



# SCIENCE RESEARCH 2019

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# SCIENCE RESEARCH

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# Northern Arizona University: Elevating research in Flagstaff and beyond

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**A**t Northern Arizona University, we've always been a part of our hometown—a city that prizes innovation—and a partner to it. If you're reading this, chances are good that you're either an NAU alum, you sent your children to NAU or you or one of your neighbors works at NAU. If you live in Northern Arizona, we are *your* university. And we're proud to share this unique high-elevation landscape and environment with you. Like most people who call Flagstaff home, we are committed to protecting it and the precious natural resources that make it so special.

You may have seen our “Elevated” campaign on billboards, ads, banners or brochures. As our neighbors in Flagstaff and the surrounding communities know, we're talking about much more than the altitude.

When we say research at NAU is elevated, we're demonstrating the tremendous growth we've experienced in the university's research enterprise as well as the heightened expectations we have for its future. “Research, Elevated” is meant to convey the pride we have in the many discoveries our researchers have made, the original knowledge they've contributed to their respective scientific fields and the many solutions they've developed to address the most pressing challenges of our time.

We've long been recognized for our work in disciplines like astronomy and planetary science, the biosciences and environmental sciences, including ecosystem science, climate science, sustainability, forestry and fire ecology and land management and conservation. Just in the last three years, we've built on these historical strengths while increasing investments in emerging technologies aligned

with bioengineering, informatics and cyber systems, health equity research and the human microbiome—all of which are generating exciting new interdisciplinary collaborations across the university.

And, for the first time, NAU was ranked in the top 100 on the National Science Foundation's latest national rankings of research universities without a medical school. We also moved up to No. 201 on the NSF list of all universities in the United States, up from No. 213 in 2017.

These are accomplishments that everyone in our community can be proud of. Of course, there are other public universities in Arizona—and hundreds of institutions across the country—that can also boast of world-class research faculty and noteworthy achievements. What sets us apart, however, are not only the mountains, forests and rivers of the Colorado Plateau, but the close partnerships we've formed that enable us to collaborate in meaningful ways throughout the region.

Research thrives at NAU, and through the efforts of our neighbors and partners, we are positioned to continue building capacity for research in a broad range of disciplines that will help improve health, the environment, the economy—and quality of life—for all. 



Rita Hartung Cheng, PhD  
*President, Northern Arizona University*

# NAU: Building a reputation for environmental research on the Colorado Plateau

By Kerry Bennett, Research Communications Officer at Northern Arizona University

Arizona Normal College opened its doors in Flagstaff in 1899 with 23 students, two faculty members and two copies of *Webster's International Dictionary* bound in sheepskin. Although the institution continued to grow through both world wars and the Great Depression, it wasn't until the 1950s that it began its transformation into a research university. After launching a forestry program in 1958 and increasing research activities, Arizona State College finally became Northern Arizona University on May 1, 1966.

Set at the base of the San Francisco Peaks in the high desert of Northern Arizona—surrounded by one of the most ecologically diverse natural labs in the world—NAU's Flagstaff campus offered scientists a range of exceptional research opportunities found nowhere else.

Over the years, faculty have successfully built a reputation for environmental research by tapping into the abundant natural resources of the region, launching world-class programs in ecosystem science, sustainability, forestry and fire ecology and land management and conservation. Here, at an elevation of 7,000 feet, students learn to conduct research beyond the traditional classroom and lab in settings on the Colorado Plateau, including the highest mountain range in Arizona and the world's largest ponderosa pine forest.

Today, NAU's College of the Environment, Forestry and Natural Sciences houses centers and institutes that centralize research strengths in several key areas. The college's School of Earth Sciences and



Bruce Hungate

## Did you know?

There are five life zones within 50 miles of NAU's main campus, and six in the state of Arizona: Lower Sonoran (low, hot desert), Upper Sonoran (desert steppe or chaparral), Transition (open woodlands), Canadian (fir forest), Hudsonian (spruce forest) and Arctic-Alpine (alpine meadows or tundra).

biochemistry, mathematics and physics and astronomy have formed the bedrock of the university's historic research success.

