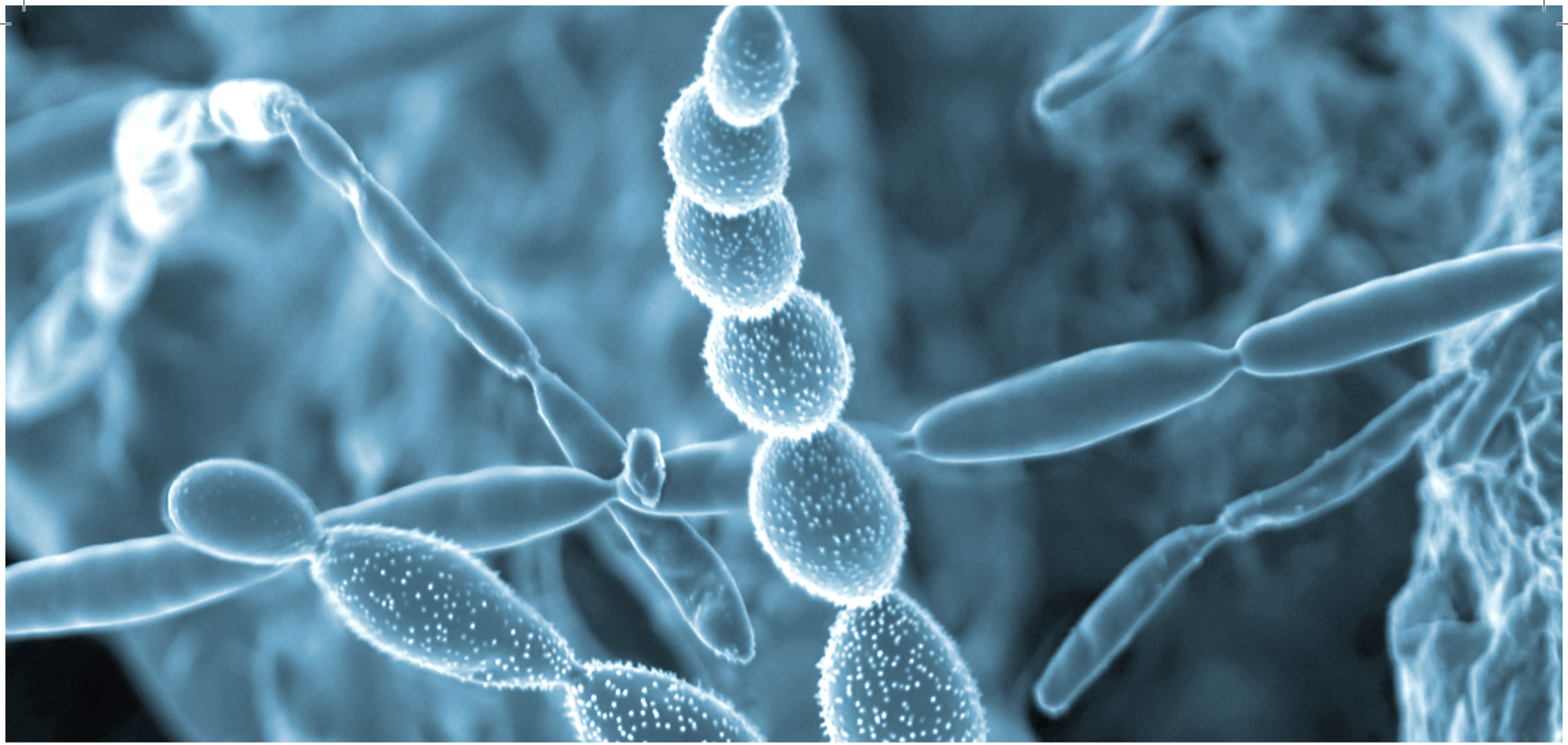

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Pining for Carbon

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. Microbes in the rhizosphere play a very important role in soil processes like mineral weathering and the transformation of soil organic matter.

Research Team: Alice Dohnalkova, Rosey Chu, Malak Tfaily, Alex Crump, Tamas Varga, Colin Brislawn and William Chrisler (PNNL).

This image was captured with the Helium Ion microscope in EMSL, the Environmental Molecular Sciences Laboratory, a DOE national user facility at PNNL.

JANUARY 2017

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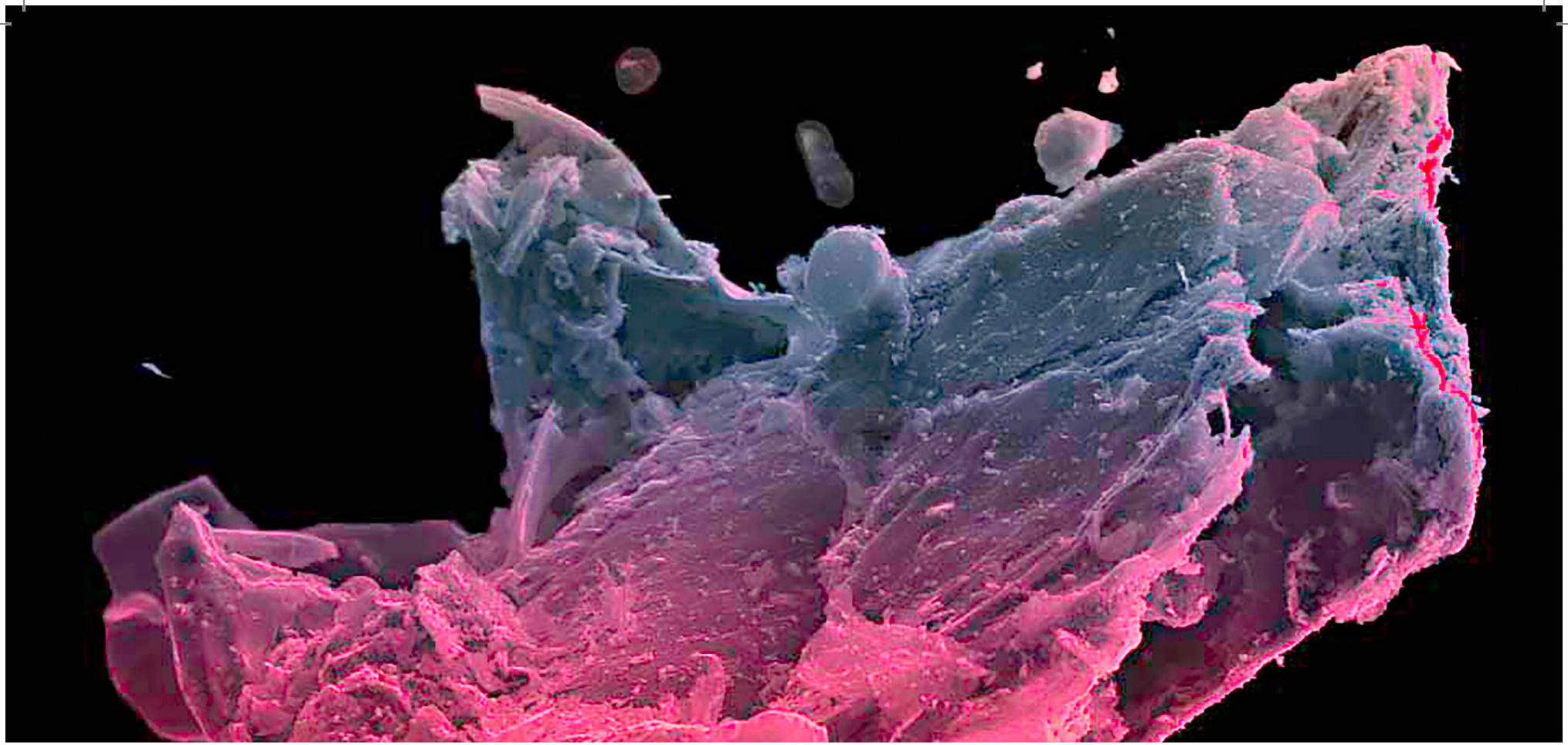

