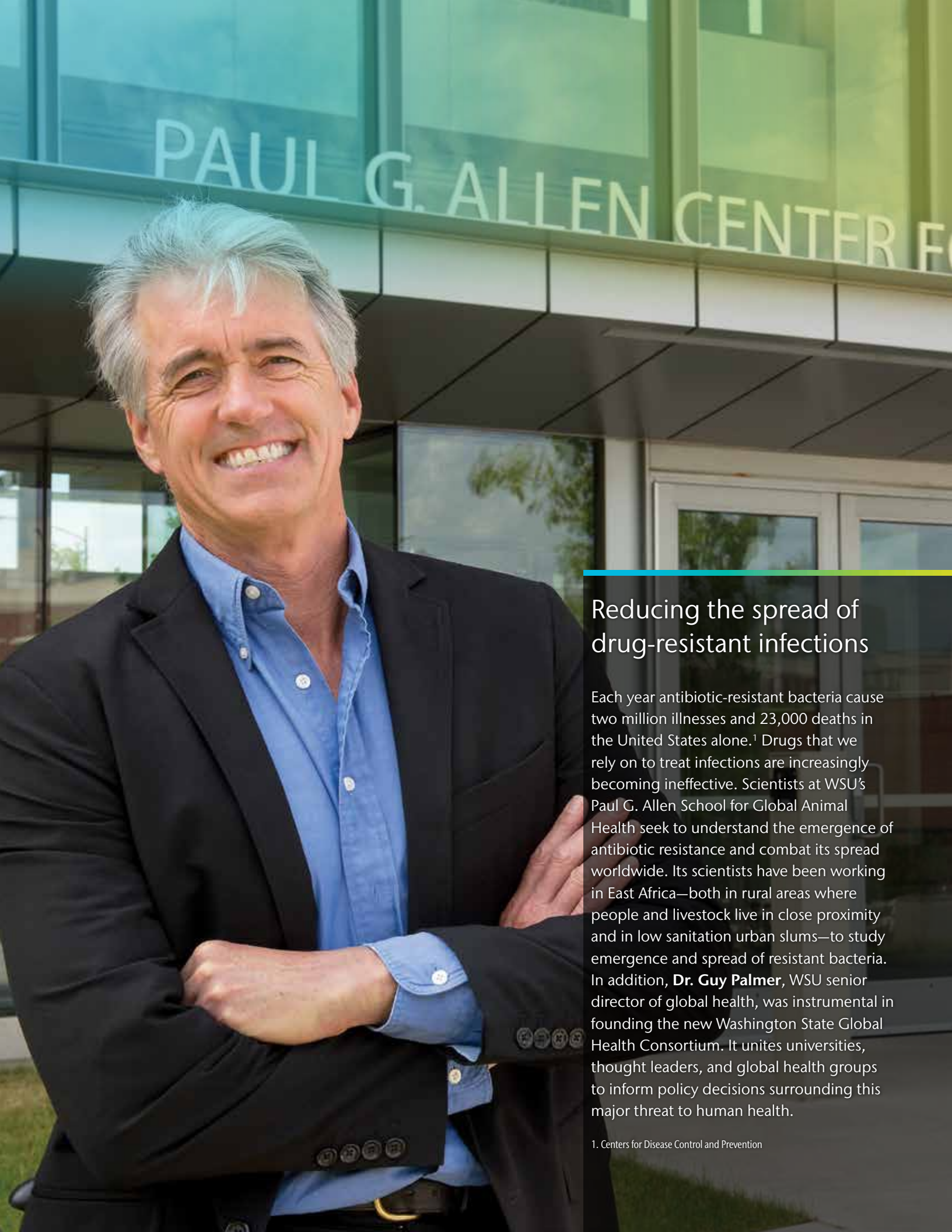




To meet the unique challenges
of the 21st century, we need
research that targets key priorities.

Washington State University

Research update | 2015 expenditures and awards



PAUL G. ALLEN CENTER FOR

Reducing the spread of drug-resistant infections

Each year antibiotic-resistant bacteria cause two million illnesses and 23,000 deaths in the United States alone.¹ Drugs that we rely on to treat infections are increasingly becoming ineffective. Scientists at WSU's Paul G. Allen School for Global Animal Health seek to understand the emergence of antibiotic resistance and combat its spread worldwide. Its scientists have been working in East Africa—both in rural areas where people and livestock live in close proximity and in low sanitation urban slums—to study emergence and spread of resistant bacteria. In addition, **Dr. Guy Palmer**, WSU senior director of global health, was instrumental in founding the new Washington State Global Health Consortium. It unites universities, thought leaders, and global health groups to inform policy decisions surrounding this major threat to human health.

1. Centers for Disease Control and Prevention

Washington State University is expanding research to strengthen our future.

With robust support from government, industry, partners, and alumni, WSU applies more than \$300 million in annual research and development expenditures to build a healthier, more secure world.

WSU research solves pressing problems for communities across Washington and around the globe.

Tapping experts in diverse fields

Each of WSU's 11 colleges brings a unique set of resources to the front lines of research challenges.

Bringing top minds together

Scholars in scores of research centers and institutes unite across disciplines to solve tough problems.

Reaching across the state

WSU has four campuses statewide, four strategically located research and extension centers, Extension offices in all 39 counties, and a Global Campus that engages students worldwide. The benefits of WSU research touch every corner of the state.



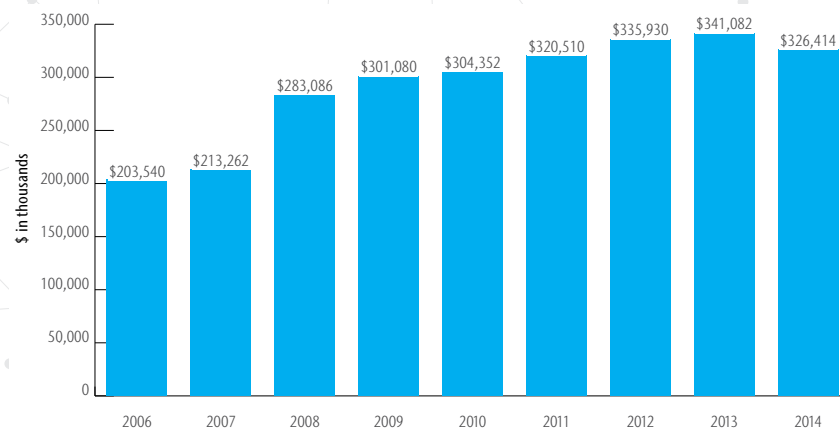
A mission to address today's most critical concerns

The University's commitment to public service grows from its land-grant mission, which makes service to society a top priority.

