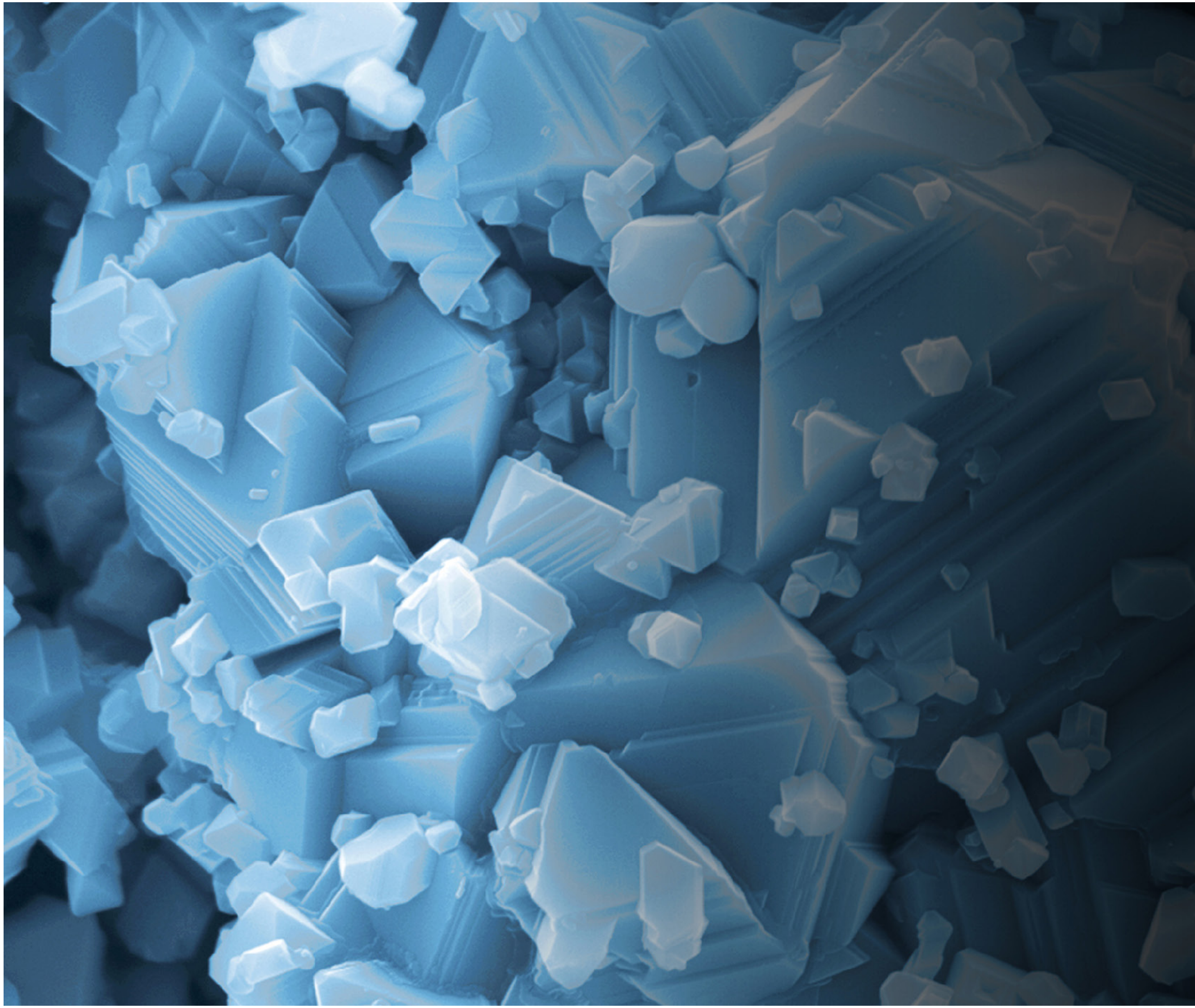

JANUARY

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Identifying Materials for Environmental Solutions

Researchers at Pacific Northwest National Laboratory have studied and synthesized spinel, a mineral, as a host for volatile radionuclides. The spinel could help increase retention of radionuclides during vitrification, a process that encapsulates radioactive waste in glass for long-term storage. This image, captured with a scanning electron microscope, showcases one of the researchers' creations—an agglomeration of crystalline trevorite spinel, made by heating oxide constituents in a molten salt flux. Millions of gallons of radioactive waste at the U.S. Department of Energy's Hanford Site will undergo vitrification at the Hanford Waste Treatment and Immobilization Plant, currently under construction. Greater retention of radionuclides in glass translates to improved efficiency and cost savings. The research was funded by the U.S. Department of Energy's Office of River Protection.

Team Members from PNNL: Brian Riley and Steven Luksic.