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A Chilling Innovation

Beating the heat might become a little easier, thanks to a new material developed at PNNL that offers outstanding refrigerant capacity and high thermal conductivity. The novel material shows promise for many advanced chiller applications, including air conditioning in buildings, U.S. Navy vessels and automobiles, as well as for power generation. The tiny structure is a metal organic framework—or MOF—overlaid on a porous carbon material using a unique method developed by PNNL. While the material development was initially funded through PNNL's Laboratory Directed Research and Development program, further development and synthetic methods to scale up production and enhance performance are being supported by the U.S. Navy Military Sealift Command and DOE's Geothermal Technologies Office.

Research Team: Radha Kishan Motkuri, Jagan Bontha, Rama Sesha Vemuri and Pete McGrail (PNNL).

This image was captured by Shuttha Shutthanandan with a Helium Ion Microscope at EMSL, the Environmental Molecular Sciences Laboratory, a DOE national user facility at PNNL.

FEBRUARY 2017

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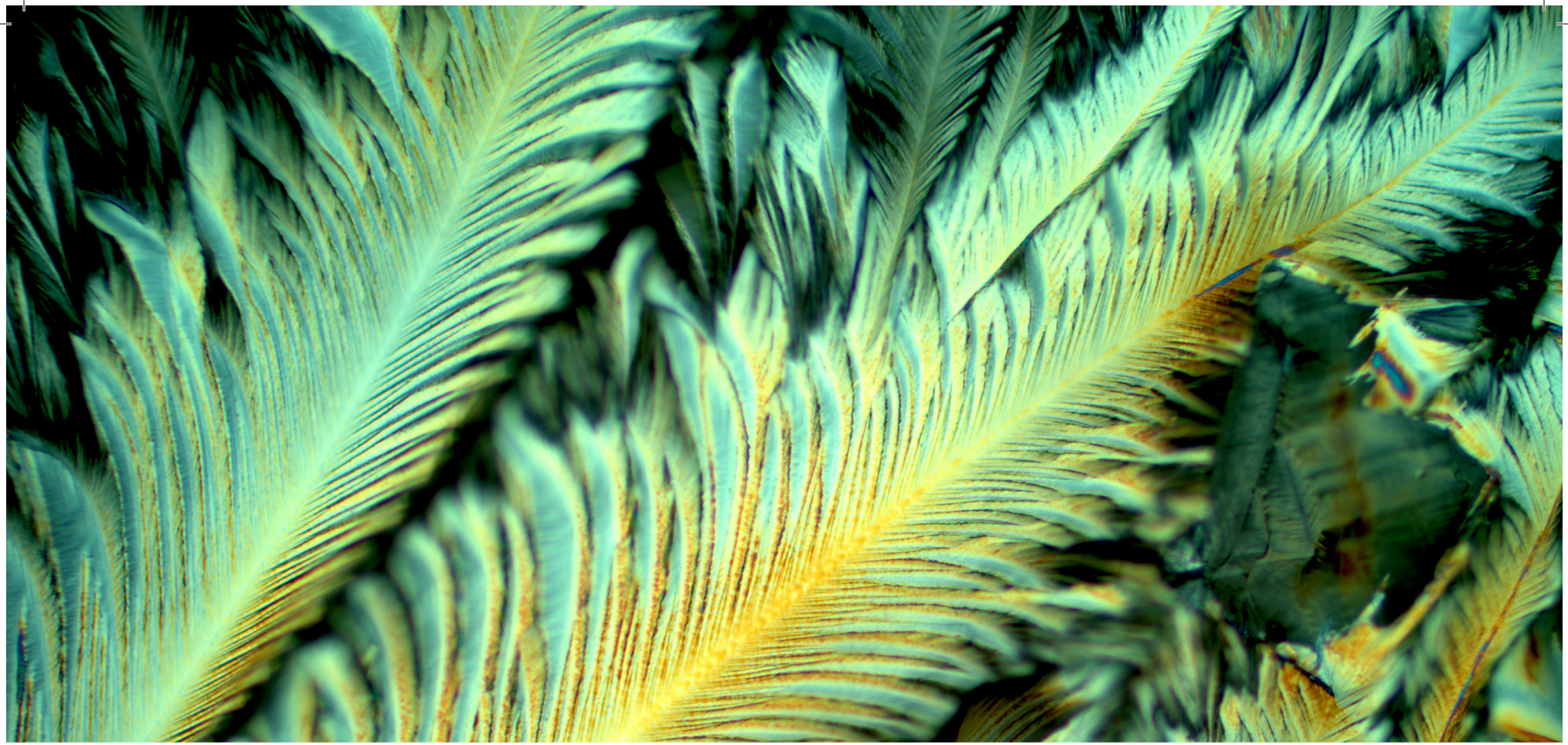

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A Snapshot of Dehydration

Researchers at PNNL and their 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, for example. Using time-resolved reflectance spectroscopy, they have captured some of the dynamics of this transformation. This image represents one moment in time; however, the picture quickly changed. Researchers watch the transformation process to examine the material's structure and behavior as it dehydrates. Studies of uranyl nitrate in the 1950s and 1960s were limited by the era's lower-resolution instruments. But 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.

