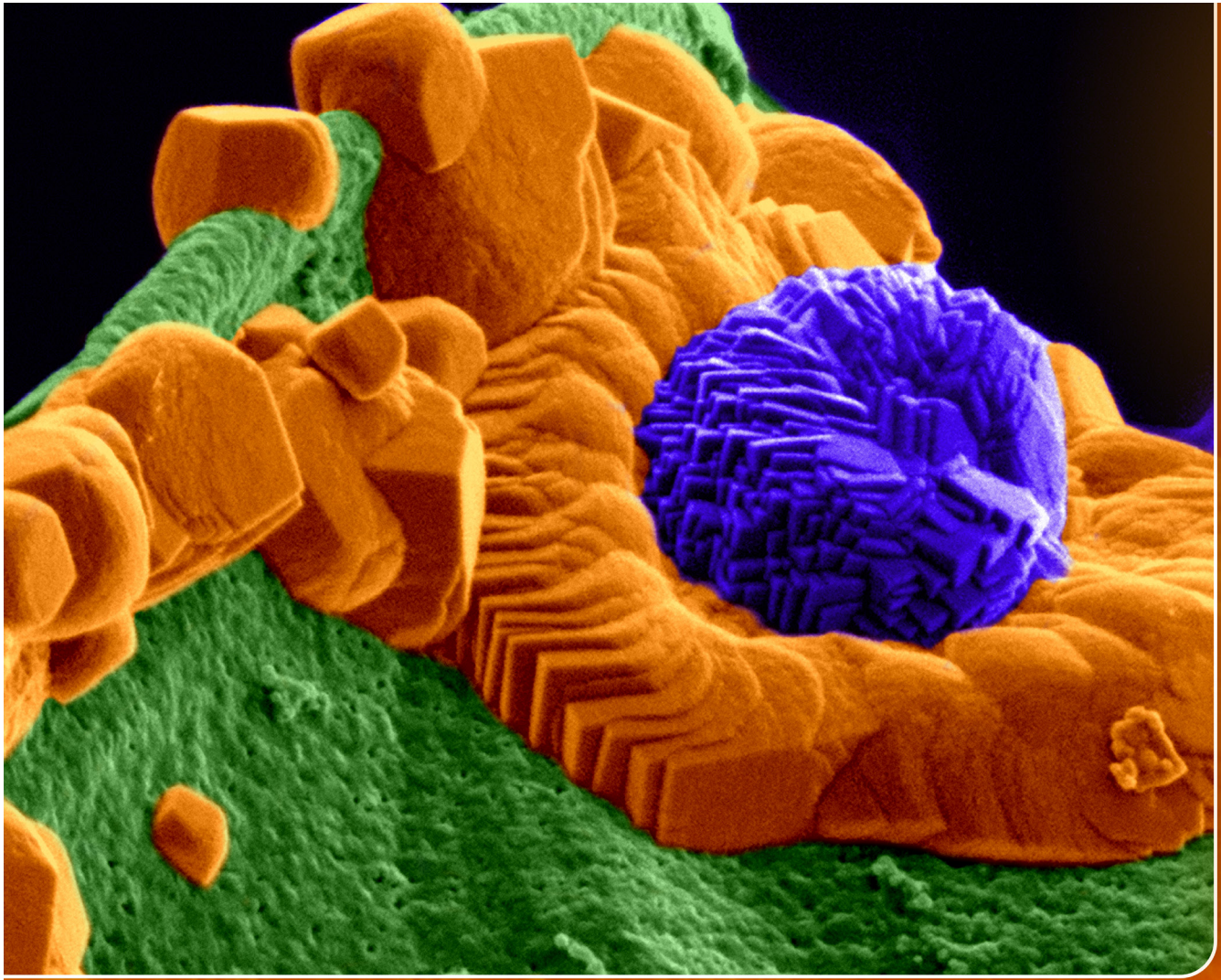

Science as Art 2015

Pacific Northwest NATIONAL LABORATORY

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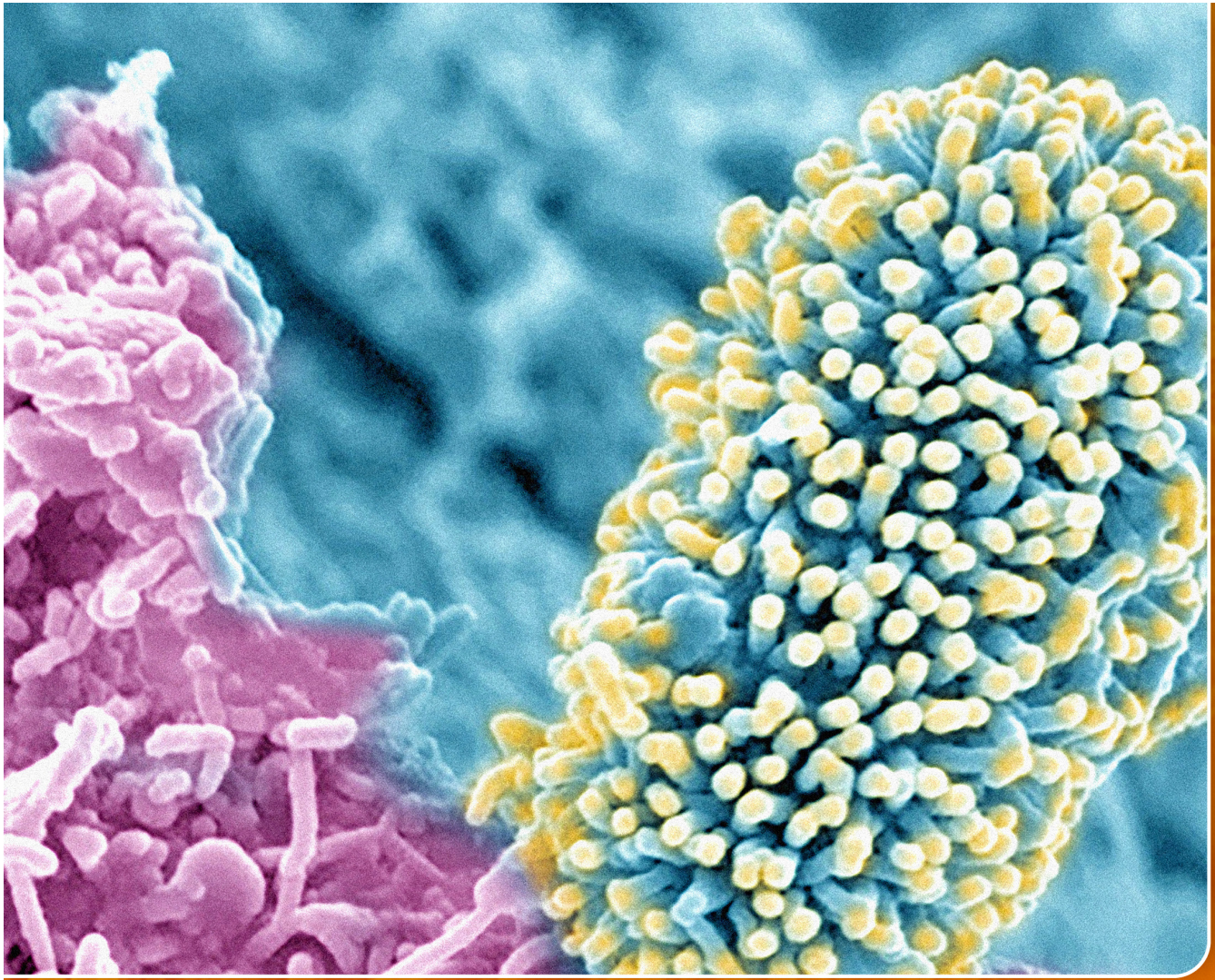

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Solutions Rooted in Knowledge

An intricately structured soil bacterium, less than a micron in size, makes its home on the root surface of an Arabidopsis plant. Much remains to be learned about the plant root zone—or rhizosphere—and its microbial communities and influence on environmental processes. A research campaign at EMSL, the Environmental Molecular Sciences Laboratory, a U.S. Department of Energy Office of Science national scientific user facility located at Pacific Northwest National Laboratory, is offering insights. The campaign includes scientists from EMSL, PNNL, DOE's Joint Genome Institute, Brookhaven National Laboratory, the University of Minnesota and the University of Missouri. The effort, funded by DOE's Office of Biological and Environmental Research, is focused on understanding how the presence and distribution of carbon within the root zone impacts the diversity and function of the rhizosphere microbial community.