**Image was colorized by Brian Riley.*

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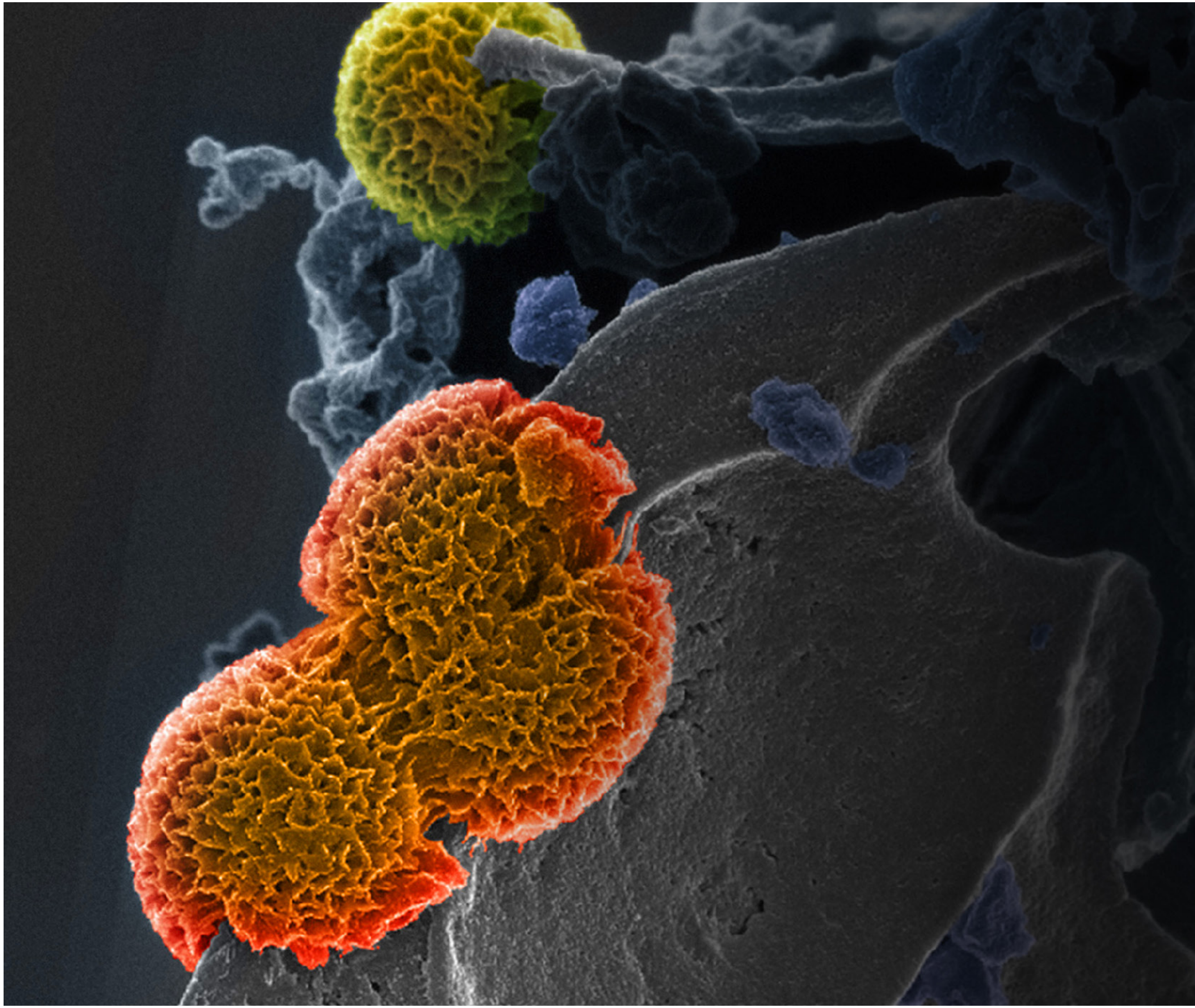

FEBRUARY

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Studying CO_2 Reactions at Low Temperatures

Pacific Northwest National Laboratory inquiries are unearthing new information about carbon dioxide (CO_2) reactions with minerals at low temperatures. Researchers at EMSL, the Environmental Molecular Sciences Laboratory, a U.S. Department of Energy national scientific user facility at PNNL, are applying electron microscopy to understand the secondary mineral phase and its chemistry, which informs efforts to capture and store CO_2 and other greenhouse gases deep underground. This image was captured with a helium ion microscope and shows forsterite (gray and blue objects) and secondary phase dypingite (orange and yellow objects) after reacting with fluid-like supercritical CO_2 for 43 days at 50 degrees Celsius. The research was funded by the U.S. Department of Energy's Office of Basic Energy Sciences.

Team Members: Andrew Felmy, Odeta Qafoku, Libor Kovarik and Bruce Arey.

**Image was captured with instrumentation at EMSL and colorized by Nathan Johnson.*

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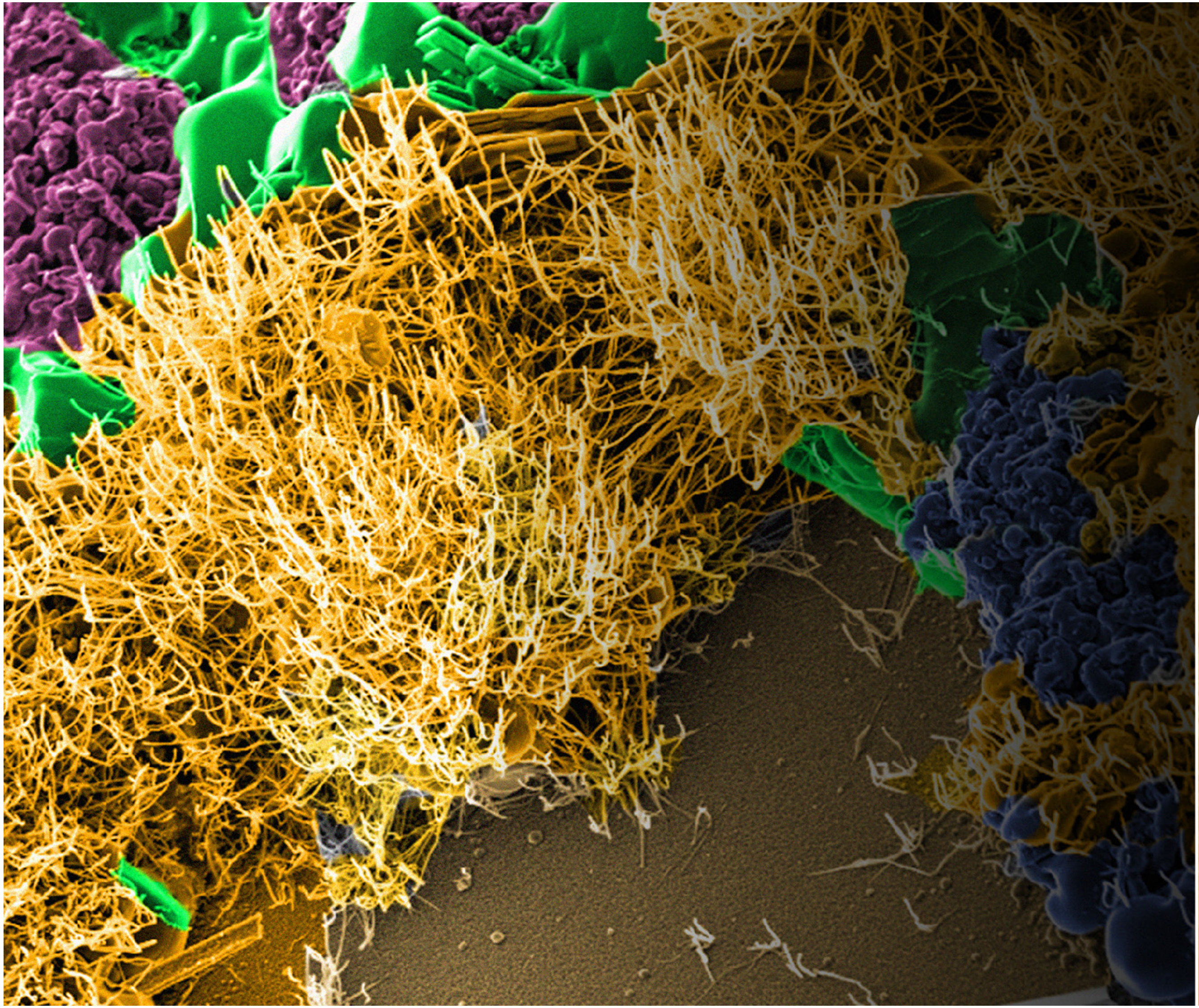