Research Team: Edgar Buck, Timothy J. Johnson and Bruce McNamara (PNNL); Edward Mausolf, Phil Weck and Kim Eunja (University of Nevada Las Vegas).

MARCH 2017

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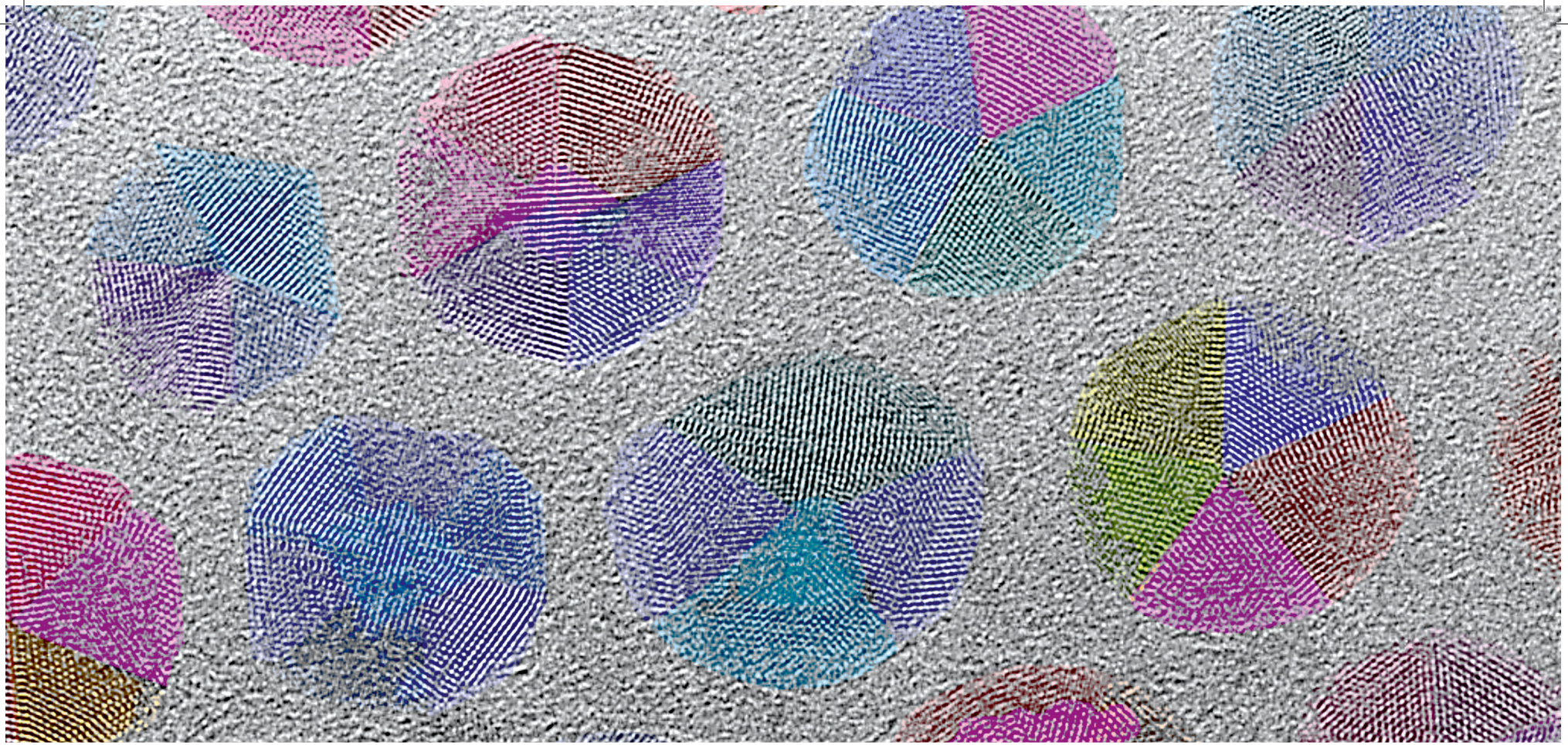

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Tiny Antennas Amplify Molecular Research

These silver nanospheres can be used as an antenna to enhance the optical properties of single molecules, creating a research platform that allows scientists to fingerprint a molecule's chemical identity. PNNL researchers study the properties of the nanospheres, including how they self-assemble with a uniform structure and how the resulting antenna effect provides a uniform signal. This level of nanometric uniformity is very difficult to achieve, but offers a new platform for researchers to take a closer look at the fundamental physical chemistry and physics of various molecules. This work was initiated with Laboratory 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.

Research Team: Patrick El-Khoury and Wayne Hess (PNNL); Patricia Abellan (former PNNL post-doc research associate) and Mikhall Zamkov (Bowling Green State University).

The image was captured with a transmission electron microscope.