Research Team Members: Ljiljana Paša-Tolić, Alice Dohnalkova, Galya Orr, David Hoyt, Heather Brewer and Angela Norbeck all of EMSL; Kevin Minard, Meng Markillie and Charles Ansong of the PNNL Fundamental & Computational Sciences Directorate; Susannah Green Tringe (DOE-JGI), Richard Ferrieri (BNL), Mike Sadowsky and Chanlan Chun of the University of Minnesota and Gary Stacey, Yaya Cui and Lihui Song of the University of Missouri.

**Image was captured with the Helios Nanolab dual-beam focused ion beam/scanning electron microscope at EMSL and was created by Alice Dohnalkova.*

JAN 2015

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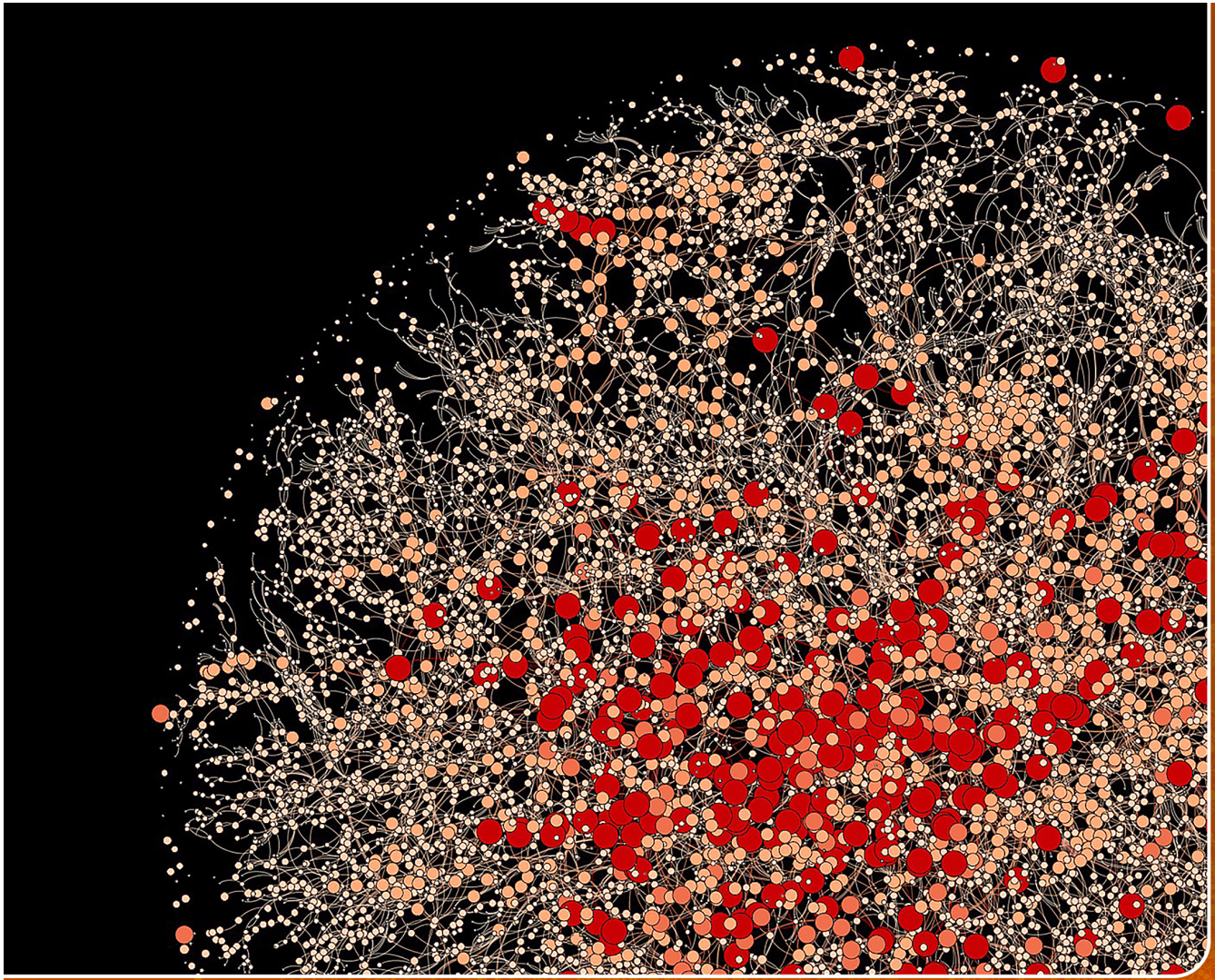

Pacific Northwest NATIONAL LABORATORY

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A High-Voltage Visual for the Power Grid

The large machine known as the electric power grid is highly complex. Researchers at Pacific Northwest National Laboratory are part of a multi-institute collaboration using and developing mathematical tools to better understand grid structure and behavior. This image, one of the outcomes from the research, represents a model of the Western U.S. power grid. The dots are nodes, or grid components such as generators, loads and substations; the color and size denote the nodes' voltage ratings. The faint lines reflect transmission lines, transformers and associated components. Together, the dots and lines illustrate the structured, hierarchical nature of the high-voltage transmission network. Such a depiction enhances the study of contingency analysis (developing the best responses for potential component failures), as well as monitoring, pricing and planning. The project was funded by the U.S. Department of Energy's Advanced Scientific Computing Research program.

Research Team Members: Mahantesh Halappanavar and Emilie Hogan of PNNL's Fundamental & Computational Sciences Directorate; Eduardo Cotilla-Sanchez and Daniel Duncan of Oregon State University; and Paul Hines of the University of Vermont.

