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Using AI to Create Proteins from Beyond Nature

By Mark Miller

Machine learning and other artificial intelligence (AI) tools have already been used in protein research to predict the structures of naturally occurring proteins. Now, biochemists are using AI to move beyond natural templates to build proteins that have never existed before. How does AI replicate the natural processes to help build proteins from scratch, and what are their possible applications?

A Text Model Like ChatGPT

According to the article "Proteins Never Seen in Nature Are Designed Using AI to Address Biomedical and Industrial Problems Unsolved by Evolution" by Michael Eisenstein in *Scientific American*, language-based generative AI models—like the one used by ChatGPT—can be adapted to generate new protein sequences and structures. In fact, an effective way to understand protein sequences is to think of them as text.

In these applications, AI algorithms are trained on vast amounts of biological information but must also follow chemical and biological rules—or biological "grammar," as Eisenstein calls it. "To generate a fluent sentence or a document, the algorithm needs to learn about relationships between different types of words, but it needs to also learn facts about the world to make a document that's cohesive and makes sense," Ali Madani, founder of the protein design company Profluent, said in the article. With this text-based modeling technology in place, AI can help develop new proteins similar to the way ChatGPT produces text based on the language it's been trained on.

Images and Landscapes

While the language-model approach is proving to work, it's not the only option. A program called Chroma employs diffusion models—typically used in image-generation AI tools—that are adept at manipulating multidimensional data.

Faruck Morcos, PhD, an associate professor of biological sciences at The University of Texas at Dallas (UT Dallas), is using a variant of this imaging strategy. According to a story published by UT Dallas, he and his team are generating 3D landscapes that allow them to visualize new proteins. "Our new framework is like a road map," Morcos said. "Rather than simply analyzing existing protein sequences, we look at the evolution of the proteins and construct maps looking both at proteins that already exist as well as generating and plotting out potential sequences."

> "For the applications we are interested in, like sustainability, medicine, food, health, and materials design, we are going to need to go beyond what nature has done."
>
> **Markus Buehler, PhD**
> *McAfee Professor of Engineering*
> *Massachusetts Institute of Technology*

Proof Is in the Folding

One of the key challenges of designing and building new proteins is the ability to validate that they will operate as natural proteins rather than just be random chains of chemical compounds.

A team of researchers at the University of Toronto is testing their AI-built proteins using OmegaFold, a version of the DeepMind software AlphaFold 2. With this system, they were able to confirm that any new sequences folded into a functional structure. This validation is critical because folding translates a protein chain into a three-dimensional structure and can determine whether it is in the correct shape to function. The team confirmed the viability of their structures by creating physical versions of them in the lab.

Protein Power

Because new proteins can be designed for specific traits, they hold tremendous promise in biomedical, industrial, and environmental applications.

A report from the Massachusetts Institute of Technology (MIT) states that while new proteins can be problematic in biomedical applications because their properties aren't fully understood, they show great potential because they can be modeled after existing natural proteins and tailored to meet specific requirements.

In the industrial world, new proteins can be used to manufacture materials with specific rigidity and pliability properties to replace petroleum or ceramic-based materials, but with a much smaller carbon footprint. Food coatings that help keep produce fresher longer and safe to eat are another possibility.

"For the applications we are interested in, like sustainability, medicine, food, health, and materials design, we are going to need to go beyond what nature has done," said Markus Buehler, PhD, McAfee Professor of Engineering at MIT.

Mark Miller is a Thermo Fisher Scientific staff writer.

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Leading the Charge in Laboratory Sustainability

Eppendorf, a global leader in the life sciences industry, is redefining lab sustainability by committing to producing eco-conscious lab consumables. Through recycled and renewable feedstocks, Eppendorf uses bio-based polymer production to reduce the need for fossil raw materials. This strategic shift embraces second-generation renewable feedstocks, fostering environmentally friendly lab practices.

Eppendorf's transparency ensures that the renewable feedstocks used in their raw material production are traceable, highlighting the company's dedication to sustainable sourcing. The final polymers also carry the ISCC PLUS certification, a globally recognized accreditation for bio-based polymers, reinforcing Eppendorf's commitment to sustainability.

