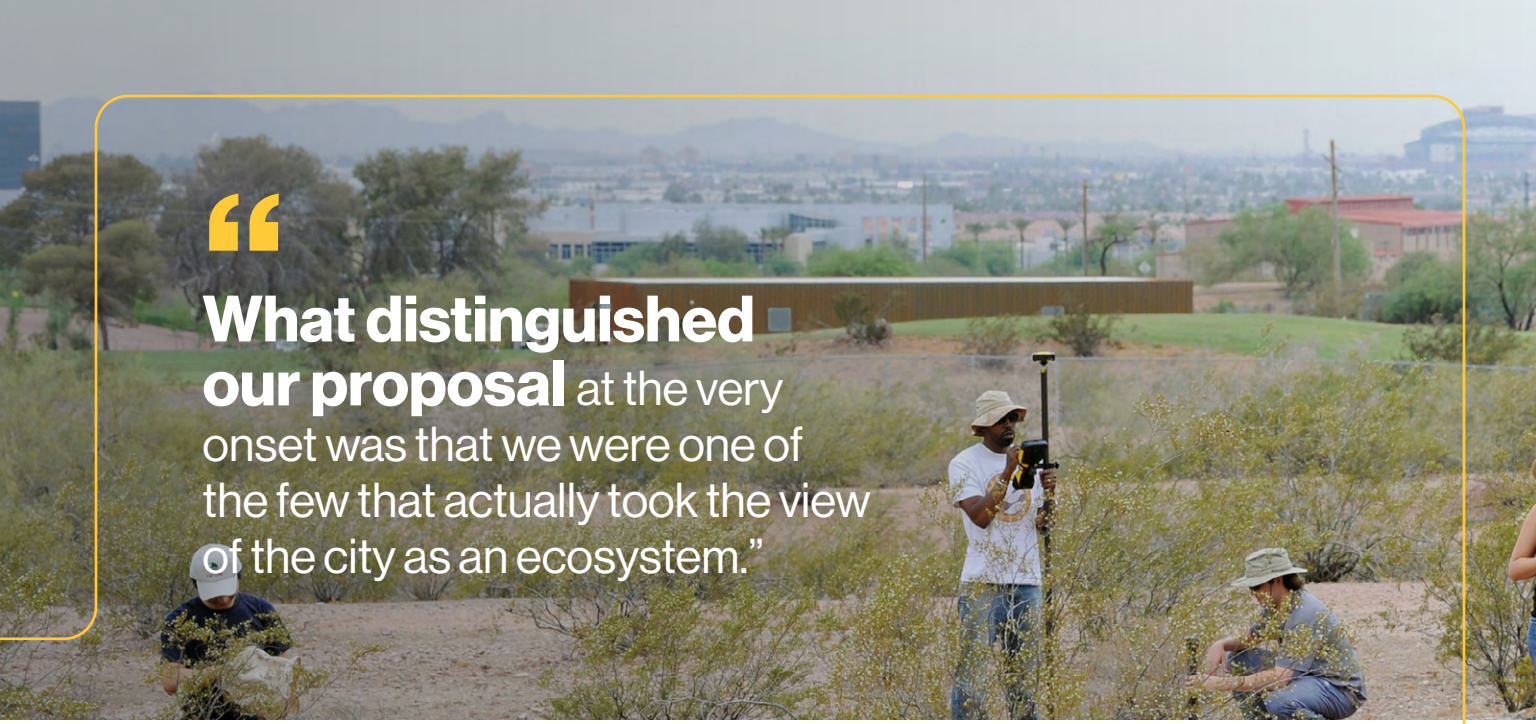
The city as ecosystem

CAP LTER researchers have published over 800 articles in research journals to date. Their findings cover a vast range of topics about animals, plants, water, soils, infrastructure and human behavior — and the interactions among them.

More importantly, CAP LTER helped to build and shape the field of urban ecology, which barely existed when the program first started.

"CAP LTER and all of the students and faculty that have been through CAP over the past 25 years have very clearly put ASU on the map as a world-renowned powerhouse for urban systems research," says Childers.

"There wasn't a whole lot of urban ecology going on in the United States when we first got started. I think what distinguished our proposal at the very outset was that



> **What distinguished our proposal** at the very onset was that we were one of the few that actually took the view of the city as an ecosystem."

we were one of the few that actually took the view of the city as an ecosystem. Whereas many others were saying, 'Cities are bad and they have a bad effect on neighboring environments,'" adds Grimm.

One of CAP LTER's keystone findings is that wildlife is more diverse and abundant in neighborhoods with higher-income residents.

"Where people of wealth live — and white, wealthy people predominantly — there tends to be higher diversity of organisms, more vegetation, more protection from heat and from flooding. This was something that we first found with vegetation, and we termed it the luxury effect," says Grimm.

"It's not so much that wealth creates the conditions that are better in the city, but that people who have been historically discriminated against live in areas that have been degraded — often purposely — through the siting of toxic industrial plants, through bad zoning, through redlining," she explains.

The next phase of CAP LTER will focus even more on these kinds of environmental justice issues. The team has already worked extensively in South Phoenix, which has a high Latino and Black population. In the upcoming funding cycle, they will expand their work into other underserved neighborhoods, as well as working with tribal communities.

"We have brought on some new researchers in CAP who aren't just Indigenous themselves, but they do Indigenous community work. We're really excited that we're being more inclusive geographically and culturally in the work that we're doing here," says Childers.

A more intentional future

This inclusive approach is particularly important for CAP LTER's scenarios and futures work. This team works with a mix of stakeholders, such as government officials, community leaders, religious leaders and nonprofit groups. Together, the researchers and stakeholders ask what the long-term future of Phoenix could look like, and how we can get there.

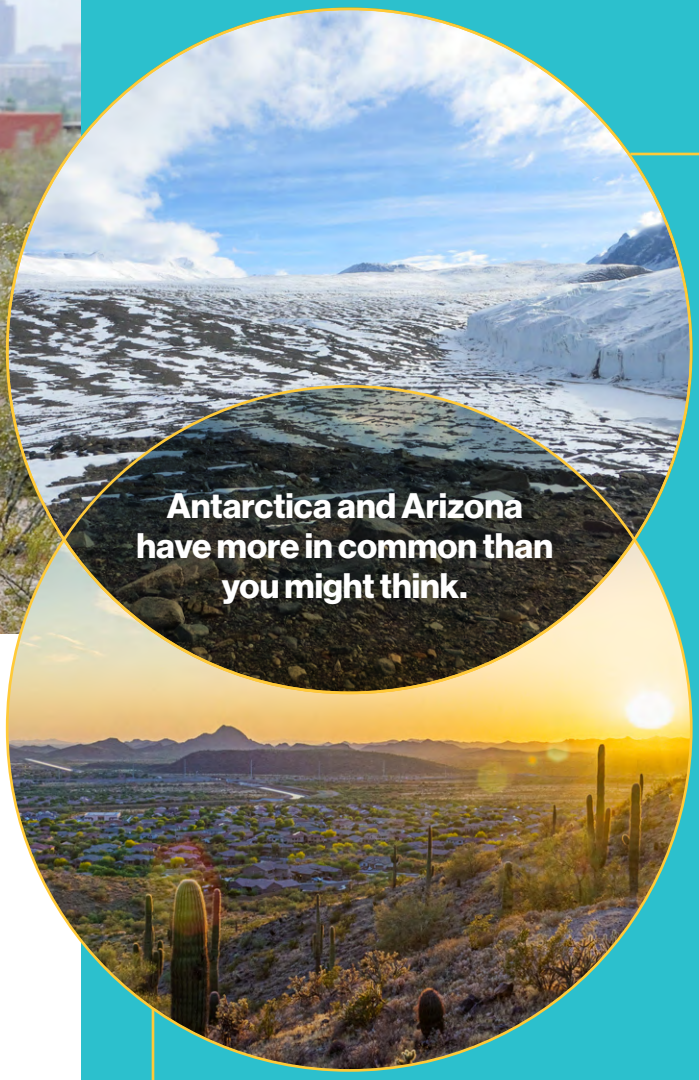
All of the scenarios rely on decades' worth of CAP LTER data. This helps participants understand the long-term implications of different decisions. For example, if stakeholders suggest planting trees to create shade, they can calculate how that will affect water supplies.

One scenario that was developed included the creation of a government office dedicated to addressing heat.

In 2021, the city of Phoenix established the Office of Heat Response & Mitigation — the nation's first publicly funded office focused on heat response. David Hondula, an associate professor in the School of Geographical Sciences and Urban Planning and a CAP LTER researcher, was named director of the new office.