FEB 2015

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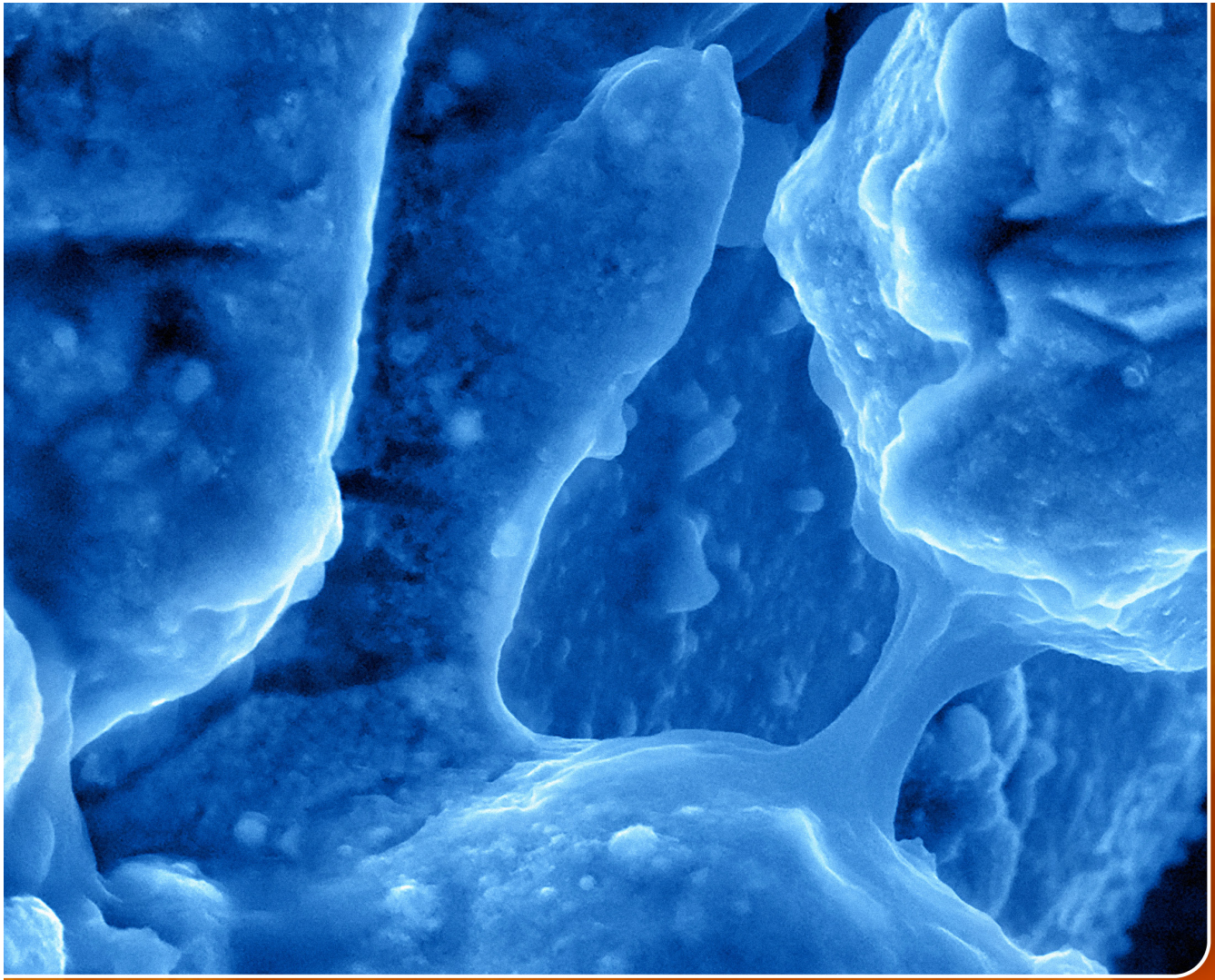

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Copper in the Gap, Holding Strong

The challenge is to make tungsten—a tough metal—even tougher, for heavy-duty applications. Researchers at Pacific Northwest National Laboratory have been exploring the question, trying to gain a better understanding of the properties that emerge when tungsten is united with copper in a model composite. In the image, which reflects this union of metals, the small connecting object is copper, between two sections of tungsten. Researchers believe that in tungsten-copper composites, copper takes on the role of helping to hold tungsten together, reduce cracking, and subsequently make the composite material tougher. PNNL's research has been funded by the U.S. Department of Energy's Office of Fusion Energy Sciences, which is advancing research in support of international efforts to develop fusion reactors for production of clean energy.

Research Team Members: Chuck Henager, Rick Kurtz, Nicole Overman, Tim Roosendaal and Brennan Borlaug, all of PNNL's Energy and Environment Directorate. Also, staff at the University of California-Santa Barbara contributed to the project.

**Image was captured with a Field Emission Scanning Electron Microscope in PNNL's Materials Science and Technology Laboratory (3410 Building) and colorized by Nicole Overman.*

MAR 2015

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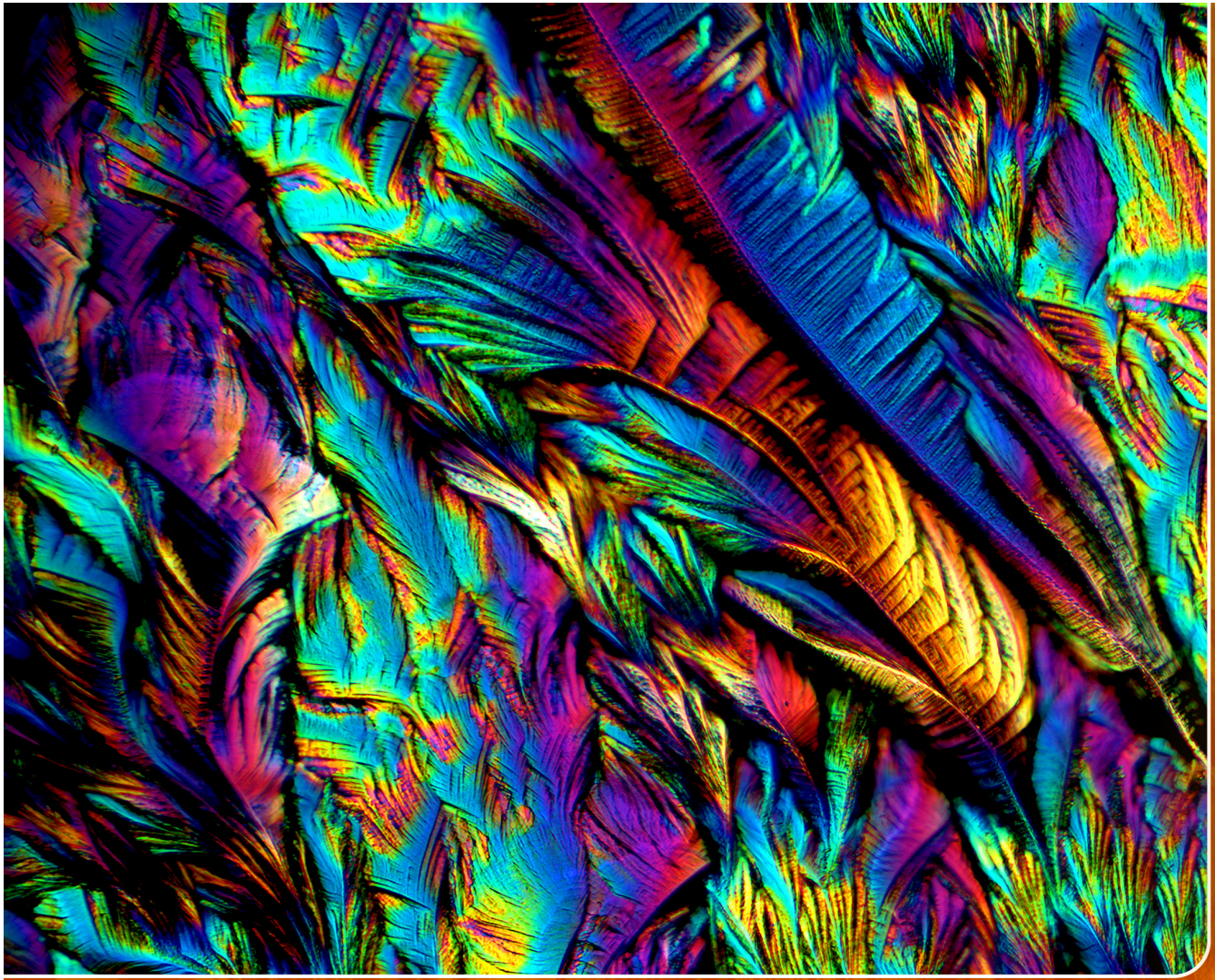

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A Signature Approach to Security

This beautiful feather-like image of uranium is a short-lived snapshot in time, but the information it contributes to the field of nuclear forensics could provide important, long-lasting outcomes for world safety. Scientists at Pacific Northwest National Laboratory are examining and imaging uranium phases, or transformations in the radioactive metal that occur due to changes in external factors, such as humidity levels. Through this study, researchers are gaining understanding of how the transformations reflect signatures, or characteristics about the material's history. The knowledge will help enhance capabilities for safeguarding nuclear materials. The work is funded by the Office of Defense Nuclear Nonproliferation in the U.S. Department of Energy's National Nuclear Security Administration.

Research Team Members: Edgar Buck, Bruce McNamara and Edward Mausolf of PNNL's Energy and Environment Directorate, and Tim J. Johnson of PNNL's Fundamental & Computational Sciences Directorate.

