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Save Money And The Environment: Green Alternatives For The Lab

Technology Spotlight
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by Laura Lane

You won't find Stellan Muller-Cohn surveying the ground in hopes of spotting a carbon footprint. Unlike other nine year-old boys, Muller knows that by simply watching television or using other electric gadgets, he can leave a physical mark on the earth. This sophisticated outlook is only natural; his mom and dad created a technology that allows research labs to turn off their energy-guzzling freezers. The increasing availability of such products, and greater awareness of the ailing environment, are gradually penetrating labs and helping them to tread lighter on the Earth—and their budgets.

"Advancing research has its price: We use $34 billion on cool storage and shipment in the biological sciences," says Rolf Muller, Stellan's father and chief scientific officer of Biomatrica, "I think that our technology can replace that cost over time."

Alternatives for DNA Storage

Biomatrica is part of a growing sector within the life science market, which is helping labs to join the green movement. While the personal lifestyle of many researchers may reflect their awareness of the environment's ailing condition, their labs have operated relatively unresponsively to ominous signs of the warming globe. Extensive use of freezers ranks high among issues to be addressed. Freezers run on the type of hydrofluorocarbons that are also "the most potent greenhouse gas," according to a recent article in the magazine *The Economist*[1]. In addition, the typical ultra-low temperature freezer consumes about 7,665 kWh per year, while releasing 54,805 pounds of carbon dioxide. That's equivalent to the emission of more than four cars.

Chances are that researchers lack the resources to plant the 7.5 acres of trees necessary to counter such emissions. Trying products that enable room temperature storage is much more feasible. One of the first such options came in the form of Whatman FTA paper, introduced 17 years ago by United Kingdom-based Whatman plc. Upon adding liquid samples to the paper, offered in cards of different sizes, its embedded chemicals lyse cells, denature proteins and protect nucleic acids from nucleases, oxidation and damage by ultraviolet light. Once dry, the nucleic acids remain stable at room temperature for years and can be retrieved for downstream applications.

"The DNA has been shown to be stable for at least the 17 years that the product has been around," says Kerri McWeeny, director of marketing at GenVault. However, "The cards are not the most efficient for storage".

For that reason, Carlsbad, Calif-based GenVault developed GenPlates, 384-well plates with each well containing a 6 mm disk of Whatman FTA paper. Since its introduction in 2003, the GenPlates provide researchers with the ability to take advantage of the Whatman technology but in a format that's most suitable for today's high throughput research style.

"We created individual aliquots for the most space- and energy-efficient format, designed specifically with life science researchers' needs in mind" McWeeny says.

Efficiency is certainly one of the greatest needs. With GenPlates, preserving DNA can be quite convenient, requiring only that cells – including blood cells, buffy coat or buccal samples – be dispensed into the wells. Once dry, the reagents in the paper not only lyse the cells but also inactivate pathogens, such as viruses and bacteria. To prevent cross-contamination, the plates feature a covering on both top and bottom that can be pierced with a pipette tip. GenVault has also provided a convenient protocol for recovering stored double-stranded DNA. Isolating it requires incubating the company's GenSolve reagents with the paper at 65ºC. Standard purification protocols complete the process.

You can choose from storage modules of different capacities. GenVault's Desktop Archive can hold up to 38,400 individual DNA samples, and is small enough to sit on the benchtop. Pouches of desiccant material control humidity. The Personal Archive can store up to 403,200 samples, using power – only a tenth of that required a minus 80 degree Celsius freezer – to regulate humidity. The Dynamic Archive is an automated storage and retrieval system with a capacity for millions of samples.

Looking To Nature for Ideas

Biomatrica, on the other hand, offers technology based on nature's own solution for dry storage at room temperature. The company's flagship product, SampleMatrix, came to fruition with the phenomenon of organisms that survive in desserts and other extreme environments while preserving their genetic material and other vital components. “I was intrigued at how these organisms can store their DNA, RNA and proteins of hundreds of years without degradation,” he says. “That was when I asked why the whole world was spending billions per year on freezer storage.”