The CAP LTER team is also working with the leaders and stakeholders of tomorrow. The award-winning Ecology Explorers program shares CAP LTER research findings with K-12 teachers and students and involves them in real research projects. CAP LTER scientists are also working directly with schools in lower-income areas of South and West Phoenix. For example, they installed air quality monitors on school campuses. Students and teachers can access the information online to understand the air quality at their schools.

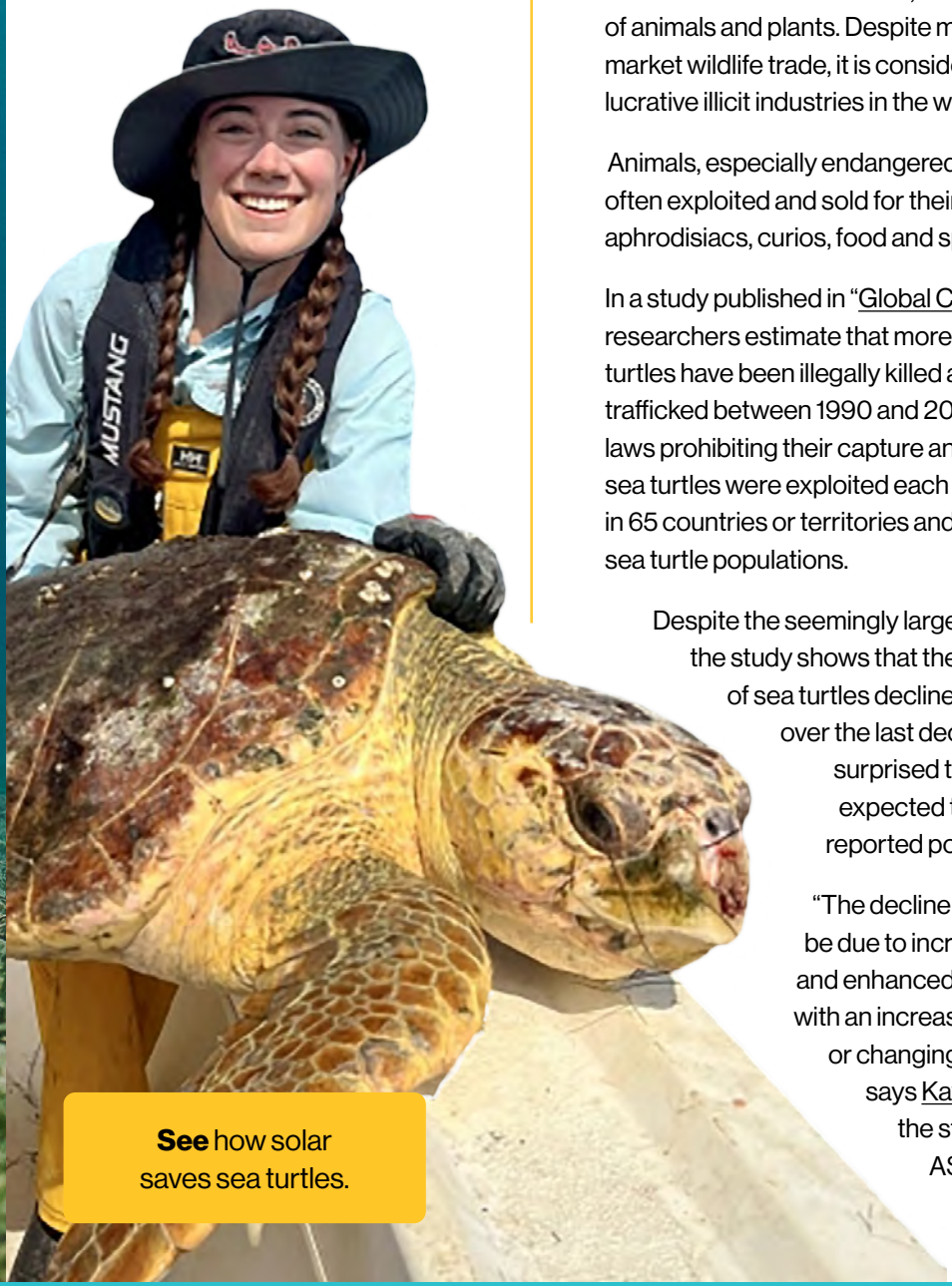
"I think that by understanding this environment as it is, we can potentially understand what it is about the environment that we could improve," says Grimm. "How can we think about ways to transform this environment and really create a sustainable city? Not just some place that is tolerable to live in, but some place where people can thrive." ■



"They deal with a lot of the same extreme limitations on life," says **Becky Ball**, associate professor and CAP LTER researcher who conducts research in both locations.

Explore the nature of cities

Good news for endangered sea turtles



See how solar saves sea turtles.

One of the most serious threats to wildlife biodiversity, in addition to the climate crisis, is the illegal killing and trafficking of animals and plants. Despite many laws against the black-market wildlife trade, it is considered to be one of the most lucrative illicit industries in the world.

Animals, especially endangered and threatened species, are often exploited and sold for their pelts or used as medicine, aphrodisiacs, curios, food and spiritual artifacts.

In a study published in "Global Change Biology," ASU researchers estimate that more than 1.1 million sea turtles have been illegally killed and, in some cases, trafficked between 1990 and 2020. Even with existing laws prohibiting their capture and use, as many as 44,000 sea turtles were exploited each year over the past decade in 65 countries or territories and in 44 of the world's 58 major sea turtle populations.

Despite the seemingly large number of poached turtles, the study shows that the reported illegal exploitation of sea turtles declined by approximately 28% over the last decade — something that surprised the researchers. They initially expected to see an overall increase in reported poaching.

"The decline over the past decade could be due to increased protective legislation and enhanced conservation efforts, coupled with an increase in awareness of the problem or changing local norms and traditions," says Kayla Burgher, co-first author of the study and a doctoral student in ASU's School of Life Sciences.

> With a few exceptions, current **levels of illegal exploitation are likely not having a major detrimental impact on most major sea turtle populations throughout the world's oceans."**

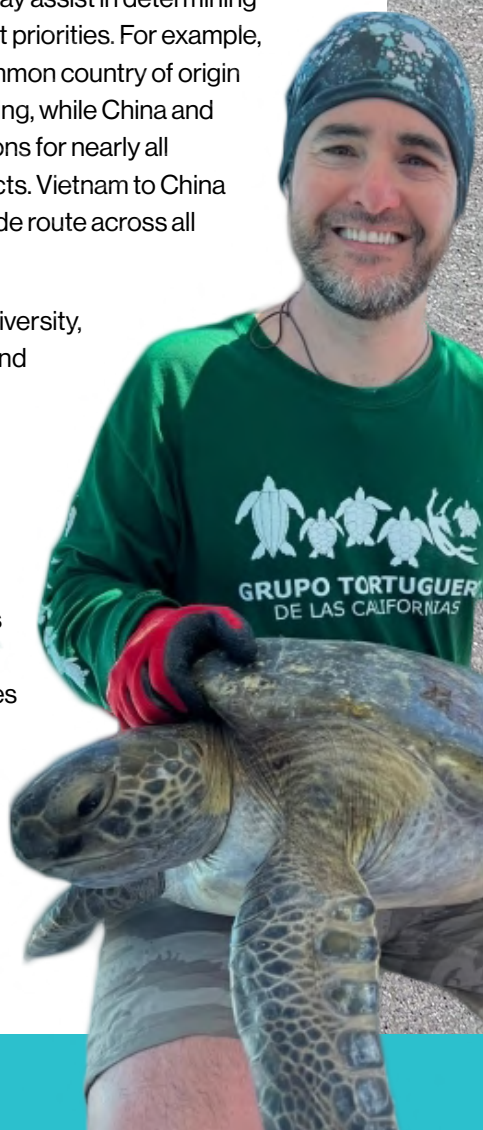
In addition to the slight decline, the researchers found that most of the reported illegal exploitation over the past decade occurred in large, stable and genetically diverse sea turtle populations.

"Most of these sea turtles came from healthy, low-risk populations, which suggests that, with a few exceptions, current levels of illegal exploitation are likely not having a major detrimental impact on most major sea turtle populations throughout the world's oceans," says Jesse Senko, co-first author of the study and an assistant research professor in ASU's School for the Future of Innovation in Society.

ASU researchers warn, however, the results should be cautiously considered. Assessing any illegal activity is difficult, and the trade of sea turtles is no exception, especially when it becomes organized or connected to crime syndicates.

In the study, the researchers reviewed data from peer-reviewed journal articles, archived media reports, NGO reports and online questionnaires for a comprehensive look at existing information on exploited sea turtles. The study revealed additional patterns and trends that may assist in determining conservation management priorities. For example, Vietnam was the most common country of origin for illegal sea turtle trafficking, while China and Japan served as destinations for nearly all trafficked sea turtle products. Vietnam to China was the most common trade route across all three decades.