MARCH

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Gaining Insights into Technetium Behavior

Vitrification involves the use of heat to incorporate radioactive waste into glass for long-term storage. Researchers at Pacific Northwest National Laboratory are trying to understand why larger volumes of technetium, a contaminant that poses a significant environmental risk, cannot be incorporated into the glass. An inquiry funded by DOE's Office of River Protection took a closer look at technetium salts. The salts—shown as the gold fibrous structures in this colorized image—form during vitrification and may impede the incorporation of technetium into waste glass. Improved understanding of the salts could be a key in making waste treatment processes at the U.S. Department of Energy's Hanford Waste Treatment and Immobilization Plant, under construction, more efficient. This image was obtained with a scanning electron microscope.

Staff Member from PNNL: Edgar Buck.

**Image colorized by Edgar Buck.*

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APRIL

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Getting to the Root of Rhizosphere Challenges

This is what it looks like when the micron-sized spores of a ubiquitous fungus, Penicillium sp., mingle in the rhizosphere—or plant root zone—with roots, microbial biofilms and soil minerals. The rhizosphere is an important and influential zone that impacts many other environmental processes. A collaboration of researchers from EMSL, the Environmental Molecular Sciences Laboratory, and Washington State University is studying the biogeochemistry of plant-microbe-soil interactions. The work is expanding understanding of biogeochemical weathering, which provides nutrients to plants by mineral dissolution, assisted by microbes. Funding for the work was provided by the National Science Foundation and the U.S. Department of Energy's Office of Biological and Environmental Research.

Team Members: Alice Dohnalkova from EMSL and Kent Keller, Zhenqing Shi, Linda Thomashow and James Harsh from Washington State University.

**Image was obtained with instrumentation at EMSL, a U.S. Department of Energy national scientific user facility at PNNL, and was created by Alice Dohnalkova.*

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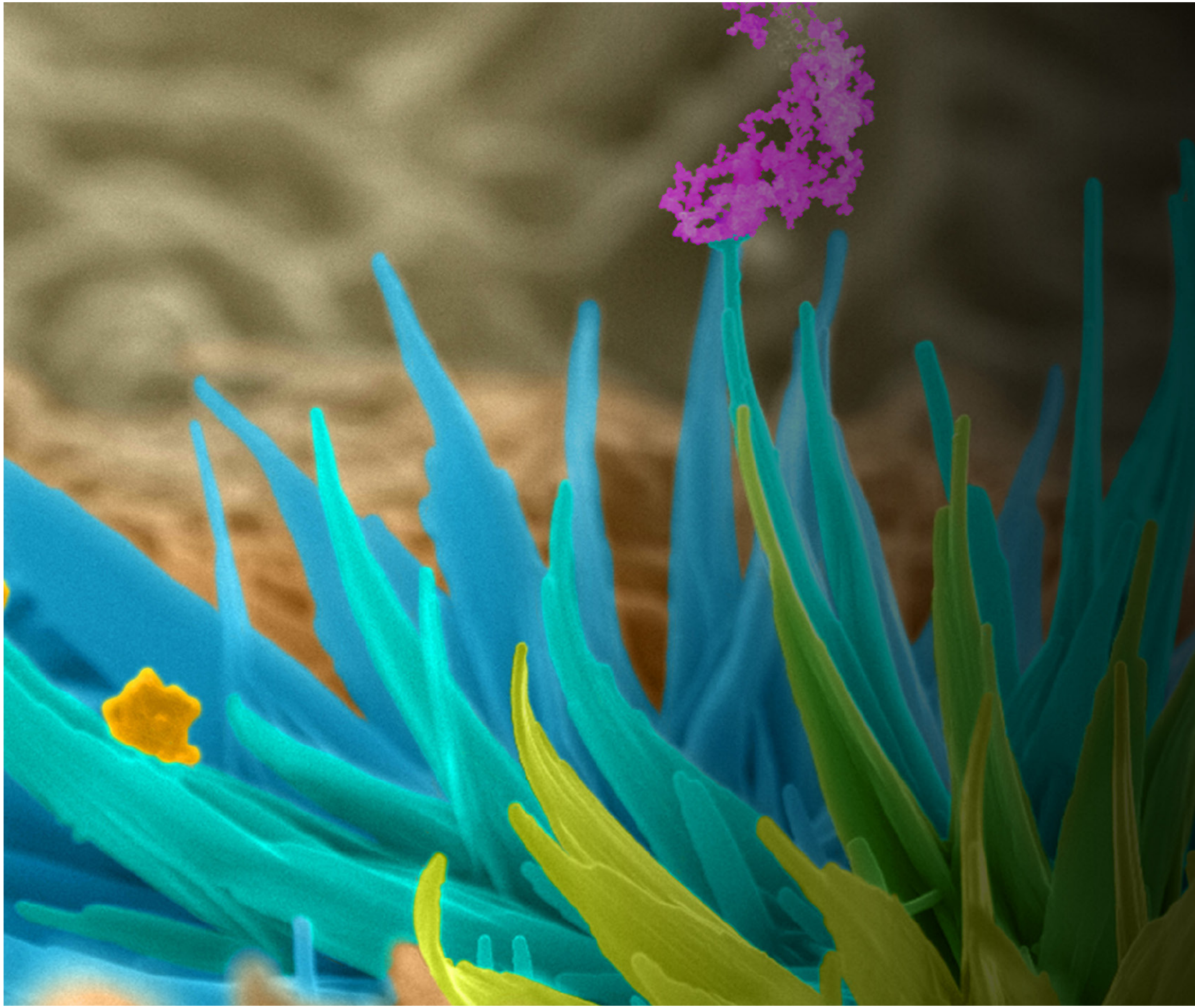