**Image was captured with Polarized Light Microscopy at PNNL's Radiochemical Processing Laboratory.*

APR 2015

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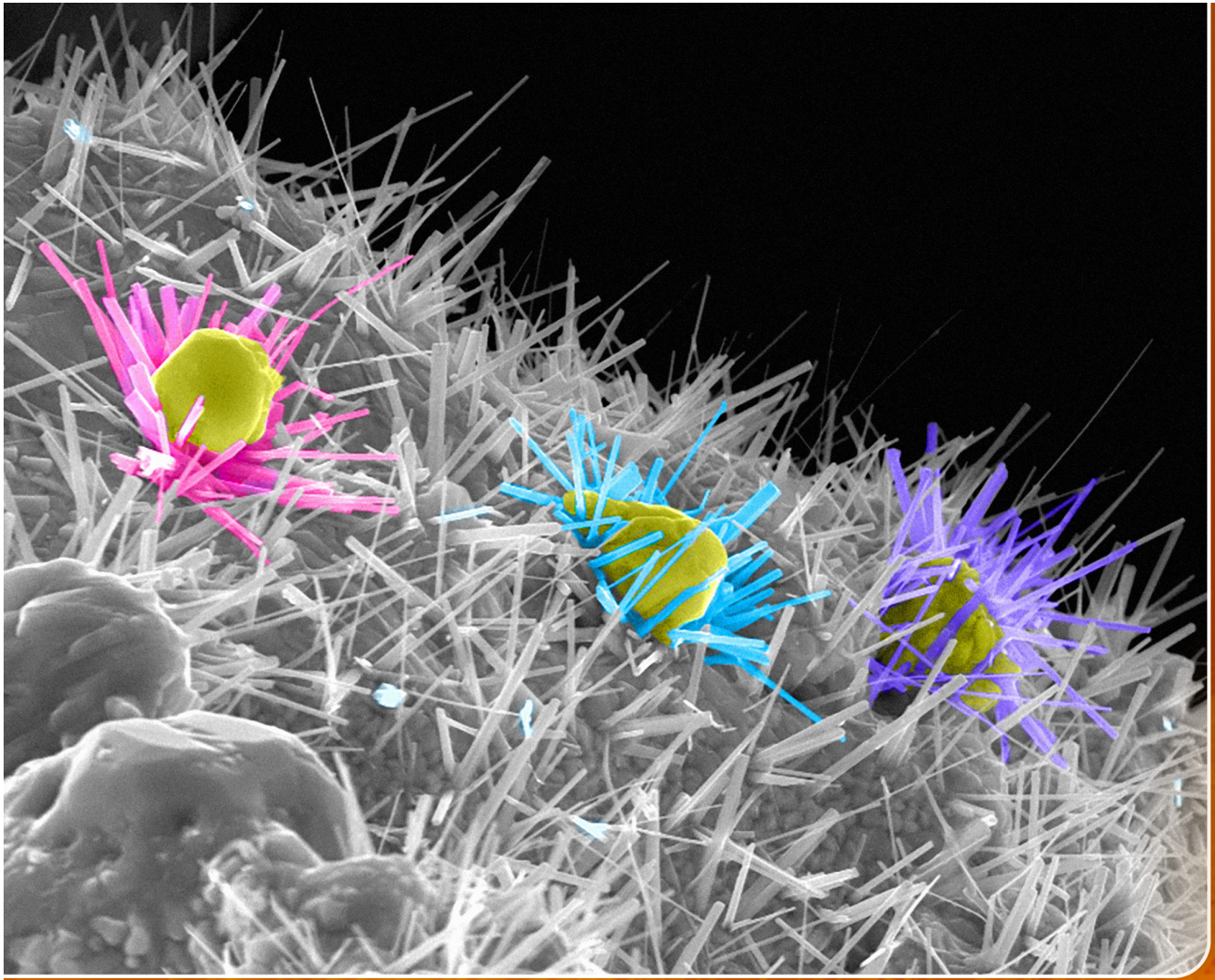

Pacific Northwest NATIONAL LABORATORY

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A Composite Manifestation of Oxygen

When a tungsten-copper composite material reacts with oxygen, multiple cactus-like "needles" emerge on the tungsten surface. Amidst these needles, three visible copper particles—accentuated here by color highlighting—also manifest the results of oxidation, but with much less visual aplomb. Researchers at Pacific Northwest National Laboratory are studying the characteristics of a tungsten-copper composite. Ultimately, the research seeks to assess the composite's viability for applications in rigorous high-temperature environments. Results have shown the copper stretches between regions of tungsten, helping to hold the composite material together, even when hot. The research has been funded by the U.S. Department of Energy's Office of Fusion Energy Sciences, which is advancing research in support of international efforts to develop fusion reactors for production of clean energy.

Research Team Members: Chuck Henager, Rick Kurtz, Nicole Overman, Tim Roosendaal and Brennan Borlaug, all of PNNL's Energy and Environment Directorate. Also, staff at the University of California-Santa Barbara contributed to the project.

**Image was captured with a Field Emission Scanning Electron Microscope in PNNL's Materials Science and Technology Laboratory (3410 Building) and colorized by Nicole Overman.*

MAY 2015

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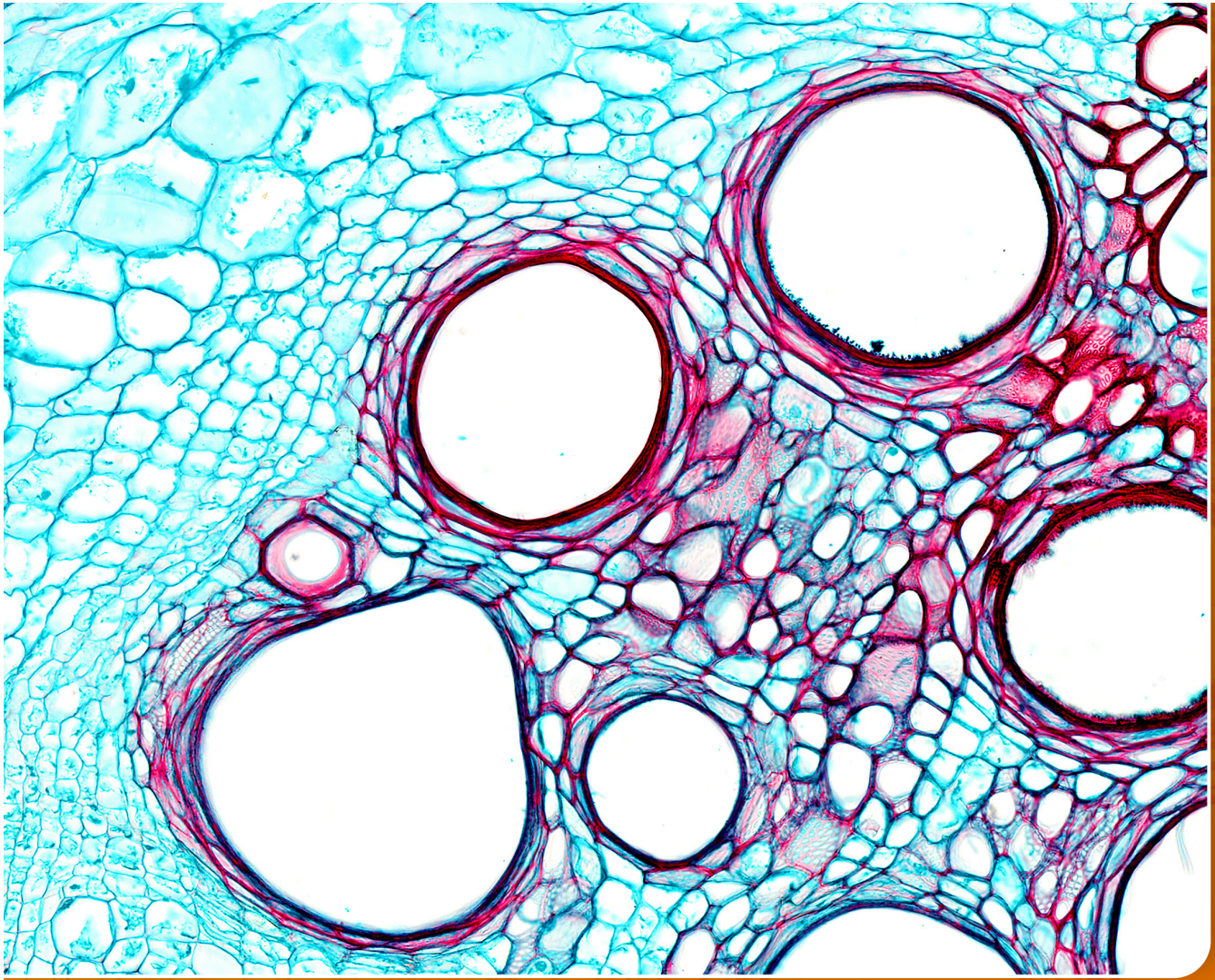