To help sustain global biodiversity, the researchers recommend increased support for governments lacking the resources to protect sea turtles, support for communities to sustain human well-being in the face of restrictions or bans on sea turtle exploitation, and conservation strategies that benefit both people and turtles. ■



(L) ASU doctoral student Kayla Burgher *holds a loggerhead turtle, which was captured in Core Sound, North Carolina, and released unharmed. Photo courtesy of Jesse Senko.*

(R) ASU researcher Jesse Senko *holds a green turtle captured at a study site in Baja California Sur, Mexico. It was released unharmed. Photo courtesy of Cindy Vargas.*

Protecting Earth's largest ecosystem

Oceans cover more than 70% of the Earth's surface and act as a temperature-regulating system by providing dynamic transport of warm waters poleward and bringing cooler waters to the tropics. Oceans also play a crucial role in absorbing carbon from the atmosphere and excess heat from global warming, mitigating some of the effects of rising atmospheric carbon dioxide.

ASU's Julie Ann Wrigley Global Futures Laboratory is dedicated to ensuring our planet's health and human well-being — and oceans are essential to both. In September 2022, the laboratory introduced a fourth school in the College of Global Futures, the School of Ocean Futures.

The school is the planet's newest academic home for studying, teaching and developing innovative solutions for the current and future states of the ocean. Led by Professor Susanne Neuer, founding director, the school will address challenges our oceans face due to increasing pressure from human activities. It combines research and teaching facilities in the Pacific and Atlantic oceans with the cutting-edge research facilities within the Rob and Melani Walton Center for Planetary Health on ASU's Tempe campus.

The clock is ticking as human impacts to waste streams and climate change are directly impacting oceans and their ecosystems. To understand how the ocean operates and adjusts to increasing pressures, ASU has forged an important partnership with the Bermuda Institute of Ocean Sciences.

With a campus of classrooms, laboratories, dormitories and vessels, including the flagship 170-foot R/V Atlantic Explorer, the institute allows scientists and scholars to venture into the northernmost coral reefs in the Atlantic and the surrounding Sargasso Sea, one of the planet's most biodiverse open-ocean ecosystems.

The institute also operates two of the world's longest-running time-series programs: Hydrostation 'S', which has provided a continuous record of the ocean's physical properties since 1954, and the Oceanic Flux Program, which has yielded unprecedented insights into deep ocean particle fluxes since 1978.

BIOS is one of the longest-serving research institutes dedicated to studying ocean processes in the Western Hemisphere, commemorating its 120th anniversary in 2023. ■

Welcome to the College of Global Futures

The newly opened **Rob and Melani Walton Center for Planetary Health** is a flagship research facility with over 280,000 square feet and is outfitted with more than 70,000 square feet of research space and classroom capacity for more than 300 students. The design is purposefully centered around empowering collaboration, which makes it a vital tool in ASU's endeavor to shape thriving global futures for all of Earth's inhabitants. The Walton Center is the embodiment of Rob and Melani Walton's commitment, through the Rob and Melani Walton Foundation, to ASU's decades-long work around sustainability and planetary health.

Learn more about what's happening here.

ASU launches humanities driven sustainability hub

A UNESCO BRIDGES Sustainability Science Coalition Flagship Hub found a home at ASU's Julie Ann Wrigley Global Futures Laboratory.

Established in October, the Flagship Hub launch included a series of events featuring leadership from ASU and global humanities and sustainability organizations. Events served not only as a celebration of the Flagship Hub, but a demonstration of BRIDGES' capacity to connect and support individuals and organizations who are already working at the intersection of humanities and sustainability sciences. BRIDGES is UNESCO's inclusive human-centered and humanities-driven approach to sustainability science, which connects diverse stakeholders for sustainable change at local, regional and national levels.

"The Julie Ann Wrigley Global Futures Laboratory is delighted to be home to the BRIDGES Flagship Hub, which will serve as a space for spearheading new front-line, humanities-inclusive sustainability science internationally," says Peter Schlosser, vice president and vice provost of Global Futures. "The Global Futures Laboratory is placing humanities at the core of its transdisciplinary mission to shape a future of opportunity."

ASU leads initiative addressing state's future water supply

The western United States is experiencing the most extreme megadrought in the last 1,200 years, leading to severe Colorado River shortages. The state of Arizona has called upon ASU to lead a multiyear initiative for the state's future water supply.

The university will join forces with industrial, municipal, agricultural, tribal and international partners to accelerate and deploy new approaches and technology for water conservation, augmentation, desalination, efficiency, infrastructure and reuse.

The state plans to invest $40 million in the Arizona Water Innovation Initiative led by ASU, using funds from the federal American Rescue Plan Act. The funds will be used to launch a new Global Center for Water Technology, which will advance solutions such as:

- Technology, policy, law and infrastructure for coastal water desalination.
- Advanced technology for more water-efficient agricultural operations.
- Commercialization and deployment of water treatment and reuse technology that supports energy production and microchip manufacturing.
- New designs for urban water conservation.

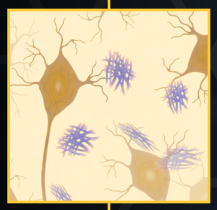
The new program, led by the Julie Ann Wrigley Global Futures Laboratory and the Ira A. Fulton Schools of Engineering, will deploy an advanced water observatory that will use technology to fully map, monitor and model all of Arizona's water supplies. It will also provide real-time decision support for water measurement, modeling and prediction, providing data for identifying critical risks, vulnerabilities and capabilities. ■

> "This is a critical innovation moment for water in the state of Arizona, and frankly for all seven basin states who have been sharing responsibility for creating water policy in this region for more than 100 years. The Arizona Water Innovation Initiative will strengthen water resilience while enhancing economic competitiveness, supporting high-value job creation and recruiting and retaining leading industries." **—ASU President Michael M. Crow**

03

Saving lives, improving health

Brain trust: A radical new approach to treating Parkinson's disease



Could your garden weed killer damage your brain?

Improving Arizonans' health, one behavior at a time


ASU ranks
#9 in Health and Human Services (including NIH) funding among institutions without a medical school.

New research offers hope for the treatment of Parkinson's disease

A driving force for health innovation and economic development, the **Biodesign Institute** at ASU has:

- Generated **$3B** in gross state impact, 2003-2020.
- Given rise to **969 inventions**.
- Launched **44 spinout companies**.

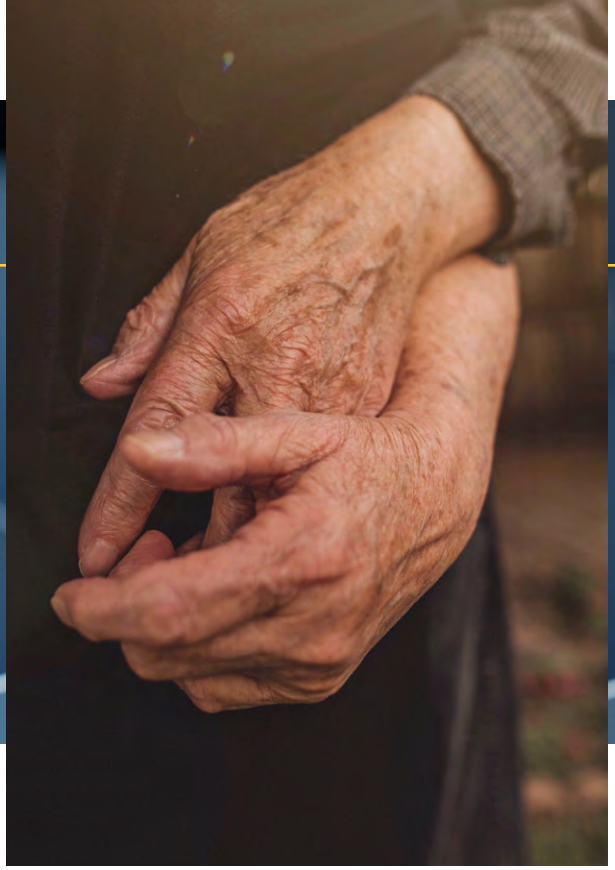
biodesign.asu.edu

Neurodegenerative diseases like Parkinson's disease damage and destroy neurons. ASU researchers are exploring strategies for replacing depleted neurons to reverse debilitating symptoms.

Parkinson's disease affects over 10 million people worldwide and nearly 1 million people in the U.S. alone. Currently, the number of patients living with Parkinson's disease exceeds those living with multiple sclerosis, muscular dystrophy and ALS (Lou Gehrig's disease) combined. By 2040, the disease is expected to affect 14 million individuals worldwide.

Among the devastating symptoms of Parkinson's disease are rigidity, tremors and difficulty with balance and walking. In many cases, problems with movement are accompanied by serious cognitive impairment, including dementia.

