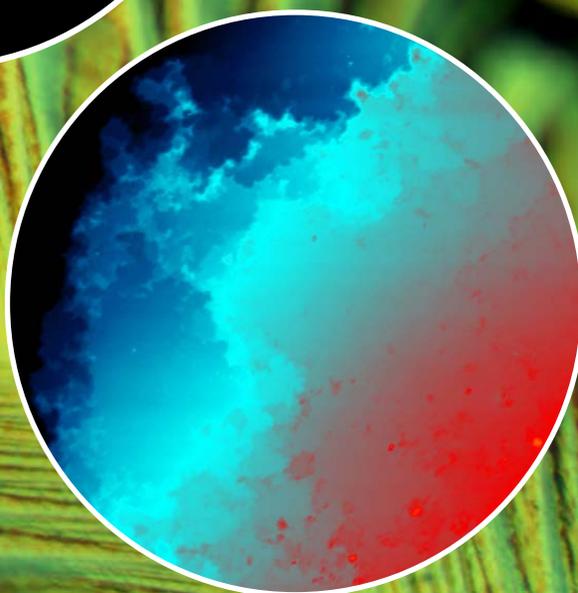
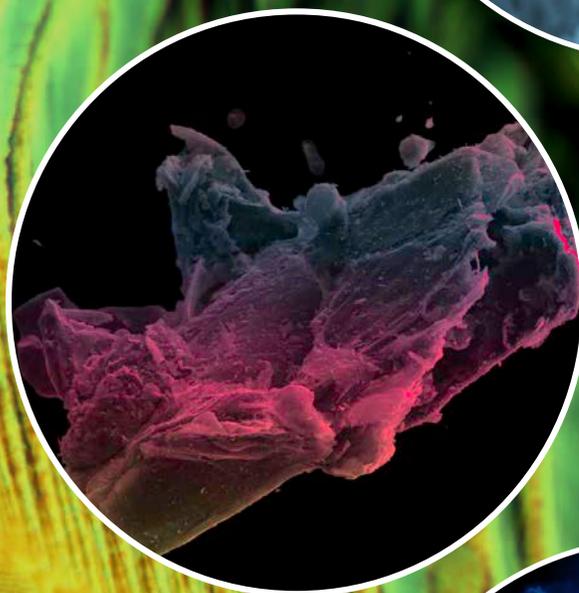




Pacific Northwest
NATIONAL LABORATORY

*Proudly Operated by **Battelle** Since 1965*



2017
LABORATORY
Agenda

U.S. DEPARTMENT OF
ENERGY

Message from Steve and Roger



Fiscal year (FY) 2017 promises to be exciting and eventful. We will build on the many successes of 2016, including strong programmatic growth, investment in our campus and people, and progress toward our vision of elevating Pacific Northwest National Laboratory's (PNNL's) stature as a world-class scientific research institution. We also managed operations with distinction, including improved safety and reduced costs. This strong record of performance not only sets the stage for 2017, but also led the Department of Energy (DOE) to extend Battelle's contract to operate the Laboratory through 2022.

As we move forward, our Laboratory strategy will guide our internal investments and external engagements, and the pursuit of it will further our mission of transforming the world through courageous discovery and innovation.

Our strategy is founded on Battelle's principle of *Simultaneous Excellence*. Excellence in Science and Technology (S&T) begins with our scientific vision—to *understand, predict, and control*

the behavior of complex adaptive systems. Underpinning this vision are several key, strategic elements, including our Laboratory and Directorate Objectives. We invest in these through a portfolio of initiatives selected to grow distinguishing technical capabilities for greatest impact, now and into the future.

Excellence in S&T is complemented by our commitment to Excellence in Management and Operations (M&O), which is vital to achieving our mission. We have an obligation to be good stewards of the funds entrusted to us, as well as to execute our programs safely, securely, and in an environmentally responsible way.