Tardigrades, microscopic organims that thrive only with water, became Muller’s springboard. These organisms shrivel up into spore-like structures to maintain vital components during dry periods. This process of anhydrobiosis – literally meaning “life without water” – relies on trehalose, a dissacharide produced in abundance in animals likely to undergo dry spells. Trehalose and other dissacharides form a highly viscous liquid that “preserves membranes and proteins in a physical state resembling fully hydrated conditions, suggesting that the hydroxyl groups of the sugar might physically interact with polar residues in these cellular components,” according to a paper in the journal *Nature Biotechnology*[2] by Lois Crowe and John Crowe—who now serves as one of Biomatrica’s advisors and is “one of the fathers of anhydrobiosis,” Muller says.

Armed with such facts of biological life, Muller developed a synthetic compound with “higher thermostability than the natural compounds, giving higher protection to the stored sample,” he says. “The big advantage of SampleMatrix technology is that it dissolves completely with addition of your liquid sample.” And, retrieving the sample, by simply adding water, doesn’t require purification. Now, you can find SampleMatrix presented in various formats, called SampleGards, including 96-well and 384-well plates, microtubes, and alpha-numeric labeled tubes presented as a 96-well format box. The company’s studies, along with those of partner Qiagen, show that storing DNA with SampleMatrix at room temperature preserves the sample’s integrity at levels comparable to a minus 80 degree Celsius freezer. The company plans to launch a product for RNA storage in the fall.

Other Green Tips

Minimizing emission of greenhouse gases is only part of the story. Storage in GenPlates and SampleGards can conserve precious lab space. For example, storing 3,000,000 DNA samples requires 3,000 square feet for the 75 freezers necessary. With the GenVault’s Dynamic Archive, you only need 240-square feet. Equally beneficial is the cost savings. To operate a single minus 80 degree Celsius freezer costs $1000 a year. For shipping, you can avoid the cost of expensive dry ice.

Of course, the environment is among the chief beneficiaries. While freezers can drink up plenty of electricity, ventilation accounts for the biggest component of energy use in the lab, says Otto Van Geet, senior engineer at the National Renewable Energy Laboratory in Golden, Colo. Van Geet also serves as a technical advisor to Laboratories for the 21st Century, a group co-sponsored by the U.S. National Department of Energy and the U.S. Environmental Protection Agency. Also known as Labs21, the group is working to improve the energy efficiency and environmental performance of labs.

To reduce energy use for ventilation, Van Geet recommends cutting exhaust rates from labs and hoods to the lowest level while still maintaining safety. Then, look into exhaust systems that change according to the lab's needs. You could save 30% to 50% energy by using a variable air volume ventilation system. Energy recovery systems that recover the heat from exhaust air and use it to precondition incoming air.

Once you've addressed your building's ventilation systems, you should look into renewable energy and producing your own power. With governmental economic incentives, photovoltaic systems can be economically feasible. Placing solar panels solely on your building may not provide enough electricity to power the entire lab. You'll need to encourage the institution to place panels at every possible place, such as the roofs of all buildings and parking lots.

But you could certainly start with your own building. If you want to power a single minus 20 degree Celsius freezer, you'll need about 4 kilowatts of photovoltaic energy, which takes up about 400 square feet, Van Geet says. While the cost of $30,000 might seem prohibitive, federal and state incentives could very well make it worth your while. For example, you could get about a 40% refund from federal tax credits. Some states also offer such incentives. California covers about 50% of the cost.

"With incentives, solar is a great way to go," he says.

Reducing energy use, however, is the focus for Muller. Not surprisingly, his work has influenced each of his four children and their appreciation of the environment—or, perhaps, the influence stems from the fact that he and his wife "both drive hybrids."

References:
[1]"Trading thin air," The Economist, May 31, 2007.
[1]JH Crowe and LM Crowe, "Preservation of mammalian cells—learning nature's tricks," Nature Biotechnology, 18:145-146, February 2000.