BioBased Pipette Tips: Greener Innovation

In July 2023, Eppendorf enhanced their laboratory consumables line and furthered their environmental sustainability goals by introducing bio-based pipette tips. This new product series includes:

- Non-filtered epT.I.P.S. BioBased Reloads (Biopur purity grade)
- Filtered variants such as ep Dualfilter T.I.P.S. BioBased Reloads (PCR clean/ sterile purity grades)
- ep Dualfilter T.I.P.S. SealMax BioBased Reloads (Biopur purity grade)

These products follow Eppendorf's 2022 launch of the industry's first bio-based conical tubes. Both innovations, crafted from renewable materials, highlight their dedication to sustainable practices and the vital importance of eco-conscious laboratory operations.

The new Eppendorf epT.I.P.S. BioBased Reload variant is the result of years of research and innovation. Composed of primarily plant-based materials, this product's carbon footprint is 60 percent less than traditional tips. Not only are these tips environmentally friendly, but their purity is guaranteed, and their compatibility helps facilitate a smooth transition to sustainable lab practices.

These tips offer:

- Environmentally friendly materials: Help decrease your reliance on non-renewable resources and mitigate carbon emissions.
- Guaranteed purity: Ensures the delivery of accurate and reliable results, minimizing contaminants like human DNA, DNase, RNase, or PCR inhibitors.
- Wide compatibility: Skillfully designed, facilitating a hassle-free transition to a more sustainable alternative.

New Reload Variant for Sterile Pipette Tips: Reducing Lab Waste

Adhering to the "reduce and reuse" principle, Eppendorf's new Reload variants for epT.I.P.S. BioBased are supplied in a compact form and can be loaded into an epT.I.P.S. Box 2.0, reducing the need for disposable racks. This requires less fossil-based polypropylene, promotes reuse, and minimizes plastic waste. It also cuts down on storage space and packaging, lowering transportation emissions and costs.

Features include:

- Reduced plastic usage
- Compatibility with various pipette brands
- Adherence to sustainability standards

Sustainable lab products help reduce your carbon footprint, decrease plastic waste, and stimulate eco-friendly innovation. Eppendorf's range of greener products reflects its devotion to fostering sustainability within the scientific community. By integrating these greener solutions into lab routines, researchers set the stage for future generations to make sustainability a cornerstone of their research.

Visit **fishersci.com/eppendorf** or **fishersci.ca/eppendorf** to learn more.

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Sustainable Solutions Offer Labs a Greener Choice

To protect the environment and reduce the effects of climate change, many scientists have a strong desire to find sustainable solutions for lab equipment and supplies.

This goal can seem at odds with the daily reality of biomedical research: waste bins are often full of single-use gloves, tips, petri plates, and flasks that need to be autoclaved before they're incinerated or buried. One study from the University of Exeter estimated that 280 scientists could generate approximately 294 tons of plastic waste in a single year.

When you add in the electricity needs of freezers and incubators, it's no wonder labs consume five to 10 times more energy per square foot than office buildings. Using sustainable lab equipment and adopting greener laboratory practices—such as removing built-up ice, closing the fume hood, and planning ahead—can make a real difference.

New Corning cell culture flask design with less plastic.

Single-use products made from virgin plastic provide sterility and unmatched consistency for cell culture and are essential for applications like high-throughput screening. However, they are unlikely to become a sustainable option anytime soon. That said, gradual steps can reduce a lab's environmental impact without compromising the quality of its work.

Finding Greener Options for the Lab

The Fisher Scientific Greener Choice program helps scientists find lab products that best align with their sustainability goals. To earn the Greener Choice designation, a product must align with the U.S. Federal Trade Commission's Green Guides and be environmentally preferable to other products in the same category.

Nearly 800 Corning products have earned the Greener Choice designation, including 275 microplates and 165 flasks, plus pipets, pipettors, filters, microcarriers, and more. Some of these products were specifically designed for sustainability, such as the Corning T-75 U-Shaped Canted Neck Cell Culture Flask. Featuring a rounded curve instead of the sharp angular shoulders of a traditional T-flask, this new design improves usability and uses 23 percent less plastic.

Corning is committed to designing sustainable products, which means considering the environmental impact at each step of the product life cycle—manufacturing, shipping, customer use, and end of life. For some containers or cell culture vessels, it's possible to use thinner walls or modify the design to use less plastic. In other cases, improved sustainability can be achieved during the manufacturing process. Compared to similar products, Corning microcavity vessels require fewer molds, processes, and equipment during manufacturing. As an added benefit, the vessels can be used to grow a much higher density of cell culture spheroids in the same traditional microplate footprint.