Jeffrey Kordower, founding director of the ASU-Banner Neurodegenerative Disease Research Center at ASU and Charlene and J. Orin Edson Distinguished Director at the Biodesign Institute, is on the forefront of promising new research into so-called neural grafting, in which stem cells are directly implanted in the brain.



This research was supported by funding from the Michael J. Fox Foundation.

In January 2022, the foundation awarded ASU **$5.2 million** to explore three pioneering treatments for Parkinson's disease, each targeting underlying causes of the disease.

Unraveling the mystery of treating Parkinson's disease

While the exact causes of the disease remain shadowy, two hallmarks of Parkinson's disease have long been recognized. The first is loss of the vital neurotransmitter dopamine in a brain region called the striatum. The second is the accumulation within nerve cells of alpha-synuclein (a-syn). While this protein is necessary for proper brain function, an overabundance of a-syn, in an aberrant, misfolded form, can wreak havoc on the nervous system. Together, deregulated dopamine levels and accumulating a-syn create a vicious cycle, causing synaptic dysfunction and progressive neurodegeneration.

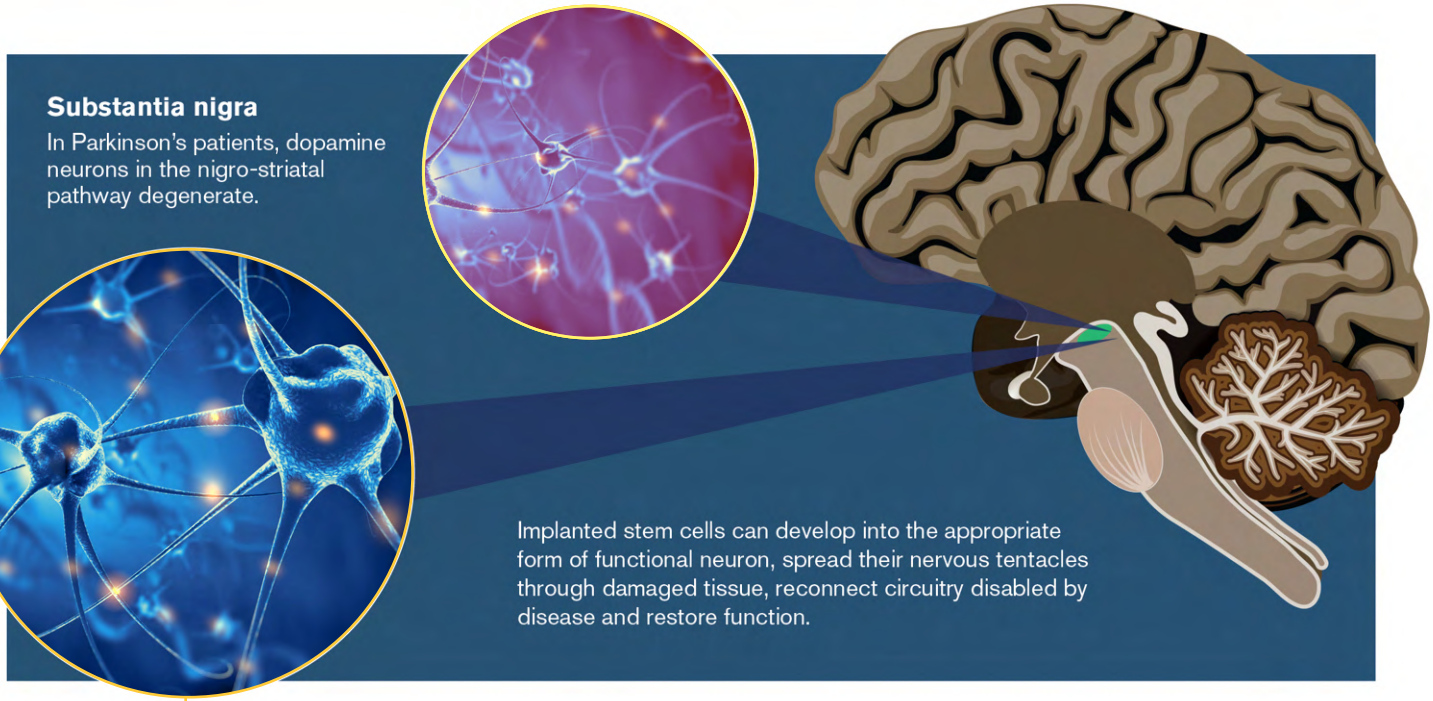
Researchers continue to explore strategies designed to protect neurons from the ravages of Parkinson's and other neurodegenerative diseases. But what if depleted neurons could be replaced with fresh, dopaminergic neurons? This is the intriguing rationale behind two new ASU studies.

Brain trust

Stem cell replacement therapy represents a radical new strategy for the treatment of Parkinson's and other neurodegenerative diseases. The futuristic approach will soon be put to the test in the first-of-its-kind clinical trial in a specific population of people with Parkinson's disease bearing a mutation in the gene Parkin. The trial will be conducted at various locations, including the Barrow Neurological Institute in Phoenix, with Kordower as principal investigator. This project is being conducted in collaboration with researchers from the Van Andel Institute in Michigan and Fuji-CDI in Wisconsin.

The approach involves infusing specially designed stem cells into the striatum where dopamine is lost. Patients who receive one or two doses of cells will be evaluated using PET scans and will be periodically re-examined to identify any adverse effects of the procedure and to assess the effectiveness of the therapy in treating symptoms of the disease.

The study aims to clarify and fine-tune the implantation approach by selecting patients with perceptible deficit due to Parkinson's disease but not so severe that the



damage is irreparable. Secondly, the study will attempt to simplify the picture by focusing on a select subset of Parkinson's patients, namely those with a specific mutation known as a Parkin mutation.

Parkin is a genetic mutation that causes the motor deficits seen in spontaneously occurring, or idiopathic, Parkinson's disease. Unlike these patients, however, those with Parkin mutations typically display only the classic Parkinsonian symptoms because their disease is pathologically limited to degeneration of the dopamine system. This makes them ideal subjects for a clinical trial to restore dopaminergic cells in the striatum.

Patients receiving the new cells are expected to show improvements in symptoms in six to 12 months. Successful results in the clinical trial of Parkin mutation cases will thereby encourage further trials in a wider population of Parkinson's patients.

Neural alchemy

The second study takes an even more radical approach to addressing dopamine deficit. This recently discovered technique also aims to produce dopaminergic neurons to replace those depleted in the substantia nigra, but instead of inducing laboratory stem cells to become neurons and then implanting them, the technique converts supportive cells in the brain known as astrocytes into dopaminergic neurons.

Astrocytes are attractive cell candidates for reprogramming as they lie in the vicinity of neurons and are liberally distributed throughout the brains of all mammals. Indeed, the astrocyte population accounts for about half of the total cells in the brain.

Researchers have found that treating astrocytes to deplete a specific RNA-binding protein known as PTB can induce these cells to transition into new neurons capable of repopulating neural circuits damaged by disease. The current study will advance the quest to successfully convert midbrain astrocytes to dopaminergic neurons, reconstitute injured nigrostriatal circuits, restore proper dopamine levels, and prevent or reverse the characteristic symptoms of Parkinson's disease in a pre-clinical animal model of Parkinson's. ■

Study shows popular weed killer crosses blood-brain barrier

Neurodegenerative diseases, such as Alzheimer's disease, are among the most perplexing in medical science. Various environmental contaminants have been implicated as possible players in the development or advancement of these diseases, including the common herbicide glyphosate.

In a study published in the Journal of Neuroinflammation, ASU Graduate Research Assistant Joanna Winstone, Assistant Professor Ramon Velazquez and their colleagues at the Translational Genomics Research Institute explore the effects of glyphosate exposure on the brains of mice.

The research demonstrates, for the first time, that glyphosate successfully crosses the blood-brain barrier and infiltrates the brain. Once there, it acts to enhance levels of the proteinTNF-a, which is linked to neuroinflammation.