MAY

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Studying Nanofibers for Energy Storage Solutions

Nanofibers are an exciting new frontier of science. To optimize their promise, researchers at Pacific Northwest National Laboratory are applying a design material synthesis approach, which achieves targeted nanoarchitectures by controlling chemical reactivity at interfaces. The fibers shown in this colorized image—captured with a helium ion microscope—were created by an electrospin technique and are helping to advance the design of novel metal alloy anodes. The anodes are expected to improve the effectiveness of sodium-ion batteries and lead to low-cost energy storage solutions for the nation. The research was funded by the U.S. Department of Energy's Basic Energy Sciences program.

Team Members from PNNL: Jun Liu, Xiaolin Li, Liwen Ji and Bruce Arey.

**Image was captured with instrumentation at EMSL, the Environmental Molecular Sciences Laboratory, a U.S. Department of Energy national scientific user facility at PNNL, and was colorized by Nathan Johnson.*

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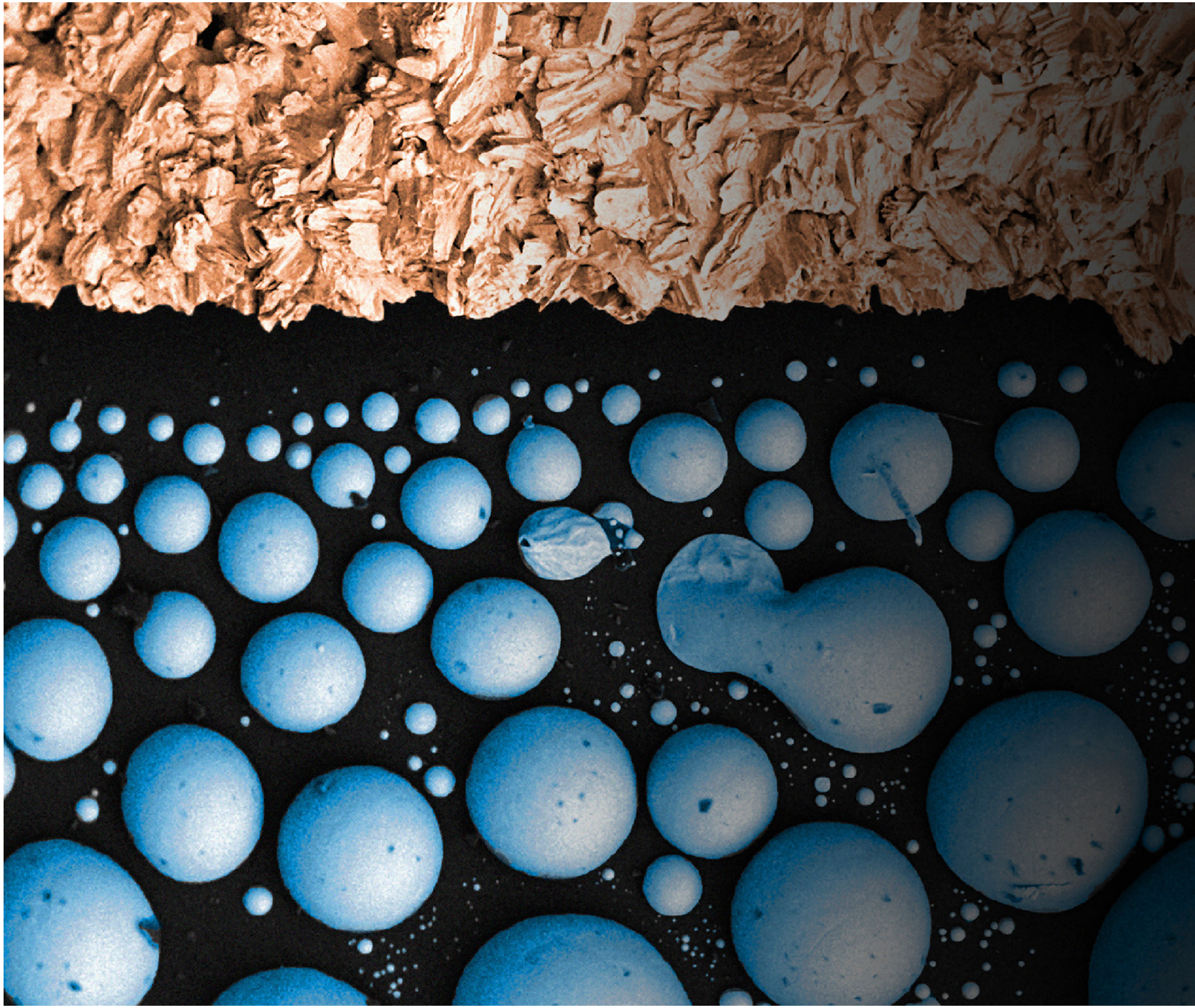

JUNE

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Exploring Selenium's Material Value

At Pacific Northwest National Laboratory, selenium microstructures, shown in crystalline (brown) and amorphous (blue) phases, were grown on a fused quartz substrate within a sealed glass vessel. The research was part of an effort to learn more about selenium as a source for semiconductor microstructures and nanostructures, which can be used in multifunctional chemical sensing devices. The colorized image was obtained with a scanning electron microscope. Research funding was provided by the Defense Advanced Research Projects Agency (DARPA).