Environmental Sustainability, School of Forestry and strong academic departments in biological sciences, chemistry and

## Center for Ecosystem Science and Society predicts social, environmental impact of climate change

Ecosystem science is understanding how plants, animals, microorganisms, soil, rocks, minerals, water and the atmosphere interact with one another. It's understanding how systems intersect on a planet that's undergoing continual

change. To successfully predict the social and environmental impact these changes will have, NAU established the Center for Ecosystem Science and Society (EcoSS) in 2013. And in a few short years, EcoSS faculty have emerged as leaders in the field.

Bruce Hungate, Regents' Professor of Ecosystem Science and Frances B. McAllister

Endowed Chair in Community, Culture and Environment, is the founder and director of Ecosystems. Dr. Hungate has been a catalyst for drawing world-class scientists to NAU from all over the world. His research focuses on the ecology and management of global change and microbial ecology from humans to the globe. He conducts research in grasslands, woodlands, forests and rivers, using experiments, models and data syntheses to understand how ecosystems respond to global change.

Because of his work and reputation, Dr. Hungate has brought more than \$35 million in external research funding to NAU. He has published nearly 200 papers in scholarly journals, including *Science* and *Nature*, with more than 13,000 citations. He is a fellow of the American Academy of Microbiology, and was appointed vice-chair of the Department of Energy's Biological and Environmental Research Advisory Committee (BERAC).

Ted Schuur, Professor of Ecosystem Science, is the lead investigator for the international Permafrost Carbon Network. His research focusing on the response of Arctic ecosystems in a warmer world has earned accolades and recognition from leading climate researchers around the world. Dr. Schuur is one of 101 scientists selected to produce a landmark report examining the effects of climate change on oceans and the frozen world for the Intergovernmental Panel on Climate Change (IPCC).

Dr. Schuur has published more than 130 articles in top peer-reviewed scholarly journals, with more than 11,000 citations. He is the lead investigator on a project awarded a \$1.4 million grant by the U.S. Department of Energy to study the regional vulnerability of permafrost carbon to climate change.

Michelle Mack, Professor of Ecosystem Science, was elected a fellow of the Ecological Society of America for her seminal research in plant ecology in the Arctic and Boreal regions.

Dr. Mack has garnered more than \$30 million in collaborative funding since 2000, and has won numerous awards for her research, teaching and mentoring. Dr. Mack was named a coprincipal investigator on a \$2 million project funded by the Department of Defense to investigate changing vegetation dynamics across DoD lands in interior Alaska. She has published more



Ted Schuur



Andrew Richardson

than 100 articles, many in journals such as *Science* and *Nature*.

Andrew Richardson, Regents' Professor of Ecosystem Science, came to NAU from Harvard University. His research in forest science and ecophysiology incorporates plant biology, earth system science, computer science, remote sensing, applied mathematics, engineering, atmospheric science and micrometeorology. He is a

world-renowned expert in phenology, the study of seasonal rhythms of plants and animals in various ecosystems, and has made significant discoveries and leading-edge contributions to research related to terrestrial ecosystem carbon cycling.

In 2018 alone, Dr. Richardson earned grants from several major federal agencies, bringing in \$9.7 million in external awards to

fund his research. He has published more than 190 peer-reviewed papers, and Clarivate Analytics has identified him as a highly cited researcher in environment/ecology and agricultural sciences. He has received more than \$40 million in grant funding in his career.

*"There are a lot of really exciting developments at NAU these days, and it is amazing to be part of this energetic and vibrant academic community,"* Dr. Richardson said.