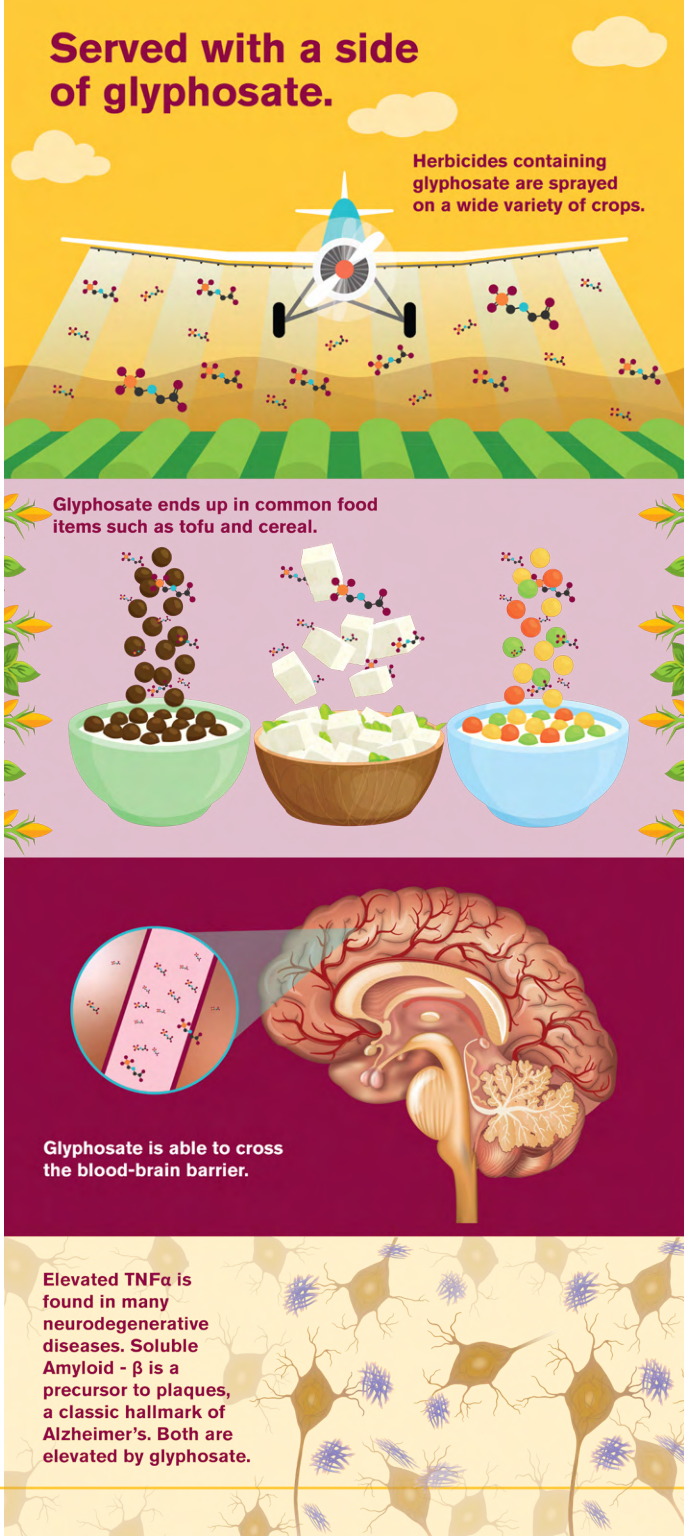
The study also suggests that glyphosate exposure increases the production of soluble beta amyloid (A) and reduces the viability of neurons. The accumulation of soluble beta amyloid is one of the central diagnostic hallmarks of Alzheimer's disease.

"We find increases in TNF-a in the brain following glyphosate exposure," says Velazquez, the senior author of the paper. "While we examined (Alzheimer's disease) pathology, this might have implications for many neurodegenerative diseases, given that neuroinflammation is seen in a variety of brain disorders."

Velazquez and Winstone, the first author on the study, are researchers with the ASU-Banner Neurodegenerative Disease Research Center at the Biodesign Institute and ASU's School of Life Sciences.

On the horizon, new drugs designed to reduce TNF-a in the brain are being explored, offering potential promise for those with Alzheimer's disease as well as other neurodegenerative ailments.

This research was supported by the Charlene and J. Orin Edson Initiative for Dementia Care and Solutions and by the National Institute on Aging. ■



Changing behavior for better health

Arizona is in the grip of societal health challenges — from substance use disorders and metabolic diseases to interpersonal violence and food deserts, where people have a lack of access to affordable, healthy foods.

Tragically, up to 40% of premature deaths are due to behavioral and other preventable factors, including modifiable habits such as tobacco use, inadequate nutrition and lack of physical activity.

The Phoenix Bioscience Core is poised to tackle these challenges that cannot be solved by any single field or sector. It is convening ASU's top experts from different disciplines and leveraging its place in downtown Phoenix, named among the top emerging bioscience markets in the U.S. by commercial real estate firm CBRE Group.

At PBC, university researchers, biomedical companies, startups, faculty, students and community members unite in this epicenter of innovation with a goal: To advance discovery, rapidly translate research findings and move innovations off-campus to solve real-world health challenges facing Arizona.

A solutions-oriented strategy

This strategy taps into the power of people and place.

PBC brings together experts at the convergence of neuroscience, behavioral economics, artificial intelligence/machine learning, biomedical engineering/technology, social determinants, policy, built environment, dissemination and implementation.

850 PBC is a state-of-the-art facility that provides key biomedical resources, including clinical suites, dry

> **It is my goal that the path to cure cancer will run through Phoenix.** We want Phoenix to be the leading place for both preventative medicine and therapeutics."
>
> **—Phoenix Mayor Kate Gallego**

labs (which feature high-tech equipment for crunching numbers, among other uses), wet labs for complex analytical chemistry and molecular biology analyses, a cardiovascular and exercise physiology laboratory, and motor control lab. Until now, most startups and many researchers were unable to access such facilities and equipment to advance their discoveries.

The $77 million facility is the first ASU-centered building on a 7-acre site on the larger PBC. ASU leases 112,000 square feet of the facility, with private companies occupying the rest.

Improving health in the community

Improving health for Arizonans begins with changing behavior — as individuals, families, communities and societies. The goal is more than simply extending the lifespan of Arizonans, but also their health span, the number of years spent in good health.

Changing behavior begins with providing equitable access to reliable, culturally appropriate, trusted, understandable and data-driven information when people need it most. The next step is empowering people to apply this information in ways that improve health and quality of life across the human lifespan.

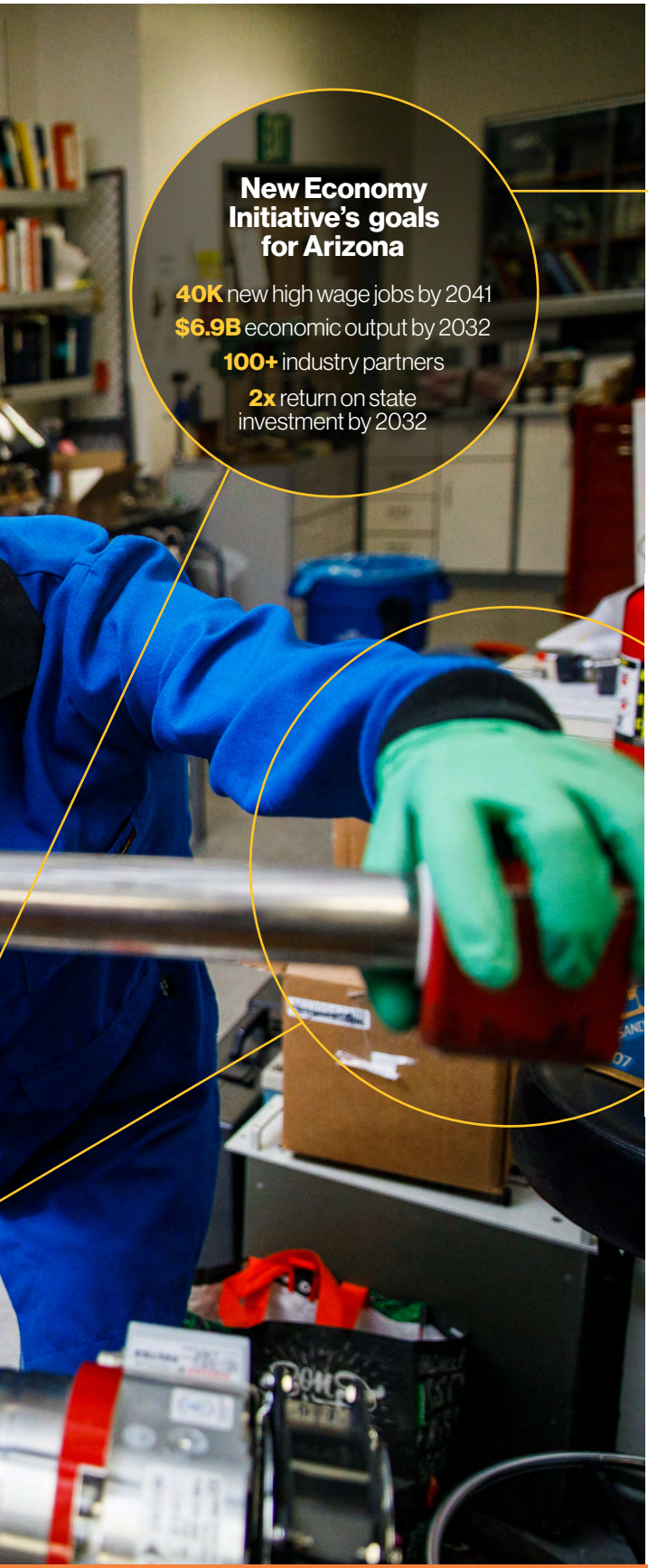
By bringing together experts from different fields and sectors to focus on pressing health issues such as addiction, diabetes, maternal mortality and intimate partner violence, PBC accelerates the pace at which problems are solved and creates real, measurable impact. ■

04 Advancing technology for a positive future

Reinventing Arizona's economy for tomorrow

Quantum countdown: The technology set to revolutionize computing

Training cyber heroes is no longer sci-fi



Creating a competitive and resilient economy in Arizona

ASU is helping to bring new high-wage jobs to Arizona and increase the state's economic output through the New Economy Initiative.