Designed using recyclable materials for sustainability.

Process Intensification: Scaling Up for Sustainability

During research and development, it's challenging to find efficiencies, but there are more opportunities as projects move toward the production phase. The key is process intensification. For cell culture, this means growing more cells in the same footprint.

Much of the plastic that makes up a traditional cell culture flask is used to protect the cells from the outside world, and only a small fraction is required for the growth surface. Through thoughtful engineering, the area available for adherent cell growth can be dramatically increased while maintaining or improving gas exchange. This can greatly reduce the amount of plastic used per unit of cells produced. Depending on the cell culture system itself, there may also be a reduction in media required per unit of cells, and improved cell growth.

Holistic Solutions for a Sustainable Future

Sustainable solutions do not stop at product design—they also consider the impact of product packaging. In 2021, the Corning Life Sciences plant in Wujiang, China, started using new shipping boxes that are strong, lightweight, and come from responsibly managed forests.

Axygen product cartons are now 100 percent recyclable.

Axygen brand product cartons were also reimagined and are now produced with aqueous inks and no lamination, making them 100 percent recyclable.

Corning's focus on sustainability has also led to new offerings. For instance, pipette tip racks and lids are designed to be refilled with bulk tips and autoclaved for sterile reuse. When the tip boxes have reached the end of their life, they can be recycled at no cost through Corning's Packaging Takeback Program. The program also accepts Styrofoam racks used for 15- and 50-mL centrifuge tubes, as well as bags and peelable film made from #2 and #4 plastic. The program accepts packaging and not actual products because the products may have been used with biohazardous materials, liquids, radioactive waste, or other regulated waste.

In addition to efforts that impact the lab, Corning has been named an ENERGY STAR Partner of the Year by the U.S. Environmental Protection Agency for the tenth consecutive year. This continued commitment to efficiency includes increasing the percentage of energy obtained from renewable sources and reducing energy intensity, ultimately using less energy to produce the same product.

To learn more about these efforts, contact your Corning or Fisher Scientific sales representative.

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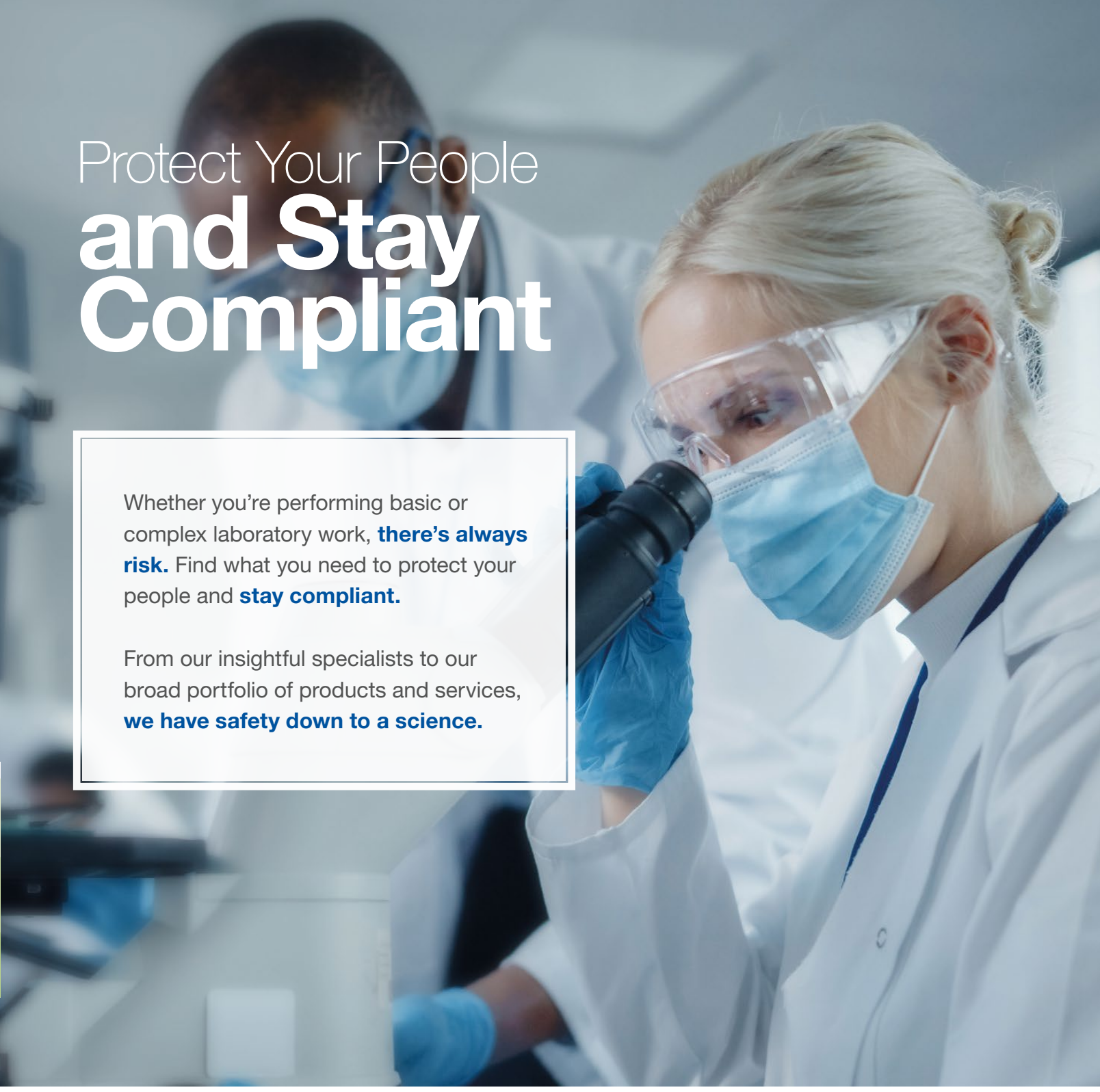