Research investment and support are growing.

Research and development expenditures have risen significantly in the last decade.

Total expenditures by fiscal year (\$ in thousands)



Awards remain high.

Total value of research, education, and outreach awards by fiscal year

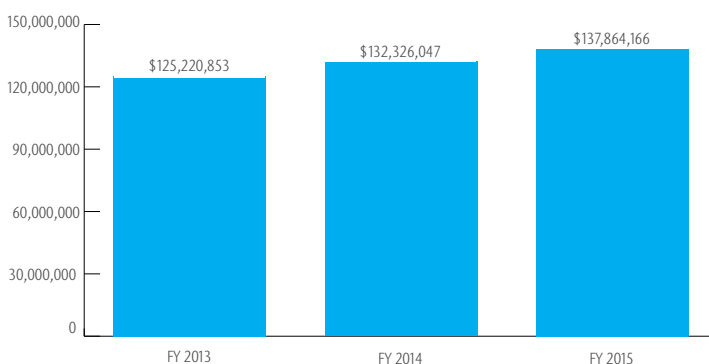
FY 2013 \$182,290,915

FY 2014 \$211,250,966

FY 2015 \$197,542,562

Federal support is on the rise.

Total federal awards



Expenditures from top federal funding agencies
FY 2015

Department of Agriculture	\$34,279,038
Department of Health and Human Services	\$24,941,170
Department of Energy	\$20,248,136
National Science Foundation	\$17,564,842
Department of Education	\$10,226,636
Department of Defense	\$9,237,637
Small Business Administration	\$2,146,246
U.S. Agency for International Development	\$2,026,806
Department of Transportation	\$1,615,961
Department of Commerce	\$1,470,699
Department of the Interior	\$1,233,899
Department of Justice	\$633,242
Other federal agencies	\$1,872,689

Broad support from non-federal sources continues.

FY 2015 expenditures, by source of support

Washington state government agencies	\$27,136,764
Washington commissions	\$10,750,063
Private foundations and institutes and other nonprofit	\$9,501,709
Local governments	\$6,354,247
Business concerns and corporations for profit	\$6,291,818
Foreign sponsors	\$1,365,342
Schools, colleges, and universities	\$1,172,776
Other non-federal programs	\$3,674,797
Total non-federal support	\$66,247,516



Helping to save salmon in the Pacific Northwest

When stormwater drains from roadways, parking lots, and rooftops, it carries a torrent of pollutants into local rivers and streams. The runoff is toxic enough to kill adult coho salmon in just a few hours. **Dr. Jenifer McIntyre** seeks to mitigate the runoff's lethal effects. The assistant professor in WSU's School of the Environment has developed a green infrastructure that mimics natural filtration provided by soil and vegetation. In a recent study, none of the salmon exposed to biofiltered stormwater fell ill or died. Dr. McIntyre's discoveries help guide ongoing improvements in the state's water management systems.

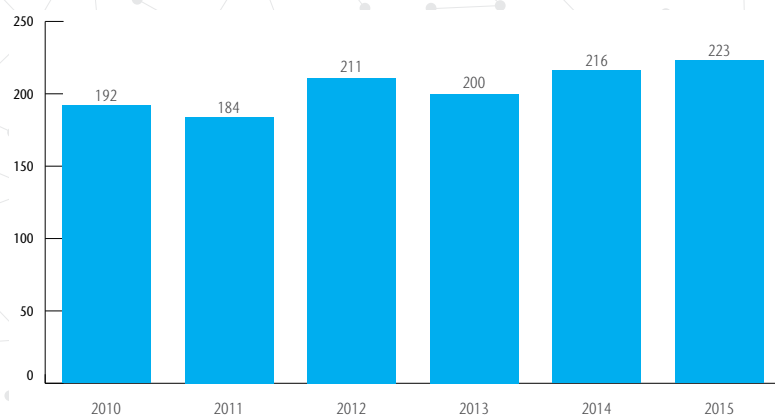
Sponsors: U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, The Boeing Company, The Bullitt Foundation, The Russell Family Foundation, NOAA Coastal Storms Program

Researchers bridge disciplines and forge alliances.

Investigations span disciplines to find answers.

Number of multidisciplinary awards funded

In FY 2015, 223 grants for multidisciplinary projects were awarded \$49.3 million.



Collaboration across institutions accelerates discovery.

Multi-institutional grants, 2014

Number of collaborating institutions: 662

Amount: \$70.7 million

Leading a nationwide effort to transform America's aviation industry

In 2012 the Federal Aviation Administration (FAA) launched the Next Generation Air Transportation System, or NextGen. This broad-based initiative aims to transform America's aviation infrastructure to optimize safety, increase capacity, and meet environmental needs. To support NextGen environmental goals, the FAA in 2013 selected WSU to lead the Center of Excellence for Alternative Jet Fuels and the Environment. It named Massachusetts Institute of Technology the co-leader.

Today the Center works to make aviation cleaner and more efficient. Drawing on scholars from 16 universities, the Center seeks ways to reduce community noise and air quality emissions impacts, limit the impact of aviation greenhouse gas emissions on global climate, improve energy efficiency, and develop and certify alternative jet fuels.

Sponsor: Federal Aviation Administration

Collaborations with commodity commissions support food and agricultural production statewide.