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A Resource for Rapid Discovery

This stained section of a pumpkin stem was captured to demonstrate the capabilities of Pacific Northwest National Laboratory's high-throughput microscopy instrumentation. The microscope's high magnification and high speed allow researchers to thoroughly examine large amounts of sample material; algorithms are then employed to pinpoint objects of interest for further analysis. This approach permits a more efficient and cost-effective application of laboratory resources, helping to shorten the path to scientific discovery.

Submitted by Micah Miller of PNNL's Fundamental & Computational Sciences Directorate.

JUN 2015

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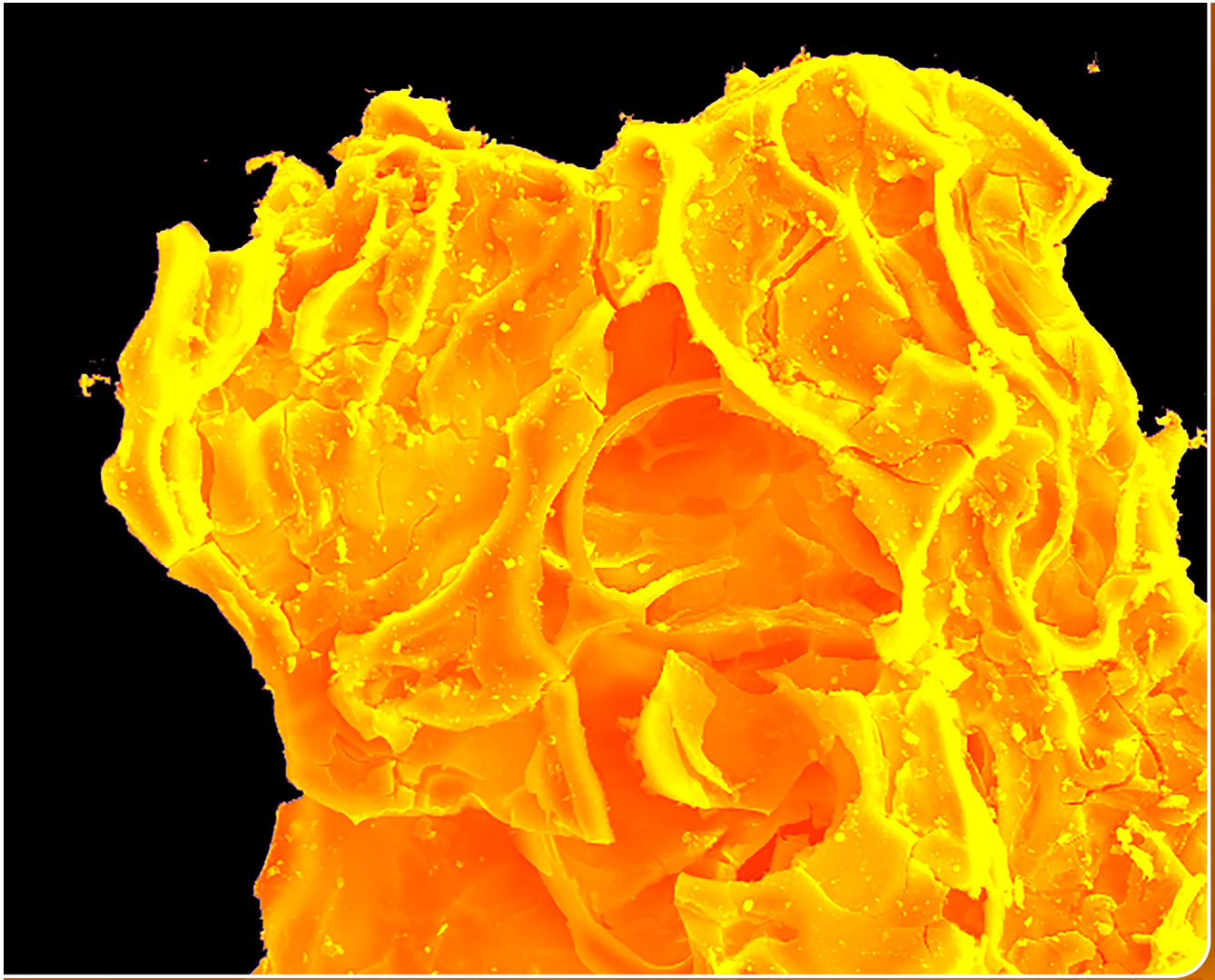

Pacific Northwest NATIONAL LABORATORY

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Elegant Material Aids Efficiency

It's a gold strike for energy efficiency! This innovative material is created by maneuvering tiny structures called metal organic frameworks (MOFs) onto porous carbon particles. The material enables more efficient operation of adsorption chiller devices, which provide air conditioning for vehicles, U.S. Navy applications and buildings. Researchers are working to foster efficient, continuous methods for production of the MOF-carbon core-shell composite material, which also may offer applications in carbon capture and catalysis. Funding for the project was provided by Pacific Northwest National Laboratory's Laboratory Directed Research and Development program and the U.S. Department of Energy's Advanced Research Projects Agency-Energy program.

Research Team Members: Radha K. Motkuri, Jagan Bontha, Igor Kutnyakov and Pete McGrail, all of PNNL's Energy and Environment Directorate.

