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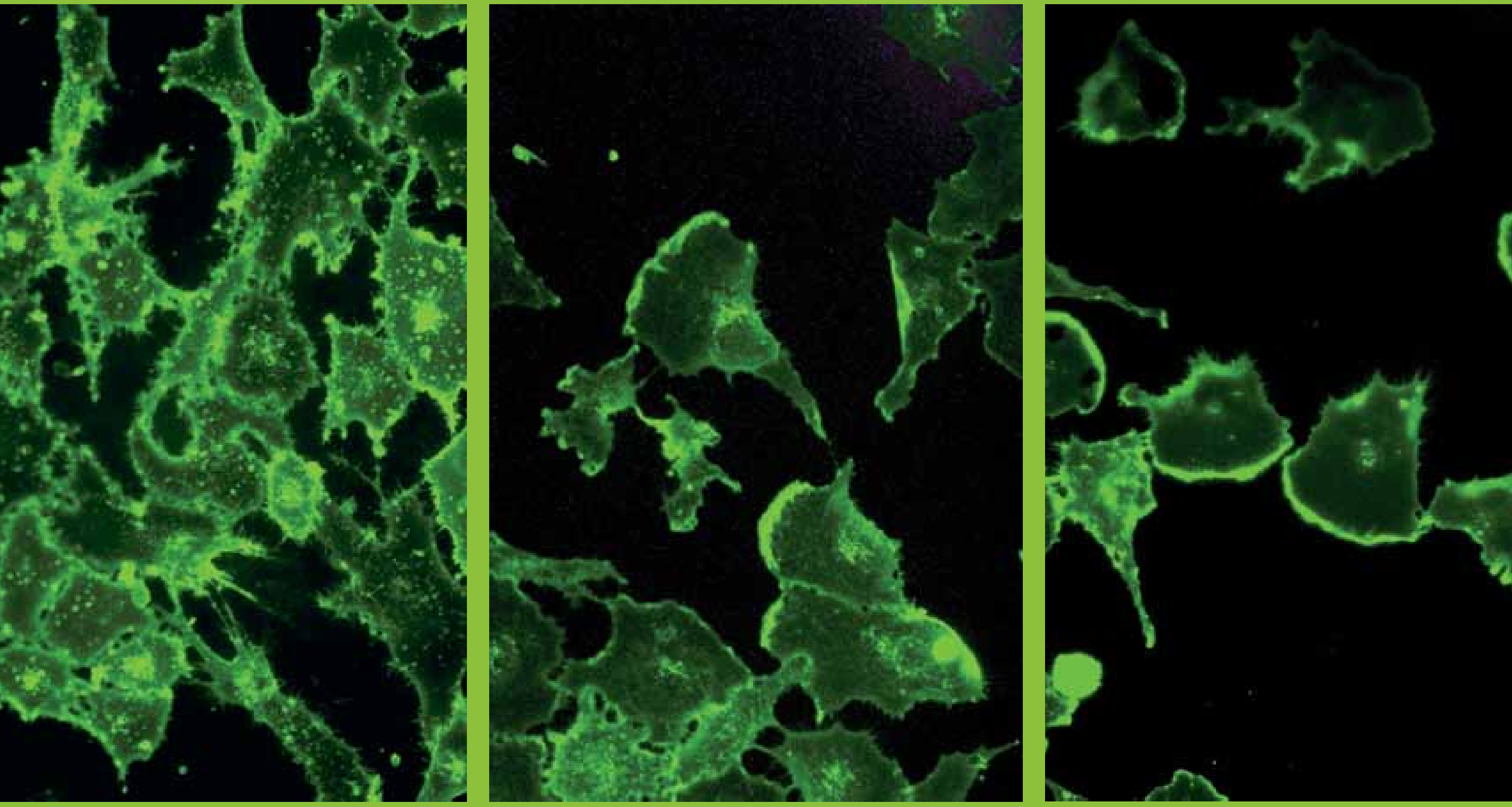

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THE HEAVY TRUTH ABOUT HELIUM

William Halperin, physics and astronomy, could sense that something was in the air. In October 2008, one of the students in his lab called a supplier to place an order for 10 liters of helium-3 to discover that prices had increased from $150 per liter to $1,000.

"That didn't sound right," says Halperin, who uses helium for basic research and discovery at low temperatures. "We checked around with other companies, and they wouldn't even give us a quote. So I knew something was happening."

Halperin later spoke with representatives from six companies, finding that only two still had helium supplies. The prices ranged from $800 to a whopping $2,000 per liter, well outside of his research budget. And things continued to worsen. The following summer, Halperin was contacted by the largest supplier of low-temperature refrigerators, which use liquid helium for cryogenic cooling. The company informed him that they were unable to obtain any helium-3 from their supplier, so their business was in jeopardy.

The helium shortage was sudden, taking businesses and researchers by surprise. And the shortage was global, touching every corner of the international market.