Team Members: Brian Riley and Brad Johnson of PNNL, and former staff member S.K. Sundaram, now of Alfred University.

**Image was colorized by Brian Riley.*

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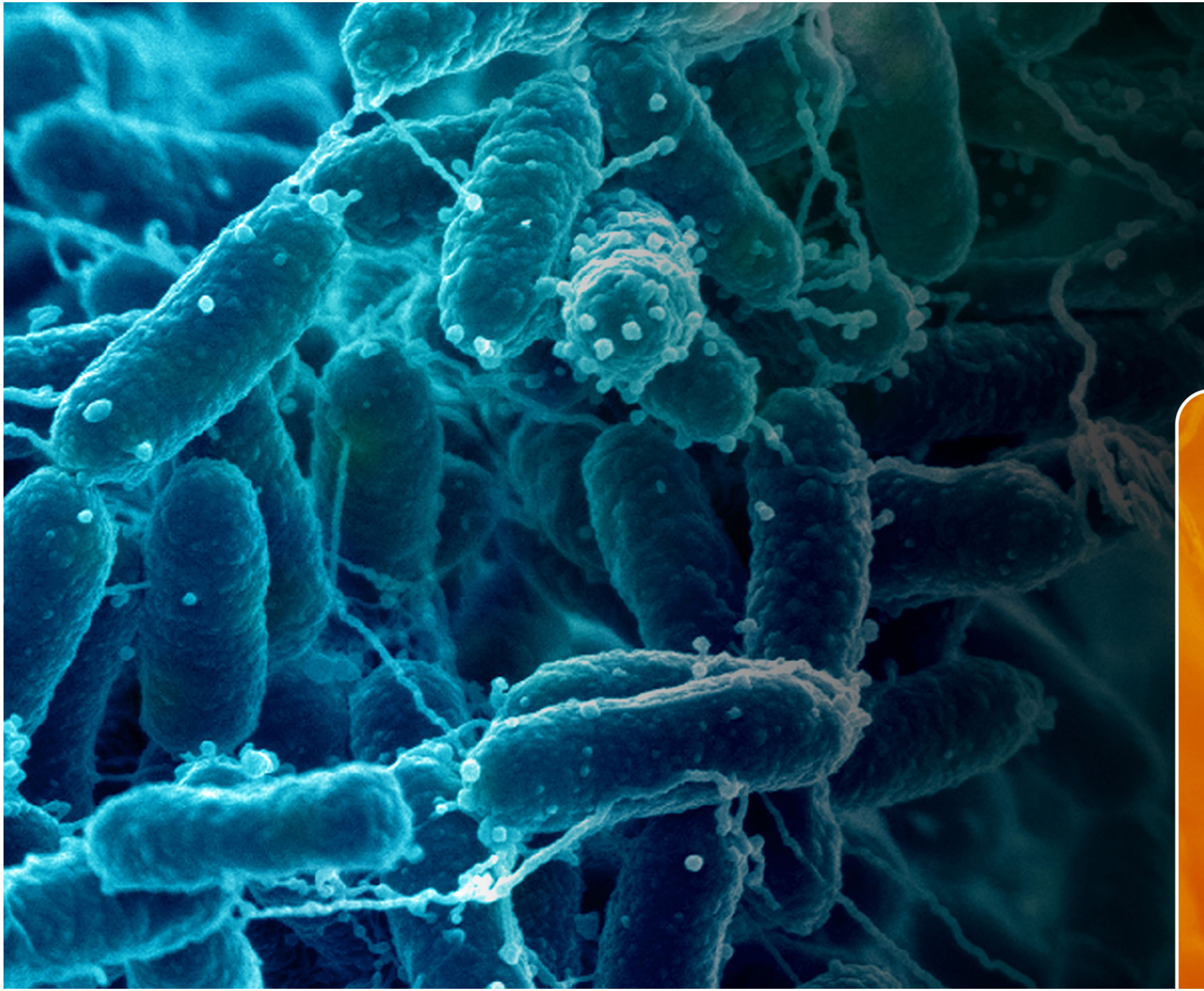

JULY

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Understanding Biofilm Roles in Reactions and Processes

Biofilms, or groups of microorganisms that form on surfaces, are tiny but mighty. They play a significant role in much larger reactions and processes, such as the migration of chemicals and radionuclides underground. To enhance our understanding of them, Pacific Northwest National Laboratory is characterizing biofilms and their chemical and physical interactions. This involves obtaining detailed microscopic images and chemical information. The biofilm in this colorized image, captured with a scanning electron microscope, was grown on a flat plastic substrate in a Constant Depth bioFilm Fermenter. The cylindrical objects are individual cells within the biofilm. Research was funded by PNNL's Laboratory Directed Research and Development program.

Team Members from PNNL: Sara Belchik, Alice Dohnalkova, Eric Hill, Leo Kucek, Matthew Marshall, Abigail Tucker.

**Image was captured with instrumentation at EMSL, the Environmental Molecular Sciences Laboratory, a U.S. Department of Energy national scientific user facility at PNNL, and was colorized by Abigail Tucker.*