**Image was captured with a scanning electron microscope at EMSL by Bruce Arey and colorized by Jagan Bontha.*

JUL 2015

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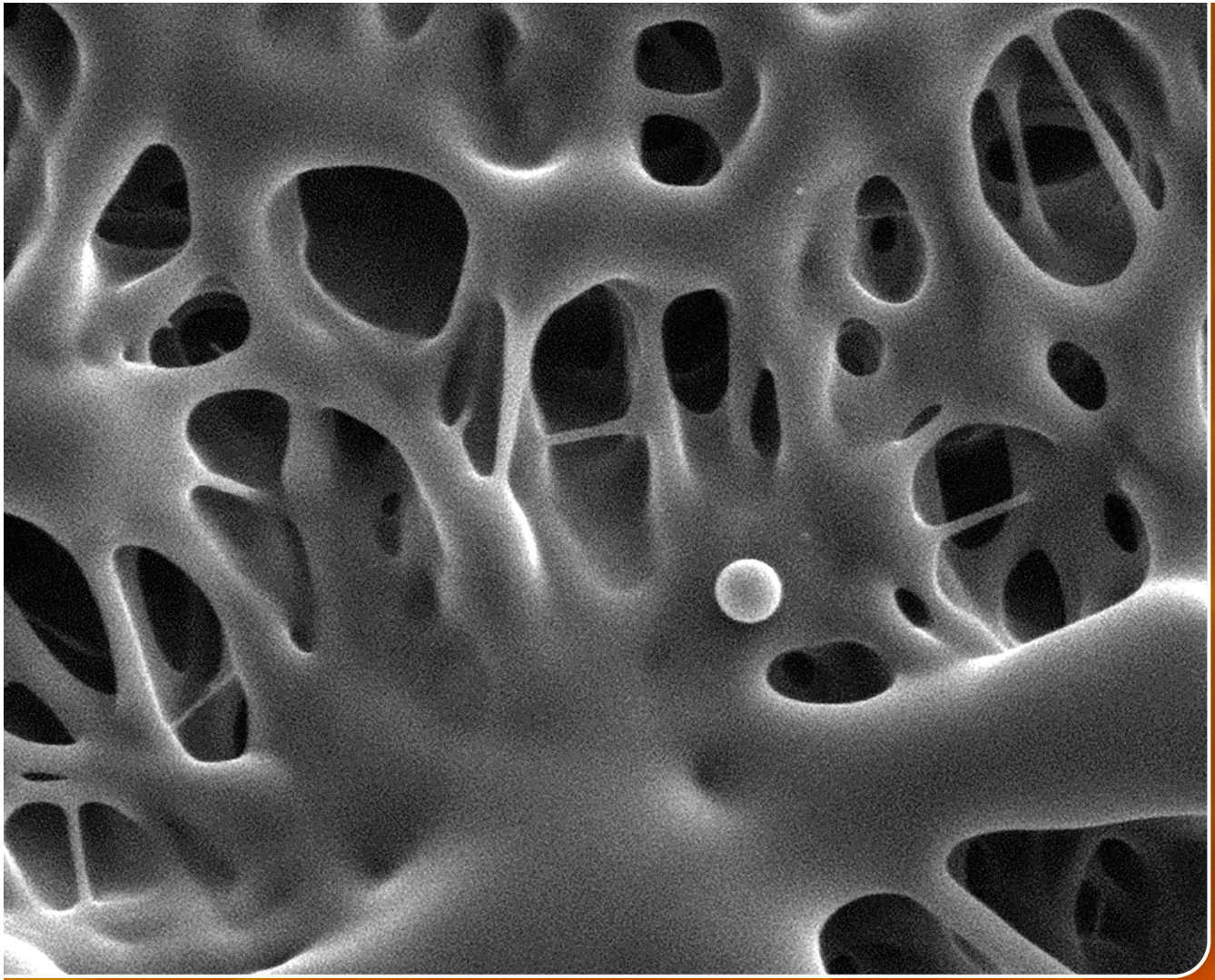

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Scale of Change in the North Pacific

Herring scales may help explain how fish populations in the North Pacific Ocean have been impacted by major biological and physical changes during the past 40 years. This image, captured with a helium ion microscope following laser ablation, reveals the collagen matrix within a single scale of a Pacific herring from Alaska's Prince William Sound. Researchers want to understand carbon isotope ratios in scales—and muscles—of present-day Pacific herrings, with the ultimate objective of performing a retrospective analysis of archived scales. Such a comparative exam will provide insights into fish dynamics in the North Pacific since 1970. The inquiry was funded by the North Pacific Research Board and conducted by researchers at Pacific Northwest National Laboratory and EMSL, the Environmental Molecular Sciences Laboratory, a U.S. Department of Energy Office of Science national scientific user facility located at PNNL.

Research Team Members: Megan Nims and Tim Linley of PNNL's Energy and Environment Directorate; Jim Moran of PNNL's National Security Directorate; Bruce Arey of EMSL; and former staff member Kathleen Carter.

**Image was captured with a Helium Ion Microscope at EMSL.*

AUG 2015

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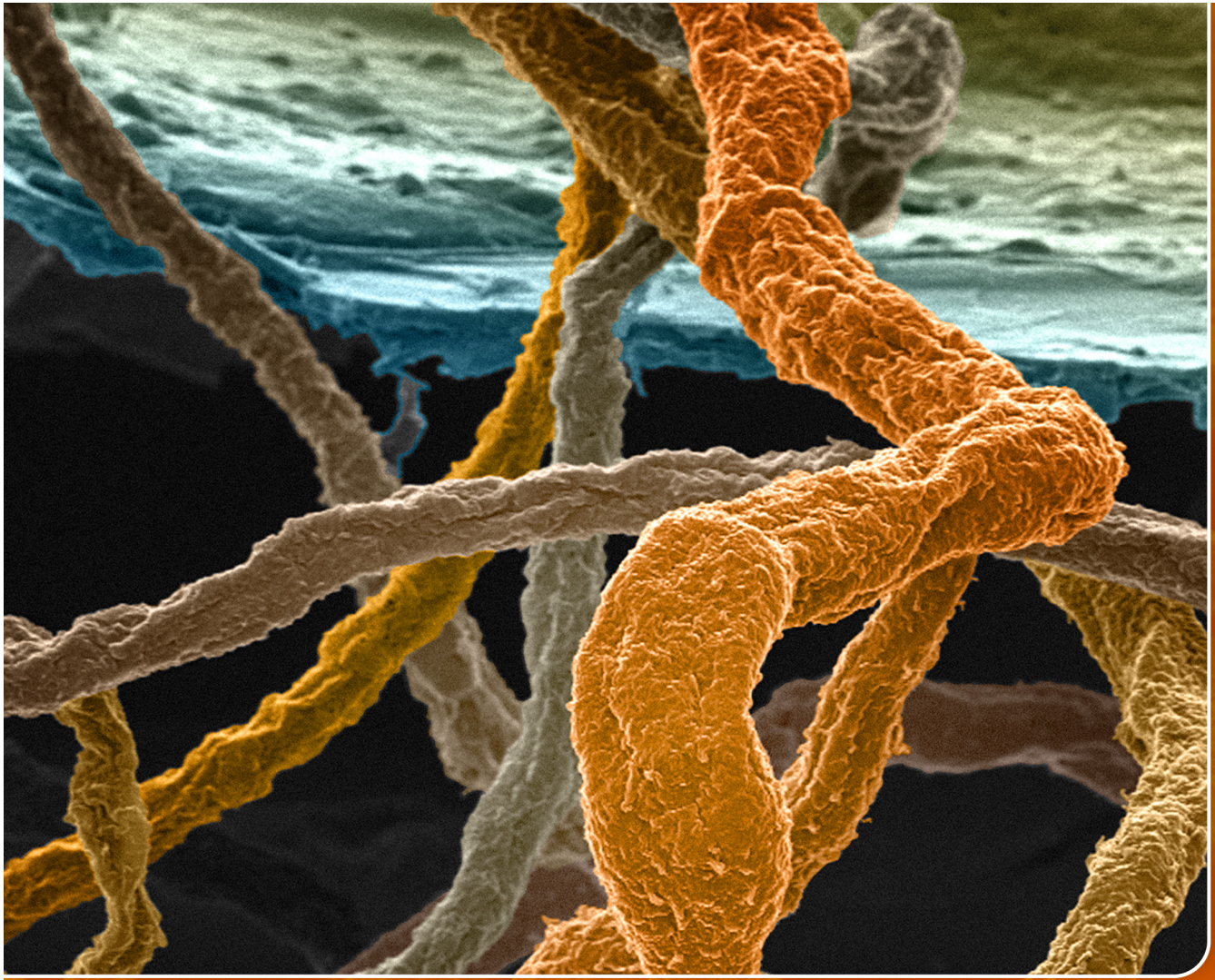

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Fungi Enlisted in Global Clean Energy Quest

Inconspicuous fungi are revealing solutions for a high-visibility need—that of abundant clean energy sources. The fungus Trichoderma reesei, shown here growing on finely-ground pieces of discarded corn stover (stalks, leaves and cobs), could foster rapid conversion of biomass to fuels. The fungus is known for its profuse production of biomass-degrading enzymes, which enhance the conversion process. Researchers have studied the genomes of Trichoderma reesei and other fungi, seeking to better understand enzyme production, and how enzymes might achieve biofuel breakthroughs. The research represented in the image was conducted at EMSL, the Environmental Molecular Sciences Laboratory, a U.S. Department of Energy Office of Science national scientific user facility located at Pacific Northwest National Laboratory. Funding was provided by DOE's Office of Biological and Environmental Research.