To build a competitive and resilient economy in the 21st century, Arizona needs to move beyond its storied five Cs: cattle, cotton, copper, climate and citrus. The Grand Canyon State plans to do so with the New Economy Initiative.

Funded by the state legislature, the New Economy Initiative tasks the state's three universities to develop a coordinated response to attract high-tech industry, drive job creation and make Arizona families prosperous. It aims to create 40,000 new high-wage jobs by 2041, increase economic output to $6.9 billion and double the return on the state's investment by 2032.

The endgame is to pivot Arizona's economy away from housing growth and tourism to something that is resilient to economic downturns, pandemics and whatever else the future has in store.

"All of us — the citizens of the state, the legislature, the governor, chambers of commerce — all said, we have to do something and we have to do something collectively," says Sally C. Morton, the executive vice president of ASU's Knowledge Enterprise.

Each university has been given distinct roles to play, aligning to their traditional strengths. While Northern Arizona University and the University of Arizona focus on health care and health care worker shortages, ASU has been tasked with growing the Ira A. Fulton Schools of Engineering, training students in skills demanded by a modern workforce and upskilling existing workers.

Partnerships and collaborations

Long before the launch of the New Economy Initiative, ASU was laying the groundwork for collaboration with tech companies in the state.

In November 2019, Grace O'Sullivan, ASU's vice president of Corporate Engagement and Strategic Partnerships, traveled with city of Phoenix and state officials to Hsinchu, Taiwan to help attract the Taiwan Semiconductor Manufacturing Company to the Valley.

Several months later, the chip giant announced plans to build a $12 billion chip plant in Phoenix — bringing with it thousands of jobs and a need for skilled graduates.

ASU has partnerships and relationships with almost every tech giant in the state: Honeywell, Raytheon, Intel and dozens of others.

"Now we have this organizing framework around the New Economy Initiative," says O'Sullivan. "This is a great way for our industry partners to connect on these really important themes for the new economy."

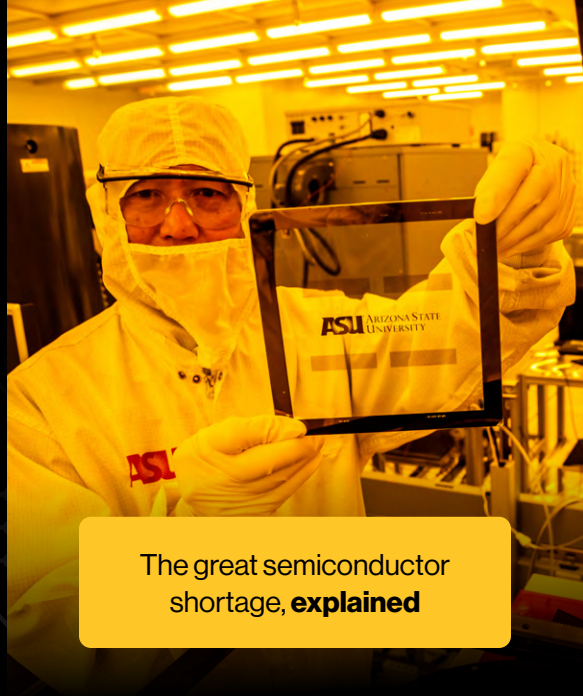
ASU has secured close to $10 million in grants from the Department of Labor for workforce development. They are focused around IT skills, cybersecurity and advanced manufacturing. The university is creating apprenticeship programs and new models for how people are getting trained in the workforce — either new talent coming in or existing employees who need to be reskilled.

Upskilling

Meredyth Hendricks is head of upskilling within ASU's Learning Enterprise, the university unit responsible for reimagining how to serve learners across their lifespan. Hendricks leads a team that builds and scales job-relevant education programs that serve two key purposes: giving learners the skills they need to succeed at every career stage, and providing employers with a more skilled workforce.

"Within the New Economy Initiative, we're focused on catalyzing Arizona's workforce to position learners and

ASU President Michael M. Crow, U.S. Sen. Kyrsten Sinema from Arizona and U.S. Sen. John Cornyn from Texas (from left to right) participate in a panel discussion during "CHIPS for America: Winning the Race to Make the Best Microchips in the World." The event was hosted by ASU and the Washington Business Journal at the Barrett and O'Connor Washington Center in Washington, D.C. Two panel discussions overviewed the importance of the new $52 billion CHIPS and Science Act as a catalyst for improving American research, innovation, manufacturing, workforce development and national security related to semiconductors. America's share of global semiconductor production has fallen from 37% in 1990 to just 12% today, posing economic and security risks to the country.



The great semiconductor shortage, **explained**

companies for success in Arizona's new economy," Hendricks says.

The Learning Enterprise has ambitious program development goals. The first type of programs are highly scalable courses that will reach learners across the state, including those already in the workforce. One initial focus for the team is developing a robust portfolio of courses related to professional skills (sometimes termed "soft skills"), such as critical thinking, emotional intelligence and teamwork. These are rarely taught comprehensively in school, but they're critical across many roles.

"Three out of four employers say that they have difficulty finding employees who have the professional skills their companies need," Hendricks says. "This skills gap in the market presents an opportunity for ASU to have an impact. Moreover, these skills are not likely to be automated in the future because they are by nature human skills."

Engineering the future

With 30,000 undergraduate and graduate students and 75 degree options offered on two campuses and online, the Fulton Schools of Engineering is the largest and most comprehensive engineering school in the United States.

Administrators of the Fulton Schools see two things as their greatest strength: their students and their faculty. Their plan to advance the New Economy Initiative is to rely on those strengths by beefing up both.

Engineering enrollment has skyrocketed at ASU, with undergraduate enrollment rising from more than 6,000 in 2010 to more than 20,000 in 2021.

Because ASU is a research university, the faculty work on the cutting edge of technology. Students are immersed in it, interning in industry or performing tasks like reprogramming a robot arm that a Raytheon supplier couldn't complete, through the eProjects program.

"They find translational pathways," says Kyle Squires, dean of the Fulton Schools. "They connect into industry partners that basically help industries see the horizon of where their industry sector is headed. It de-risks that process. It basically brings us into it. And that's something universities are uniquely able to do. ASU has really leaned into that. I think that's one area where ASU really has a competitive advantage. We can scale that through the NEI." ■

How ASU will help industry work on the cutting edge of tech

Within the scope of the New Economy Initiative, ASU has been charged with lending its muscle as a research powerhouse to industry partners to better position Arizona for global tech leadership. ASU is making good on this promise by launching five new science and technology centers (STCs).

ASU has already launched two STCs:

1 **The MADE (Manufacturing, Automation and Data Engineering) STC** focuses on the development of new technologies aimed at transforming manufacturing through 3D printing, robotics and automation, and new materials, with strong links to private industry support in aerospace, defense and space systems.

2 **The AMPED (Advanced Materials, Processes and Energy Devices) STC** is a national research resource for advancing new energy materials and device technologies in solar, batteries and electronics to market, growing industry engagement and workforce training.