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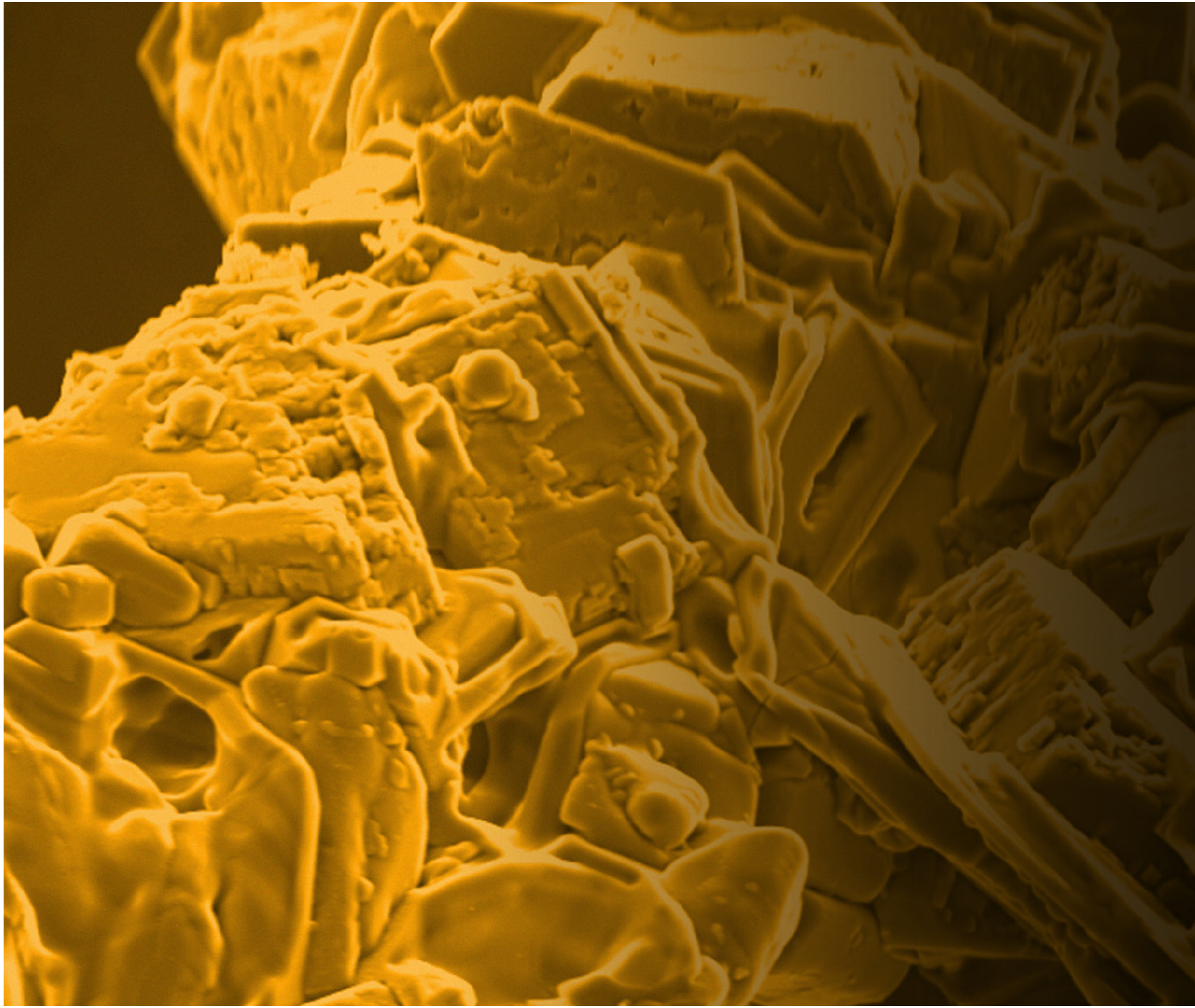

AUGUST

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Examining Historic Material for Future Security

Pacific Northwest National Laboratory has reached back into the past to help make the world safer and more secure for the future. Researchers at PNNL and the University of Notre Dame studied trinitite, the glassy residue left by the 1945 Trinity test, the world's first detonation of a nuclear device. Using gaseous nitrogen trifluoride to whisk away extraneous substances from the trinitite and prepare it for closer analysis, the inquiry produced new knowledge that's helping to inform national security objectives. The colorized trinitite image was obtained with a scanning electron microscope. Research funding for this project was provided by the U.S. Department of Energy's Nuclear Energy University Programs.

Team Members from PNNL: Edgar Buck and Bruce McNamara.

**Image colorized by Edgar Buck.*

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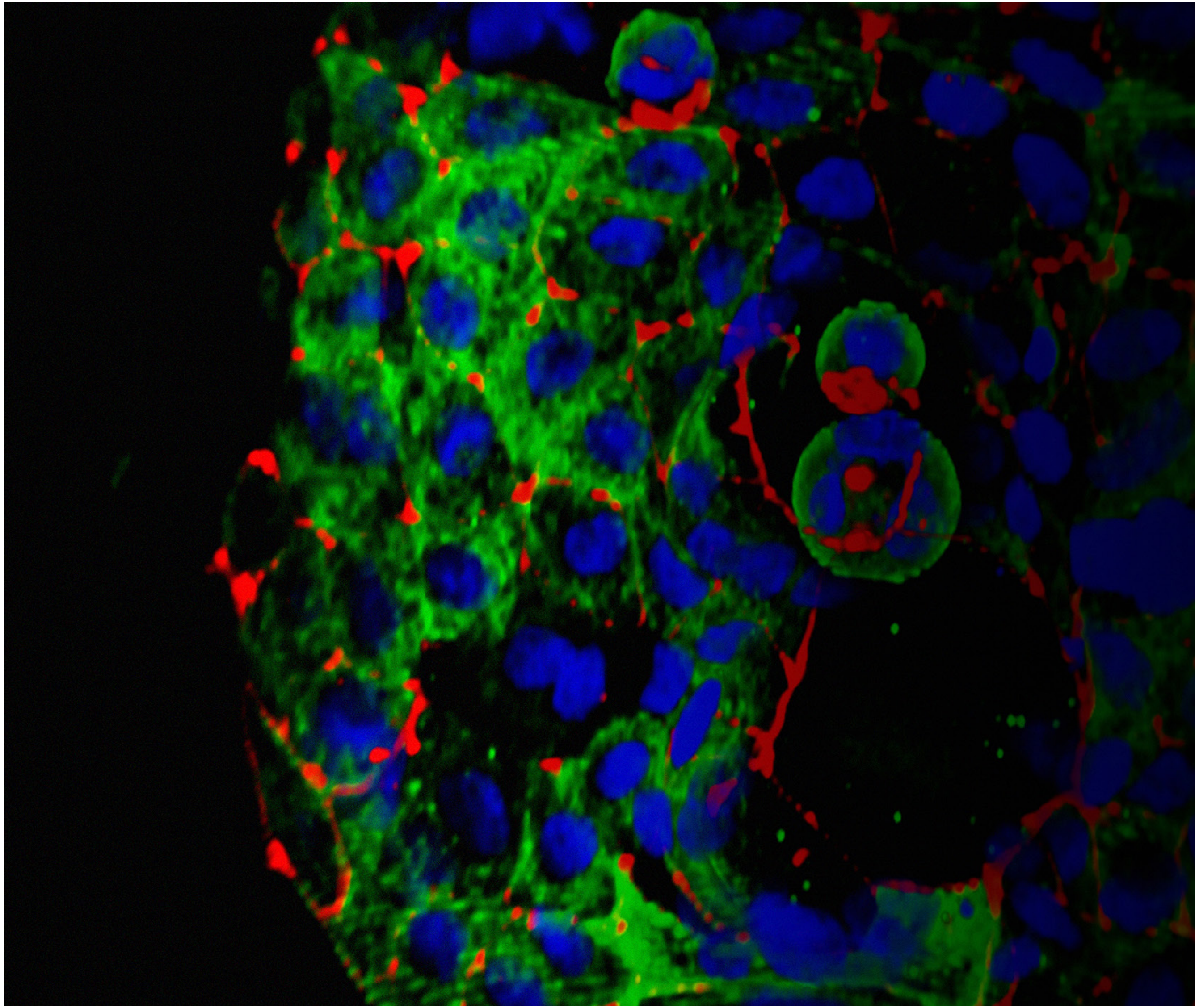