Leading Washington commodity commission research projects in FY 2015

Commission sponsor	Research project
Washington Dairy Products Commission	Induction of Protective Secretory Immunoglobulin A in Claves Principal investigator: Lawrence Fox, \$23,152
Washington Grain Commission	Molecular Technology for Winter Wheat Improvement Principal investigator: Arron Carter, \$131,712
Washington Hop Commission	Cost estimation of hop production in the Pacific Northwest Principal investigator: Suzette Galinato, \$11,965
Washington Potato Commission	Identification and Characterization of Elicitors to Maximize Defense System Against Powdery Scab Principal investigator: Kiwamu Tanaka, \$40,503
Washington Red Raspberry Commission	Combining Miticides and SWD Controls into a Season Long Effective Program Principal investigator: Lynell Tanigoshi, \$11,657
Washington Tree Fruit Research Commission	Maintenance of WSU-IAREC Cherry Breeding Principal investigator: Gary Grove, \$90,952
Washington Wine Commission	FY15 Washington Wine Advisory Commission Research Funding Principal investigator: Doug Walsh, \$23,752



Serving the wine industry with expertise

The way your palette perceives a certain wine may be influenced by how much you like the food that accompanies it. WSU Tri-Cities hospitality and wine business management professor **Robert Harrington** seeks to understand complex relationships among wine-food pairings. His research fuels prosperity in the region's vibrant wine industry. Dr. Harrington teaches and collaborates with faculty at the new Ste. Michelle Wine Estates WSU Wine Science Center in Richland. He stands among the most productive and frequently cited researchers in his field.¹

1. Journal of Teaching in Travel and Tourism, 2016



Startup venture's innovation could reverse Alzheimer's and Parkinson's diseases

M3 Biotechnology has an ambitious mission: to cure neurodegenerative diseases. The WSU spinoff company, created by professors **Joe Harding** (physiology and neuroscience), **Jay Wright** (psychology), and former graduate student **Leen Kawas** (physiology and neuroscience), has made great strides toward achieving

its goal. M3 Biotechnology has developed MM-201, an oral drug that activates a growth factor in the brain that repairs nerve cells. The drug is now approaching clinical trials. Researchers hope it will slow progression of—and perhaps reverse—the cognitive and movement deficits seen in Alzheimer's and Parkinson's diseases.

Strong industry partnerships boost economic development.

Industry sponsors help drive innovation.

Industry agreements over 100K finalized in FY 2015: 11

Estimated total value: \$4,049,777

Leading private sector research projects in FY 2015

Industry sponsor

CPB

Southern California Edison

United Airlines

Research project

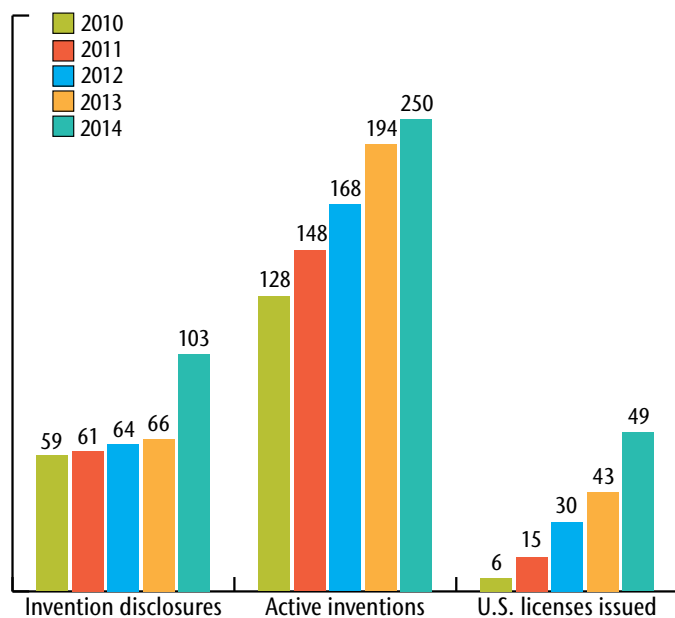
FY15 Television Community Service Grant Agreement
Principal investigator: Marvin Marcelo, \$789,353

Voltage and VAR Control of SCE Transmission System
Principal investigator: Vaithianath Venkatasubramanian, \$425,191

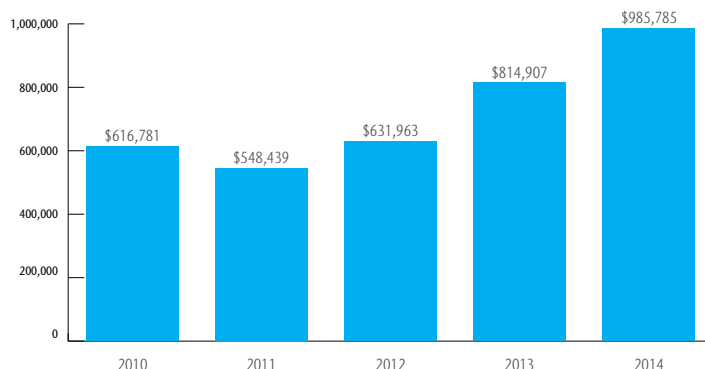
Fatigue Risk Management System Flight Studies
Principal investigator: Gregory Belenky, \$818,968

Inventions of WSU researchers invigorate the marketplace.

Commercialization indicators



Royalty revenue



Patent applications

Year	2010	2011	2012	2013	2014
Patent applications	70	60	85	83	69

Number of startups

Year	2010	2011	2012	2013	2014
Number of startups	2	3	6	4	5

Resources accelerate research throughout the University.

Core research labs and facilities serve WSU's research community.

Instrumentation core facilities

Biomolecular X-Ray Crystallography Center (BXC)

Provides biophysical and biochemical data for a wide range of research projects and serves as a center of teaching and outreach.

Center for Nuclear Magnetic Resonance (NMR) Spectroscopy

Allows researchers to determine the spectrum (or fingerprint) that reveals the identity and structure of molecules. Equipment can be used to study both solids and liquids.

Franceschi Microscopy and Imaging Center (FMIC)

Enables the observation, imaging, and ultrastructural study of biological and nonbiological specimens using light and electron microscopy.