Research Team Members: Scott Baker, Bruce Arey and Kyle Pomraning, all of EMSL, and Sue Karagiosis of PNNL's Energy and Environment Directorate.

**Image was captured with a Helium Ion Microscope at EMSL and colorized by Nathan Johnson.*

SEP 2015

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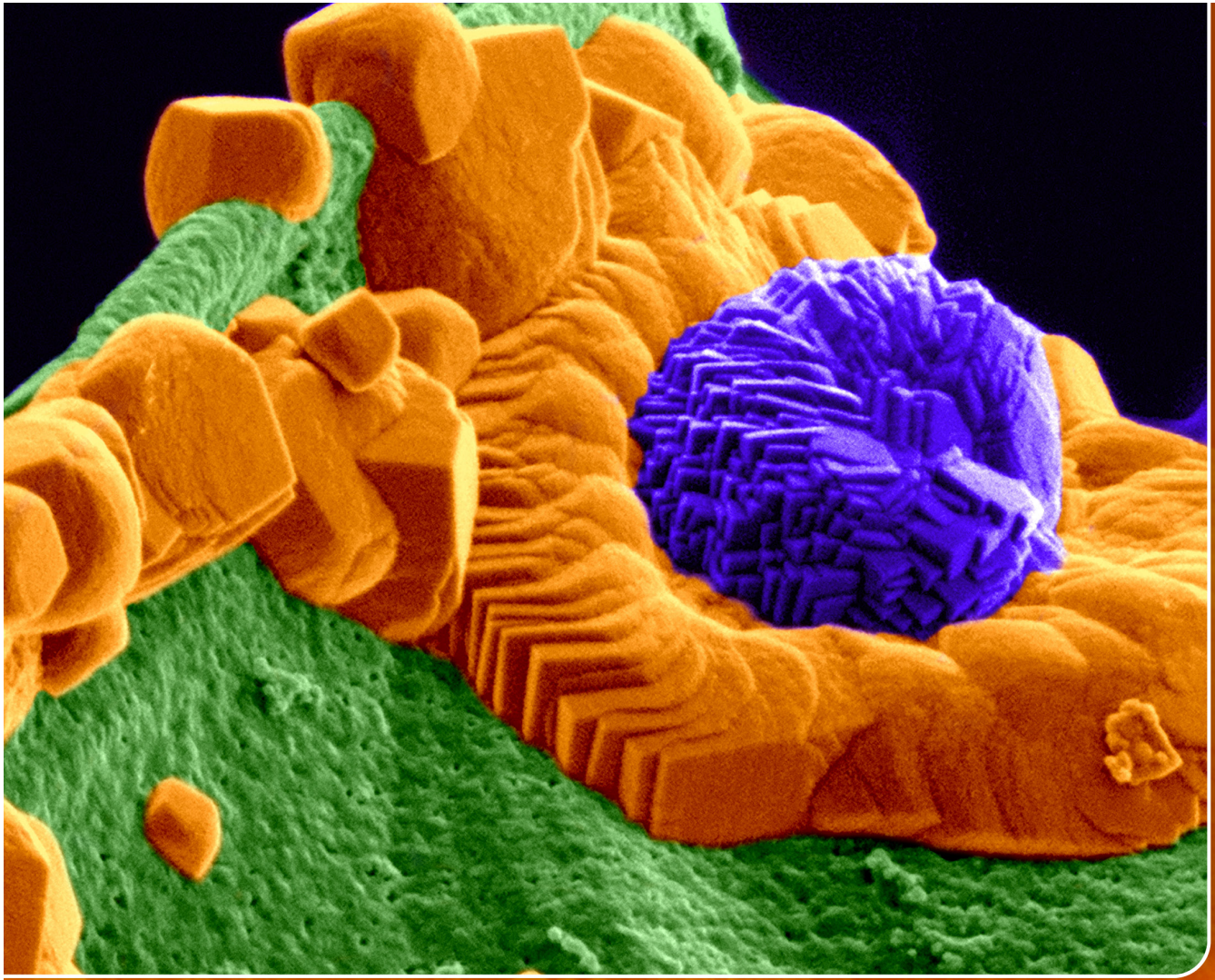

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A Subsurface Search for Terrestrial Solutions

The realm below our feet may be a key to protecting what's above. Researchers are exploring permanent safe storage of harmful greenhouse gases, such as carbon dioxide (CO_2), deep underground. The work has unearthed a key finding: the reaction between the mineral forsterite (green object in image) and CO_2 results in a different mineral, siderite (orange and blue). Siderite effectively captures the CO_2 in place, in a solid stable form. The discovery could help enable storage strategies that protect the climate and environment. Research funding was provided by the U. S. Department of Energy's Office of Basic Energy Sciences. The work was conducted at EMSL, the Environmental Molecular Sciences Laboratory, a DOE Office of Science national scientific user facility located at Pacific Northwest National Laboratory.

Research Team Members: Bruce Arey of EMSL, and Odeta Qafoku and Andrew Felmy of PNNL's Fundamental & Computational Sciences Directorate.

**Image was captured with a Helium Ion Microscope at EMSL and colorized by Bruce Arey.*

OCT 2015

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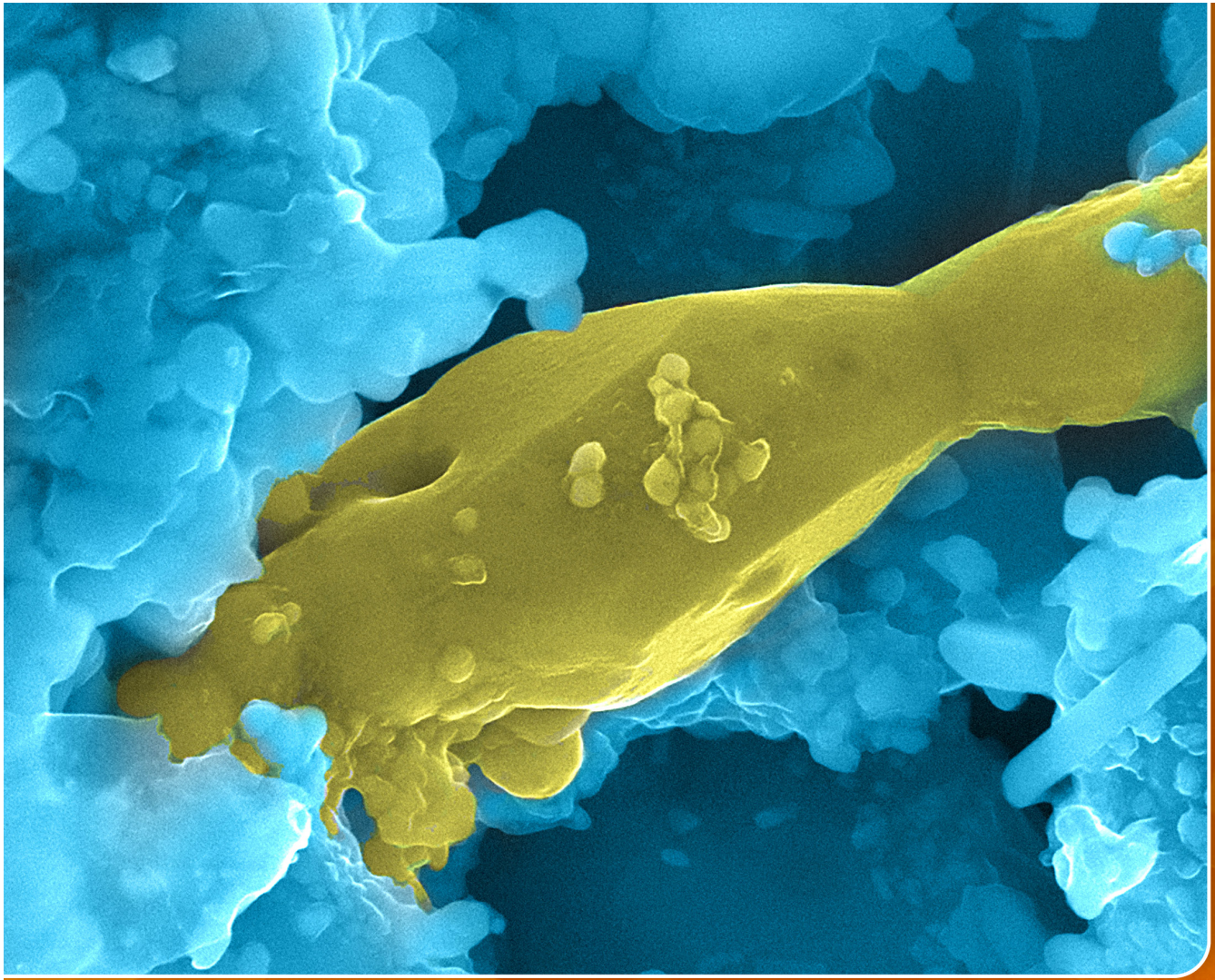