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New Technologies May Rebalance the Carbon Cycle

By Lynne Lescott

Oppressive heat, wildfires, torrential rain, catastrophic flooding, persistent tornadoes, and a generally unsettled climate: North Americans have experienced it all this year, and it's troubling. Carbon is the element driving these conditions and understanding it can crack open new solutions.

Carbon Isn't the Bad Guy

Living organisms can't exist without carbon. It's the key component of organic compounds—carbohydrates, proteins, nucleic acids, and lipids—that cells need to perform life-supporting functions.

Carbon isn't lazy, either. It's in constant motion within, between, and around us as we breathe and speak, as plants perform photosynthesis, as marine life sheds exoskeletal matter, and as livestock grazes. Carbon is also released during daily human activities, plus during most agricultural, industrial, and commercial processes.

Because organisms use carbon, they also store it. Carbon is found trapped in Earth's minerals, rocks, matter, and atmosphere. Earth, and most things within and above it, serves as a home for carbon storage units.

Carbon's constant movement in and between these storage units is called the carbon cycle. Despite its nomadic nature, the overall amount of carbon in the cycle never changes because, according to the National Oceanic and Atmospheric Administration, our Earth and its atmosphere are one closed environment and carbon can't escape.

Carbon's sum quantity may not change but the amount stored in each part of the cycle fluctuates as carbon is released, absorbed and used, and released again. The cycle is a natural process that is typically balanced by an equal amount of carbon release and absorption across its phases and parts. But human activities that send stored carbon into the atmosphere at increasing levels can shift the release-and-absorption balance quicker than the cycle can adapt.

The bad guy? Emissions. Household appliances and cars as well as industrial and commercial transportation and manufacturing processes contribute to increased emissions and carbon release.

Giant Carbon Technology Investments

With broad scientific consensus that human activity has altered the carbon cycle's natural balance, most restorative solutions focus on changing human activities that trigger the imbalance. Some solutions can be implemented at individual and household levels. Large-scale carbon capture and storage solutions are currently used by some of the world's biggest industrial organizations. ExxonMobil and Dow Chemical are two, and the agricultural company Corteva is part of a Greenhouse Gas Protocol Land Sector and Removals Guidance pilot.

More solutions will come, too. Millions of investment dollars were awarded to U.S. industrial, energy, and academic organizations to create technologies that can replace traditional carbon-emitting processes. In June 2023, the U.S. Department of Energy (DOE) announced $135 million of funding for 40 decarbonization projects across industrial and academic sectors.