Molecular Biology and Genomics Core

Provides two sequencing platforms (Ion Torrent and 454 Life Sciences), services, and instrumentation to support investigations in molecular biology, genomics, and proteomics.

Washington Animal Disease Diagnostic Lab (WADDL)

Part of a network of tax-supported state diagnostic reference facilities throughout the U.S. dedicated to protecting the public from animal-borne diseases. Offers consultation to veterinarians, animal industry groups, regulatory officials, and physicians.

Stable Isotope Core Facility

Allows researchers to measure naturally occurring, stable isotopes of important elements in plant, soil, water, and atmospheric samples.

Tissue Imaging and Proteomics Laboratory

Uses mass spectrometry imaging techniques to explore metabolic processes in all types of organisms, from animals to plants to microbes, down to the subcellular level, using high-spatial resolution.

Flow Cytometry Laboratory

Supports biotechnology research and the diagnosis of health disorders by analyzing and sorting cells using eight different parameters.

Monoclonal Antibody Center

Provides technology to study the immune system and how microorganisms can cause disease. Pivotal in research related to vaccine development, disease resistance, food, and companion animals.

WSU Spokane Instrumentation Core Facilities

Instrumentation core facilities located on the WSU Spokane campus include mass spectrometry, nuclear magnetic resonance imaging, genomics, flow cytometry, and microscopy.

Non-instrumentation core facilities

Social and Economic Sciences Research Center (SESRC)

Conducts social science surveys and evaluations that shed new light on people's opinions, needs, behaviors, attitudes, and preferences.

Consortium for Interdisciplinary Statistical Education and Research (CISER)

Coordinates consultation and assistance in statistical analysis and provides statistical support for research grants and training grants.



High-performance computing technology supports researchers' simulation and data science needs.

WSU is making significant strategic investments to extend its research computing capabilities. With support from recently awarded grants, WSU is investing in a high-performance computing (HPC) infrastructure to accelerate scientific and data-intensive research. The new, centralized Kamiak HPC cluster lowers barriers to collaboration by providing a space in which researchers from across the university can store data, share code, and build communal software. Initial applications propel investigations that align with WSU's top research priorities. Find out more at hpc.wsu.edu.

Libraries enable discovery across many disciplines.

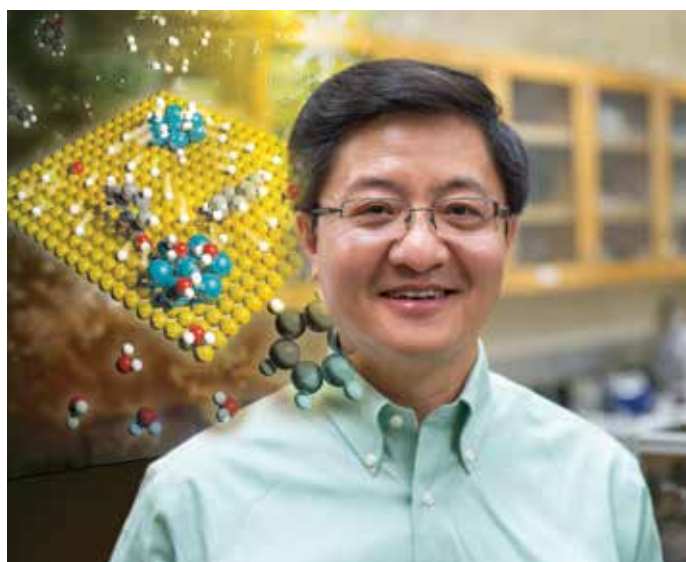
The WSU library system, one of the largest in the Pacific Northwest, supports research at locations throughout the state:


- Pullman (3 libraries)
- Spokane
- Tri-Cities
- Vancouver

Pacific Northwest National Laboratory: A partnership for catalyzing change

A breakthrough by WSU scientists may help the chemical industry transition from fossil fuels to environmentally friendly alternatives. The industry has long used a crude-oil-based chemical known as isobutene to make plastic bottles, rubber tires, and a vast array of other products. WSU chemical engineering expert **Yong Wang** has discovered a way to create isobutene without a drop of crude oil. In collaboration with the Archer Daniels Midland (ADM) Company, he and his colleagues developed a catalyst that converts biomass-based ethanol into the industrial chemical in one efficient step.

Dr. Wang is among a growing number of WSU faculty members who hold joint appointments with the U.S. Department of Energy's Pacific Northwest National Laboratory (PNNL) in Richland. These scientists fuse fundamental and applied research to address critical challenges in energy, the environment, and national security.