We are also committed to Excellence in Community Service. This means that we are good neighbors and get involved in ways that make our community better. We do this through our individual efforts, Team Battelle projects, and Battelle's corporate philanthropy.

Looking to the year ahead, we will continue our focus on creating a culture of creativity and innovation, strengthening partnerships with our sponsors and the scientific community, and increasing the visibility of the Laboratory and our contributions both regionally and nationally. The coming year will also see continued investment in our campus, including construction of the new S&T Collaboration Center.

None of this can happen without you—our dedicated staff of scientists, engineers, and support professionals. Through your efforts, we will make great scientific discoveries, deliver innovative technologies, and consistently exceed our sponsors' expectations. We thank you for your exemplary commitment to the Laboratory, our sponsors, and the nation. Together, we are ensuring that PNNL will have a bright future for decades to come.

We now invite you to read on and take pride in the many ways you are bringing our strategy to life.

Steven Ashby, Director
Pacific Northwest National Laboratory

Roger Snyder, Manager
DOE Pacific Northwest Site Office

Excellence in Science and Technology



Pacific Northwest National Laboratory's Scientific Vision

PNNL's scientific vision is to *understand, predict, and control the behavior of complex adaptive systems*, with an emphasis on specific earth, energy, and security systems that are central to the United States (U.S.) DOE's strategic objectives.

In order to realize this vision, as well as our aspiration to be more widely recognized as a world-class scientific research institution, we have a S&T strategy centered on accomplishing the following four key outcomes:

- Unifying scientific themes that lead to PNNL being recognized as a thought leader in nationally relevant scientific areas; these are our Laboratory Objectives.
- A world-class technical foundation consisting of multidisciplinary science and engineering expertise, equipment/instrumentation, and facilities.
- An environment that promotes creativity, develops technical leaders, and encourages staff members to be bold in their research.
- Institutional collaborations that further PNNL's S&T strategy and enable our staff members to perform high-impact research.

Contact: Deputy Director for Science and Technology – Malin Young (malin.young@pnnl.gov)

Science and Technology Laboratory Objectives

The S&T Laboratory Objectives are distinct scientific focus areas where PNNL can be a thought leader and have significant impact on both science and society. They distinguish us, represent our greatest potential for scientific and technical leadership, and inspire sustained stewardship investment from our sponsors and stakeholders.

In the coming year, we are "retiring" two Laboratory Objectives, Chemical Imaging and Disrupt Illicit Nuclear Trafficking, that have achieved their primary outcomes. The remaining two Objectives have new outcomes, and we have created two new Laboratory Objectives, Radiation Dynamics and Terrestrial Aquatic Ecosystems, which are explained on the following page.

We also have a set of S&T Directorate Objectives focused on developing thought leadership and building capabilities in critical mission areas. These activities are stewarded by the research directorates.

“Every great advance in science has issued from a new audacity of imagination.”

—John Dewey



AS SMOOTH AS GLASS – In this false-color topographic map of the surface of a piece of polished glass, the most corroded areas (dark blue) are contrasted with the areas most protected (red). PNNL researchers are exposing glass samples to different chemical solutions and studying these topographic images to better understand and predict how glass would corrode in various conditions for thousands of years—

Terrestrial-Aquatic Ecosystems



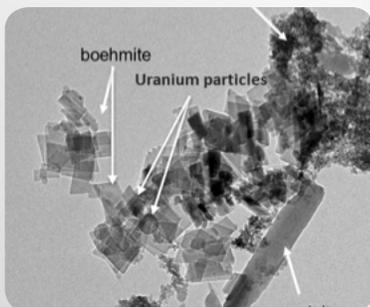
Understand and optimize terrestrial-aquatic ecosystems to mitigate impacts of extreme weather and climate
POC: Charlette Geffen
ca.geffen@pnnl.gov

Chemical Conversions for C Neutral Energy



Reinvent chemical conversion processes to have minimal or no environmental impact
POC: Karl Mueller
karl.mueller@pnnl.gov