APRIL 2017

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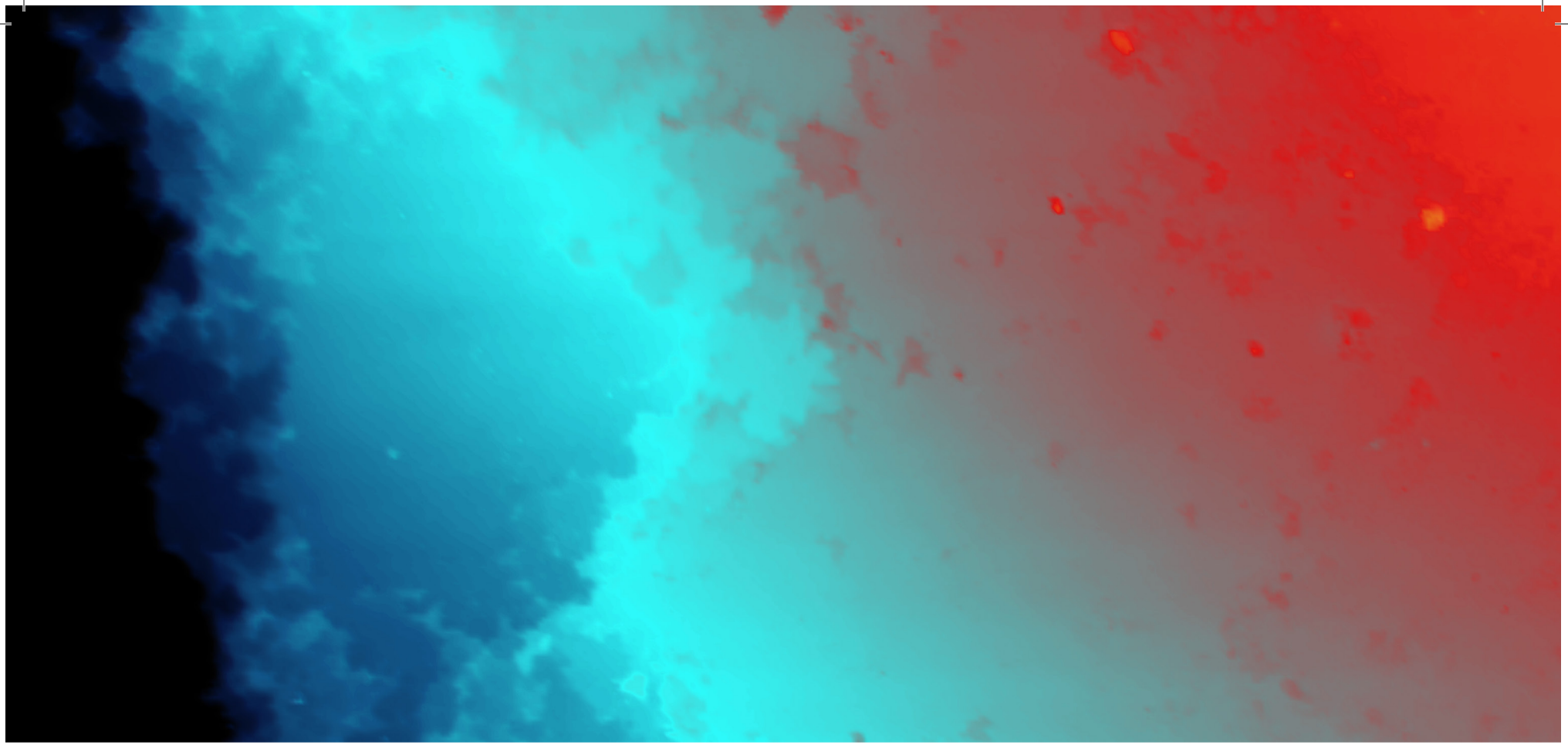

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As Smooth as Glass

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. Directly quantifying corrosion with these images is faster than analyzing the solution to determine how much material has leached from the glass. This research is funded by a joint DOE Office of Environmental Management and Office of Nuclear Energy project and by Washington River Protection Solutions.

Research Team: Tiffany Kaspar, Matthew Asmussen, James Neeway and Joseph Ryan (PNNL).

This image was captured by Tiffany Kaspar using a Bruker DI MultiMode atomic force microscope.

MAY 2017

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Purifying Copper Nuggets for New Knowledge

Whether hunting for elusive clues to particle physics questions, like the nature of dark matter, or detecting signatures from nuclear explosions, there is a need to analyze samples for minute traces of radiation. At PNNL's Shallow Underground Laboratory—buried underground to provide shielding equivalent to 30 meters of water—researchers conduct copper electroforming to further reduce background radioactivity in commercial, high-purity copper nuggets like those shown here. Over the last decade, PNNL has refined the copper electroforming process so that researchers can use this copper to develop some of the world's most sensitive radiation-detection systems. High-purity copper is used in ultra-low background detectors for national security applications, fundamental physics research and environmental science, with support from DOE's National Nuclear Security Administration and the Office of Science.

Research Team: Eric Hoppe, Craig Aalseth, Isaac Arnquist, Todd Hossbach, Martin Keillor, Harry Miley, Cory Overman, Nicole Overman and Anne-Marie Suriano (PNNL).

Photograph by Scott Butner, formerly of PNNL.