Among the world's most significant and valued researchers

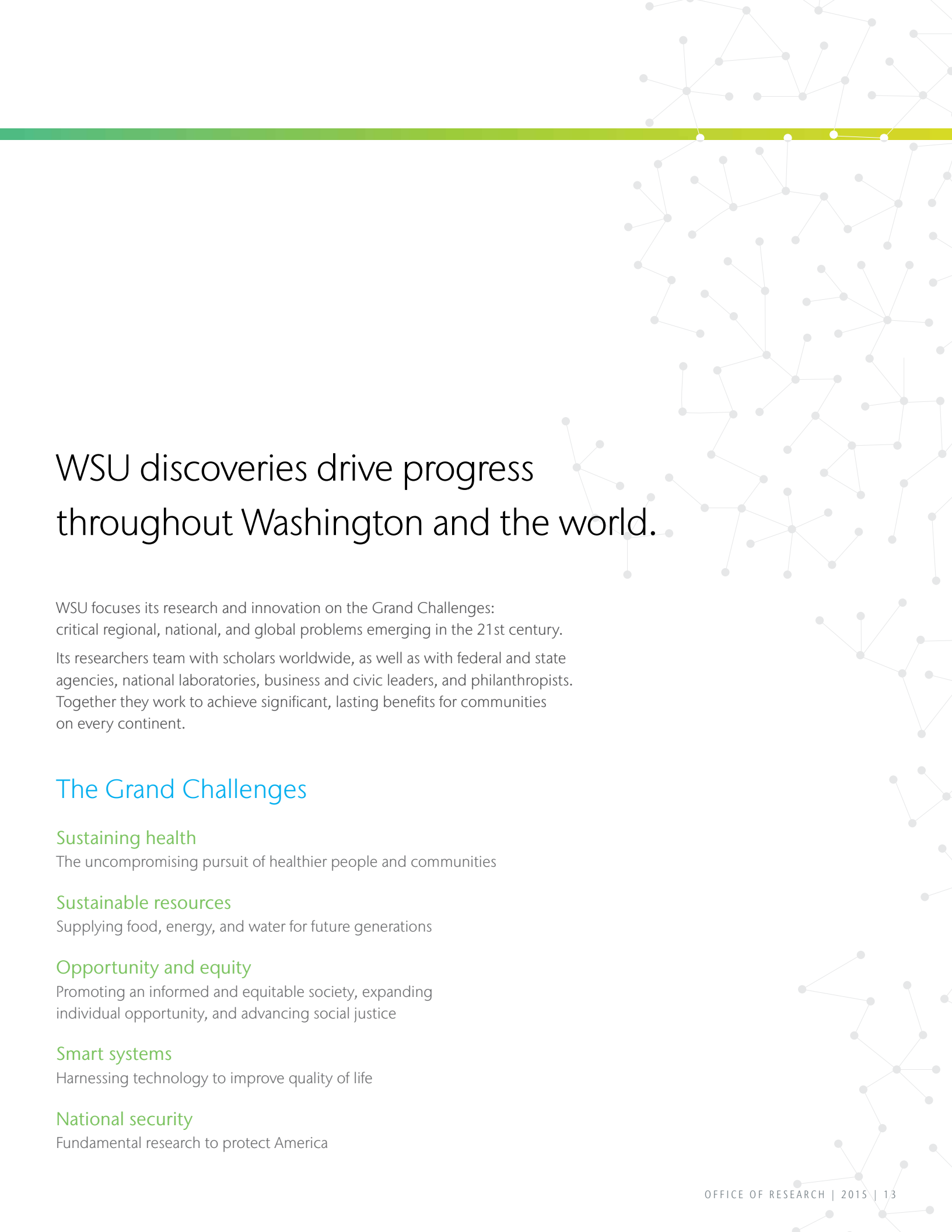
With 380 publications, many cited hundreds of times, **Dr. Yuehe Lin** stands among the world's most influential scientific minds, according to mass media giant Thomson Reuters (2015).

A professor in WSU's School of Mechanical and Materials Engineering who also holds an appointment with Pacific Northwest National Laboratory, Dr. Lin is working to develop new materials and systems for biomedical, energy, and environmental applications. Among his recent innovations is a handheld biosensor that can detect the presence of harmful *Escherichia coli* (*E. coli*) 0157:H7 bacteria in food.

Dr. Lin's work ranks among the top 1 percent most cited in his field in the past decade.

A measure known as the "h-index" reflects the number of highly important papers that a scientist has published. The more frequently a scholar's papers are cited in scientific literature, the higher his or her h-index. While h-index levels vary by discipline, an outstanding scientist at a top university or major research lab may typically have an h-index of about 40.

With total citations of approximately 32,000, Dr. Lin has an h-index of 93.



WSU discoveries drive progress throughout Washington and the world.

WSU focuses its research and innovation on the Grand Challenges:
critical regional, national, and global problems emerging in the 21st century.

Its researchers team with scholars worldwide, as well as with federal and state
agencies, national laboratories, business and civic leaders, and philanthropists.
Together they work to achieve significant, lasting benefits for communities
on every continent.

The Grand Challenges

Sustaining health

The uncompromising pursuit of healthier people and communities

Sustainable resources

Supplying food, energy, and water for future generations

Opportunity and equity

Promoting an informed and equitable society, expanding
individual opportunity, and advancing social justice

Smart systems

Harnessing technology to improve quality of life

National security

Fundamental research to protect America



Relief from rheumatoid arthritis

An anti-inflammatory compound in a popular beverage could alleviate the joint pain, inflammation, and tissue damage caused by rheumatoid arthritis. Under the leadership of **Dr. Salah-Uddin Ahmed**, a Spokane-based research team found that a phytochemical called epigallocatechin 3-gallate (EGCG), present in high quantities in green tea, suppresses the effects of the disease without blocking other cellular functions. The study suggests that EGCG could be developed as an effective alternative or adjunct therapy to existing drugs, which are expensive, immunosuppressive, and sometimes unsuitable for long-term use.

Sponsors:

National Institute for Arthritis and Musculoskeletal
Skin Diseases (part of the National Institutes of Health)

The Arthritis Foundation

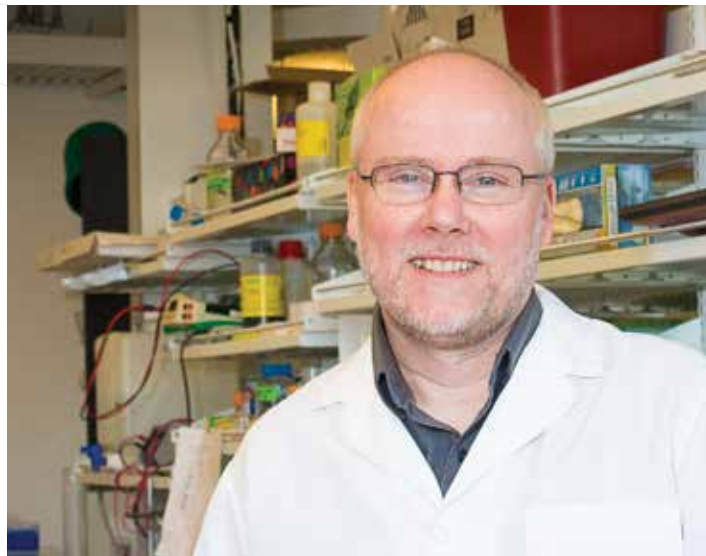
Sustaining health

The uncompromising pursuit of healthier people and communities

Genetic tests to boost cancer survival

A College of Pharmacy research team identified 16 genes that are biomarkers for predicting prostate cancer survival and breast cancer recurrence. The Spokane-based team, led by **Dr. Grant Trobridge**, licensed the knowledge to a genetic testing company. Tests for prostate cancer survival and breast cancer recurrence will enable physicians to tailor treatment based on each patient's expression of the genes.