Pacific Northwest NATIONAL LABORATORY | U.S. DEPARTMENT OF ENERGY

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The Bridge to Fusion Energy

Researchers at Pacific Northwest National Laboratory are studying tungsten-copper composites as a model material for use in a futuristic clean energy source—nuclear fusion reactors. Experts believe reactor components will need to be robust and durable. Tungsten offers both characteristics, and combining it with copper or a similar, higher-melting metal, makes it even stronger and better able to withstand the wear and tear of fusion reactor operation. As PNNL's research effort demonstrates, the copper (green feature in image) acts as a bridge—helping to hold the tungsten (blue objects) together and prevent cracking. Much work remains to be done to confirm the viability of fusion reactors; it is anticipated that PNNL's materials expertise will be a key component in ongoing studies. This project, which is supporting international fusion energy efforts, was funded by the U.S. Department of Energy's Office of Fusion Energy Sciences.

Research Team Members: Chuck Henager, Rick Kurtz, Nicole Overman, Tim Roosendaal and Brennan Borlaug, all of PNNL's Energy and Environment Directorate. Also, staff at the University of California-Santa Barbara contributed to the project.

**Image was captured with a Field Emission Scanning Electron Microscope in PNNL's Materials Science and Technology Laboratory (3410 Building) and colorized by Nicole Overman.*

NOV 2015

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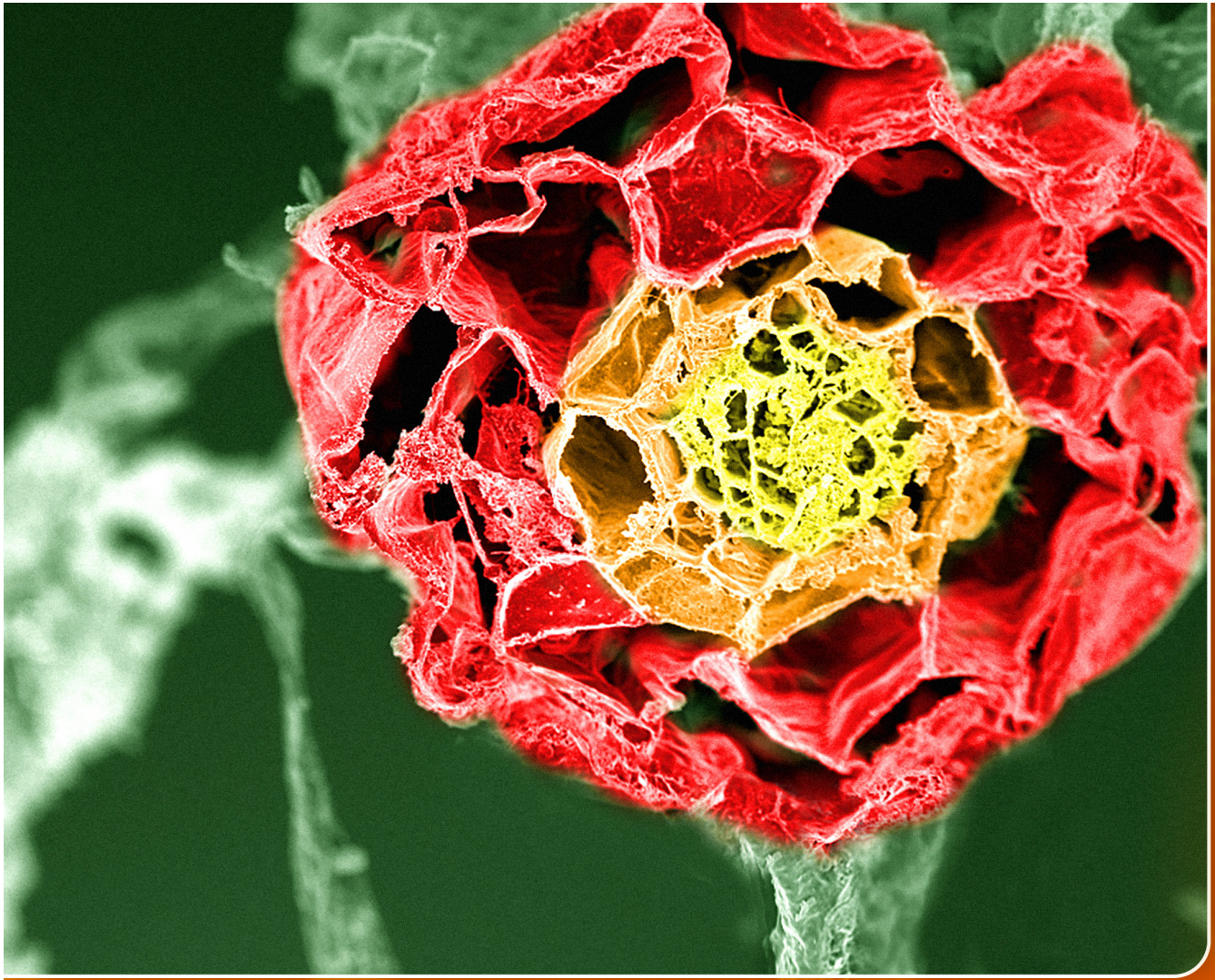

Pacific Northwest NATIONAL LABORATORY

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Revelations of a Root

The Arabidopsis plant's root structure, shown in a cross-section view, is helping to improve understanding of the rhizosphere, or plant root zone. Researchers believe learning more about the rhizosphere will help clarify environmental processes, and perhaps give rise to future climate and environmental solutions. Toward this goal, a rhizosphere research campaign was initiated at EMSL, the Environmental Molecular Sciences Laboratory, a U.S. Department of Energy Office of Science national scientific user facility located at Pacific Northwest National Laboratory. The effort has focused on the Arabidopsis plant's management of carbon nutrients and subsequent impacts on the diversity of the rhizosphere. The campaign includes scientists from EMSL, PNNL, DOE's Joint Genome Institute, Brookhaven National Laboratory, the University of Minnesota and the University of Missouri. The work is funded by DOE's Office of Biological and Environmental Research.

Research Team Members: Ljiljana Paša-Tolić, Alice Dohnalkova, Galya Orr, David Hoyt, Heather Brewer and Angela Norbeck all of EMSL; Kevin Minard, Meng Markillie and Charles Ansong of the PNNL Fundamental & Computational Sciences Directorate; Susannah Green Tringe (DOE-JGI), Richard Ferrieri (BNL), Mike Sadowsky and Chanlan Chun of the University of Minnesota and Gary Stacey, Yaya Cui and Lihui Song of the University of Missouri.

**Image was captured with the Helios Nanolab dual-beam focused ion beam/scanning electron microscope at EMSL and was created by Alice Dohnalkova.*

DEC 2015

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