Yiqi Luo, Professor of Ecosystem Science, has collaborated on key global change experiments in grasslands, forests, deserts and wetlands. His lab is among the first for development and applications of data assimilation to ecological research for improving models against data from multiple sources and ecological forecasting. Dr. Luo's group has invented an analytic approach to spin-up and a traceability framework for evaluation and improvement of Earth system models (ESMs).

#### **Ecological Restoration Institute heals forests after cataclysmic wildfires**

Faculty researchers in NAU's Ecological Restoration Institute (ERI) work to heal forests after cataclysmic wildfires and find innovative ways to reduce fire risk.

Wally Covington, Regents' Professor of Forestry, is the Executive Director of ERI. He is the recipient of the Biswell Lifetime Achievement Award from the Association of Fire Ecology, honoring his pioneering research on dry, frequent-fire forests of the American West. Dr. Covington also testified before the U.S. Senate Committee on Energy and Natural Resources to review past wildfire seasons and to improve future federal wildland fire management strategies.

Peter Fulé, Regents' Professor of Forestry and the inaugural Charles O. and Mary Minor Endowed Professor in the School of Forestry, is an internationally recognized expert in restoration ecology and fire ecology. He has worked in the Grand Canyon, the Sierra Madre of Mexico, Patagonia in Argentina, the Sumatran rain forests in Indonesia, the mountains of Spain and Greece and the Himalayas, studying fire-adapted forests that provide a vital habitat to a variety of plant and animal life and people.

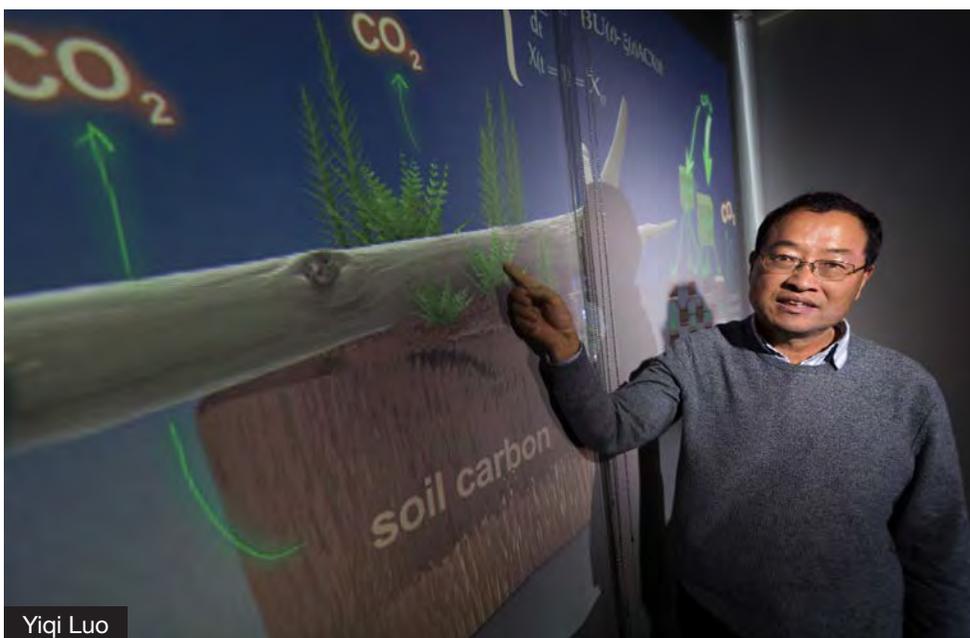
Dr. Fulé has been awarded \$13.8 million in grant funding over his career. He has authored or co-authored 285 refereed journal articles and



Michelle Mack



Catherine (Kitty) Gehring



Yiqi Luo

six book chapters, with his research appearing in *Science*, *Ecological Applications*, *Ecology*, *International Journal of Wildland Fire* and *Forest Ecology and Management*. He also has worked on significant research projects with the Mescalero and White Mountain Apache tribes, the Hualapai Tribe and the Navajo Nation to help them prepare for and recover from devastating fires.