Sponsor: National Cancer Institute

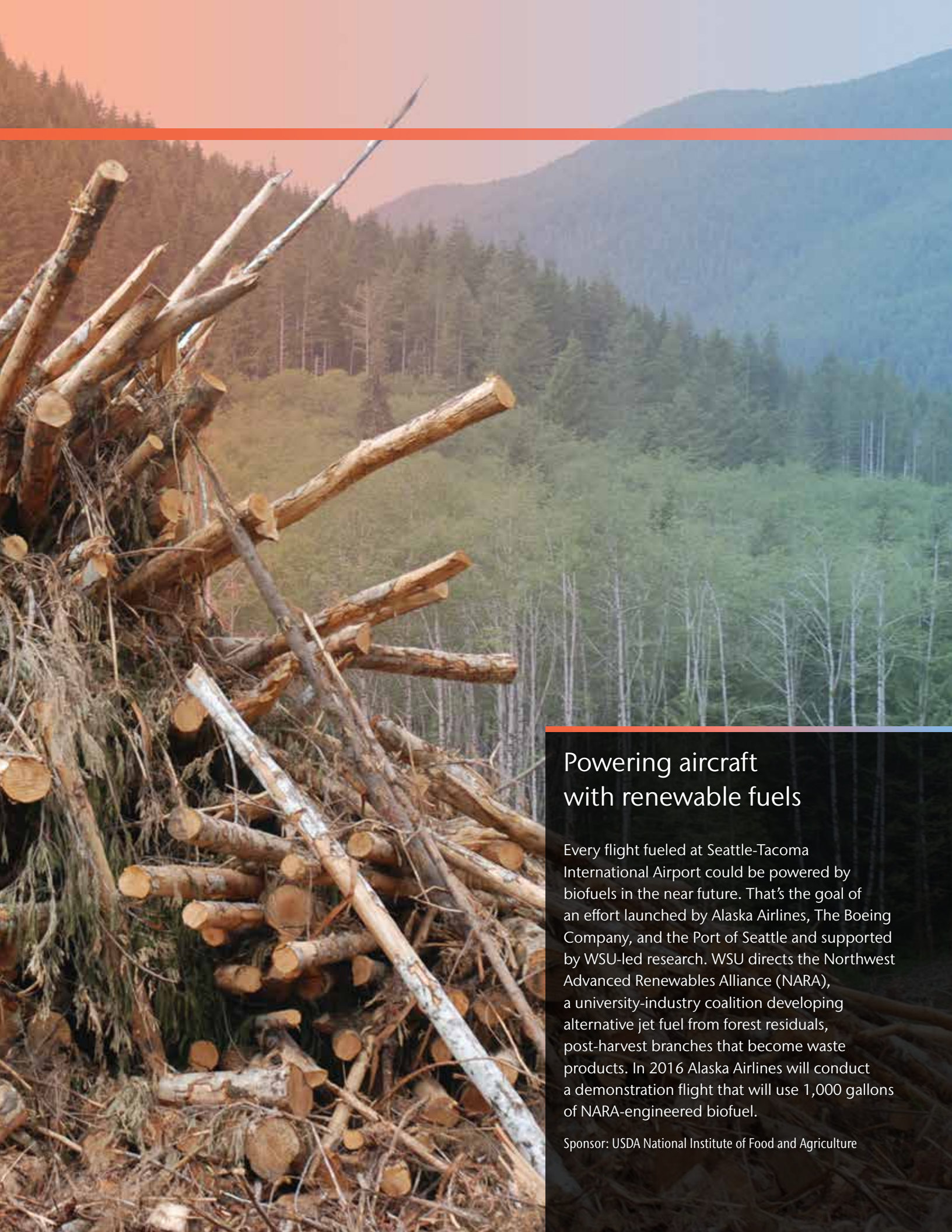


Documenting safety of drugs taken with natural remedies

Little is known about the safety of natural dietary supplements and herbal remedies when combined with prescription or over-the-counter medications. To study possible interactions, WSU professors in the fields of pharmacy and communication have teamed with colleagues at the University of Washington and the University of North Carolina at Greensboro to form a Center of Excellence for Natural Product Drug Interaction Research. The Center aims to provide leadership on how best to study these complex interactions. Among its plans: Developing a public database that will help pharmacists counsel patients about natural products' safety.

Sponsor: National Institutes of Health





Powering aircraft with renewable fuels

Every flight fueled at Seattle-Tacoma International Airport could be powered by biofuels in the near future. That's the goal of an effort launched by Alaska Airlines, The Boeing Company, and the Port of Seattle and supported by WSU-led research. WSU directs the Northwest Advanced Renewables Alliance (NARA), a university-industry coalition developing alternative jet fuel from forest residuals, post-harvest branches that become waste products. In 2016 Alaska Airlines will conduct a demonstration flight that will use 1,000 gallons of NARA-engineered biofuel.

Sponsor: USDA National Institute of Food and Agriculture

Sustainable resources

Supplying food, energy,
and water for future generations

Raising the bar for packaged food quality

Packaged entrees like TV dinners and military rations have traditionally been chock full of extra salt and additives, but short on flavor, texture, and nutritional value. **Dr. Juming Tang** has developed new food preservation methods that make packaged food naturally tasty and highly nutritious—while keeping bacteria and viruses in check. A \$4 million grant from the U.S. Department of Agriculture's National Institute of Food and Agriculture (NIFA) established a new Center of Excellence at WSU that focuses on food safety processing technologies. The Center will accelerate transfer of Dr. Tang's revolutionary Microwave Assisted Thermal Sterilization and Pasteurization technologies to the marketplace. Meanwhile, the Australian government has invested \$7.2 million to support adoption of the technologies in the South Pacific region.