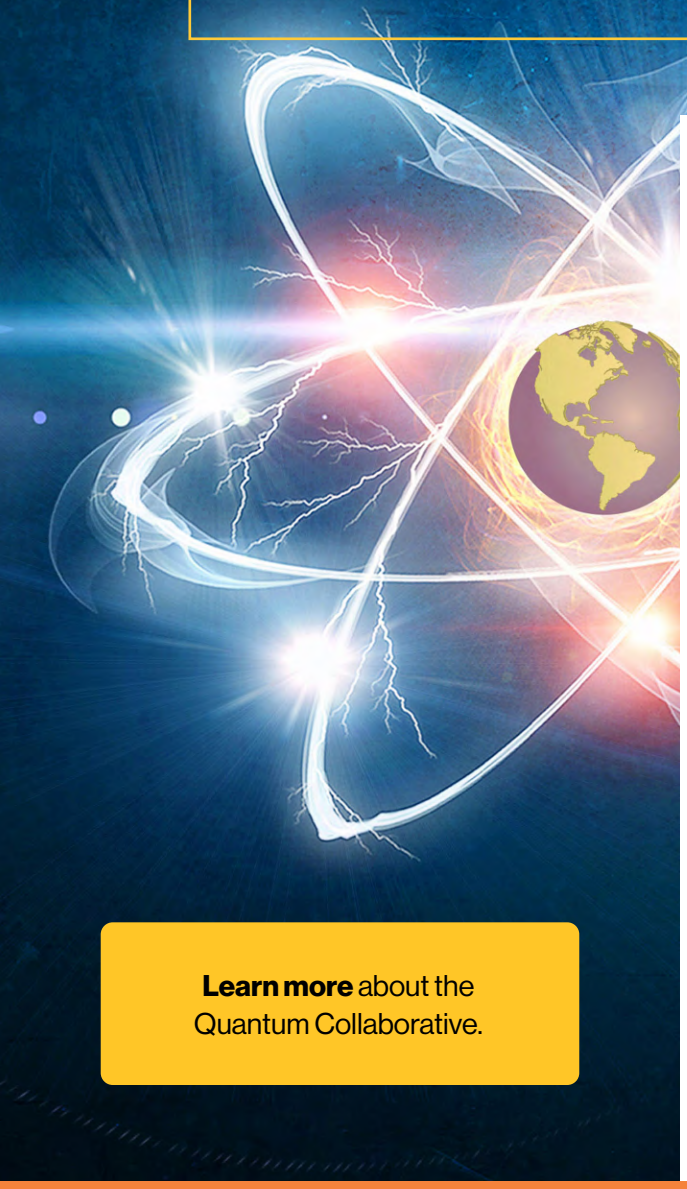
The other three STCs are launching soon:

1 **Extreme Environments** will focus on management and technology opportunities associated with growing population centers, and research to engineer resiliency into the energy, water, materials and transportation systems in the built environment of future cities and regions.

2 **Future Communications** will develop physical information systems as the Internet of Things continues, and as users increasingly desire greater access, information and reliability in communications.

3 **Human Performance** will leverage regional strength and technology opportunities to enhance physical and cognitive performance, medical prevention and intervention, and drive research from discovery to marketplace.

ASU launches new quantum research collaborative



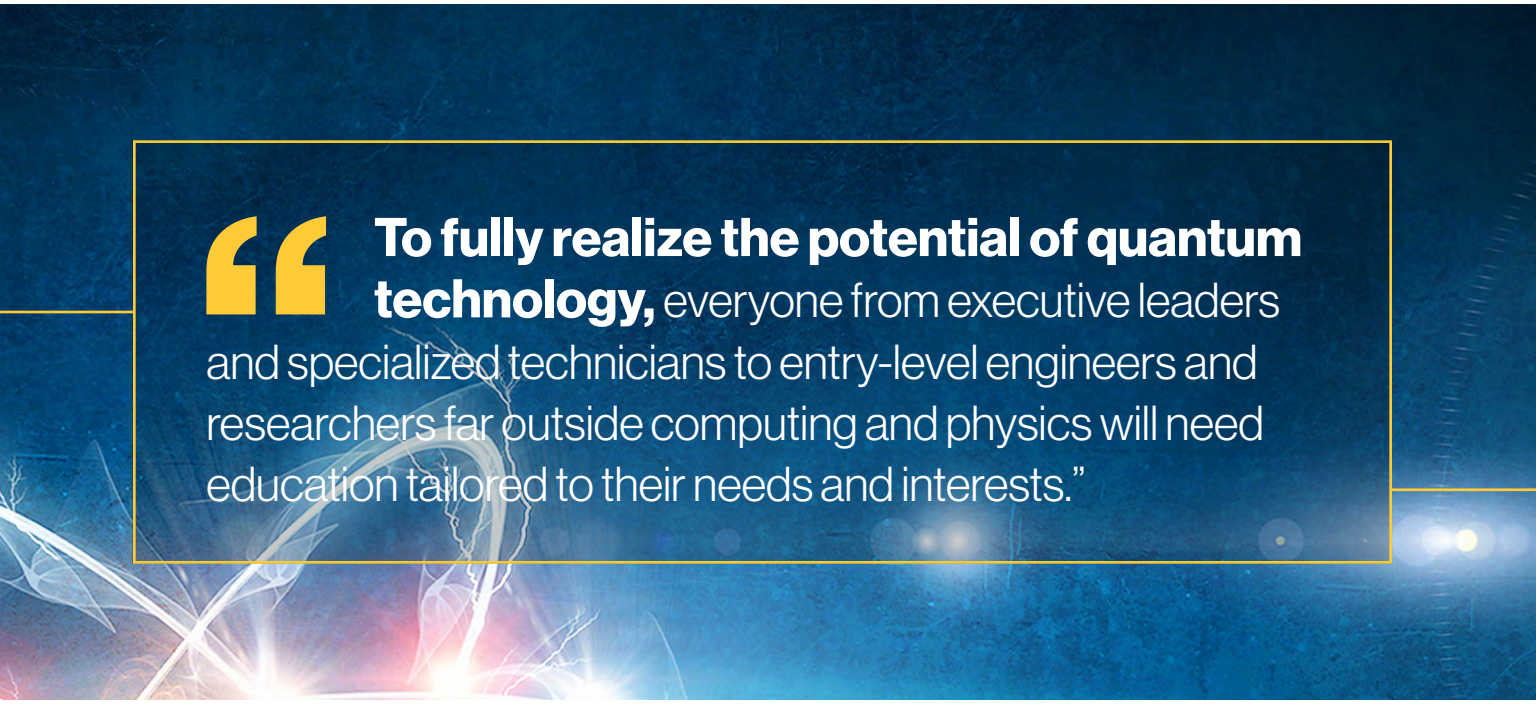
Learn more about the Quantum Collaborative.

ASU has launched the Quantum Collaborative, a major 21st century initiative poised to profoundly impact society and the American economy with new discoveries and applications in advanced quantum technology.

State-funded and globally oriented, the Quantum Collaborative aims to promote understanding of this important technology, forge academic and industry partnerships to advance it and train a skilled quantum workforce.

"A key objective for ASU's Knowledge Enterprise is to fundamentally change how the world solves problems," says Sally C. Morton, executive vice president of the ASU Knowledge Enterprise. "Quantum technology holds a unique promise to accomplish this, and I am thrilled to see what we can accomplish with our partners in the Quantum Collaborative."

The Quantum Collaborative's founding industry partners are Quantinuum, Google Quantum AI, SandboxAQ and CR8DL. Founding academic partners include Purdue University, Tecnológico de Monterrey, Virginia Tech and The University of Texas at San Antonio.



> **To fully realize the potential of quantum technology,** everyone from executive leaders and specialized technicians to entry-level engineers and researchers far outside computing and physics will need education tailored to their needs and interests."

A key asset of the Quantum Collaborative is ASU's Quantum Innovation Center in the IBM Quantum Network, a global community of Fortune 500 companies, academic institutions, startups and national labs with cloud access to IBM's premium quantum computers, experts and resources.

"We're excited to welcome ASU into the IBM Quantum Network," says Aparna Prabhakar, vice president, partner ecosystem, IBM Quantum. "They're already building a diverse academic and industry ecosystem, with an academic and workforce program focused on how quantum computing can be applied to key demonstrations of the technology."

The Quantum Collaborative's scope encompasses the full breadth of Quantum Information Science and Technology, or QIST. QIST stands to revolutionize many areas of industry such as pharmaceutical development, finance, telecommunications, artificial intelligence and cybersecurity.

"There are few organizations engaging across all QIST areas simultaneously, because each individual area is advancing so quickly and focused on individual goals," says Sean Dudley, assistant vice president and chief research information officer of ASU's Knowledge Enterprise. Dudley oversees the Quantum Collaborative with support from internal and external advisory boards. "We've found that groups working in specific areas of QIST struggle to keep tabs on advancements across other areas, even when co-dependencies are in the mix."

The Quantum Collaborative solves for this silo effect by aligning research and development efforts where appropriate to create joint initiatives and mechanisms for knowledge exchange.

A key aim of the Quantum Collaborative is workforce and education program development. To fully realize the potential of quantum technology, everyone from executive leaders and specialized technicians to entry-level engineers and researchers far outside computing and physics will need education tailored to their needs and interests.

One goal of the Quantum Collaborative is to demonstrate that quantum technology is a skill area

within reach that has potential to create economic mobility for many people.