Radiation Dynamics



Understand and control change in radioactive systems or those undergoing irradiation
POC: Sue Clark
sue.clark@pnnl.gov

Efficient and Secure Electricity Management



Define the inherently clean, resilient, and affordable grid of the 21st Century
POC: Carl Imhoff
carl.imhoff@pnnl.gov

Contact: Deputy Director for Science and Technology –
Malin Young (malin.young@pnnl.gov)

helping fine-tune new glass corrosion models to ensure vitrified nuclear waste is confined in the glass for safe, long-term storage and disposal. This research is funded by a joint DOE Office of Environmental Management and Office of Nuclear Energy project and by Washington River Protection Solutions.

Core Capabilities

PNNL has 19 core capabilities, each a powerful combination of people, equipment, and facilities. These capabilities represent a collective set of skills and a body of world-leading scientific and engineering work that provides exceptional value and mission delivery to our sponsors and stakeholders.

“Look deep into nature, and then you will understand everything better.”

—Albert Einstein

SUPER STICKY COPPER – PNNL scientists have developed an electroplating process to coat a titanium alloy with copper, overcoming the challenge of getting copper to stick to the surface. The copper-coated superconducting titanium alloy will be used in the cabling of detectors being built to help in the search for dark matter. In this microscope image of an early research sample, the copper did not adhere completely

Scientific User Facilities

Atmospheric Radiation Measurement (ARM) Climate Research Facility

The world's premier ground-based observatory for climate change research, the ARM Climate Research Facility, provides a global network of instrumented fixed, mobile, and aerial observatories for obtaining cloud and aerosol measurements, as well as precipitation, solar and thermal radiation, surface heat and moisture, and meteorological conditions. For more information on the ARM Climate Research Facility and its scientific accomplishments, please visit <http://www.arm.gov>.

Environmental Molecular Sciences Laboratory (EMSL)

As a national scientific user facility, the Environmental Molecular Sciences Laboratory (EMSL) seeks to pioneer molecular-level discoveries and effectively mobilize the scientific community to generate the predictive understanding and accelerate solutions that will provide the scientific foundations for DOE's Biological and Environmental Research (BER) priorities and our nation's critical biological, environmental, and energy challenges. For more information on EMSL and its scientific accomplishments, please visit <http://www.emsl.pnnl.gov>.

and began oxidizing after being set aside. Efforts to develop a successful process are part of the Super Cryogenic Dark Matter Search, an international collaboration supported by DOE's Office of High Energy Physics. Research Team: Eric Hoppe (PNNL) and Martin Mathews (former PNNL post-master's research associate).

Strategic Investments

PNNL has a portfolio of investments to deliver transformational S&T, accelerate innovation, develop new partnerships for national and international impact, transform our workforce, and nurture and evolve our core capabilities.

“Science is the acceptance of what works and the rejection of what does not. That needs more courage than we might think.”

—Jacob Bronowski

A MATERIAL IMPROVEMENT FOR FUSION REACTORS – Researchers at PNNL are studying tungsten-copper composites as a model material for use in nuclear fusion reactors. On its own, tungsten is durable but brittle. Combining it with copper or other metals with a high melting point, however, makes it tougher and better able to withstand the wear and tear of fusion reactor operation. This project supports international efforts to develop tough tungsten composites and was funded by

Our S&T Initiatives are large (\$15 million), multi-year (3 to 5 years) investments with specific strategic and scientific leadership aspirations in areas such as catalysis, plant sciences, and high energy physics.

We also invest in our facilities, in both campus modernization and in the addition of new facilities to support research in the grid, chemistry, and materials science and engineering, as well as a new collaboration facility for scientific and technical meetings.