Sponsor: USDA National Institute of Food and Agriculture



Improving water quality while repurposing waste

Permeable pavement traps pollutants by filtering stormwater that seeps through its surface. Its widespread use could dramatically reduce the toxic impact of stormwater runoff. But today's porous paving materials break down too easily to be suitable for heavily trafficked highways. WSU scientists at the Washington Stormwater Center are exploring a solution using repurposed carbon fiber discarded from The Boeing Company's manufacturing operations. Integrated into porous concrete and asphalt, the fiber improves pavement durability. It's a breakthrough that could improve water quality while keeping waste out of the landfill.

Sponsor: The Boeing Company





Identifying best practices in teaching STEM disciplines

Education in the STEM subjects—science, technology, engineering and mathematics—serves as a steppingstone to social and economic opportunity. How can teachers inspire interest in these disciplines and make lessons stick? More than 140 WSU researchers collaboratively investigate STEM education. These scholars examine instruction and monitor student learning outcomes. They strengthen understanding of best practices in teaching while developing cutting-edge curricula in STEM subjects.

Sponsors:

National Science Foundation

U.S. Department of Education

U.S. Department of Education,
Office of Elementary and Secondary Education

U.S. Department of Justice

U.S. Department of Commerce,
Economic Development Administration

Opportunity and equity

Promoting an informed and equitable society, expanding individual opportunity, and advancing social justice

Measuring the impact of the Affordable Care Act on adults with disabilities

The federal Affordable Care Act could profoundly affect the lives of the estimated 18 million Americans with work disabilities, many of whom struggle with unique and intensive health care needs. Professor **Jae Kennedy** is leading a multi-institution study of the law's effects. The investigation tracks recent changes in health insurance coverage, health care access, use and cost for working-age adults with disabilities.

Sponsor: US Department of Health and Human Services, National Institute on Disability, Independent Living and Rehabilitation Research

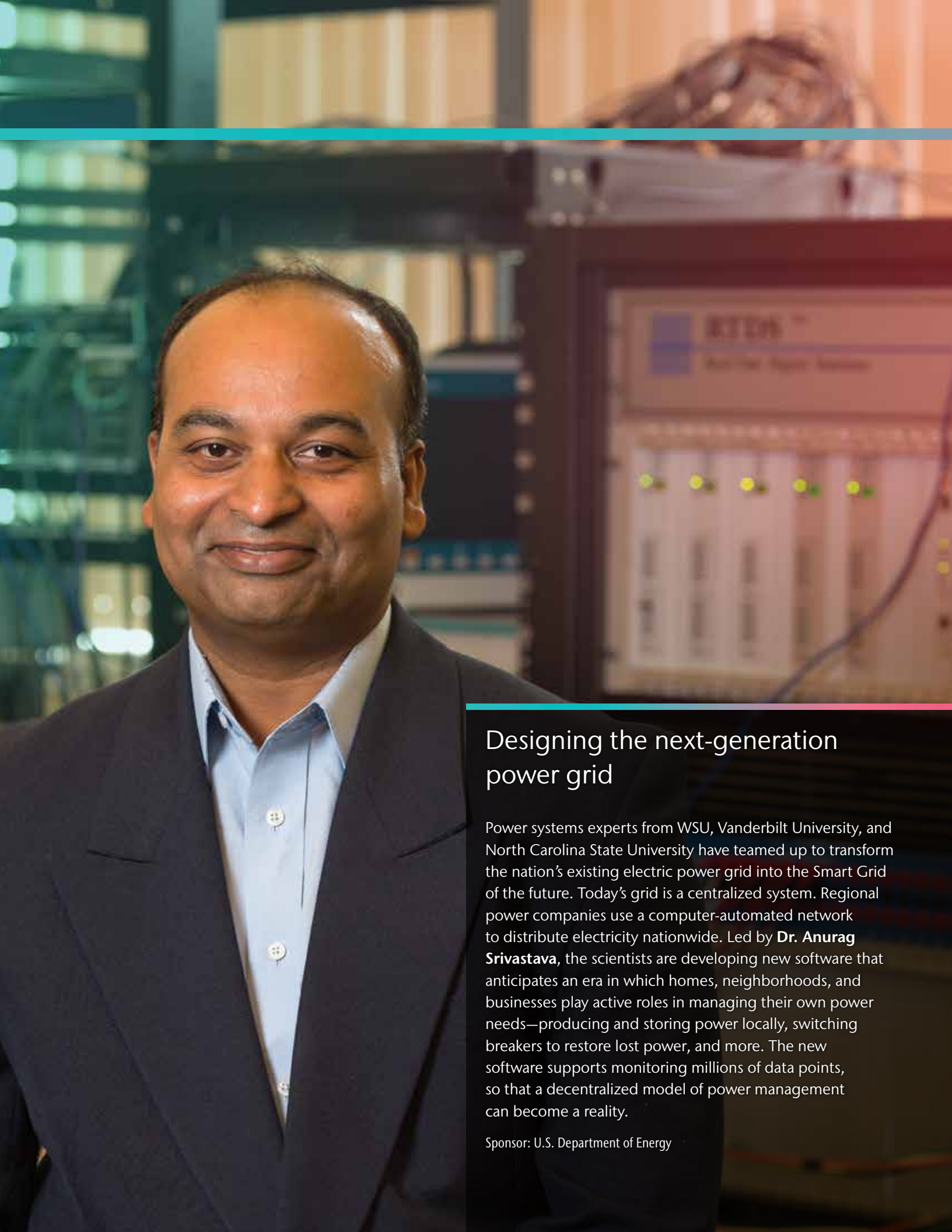


Helping police handle tense encounters

Policing experts **Lois and Stephen James** aim to help officers achieve the best possible outcomes when reacting to people in crisis—and reduce the use of force. The duo investigates ways to improve training for Crisis Intervention Team (CIT), a method for de-escalating confrontations. Police often use CIT to manage situations with mentally ill individuals. The researchers surveyed hundreds of law enforcement and mental health professionals nationwide. With their findings, they developed metrics for assessing police performance at specific intervals in CIT encounters. Their metrics became the building blocks of new CIT learning objectives for the City of Spokane Police Department.