"When I was growing up in a small manufacturing town in Wisconsin, people were excited about the opportunity offered by a radiology certification. It was two years of learning and then you could make great money without having to follow the previous generation into a factory," Dudley says. "While the manufacturing industry certainly took great care of many families in the Midwest, radiology brought hope as something that might lift you up and out of a limited professional destiny. We at ASU, with our many partners, will work within and outside STEM-engaged populations to bring a new set of professional opportunities to families across all communities." ■

What is quantum computing?

The bedrock of the emerging field more formally known as Quantum Information Science and Technology, or QIST, is quantum computing.

Essentially, quantum computing is a marriage between computing and quantum theory — a branch of physics that focuses on the behavior of atoms and the subatomic particles within them.

Traditional computers — be it your laptop, cell phone or high-performance supercomputers — operate using binary digits, or bits. Bits have only two possible values, one or zero. They make up binary code, which your computer reads to carry out its tasks.

Conversely, quantum computers use quantum bits, or qubits, to process information. Qubits can exist not only as a one or a zero, but also as both a one and a zero simultaneously. Together with other quantum mechanical features, this behavior allows quantum computers to run certain computations much faster than any classical computer.

The power and speed of quantum computers stands to revolutionize many areas of industry such as pharmaceutical development, finance, telecommunications, artificial intelligence and cybersecurity.

Creating the future cybersecurity workforce

Cybersecurity is critical to national security, yet the demand for professionals in the field far exceeds the supply. Between 2013 and 2021, the number of unfilled cybersecurity jobs around the world grew 350%, according to Cybersecurity Ventures. The industry researcher also predicts the same number of jobs — more than 700,000 — will still be open in five years. With so many people needed to fill seats in cybersecurity roles, ASU has sprung into action to prepare tomorrow's workforce with the field's rapidly evolving skill requirements. Here's how:

> "With so much of our lives taking place online, cybersecurity is **everyone's** concern."
>
> **Sally C. Morton**
> *Executive vice president*
> *ASU Knowledge Enterprise*

1 Filling the cybersecurity expertise gap

ASU's Center for Cybersecurity and Trusted Foundations is expanding the cybersecurity workforce by training professionals at all career levels, from building the skills of novice learners to arming established professionals with knowledge of the latest hacking techniques. From Facebook data breaches to ransomware groups shutting down national pipelines, cybersecurity attacks are becoming increasingly sophisticated and harder to defend. Now more than ever, regular technical upskilling for professionals is a must for staying abreast of the latest technologies and threats.

2 Expanding the reach of ASU's cybersecurity training

ASU's pwn.college is an online educational platform that provides training modules to aspiring cybersecurity professionals both within and outside of the university. Here, the next generation of cybersecurity experts learn how hackers think and infiltrate networks while gaining hands-on practice blocking modern-day computer exploitation techniques.

3 Helping ASU students master in-demand skills

Recognized as an academic leader in cybersecurity by industry and government organizations, ASU offers 12 robust bachelor degree programs related to cybersecurity, all designed to make graduates stand out from other traditional degree programs. ASU addresses cybersecurity from many angles, offering relevant degree options in computer science, business, math, natural sciences and other academic units. Students from all disciplines can participate in hands-on learning.

4 Training high school students in cybersecurity principles

The Center for Cybersecurity and Trusted Foundations hosts a high school summer internship program that exposes students to a world-class cybersecurity research lab, where they learn what it means to conduct impactful research. The program exposes students to emerging concepts and technologies as well as prominent researchers in the field, giving them valuable connections for future pursuits within and outside of academia.

Your VPN isn't as secure as you think

In countries where internet censorship and surveillance are government policy, online safety is crucial for at-risk users. Those who have a prominent online presence, like journalists, activists and politicians, can face dire consequences for simply browsing certain websites.

Virtual private networks, or VPNs, are designed to keep users' data protected from surveillance, but for those whose lives can depend on their effectiveness, whether VPNs can do what they claim is of utmost importance.

ASU researchers explored VPNs' ability to protect users, questioning claims of privacy and asking whether VPNs might create a false sense of security.

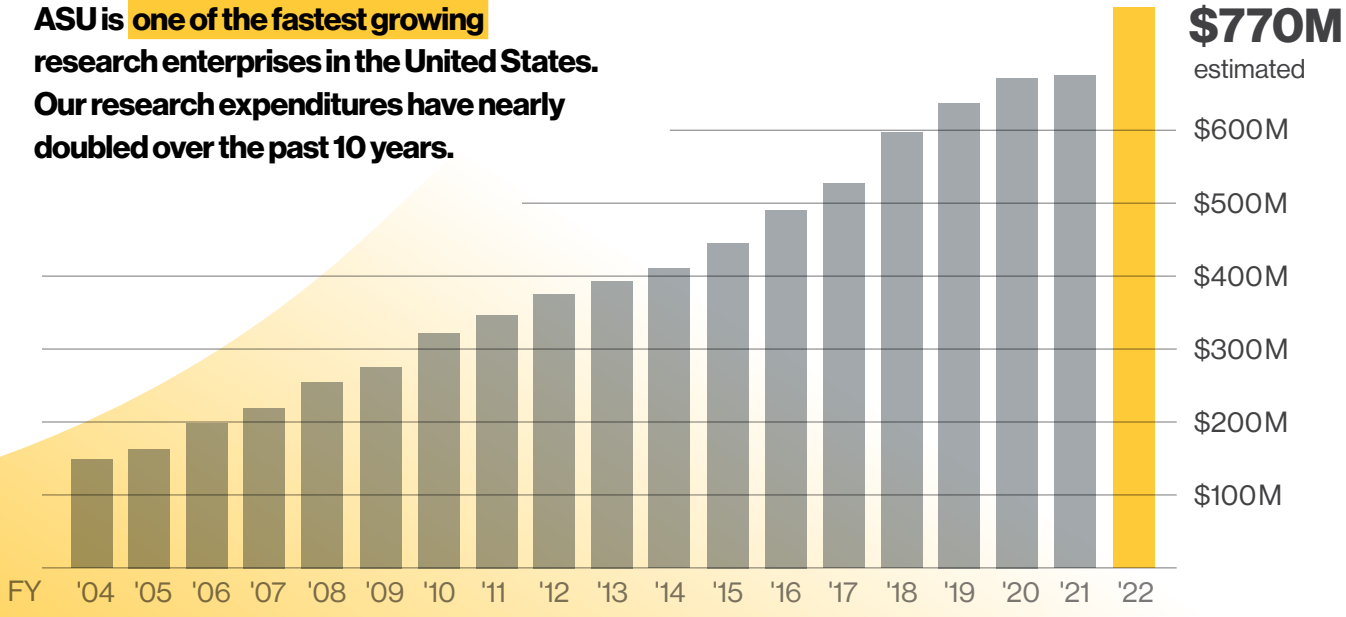
They have discovered that online traffic can still be attacked by accessing the user's device, or the VPN tunnel, in the same ways as if VPNs were not being used, with attackers able to redirect connections and serve malware, which is what users believe a VPN protects them from.

Other research addresses how VPN adoption has seen steady growth due to increased public awareness of privacy and surveillance threats and how some governments are attempting to restrict access by identifying connections using deep packet inspection, or DPI, technology, which is commonly used for online eavesdropping and censorship.

***At a competition organized by ASU's Global Security Initiative**, aspiring and professional cybersecurity experts find their glory through real-world hacking challenges.*

05 Leading the nation in research and innovation

ASU is one of the fastest growing research enterprises in the United States. Our research expenditures have nearly doubled over the past 10 years.



Rankings by research expenditures

Source: National Science Foundation HERD Survey **2021**

#1 **Transdisciplinary research**, ahead of Johns Hopkins, Northwestern and the University of Pittsburgh

#1 **Anthropology**, ahead of Harvard, Stanford and the University of Michigan

#1 **Geological and earth sciences**, ahead of MIT, Penn State and the University of Arizona

#4 **Social sciences**, ahead of Cornell, UCLA and University of North Carolina at Chapel Hill

#5 **Business management and business administration**, ahead of Georgetown, Duke and Columbia

#9 **Education**, ahead of UCLA, Michigan State University and University of Oregon

ASU innovations 2022

In fiscal year 2022, ASU innovators working with Skysong Innovations* generated:

305
invention disclosures

166
U.S. patents

21
new startup companies

#1
BEST COLLEGES U.S.News MOST INNOVATIVE 2022-2023

in the U.S. for innovation

ASU ahead of MIT and Stanford
– U.S. News & World Report
8 years, 2016–2023

*** Skysong Innovations is ASU's exclusive intellectual property management company.**

#6 **Total research expenditures** among institutions without a medical school

#9 **HHS-funded expenditures (including NIH)**, among institutions without a medical school

#9 **Civil engineering**, ahead of Duke, University of Illinois at Urbana-Champaign and Clemson

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