Lastly, we make strategic investments in capital equipment. For example, we recently acquired an aberration-corrected scanning transmission electron microscope that provides unrivaled capabilities for radioactive and potentially dispersible radioactive materials analysis and is a critical capability for our Radiation Dynamics Laboratory Objective. These capabilities enable real-time, dynamic studies at the molecular scale of interfacial phenomena in radiation environments that drive solid phase nucleation, precipitation, and dissolution in potentially dispersible radioactive materials and systems. Such studies provide an unprecedented opportunity to understand (and ultimately control) the chemical and physical processes that lead to precipitation and dissolution of desirable and undesirable phases.

Contact: Manager, Institutional S&T Investments – Kelly Sullivan
(kelly.sullivan@pnnl.gov)

DOE's Office of Fusion Energy Sciences. The image shown is three-dimensional; put on some 3D glasses to see the full effect. Research Team: Charles H. Henager, Jr.; Richard Kurtz; Nicole Overman; Timothy Roosendaal; and Matthew Olszta (PNNL); and Brennan Borlaug (former PNNL intern). Staff members at the University of California, Santa Barbara also contributed to the project.

Culture of Creativity and Innovation

We are nurturing a culture of creativity and innovation by launching a variety of efforts focused on exposing our staff members to new ideas and supporting their efforts to take on bolder research with the potential for high impact.

QuickStarter, a new program in which staff members are able to crowd-fund new and innovative ideas developed by their colleagues across the Laboratory, was a great success in engagement and innovation. We also launched several other concepts including a new seminar series titled “Food for Thought” where new ideas are explored and staff members are invited to participate in discussions. SciChats, web-based discussions, were initiated creating a venue where staff members can interact with the Deputy Director for Science and Technology on a variety of S&T topics. And lastly, we launched the Discovery Speaker Series where members of the Laboratory Leadership Team talk to staff about the strategic activities they are leading for PNNL.

Contact: Deputy Director for Science and Technology – Malin Young (malin.young@pnnl.gov)

“The best scientist is open to experience and begins with romance—the idea that anything is possible.”

—Ray Bradbury

A SEARCH ENGINE FOR SCIENTIFIC RESEARCH – PNNL researchers have developed automated software that can analyze these vast amounts of microscopic imagery in a matter of minutes. Their approach also can identify specific areas of interest for further analysis—using microscopy as a search engine of sorts and opening new horizons for studies previously not

Strategic Partnerships

We partner with both academic and industrial institutions to increase the impact of our research and contribute to solving the nation's most complex scientific research challenges. This includes building strategic academic alliances with key U.S. research universities, strengthening PNNL's presence in—and raising visibility of—the Northwest region, and working with DOE and industry to move PNNL technology to market.

Our academic partnerships increase collaborative research opportunities, facilitate transdisciplinary research, and provide our university partners access to specialized instrumentation and other research tools. We have joint appointments with 16 universities across the United States with nearly 50 joint appointees. Flagships of PNNL's strategic academic partnerships are the PNNL-University of Maryland Joint Global Change Research Institute, the PNNL-University of Washington Northwest Institute for Advanced Computing, the PNNL-Oregon Health and Science University Northwest Co-Laboratory for Integrated 'Omics, and the PNNL-Washington State University Distinguished Graduate Research Program. We expect to expand the number of joint research institutes and the number of students performing their doctoral thesis research at PNNL in 2017.

Later in this Agenda, in the Excellence in Community Service section, you read about our partnerships in science, technology, engineering, and mathematics (STEM) education and technology transfer, as well as how we are using these partnerships to strengthen PNNL's presence in the Northwest and move PNNL technology to market to increase the impact of our research.

Contact: Director, Strategic Partnerships – Doug Ray (doug.ray@pnnl.gov)

economical or practical. For example, in this cross-section of a pumpkin stem, scientists could quickly identify damaged cell walls, characterize the cause of damage, and then apply more time-consuming instrumentation to study select areas. Research Team: Micah Miller (PNNL).