*"I feel fortunate to have been able to pursue a career of research and teaching focused on the magnificent forests of the Southwest and many other*

*parts of the world, with terrific students and colleagues," Dr. Fulé said.*

Han-Sup Han, Professor of Forestry, is Director of Forest Operations and Biomass Utilization for ERI. Dr. Han comes to ERI from Humboldt State University as a top researcher with 20 years of experience evaluating the economics and operational efficiencies of various timber and biomass harvesting systems. While at Humboldt, he received a \$5.88 million grant from the Department of Energy to develop the

Waste to Wisdom program, which gained much attention from the forest products industry.

Dr. Han collaborates with NAU forest scientists, private industry and land management agencies to improve the efficiency and economics of harvest operations and the utilization of wood for a wide range of forest products. He focuses on lessening the environmental impacts that potentially occur from thinning treatments aiming to reduce fire danger and improve forest health.

project funded by a \$1.3 million grant from the National Science Foundation exploring how

### The world is our lab

NAU researchers don't confine their studies to the labs. In addition to performing research in Northern Arizona, they conduct field projects all over the world, including the Arctic tundra, the caves of Easter Island, the waters off southern Argentina, a rainforest in Ghana and the Anindilyakwa communities on Groote Island, Australia. Many faculty researchers offer opportunities for their students to participate in these projects, too.

administrative partitioning of undeveloped lands affects feedbacks within and between social and ecological systems.

### Merriam-Powell Center for Environmental Research crosses disciplines to understand environmental processes

Faculty researchers in NAU's Merriam-Powell Center for Environmental Research (MPCER) cross disciplines to understand critical environmental

### Landscape Conservation Initiative forges new solutions to environmental challenges

Faculty researchers in NAU's Landscape Conservation Initiative (LCI) forge new solutions to environmental challenges through applied biological science, collaborative planning and field-based educational experiences.

Clare Aslan, Assistant Professor of Earth Sciences and Environmental Sustainability, is Associate Director of LCI. Dr. Aslan is a community ecologist and conservation biologist who is passionate about solutions-oriented research in the ecology and conservation of species interactions. She is principal investigator on a

processes and the implications of change resulting from human activities.

Catherine (Kitty) Gehring, Professor of Biology and the inaugural John and Pit Lucking Family Professor, is co-executive director of MPCER. Dr. Gehring explores the effects of climate change and invasive species on the mycobiome. She has been principal investigator or co-principal investigator on multiple projects funded by the National Science Foundation and the Department of Defense, including a \$700,000 grant to study the changing climate as an agent of selection for pinyon pine.

# *Nationally recognized, locally vital*

**#96** ranking in US by National Science Foundation among  
research universities without a medical school

**Top 10%** for number of times NAU faculty are cited in  
scholarly publications, worldwide

**Nearly 60%** increase in research and public service expenditures  
in the past decade, totaling **\$88.2M** in FY19

**50** invention disclosures

**Nearly 3K** undergraduate students participate  
in hands-on research projects each year

**Research, Elevated.**

[nau.edu/Research](http://nau.edu/Research)

# Illuminating the Dark Sky

## Astronomy and Planetary Science

NAU astronomers and planetary scientists are expanding the frontiers of knowledge as they search for new planets, study the surface of Mars, and investigate near-Earth objects.



Professor **David Trilling** studies near-Earth asteroids and other small bodies in our solar system.



Assistant Professor **Chad Trujillo** is co-discoverer of some of the farthest observed objects in our solar system, and is searching for Planet X.



Assistant Professor **Cristina Thomas** observes asteroids and other near-Earth objects.



Assistant Professor **Christopher Edwards** studies the composition, physical properties, and processes and morphology of planetary surfaces.