JUNE 2017

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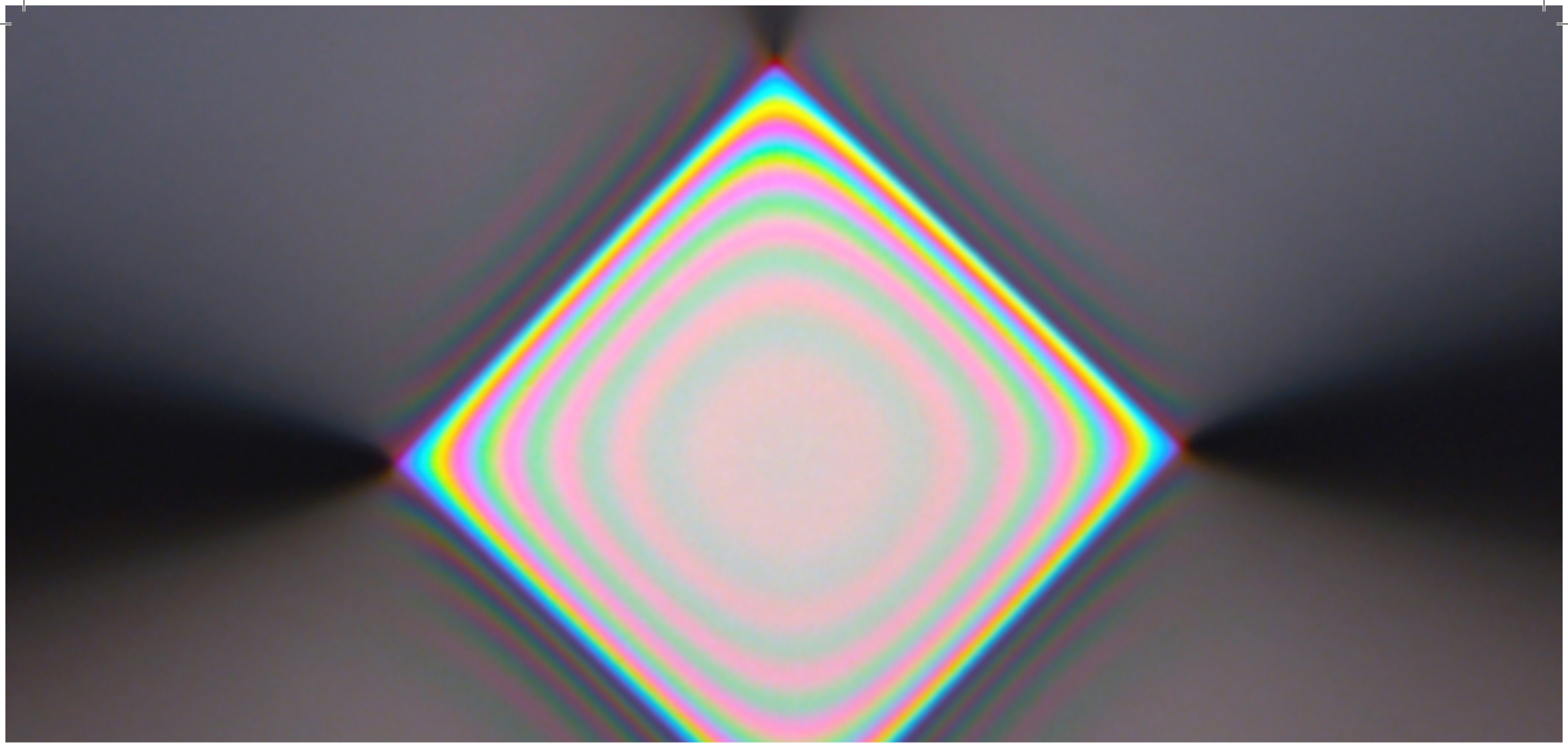

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Liquid Samples Locked and Loaded

PNNL scientists are studying biological and chemical system dynamics in real-time, thanks to their work in an emerging field called in situ fluid or liquid cell transmission electron microscopy. This microscopic image shows colored ripples of a thin liquid sample trapped between two transparent membranes centered on a device smaller than a pencil eraser. Preparing the sample like this allows researchers to observe dynamics at high magnifications while protecting the sample from the high vacuum of the instrument, which can cause it to degrade or change. With initial investments from PNNL's Chemical Imaging Initiative, this work is the foundation for new research supported by DOE's Biological and Environmental Research program, which is striving to image whole cells and dynamics relevant to bioenergy applications.

Research Team: James Evans, Trevor Moser (PNNL).

This image was captured with an optical microscope during sample loading prior to imaging on a transmission electron microscope in EMSL, the Environmental Molecular Sciences Laboratory, a DOE national user facility at PNNL.

JULY 2017

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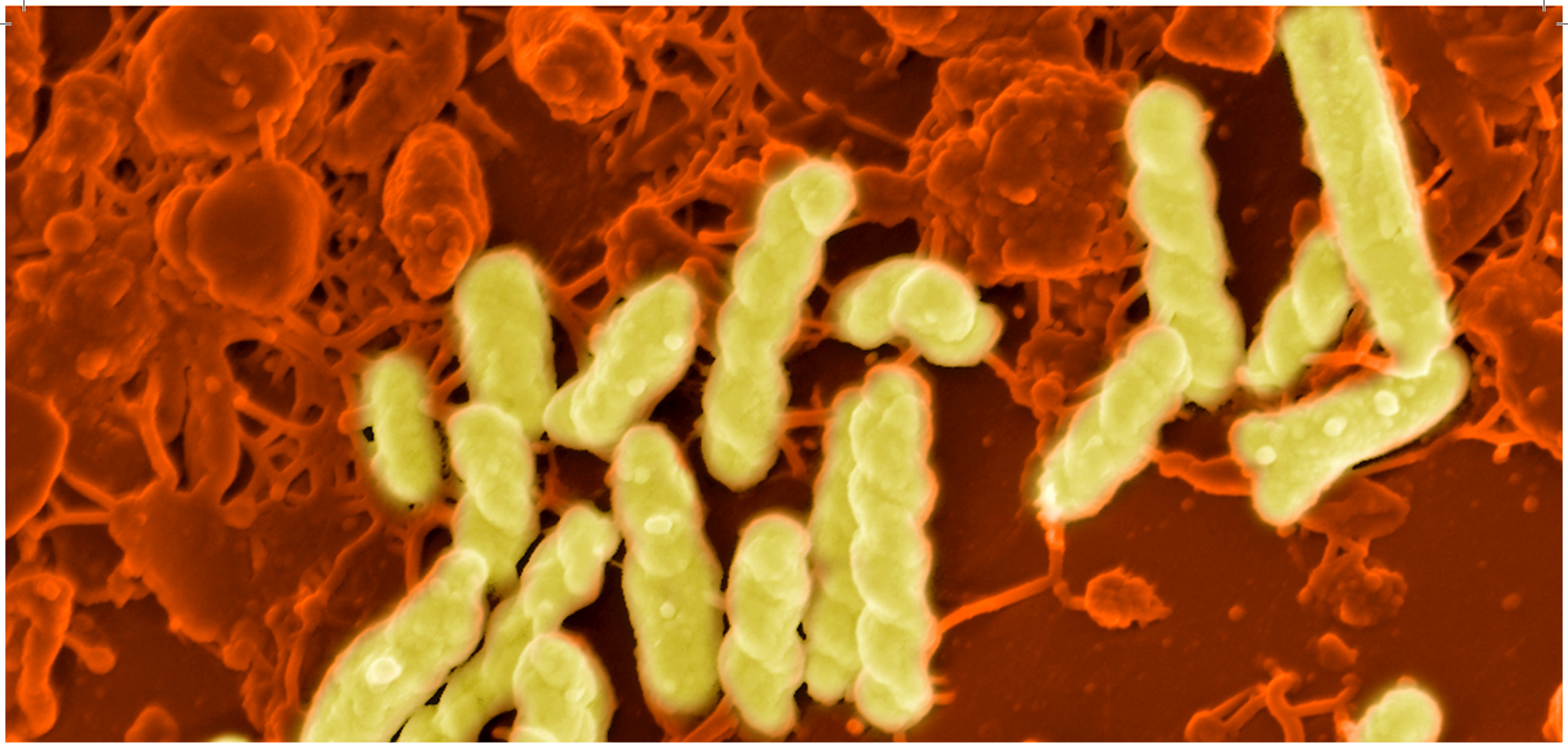