Sponsor: City of Spokane Police Department





Designing the next-generation power grid

Power systems experts from WSU, Vanderbilt University, and North Carolina State University have teamed up to transform the nation's existing electric power grid into the Smart Grid of the future. Today's grid is a centralized system. Regional power companies use a computer-automated network to distribute electricity nationwide. Led by **Dr. Anurag Srivastava**, the scientists are developing new software that anticipates an era in which homes, neighborhoods, and businesses play active roles in managing their own power needs—producing and storing power locally, switching breakers to restore lost power, and more. The new software supports monitoring millions of data points, so that a decentralized model of power management can become a reality.

Sponsor: U.S. Department of Energy

Smart systems Harnessing technology to improve quality of life

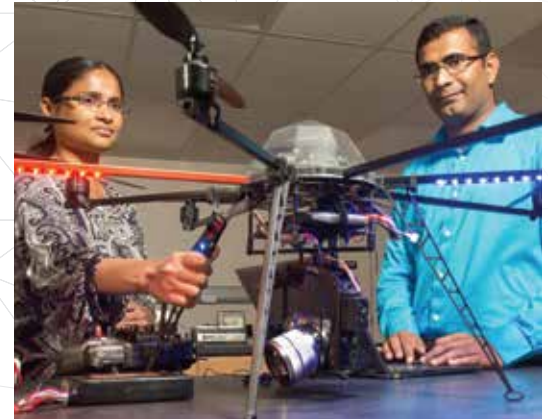
Employing unmanned aerial vehicles to make agriculture more sustainable

As the global population rises, farmers must produce more food with less water, fewer fertilizers and pesticides, and a dwindling workforce. WSU researchers see part of the solution in unmanned aerial vehicles (UAVs). Outfitted with sensors, UAVs could monitor crop health, assess water use and irrigation scheduling, and optimize nutrient applications. Agricultural automation experts **Lav Khot** and **Sindhuja Sankaran** are testing how UAVs perform these tasks and others, aiming to boost farm efficiency. The data they collect will also enable scientists to select new, high-yield crop varieties that tolerate stress and resist disease.

Sponsors:

U.S. Department of Agriculture, Agriculture and Food Research Initiative,
Food Security Challenge Area

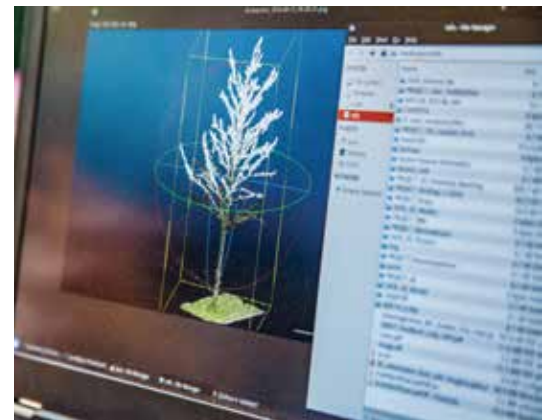
Washington Tree Fruit Research Commission



Growing cyberforests to predict the impacts of climate change

To determine how drought, warmer weather, wildfires, and other climate-related changes will affect North American forests, mathematicians **Nikolay Strigul** and **Jean Lienard** created a computer forest simulator. Their 3-D model is so realistic and detailed, it even represents the branches, leaves, and roots of individual trees. The simulator lets forest managers predict wildfires and other disturbances. If a forest is destroyed, the tool can help determine the species of trees and ecological factors necessary to reestablish it.

Sponsor: Simons Foundation



Newly patented technology adds the sense of touch to digital experiences

The day may soon come when online shoppers can feel a shirt or sweater with their fingertips before they buy. Haptic technology, which conveys a sense of touch, already exists for selected applications. Professor **Hakan Gurocak** at WSU Vancouver has patented two technologies that could help push haptic interfaces into the mainstream. The robotics and automation expert has found ways to make haptic devices smaller using a magnetic fluid.

Sponsor: National Science Foundation





Exploring matter at the extremes

The study of matter at extreme conditions of pressure and temperature is central to many fundamental and exciting scientific challenges in the physical sciences. It provides the foundational research for addressing significant national security objectives related to both military (conventional and nuclear security) and energy (fusion, mining, oil and gas production) needs.

Dr. Yogendra Gupta and his colleagues at the WSU Institute for Shock Physics investigate the fundamental response of materials under extreme conditions, related theory and computational modeling, and the development of advanced materials. Scientists collaborate with universities and national laboratories in the United States and abroad.

National security

Fundamental research to protect America

Working in Kenya to prevent diseases that originate in animals

The 2014 Ebola epidemic exposed gaps in West Africa's preparedness to respond to a severe disease outbreak. The Centers for Disease Control and Prevention has since launched the Global Health Security Agenda, which aims to improve nations' capacity to prevent, detect, and respond to zoonotic diseases—those that originate in animals. WSU's **Dr. M.K. Nienga**, along with co-investigators **Dr. Terry McElwain** and **Dr. Thumbi Mwangi** (pictured at right), will collaborate with officials in Kenya to establish surveillance for zoonotic diseases in animals. They will work to strengthen Kenya's animal disease workforce.

Sponsor: Centers for Disease Control and Prevention



Fostering agricultural productivity and global stability

Abundant food is vital to a stable and secure world. WSU's International Research and Agricultural Development program works to expand the capacity of farmers in the developing world, often in areas of conflict. It employs a community-based approach to support agricultural and community development in Asia, the Middle East, Africa, and South America.

Sponsors:

USAID

U.S. Department of Agriculture, Foreign Agricultural Service

Altria Group, Philip Morris

Kickstart International





WASHINGTON STATE UNIVERSITY



Office of Research
PO Box 641060
Washington State University
Pullman, WA 99164-1060

509-335-1517

research@wsu.edu