**NORTHERN ARIZONA UNIVERSITY**

# Harnessing Emerging Technologies

## Informatics, Computing, and Cyber Systems

NAU experts, some of the nation's top thought leaders, are addressing a broad range of emerging challenges in science, engineering, and other disciplines that involve extremely large datasets, critical cybersecurity issues, and high-performance networked computation.

Assistant Professor **Fatemeh Afghah** studies wireless communications, game theoretical optimization, and biomedical signal processing.

**Research, Elevated.**

[nau.edu/Research](http://nau.edu/Research)



Professor **Scott Goetz** studies environmental informatics, carbon cycle science, climate change, and terrestrial ecology.



Professor **Kiona Ogle** conducts research integrating mathematics, statistics, computing, and ecology.



Professor of Practice **Bertrand Cambou** studies cybersecurity and how to apply microelectronics to strengthen hardware security.



**Joseph Espinoza** studies the health effects of environmental toxins.



**Mia Ornelas** works to protect substance-exposed newborns and their mothers.



**Jordan Ojeda** studies health promotion to help prevent cancer in Native American communities.



**Taylor Lambrigger** uses isotopic analysis to identify human remains in forensic cases.

# *Changing the World*

## *—What's NEXT for You?*

**The Next Generation of Innovators, Collaborators, and Change Makers**

**NAU** NORTHERN ARIZONA  
UNIVERSITY

Watch as our undergraduate  
researchers overachieve—  
one breakthrough at a time.

[nau.edu/Next](https://nau.edu/Next)

# Understanding and Treating Disease

Pathogens, the Human Microbiome, and Tissue Regeneration

NAU disease ecologists, microbiologists, evolutionary biologists, and biomedical engineers work to understand pathogens to prevent outbreaks and develop novel treatments to improve quality of life.



Assistant Professor **Emily Cope** develops novel therapeutics to treat asthma.



Professor **David Wagner** studies the most infectious pathogenic bacteria to prevent potential bioterrorism threats.