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The Good, the Bad and the Ugly

Every ounce of soil contains thousands of microorganisms—or microbes—including bacteria, fungi and viruses. Good ones contribute to natural processes such as carbon and nutrient cycling and nitrogen fixation. Bad ones can cause plant disease and death. And although some bacteria form nasty-looking biofilms, others have various unexpected shapes, such as the ones that look a bit like rotini pasta in this image. PNNL researchers are using Laboratory Directed Research and Development funding to study underground communities of microbes in the forests of the Pacific Northwest. They are striving to unravel the role of microorganisms in soil processes, such as how they extract nutrients from minerals and how they produce and stabilize soil organic matter, while transforming carbon to more persistent forms.

Research Team: Alice Dohnalkova, Rosey Chu, Malak Tfaily, Alex Crump, Tamas Varga, Colin Brislawn and William Chrisler (PNNL).

This image was captured using the Helium Ion microscope in EMSL, the Environmental Molecular Sciences Laboratory, a DOE national user facility at PNNL.

AUGUST 2017

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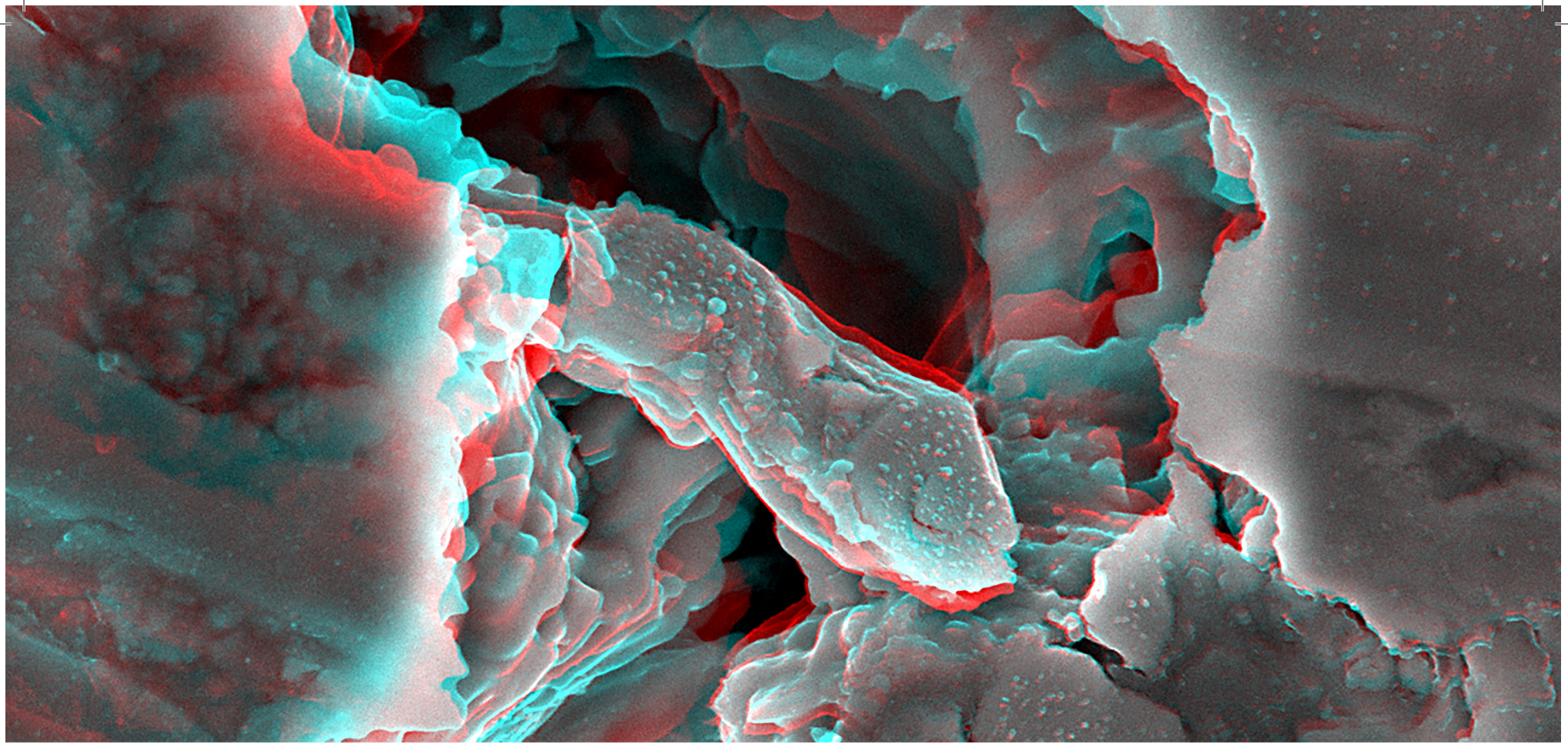

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A Material Improvement for Fusion Reactors

Researchers at PNNL are studying tungsten-copper composites as a model material for use in nuclear fusion reactors, a potential future source of clean energy. 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. As PNNL's research effort demonstrates, the copper acts as a bridge—helping to hold the surrounding tungsten together and prevent cracking. This project supports international efforts to develop tough tungsten composites and was funded by 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.

This image was captured with a Field Emission Scanning Electron Microscope in PNNL's Material Sciences and Technology Laboratory (3410 Building) by Nicole Overman.