SEPTEMBER

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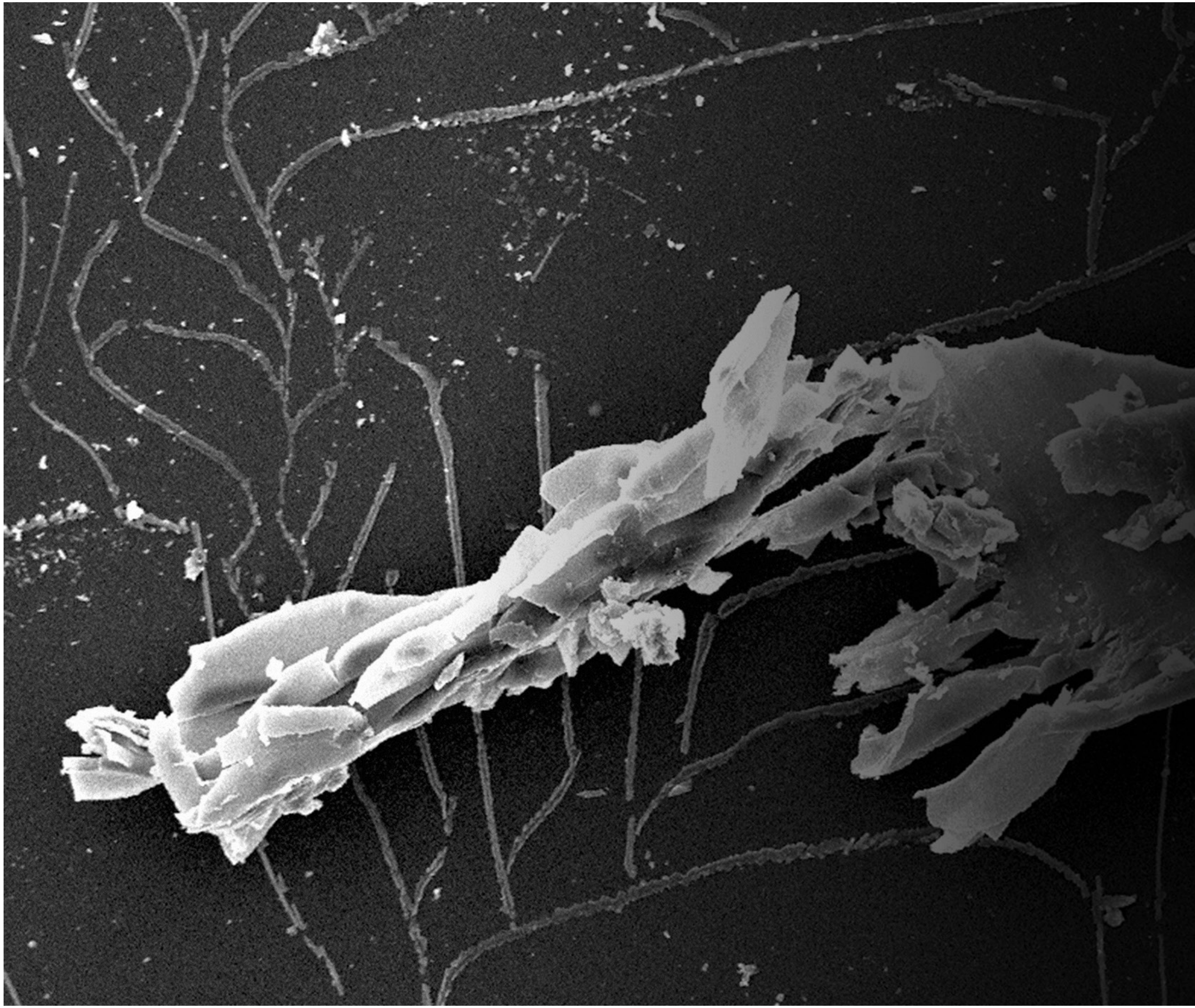
Improving Knowledge of Cell Biology

Researchers at Pacific Northwest National Laboratory are examining three-dimensional views of differentiated intestinal cells, atop microspheres, to better comprehend the biology of the cells. This work, funded through PNNL's Laboratory Directed Research and Development program, will contribute to improved methods for cell growth, purification and protein analysis, and is advancing methods and tools to understand human tissues and overall human health. The image was obtained using confocal microscopy and antibody staining.

Team Members: Janine Hutchison, William Chrisler, Helen Kreuzer, and Tim Straub.

**Image was captured with instrumentation at EMSL, the Environmental Molecular Sciences Laboratory, a U.S. Department of Energy national scientific user facility at PNNL.*



OCTOBER

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Expanding the Boundaries of Nanowire Potential

This image showing vapor deposition of arsenic sulfide on a fused quartz substrate was part of a Pacific Northwest National Laboratory inquiry into semiconducting nanowires. The tiny structures offer considerable potential for advances in electronics and other fields. PNNL's research, funded through the Laboratory Directed Research and Development program, explored the use of nanowires in telecommunications applications. The work resulted in a patent and was recognized by R&D magazine with an R&D 100 Award as a top technology product. The image was captured with a scanning electron microscope.