Helium-3 has its origins in the nuclear weapons industry. Tritium, an isotope of hydrogen used as fuel for the H-bomb, has a shelf life and decays with time into the more inert helium-3. Helium-3 must be extracted as a maintenance measure. Naturally occurring helium-3, on the other hand, is a million times more rare than helium-4, the more massive isotope that's found in party balloons.

Because it can achieve cryogenic temperatures as low as within a few thousandths of a degree of absolute zero, helium-3 is ideal for low-temperature scientific programs, including superconductivity, magnetism, nanoscience, and quantum information technology. In addition, the valuable isotope is used for neutron detection, oil- and gas-well evaluation, building construction technology, and the improvement of lasers.

"Since the end of the Cold War, helium-3 has diminished year by year," Halperin explains. "There was a huge stock available early in 2001 that vanished due to a tremendous increase in demand."

The question on Halperin's mind was what caused the sudden increase in demand, and he found that the answer was amazingly opaque. "I'm not normally in tune with this," he says. "I have a lab. We use helium. But I don't know the marketplace."

Halperin began making phone calls and was ultimately put in touch with three men at the Department of Energy (DOE) and Department of Homeland Security. Through this chain, he discovered that helium-3 played a major role in security upgrades established after September 11, 2001. The gas is used as a detector of radioactive materials, such as plutonium and enriched uranium, at ports, airports, and border crossings.

"Homeland Security decided it needed many of these screening devices and contracted a company to develop the detectors," Halperin says. "The company made them without first checking how much gas was available. So Homeland Security committed itself to a major capital program with billions of dollars invested, but it turns out there's insufficient helium-3. The first reaction of the DOE and Homeland Security was that they'd just take everything they could. They depleted the stockpiles — taking about 150,000 liters — without looking to see what the equilibrium was between supply and demand."

This left the stocks near zero, putting cryogenic research in a desperate situation. Matthew Grayson, electrical engineering and computer science, is one of the many scientists feeling the crunch.

"I was extremely lucky because I purchased and received my refrigeration system before the shortage hit," says Grayson, who uses low temperatures to study conductors and quantum electronics. "But if I want to buy another system, I can just forget it. Not because the equipment is too expensive but because there is nothing. Nothing. The cupboard is bare."

Armed with a comprehensive e-mail list of contacts from the global cryogenics community that he created when he chaired an international conference on low-temperature physics at Northwestern, Halperin became a point person for communications on the issue. With help from staff at Weinberg College, he created and conducted a survey finding that the purchase of helium-3 for low-temperature science averaged 3,500 liters of gas per year and grows at a rate of 12 percent per year. The current demand worldwide for all applications is about 20 times greater. The production of helium-3 from the tritium in the remaining nuclear bomb stockpiles in the United States is 8,500 liters per year, creating a crisis for not just scientists but Homeland Security as well.

"The cryogenic community does not have any possibility for development of an alternative scheme," Halperin says. "Helium-3 is in its DNA. There are no other alternatives."

Helium's stability and low energy of the electron cloud state make it inert, meaning that it is not chemically reactive like hydrogen and nitrogen. This quality combined with its ability to produce the lowest melting and boiling points of all elements, make it irreplaceable in the field of science.

When the U.S. Congress caught wind of the helium crisis, the Committee on Science and Technology organized a hearing called "Caught by Surprise: Causes and Consequences of the Helium-3 Supply Crisis." Halperin was called to testify.

In his testimony, Halperin noted that eight Nobel laureates in physics in the past 25 years owed their accomplishments to the availability of helium-3. He stated that the DOE needs to explore alternate strategies for the detection of radioactive materials, implement helium recycling, and establish effective communication with the cryogenic community. He added that new sources of helium-3 must also be developed, and — because it takes tritium 12 years to decay — the process needs to start immediately.

Halperin's lab has an immediate need for 20 liters and currently survives by recycling what it has. "When helium is released, the atoms go into the upper atmosphere and escape," he explains. He keeps the gas in a closed circuit and says he "tries very hard not to let it go." But even the smallest threat to the system could be disastrous.

Bill Halperin and the ultra-low temperature demagnetization cryostat. This cryostat requires the rare isotope, helium-3, to achieve temperatures less than one thousandth of a degree from absolute zero temperature. Photo by Jai Li.

"We have to eliminate any risk of damaging our measurement system," Grayson says. "It's zero percent tolerance for any mistakes in the lab."

In the meantime and under Halperin's leadership, communication between government officials and the cryogenic community is improving. Working together, there are hopes that new solutions will be discovered, and the future of low-temperature science will become a lighter topic of discussion. — *by Amanda Morris*

Halperin (middle) testifies before Congress with Richard Arsenault (left) director of health, safety, security and environment at ThruBit LLC and (right) Jason Woods, assistant professor of radiology at Washington University in St. Louis. Photo courtesy of the U.S. House of Representatives Committee on Science and Technology.