SEPTEMBER 2017

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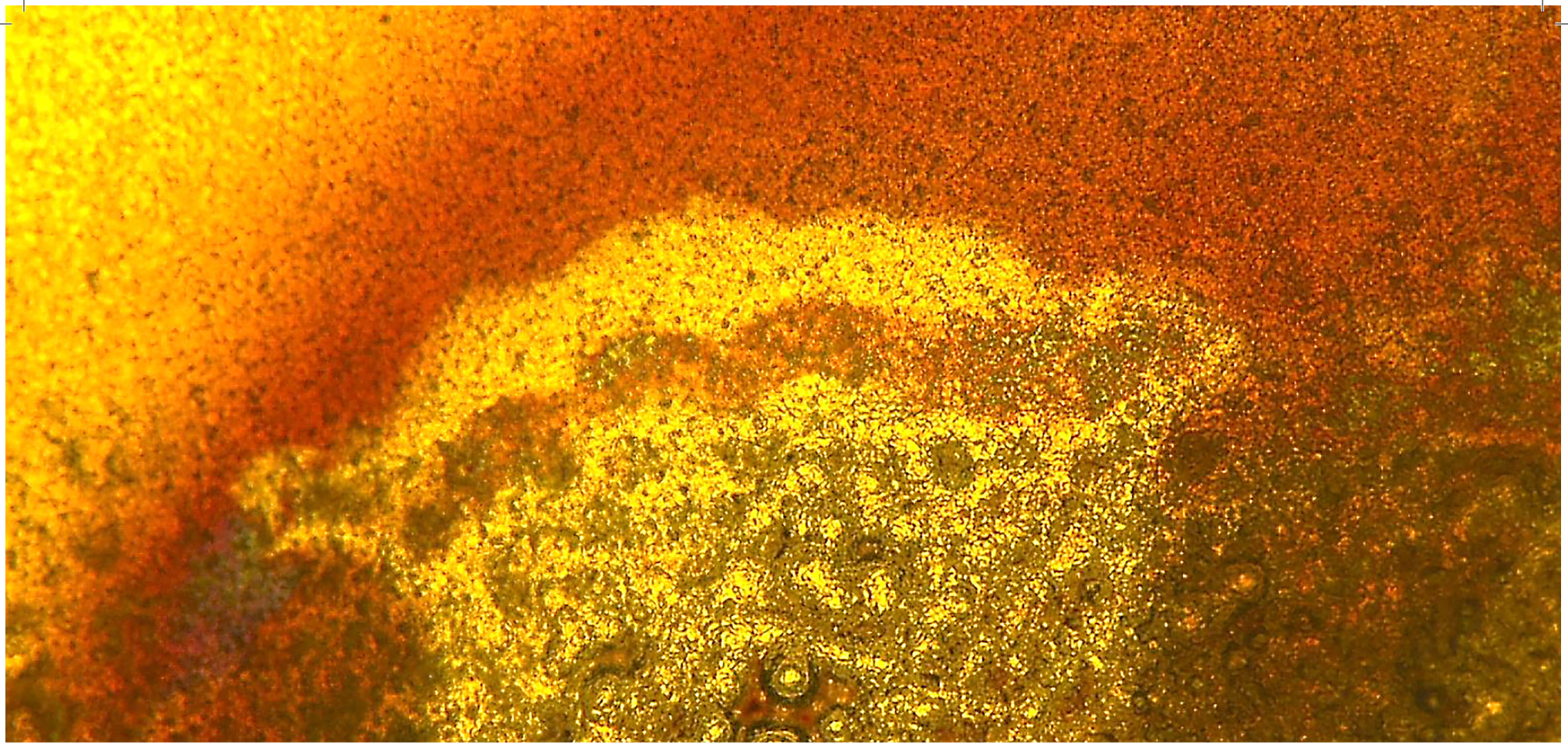

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Super Sticky Copper

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 addition to drawing upon PNNL's expertise in plating and annealing, the process involves pretreating the alloy with a PNNL-developed etching technology that allows the copper to stick even better. In this microscope image of an early research sample, the copper did not adhere completely 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).

OCTOBER 2017

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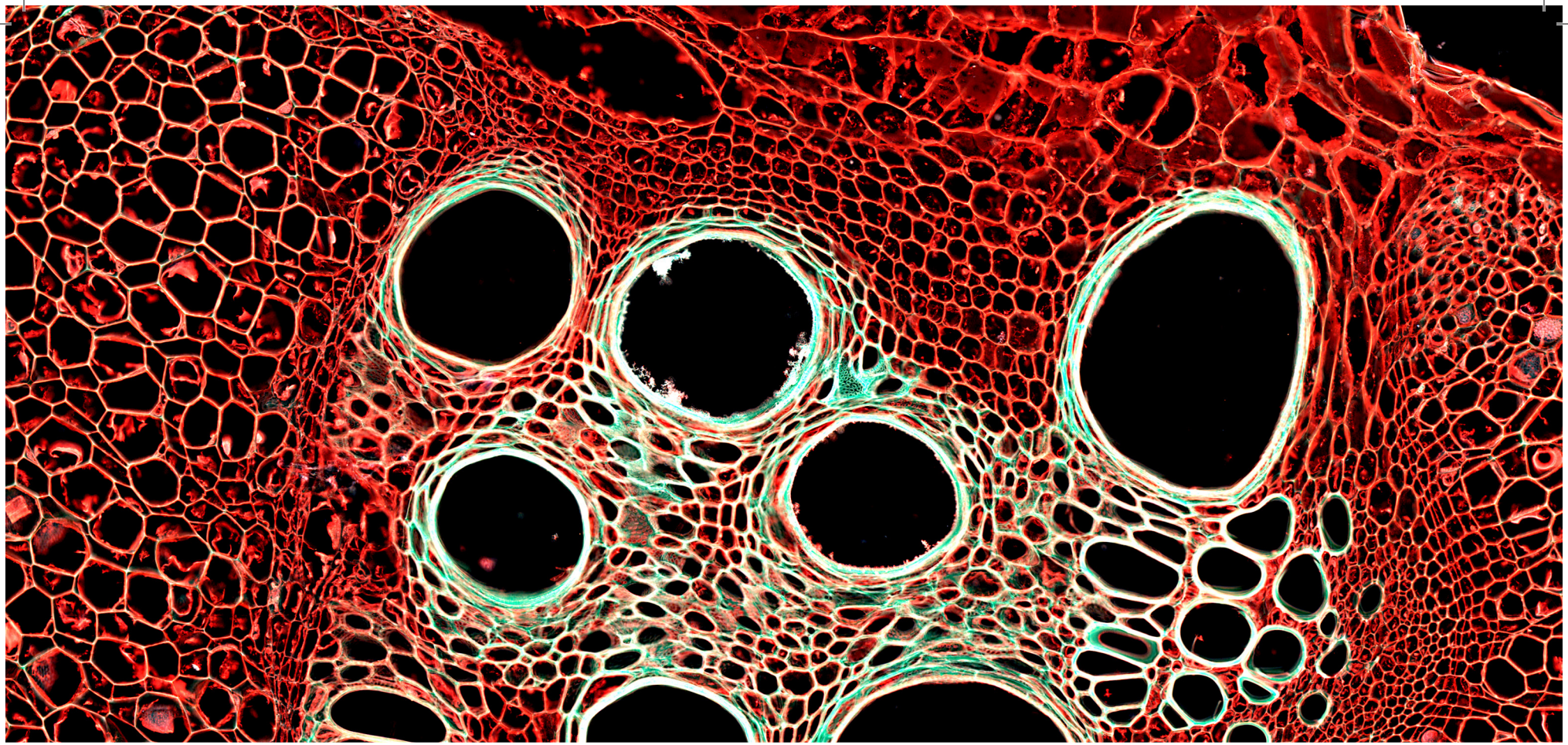