Team Members: Brian Riley and Brad Johnson of PNNL, and former staff member S.K. Sundaram, now of Alfred University.

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NOVEMBER

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Dedicating Computational Power to Scientific Inquiry

Computing resources serve as a foundation for impactful scientific results. The Aurora archive tape library, shown in this photo, is but one component of extensive computing capabilities available at Pacific Northwest National Laboratory. The Aurora system is a scientific data archive that plays a critical role in storing and protecting valuable and often irreplaceable research information. The system is based in EMSL, the Environmental Molecular Sciences Laboratory, a U.S. Department of Energy national scientific user facility at PNNL. Aurora was funded through the American Recovery and Reinvestment Act. Additional investment from PNNL's Institutional Computing program expanded the tape library's capacity. Aurora serves both EMSL and PNNL research projects.

Photo submitted by staff member Scott Butner, who retired in August 2013.

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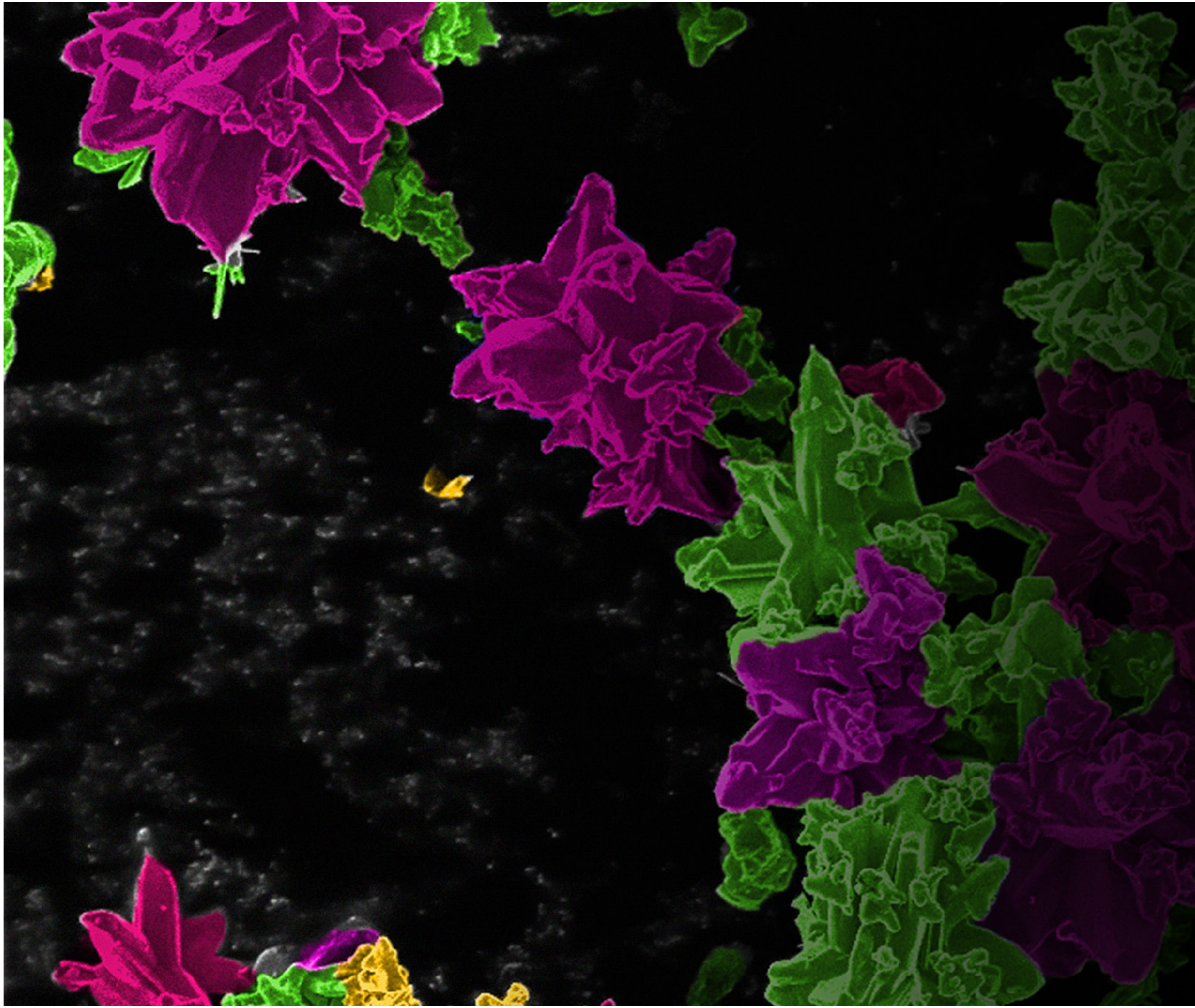

DECEMBER

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Advancing the Potential of Zinc Oxide

Researchers from EMSL, the Environmental Molecular Sciences Laboratory, are part of a multi-institute effort synthesizing and characterizing zinc oxide nanostructures, shown in the image above. Zinc oxide is a unique and versatile semiconductor material that's attracting increased attention due to its potential applications in a wide range of technologically important fields, including electronics, spintronics and radiation detection. Further, zinc oxide nanostructures offer substantial promise for miniaturizing electronic devices. Funding for this research has been provided by DOE's Office of Biological and Environmental Research and Office of Basic Energy Sciences, and additional research partners include Oak Ridge National Laboratory and the University of Tennessee, Knoxville. The image was captured with a helium ion microscope.

Team Members: Shuttha Shutthanandan and Manjula Nandasiri of EMSL, and Yanwen Zhang of ORNL and UT-Knoxville.

**Image was captured with instrumentation at EMSL, a U.S. Department of Energy national scientific user facility at PNNL, and was colorized by Shuttha Shutthanandan.*