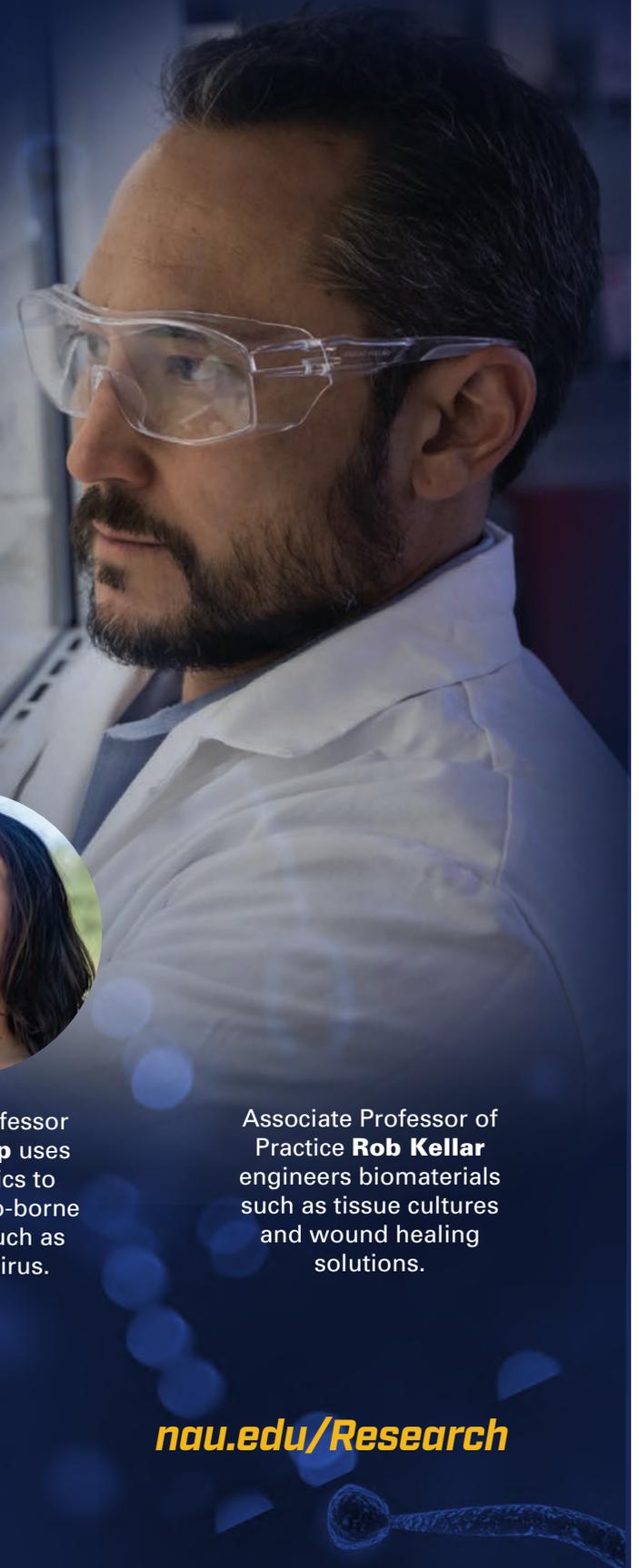


Assistant Professor **Crystal Hepp** uses bioinformatics to fight mosquito-borne pathogens such as West Nile Virus.

Associate Professor of Practice **Rob Kellar** engineers biomaterials such as tissue cultures and wound healing solutions.

**Research, Elevated.**

[nau.edu/Research](http://nau.edu/Research)



# Healing through Collaboration

## Community Health and Health Equity

NAU health science and public policy experts address health disparities among the underserved populations of the region to improve health outcomes and achieve equity for all.

Associate Professor  
**Priscilla Sanderson**  
works with Native American communities to promote health and resilience.

**Research, Elevated.**

[nau.edu/Research](http://nau.edu/Research)



Regents' Professor **Julie Baldwin** works to address health disparities among the underserved populations of the Southwest by building biomedical, clinical, and behavioral health research capacity at NAU.



Professor **Jani Ingram** investigates the health impact of environmental contaminants uranium and arsenic on the Navajo Nation.



Professor **Nicky Teufel-Shone** builds community capacity to address health promotion in Native American communities.



# *Finding Opportunity —What's NEXT For You?*

## **Research Opportunities for Every Undergraduate in Every Discipline**

Whatever your major, at NAU you'll find a world of ideas that lead you to a lifetime of discovery. You can engage in scholarly inquiry and apply research skills for greater learning in every subject—the arts, astronomy, business, earth sciences, education, engineering, forestry, health sciences, history, informatics, literature, mathematics, psychology, and more.

▲ Through NAU's Grand Canyon Semester, students join world-class faculty to explore the deep canyon country of the Colorado Plateau and engage in interdisciplinary research.

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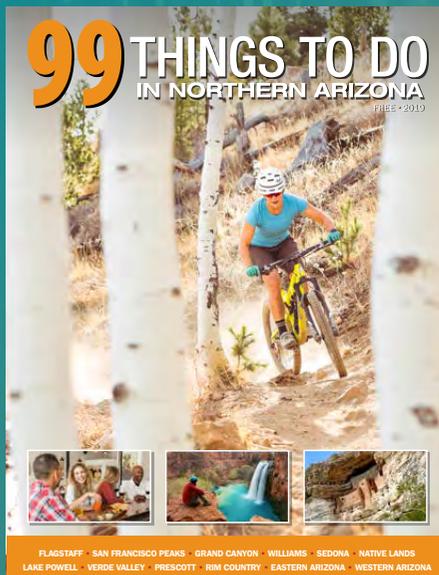
# Arizona Daily Sun provides many special edition publications throughout the year to provide vital and exciting stories from various aspects of the community.



**Progress:** An annual report on the economic growth and vibrancy in the community. We look at various sectors, from commerce to education to tourism and construction. Appears in April.