Excellence in Management and Operations

Excellence in M&O is vital to achieving our scientific vision. To that end, we have transformed what were M&O Imperatives into actionable Mission Support Laboratory Objectives. Their purpose is both simple and clear: to make it easier for our scientists and engineers to become thought leaders and deliver world-class research for our sponsors and stakeholders. In everything we do, we strive to simplify the way we work, provide our staff members with the most modern (and mobile) systems and tools, and help increase the time our scientists and engineers spend performing research.

*“Effective leadership is putting first things first.
Effective management is discipline, carrying it out.”*

—Stephen Covey

TINY ANTENNAS AMPLIFY MOLECULAR RESEARCH – PNNL researchers study the properties of silver nanospheres (pictured here), including how they self-assemble with a uniform structure and how they can function as an antenna with a uniform signal. This level of nanometric uniformity is difficult to achieve, but offers a new platform for researchers to understand the fundamental physical chemistry and physics of various molecules. This work was initiated with Laboratory

The newly proposed Mission Support Laboratory Objectives are currently in review, and in 2017, we are engaging teams of research and mission support staff members to develop strategic plans and outcomes to:

- build the diverse workforce necessary to transform PNNL into a recognized, world-class scientific research institution
- accelerate scientific breakthroughs and technological innovation through increased collaboration
- create a competitive advantage for ourselves by being a leader in scientific data management
- leverage our leadership in data analytics to derive insight from operational and performance data streams to drive better decision-making
- take full advantage of the scientific and technological advances we provide to our sponsors to modernize the way we work
- modernize the PNNL campus experience.

In all of these areas, we will need the strong engagement of both research and mission support staff to focus our investments and assure that we accomplish our ultimate objective: make it easier for our scientists and engineers to become thought leaders and deliver world-class research to our sponsors and stakeholders.

Contact: Deputy Director for Operations and COO – Mike Schlender (mike.schlender@pnnl.gov)

Directed Research and Development funding and is now supported by the Condensed Phase and Interfacial Molecular Sciences Program within DOE's Basic Energy Sciences program. The image was captured with a transmission electron microscope. Research Team: Patrick El-Khoury and Wayne Hess (PNNL), Patricia Abellan (former post-doc research associate at PNNL), and Mikhail Zamkov (Bowling Green State University).

Excellence in Community Service

Excellence in Community Service is a foundational principle for both PNNL and Battelle as we look to increase the value we provide to the nation, as well as regional and local communities. We demonstrate our value when we nurture relationships with key national, regional, and local stakeholders; deliver socially responsible programs that act to benefit society; and contribute to the economic prosperity of the communities in which we live and work. <http://regionaloutreach.pnnl.gov>

Contact: Director, External Relations – Paula Linnen (paula.linnen@pnnl.gov)

*“Science literacy is the artery through which
the solutions of tomorrow's problems flow.”*

—Neil deGrasse Tyson

THE GOOD, THE BAD, AND THE UGLY – Every ounce of soil contains thousands of microorganisms. Good ones contribute to natural processes such as carbon and nutrient cycling and nitrogen fixation. Bad ones can cause plant disease and death. And some bacteria have unexpected shapes, like the ones that look a bit like rotini pasta in this image. PNNL researchers are

Creating Economic Value with Innovative S&T

Our world-class scientific research and development activities not only advance the mission objectives of DOE, but also result in technological advances that contribute to U.S. competitiveness in the global marketplace. In 2015, the total economic impact of the Laboratory payroll and domestic purchased goods and services on the Washington State economy included \$1.38 billion in total economic output, with 6,786 total jobs generated in the state. In addition, there are 99 companies still operating that can trace their roots to PNNL. The total economic impact of these companies on the Washington State economy includes \$567 million in total output and 3,701 jobs. <http://www.pnnl.gov/business>