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A Search Engine for Scientific Research

Considering that images captured with high-throughput microscopy often contain over 5,000 megapixels, compared to the 8 megapixels produced by the camera on an iPhone 6, it could take days or even months for a scientist to manually analyze a single image, depending on the experiment. PNNL researchers, however, 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 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).

NOVEMBER 2017

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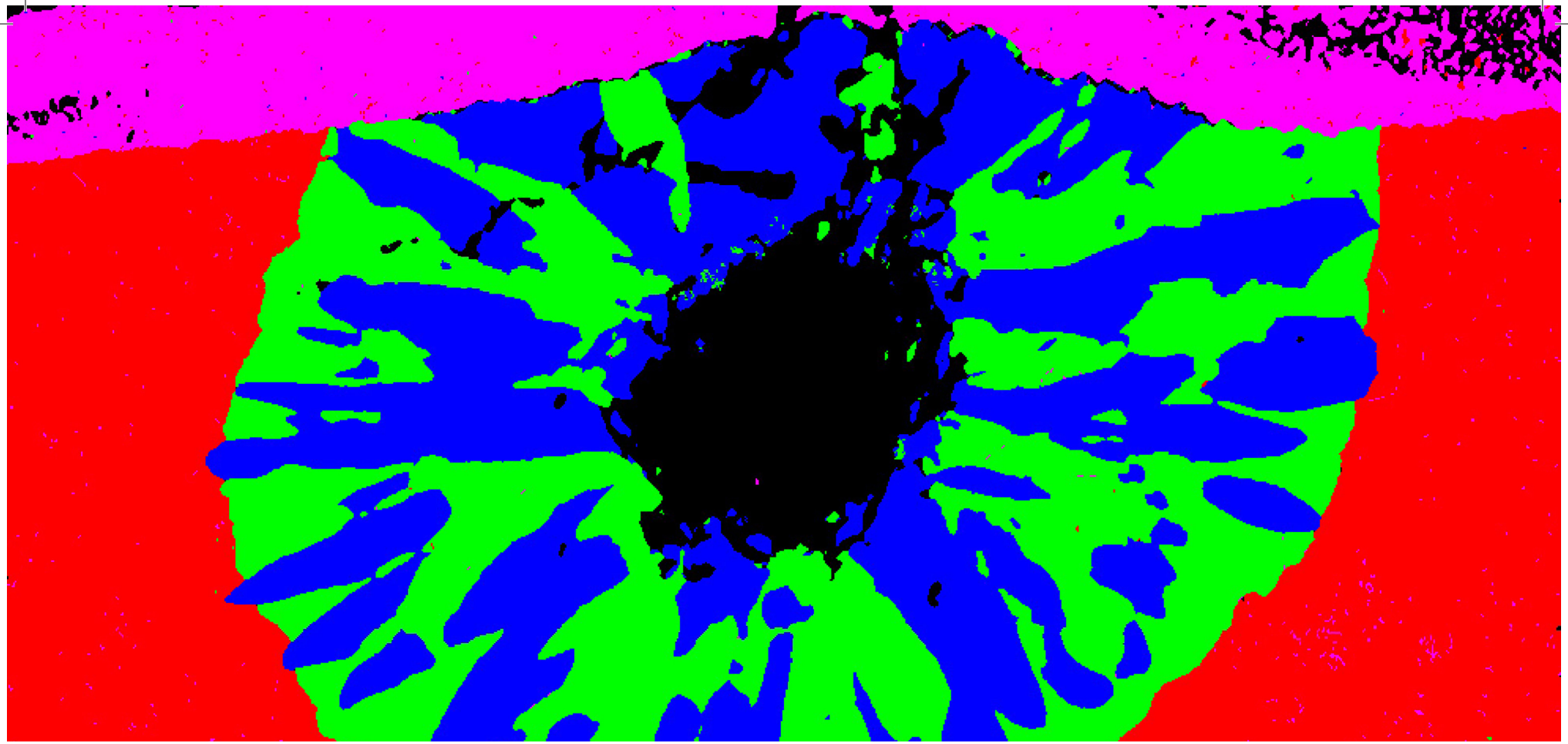

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Tougher Tungsten

Materials scientists at PNNL are developing a process to improve the toughness of tungsten at high temperatures, including reinforcing the brittle material with silicon carbide fibers. Their efforts, supported by Fusion Energy Sciences, focus on creating a tungsten composite that can handle the high-heat flux inside a fusion reactor without becoming brittle. Researchers embedded tungsten powder with silicon carbide fibers and then observed the reaction as it was heated. The different colors in this electron microscope image indicate different phases of the reaction. The red is the tungsten matrix, the black is the silicon carbide fiber and the green and blue are tungsten silicide and tungsten carbide—products that formed as a result of the reaction between the tungsten and silicon carbide.

Research Team: Aashish Rohatgi; Charles H. Henager, Jr.; Danny J. Edwards; Greg Coffey; John G. Frye; Karl Mattlin and Curt Lavender (PNNL); and David Catalini (formerly of PNNL).

This is a phase map created by indexing diffraction patterns taken at each pixel in a scanning electron microscope image.

DECEMBER 2017

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