**Best of Flag:** Our long-standing Best of Flag contest now has a magazine component with in-depth stories and various features on the winning contests. Appears in November.



**99 Things to Do:** A comprehensive guide to all the great attractions, trails, locales and activities Northern Arizona has to offer. It makes one the most encompassing collections of the things to do in our region.



**Science & Research:** A annual publication that shares the best and brightest stories and ideas coming out of the science and technology sectors of northern Arizona.

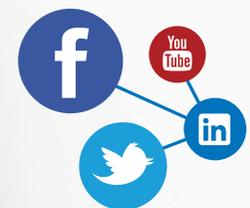


## Fighting Disease from A to Z

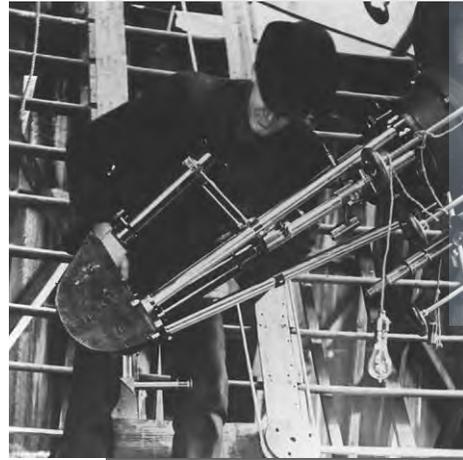
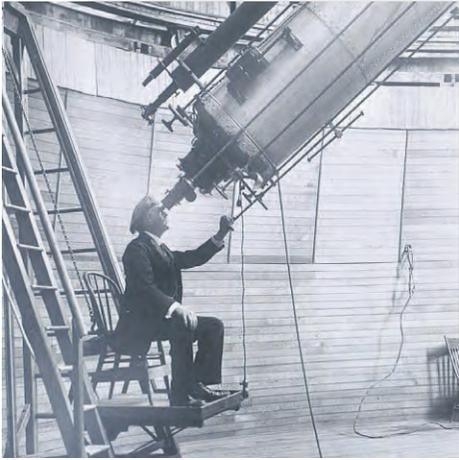
When it comes to fighting off bacterium, viruses, fungi, or infectious pathogens, the scientists at TGen North stand shoulder-to-shoulder with the CDC, World Health Organization and others to apply cutting edge tools to detect and investigate disease outbreaks that threaten public health.

Dr. Jolene Bowers, Assistant Director of the Public Health and Clinical Translation Center at TGen North, guides development of next-generation of molecular tools for clinical diagnosis, detection and monitoring of everything from Anthrax to Zika.

To learn more about the work of Flagstaff's hometown scientists, visit [tgennorth.org](http://tgennorth.org)



Dr. Jolene Bowers  
Research Assistant Professor  
TGen Pathogen and Microbiome Division  
TGen North, Flagstaff



## Imaginative Lowell Observatory researchers have been pushing the envelope of astronomy since 1894.

These trailblazers have taken advantage of the most advanced instruments of their time, from the Clark Telescope of yesteryear to Lowell Observatory's Discovery Channel Telescope (DCT), the fifth largest in the continental US. This fusion of science and technology is allowing our scientists to play a critical role in unraveling the mysteries of the Universe for decades to come. It all started with Percival Lowell, who in 1896 acquired one of the finest refracting telescopes ever built to facilitate his search for life on Mars. This effort stimulated further research programs that led to V.M. Slipher's pioneering collection of data that led to the discovery of the expanding Universe in 1912 and Clyde Tombaugh's discovery in 1930 of Pluto, a world near and dear to the heart of Flagstaff. One hundred and twenty-five years later, Lowell Observatory continues to push the limits of planetary and astronomical research.

Jeffrey Hall  
Director, Lowell Observatory



LOWELL  
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125 YEARS | 1894 - 2019

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