Inspiring the Next Generation of Scientists and Engineers

As a DOE national laboratory, we are stewards of national scientific and technological capabilities, and we are committed to developing future generations of scientists and engineers critical to our nation's ability to compete in an increasingly competitive global market. Our commitment to STEM education spans the entire educational lifecycle, from our school children, to providing rich, hands-on learning experiences for educators and potential PNNL employees. <http://science-ed.pnnl.gov>

Mid-Columbia STEM Education Collaboratory

The Collaboratory is a project that demonstrates the passion that PNNL, Battelle, and like-minded organizations have to impact the educational ecosystem, serving as a model for amplifying and accelerating progress and addressing our STEM education and workforce challenges. The Collaboratory's goals are to improve STEM education, increase STEM workforce preparation, and actively engage the Mid-Columbia community—including parents, business leaders, educators, and the public—in its projects. <http://science-ed.pnnl.gov>

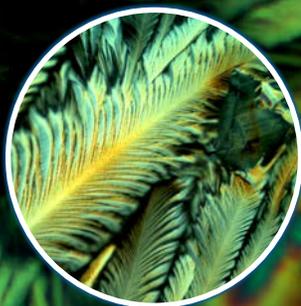
using EMSL Seed Laboratory Directed Research and Development funding to study underground communities of microbes in the forests of the Pacific Northwest. This image was captured using the Helium Ion microscope in EMSL. Research Team: Alice Dohnalkova, Rosey Chu, Malak Tfaily, Alex Crump, Tamas Varga, Colin Brislawn, and William Chrisler (PNNL).



On the Cover

A SNAPSHOT OF DEHYDRATION

PNNL researchers and collaborators are studying uranyl nitrate—a key ingredient in the nuclear fuel cycle—to better understand how its properties change as it loses moisture in different climates or storage scenarios. Using time-resolved reflectance spectroscopy, they have captured some of the dynamics of this transformation, watching the transformation process to examine the material's structure and behavior as it dehydrates. With support from DOE's National Nuclear Security Administration, researchers are now correlating their real-time, high-resolution observations with computational studies to help understand environmental effects on several components of the fuel cycle.



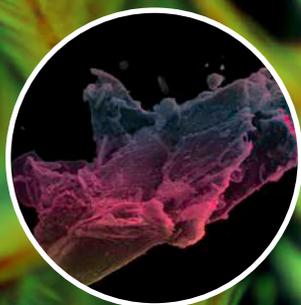
PINING FOR CARBON

Soils are vital to our future supply of water and food, but they also play a critical role in adapting to climate change and sustaining the planet's biosphere—the land, sea and atmosphere occupied by living things. With funding from the Laboratory Directed Research and Development program, PNNL researchers studied microbes from the typical rhizosphere found in the Northwest's Central Cascades pine forests to better understand how microbes help stabilize carbon in soils. The rhizosphere is the small area surrounding plant roots where microbes interact with minerals in the soil—a hot spot for biogeochemical activity that is constantly changing.



HEADED FOR THE HIGHWAY?

This tiny structure is a metal organic framework—or MOF—overlaid on a porous carbon material. The novel material offers outstanding refrigerant capacity and high thermal conductivity for advanced chiller applications that could include air conditioning in buildings, U.S. Navy vessels and, perhaps not so coincidentally, automobiles. Researchers are developing synthetic methods to scale up production and enhancing the performance of MOFs with support from PNNL's Laboratory Directed Research and Development program, U.S. Navy Military Sealift Command and DOE's Geothermal Technologies Office.



AS SMOOTH AS GLASS

In this false-color topographic map of the surface of a piece of polished glass, the most corroded areas (dark blue) are contrasted with the areas most protected (red). PNNL researchers are exposing glass samples to different chemical solutions and studying these topographic images to better understand and predict how glass would corrode in various conditions for thousands of years—helping fine-tune new glass corrosion models to ensure vitrified nuclear waste is confined in the glass for safe, long-term storage and disposal. This research is funded by a joint DOE Office of Environmental Management and Office of Nuclear Energy project and by Washington River Protection Solutions.