DOE investments range from a $1 million award for Case Western Reserve University to develop a zero-carbon metal production process to $13 million for Siemens Energy and its partners, including Dow Chemical and the Southwest Research Institute, to design and implement new turbocracker and process steam technologies that can replace current high-emissions methods.

All We Need Is Air We Can Breathe

Air monitoring is a basic practice that helps experts understand the status of the carbon cycle's balance. According to the U.S. EPA, three monitoring methods are commonly used:

- Continuous emissions monitoring systems (CEMS): measure of actual emissions from a stationary source.
- Continuous opacity monitoring systems (COMS): measure of light's intensity at an emissions source. If a light source is obscured by heavy particulate matter it's considered "opaque," and emissions need to be corrected.
- Continuous parametric monitoring systems (CPMS): include measuring temperature, pressure, flow rate, and other parameters that reflect the efficacy of site or regional air pollution control systems.

Emissions testing and air quality monitoring are one aspect of carbon management. The EPA's methods provide detailed procedures that emissions-intensive industrial and commercial organizations must implement to meet air quality standards. Cooperative efforts like the Canada-U.S. Air Quality Agreement, established in 1991, are another tool.

The most urgent efforts are large-scale investments in new technologies and processes that can help rebalance the carbon cycle sooner, versus later. Earth, and everything within and above it, are counting on it.

Visit **fishersci.com/environmental** and **fishersci.ca/environmental** to shop essentials.

Lynne Lescott is a Thermo Fisher Scientific staff writer.

Flow Cytometry Panel Design Journey

Panel design is one of the most crucial parts of a flow cytometry experiment. It involves selecting the right combination of marker and fluorochrome for a given population of cells. But a badly designed panel can mean overlapping emission spectra, leading to the lost resolution of cell populations. Your choice of fluorochrome depends on a variety of factors, including antigen expression level, emission and absorption wavelengths, laser and instrument settings, and the biology of the experiment.

It is very important for anyone starting to explore flow cytometry to understand the principles of panel design and correctly implement them. While a lot of this will come from trial and error, having a working knowledge of these principles, plus lasers, fluorochromes, and panel design can help simplify the learning curve considerably. The best way to acquire such knowledge is to listen to experts in the field and learn from their experience.

Multicolor flow cytometry is a powerful way to enable the simultaneous analysis of multiple markers at the single-cell level. With an increase in detectable parameters, the design of a multicolor panel can be challenging and requires an understanding of several factors that can influence panel performance:

- Biology: Antigen density and co-expression
- Fluorochrome: Brightness and spillover
- Instrument: Configuration and setup

Step 1: Define Your Experimental Hypothesis

This is the first step in panel design. Start by identifying:

- The biological information you want to gather
- The population(s) of cells you wish to interrogate
- Whether targets are found on the cell surface or intracellularly

Step 2: Marker Selection

During the second step of the panel design process, you will need to determine which and how many markers you will need to identify the population of interest.

Pay attention to:

- Marker expression levels
- Marker co-expression, especially dim markers
- The gating strategy needed to identify the population(s) of cells you plan to interrogate

Step 3: Know Your Flow Cytometer

Knowing your instrument is essential and understanding your instrument's configuration will help you determine how many markers and which fluorochromes it can detect.

You should consider the:

- Laser wavelength for excitation
- Number of detectors for each laser
- Filters available to detect the fluorochromes

Step 4: Fluorochrome Assignment

Carefully select fluorochromes to resolve markers at all expression levels and minimize spectral overlap. Consider tools like fluorochrome resolution ranking and spectrum viewers to help assess:

- Fluorochrome resolution
- Cross laser excitation
- Fluorochrome spillover

Remember to pair bright fluorochromes with low-expressing antigens and dim fluorochromes with high-expressing antigens. Keep in mind that spread only impacts the resolution of co-expressed markers.

Step 5: Review Panel

Review your panel design and begin ordering your reagents. Remember to titrate your reagents and optimize your staining protocol. Include proper controls for compensation and FMO, and biological controls to help ensure optimal panel performance.

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Five Ways to Help Make Your Lab More Sustainable

Laboratories are essential for scientific testing and research. But they require more energy consumption and generate more waste than other types of buildings. While many scientists fear that implementing environmentally sustainable processes may compromise the integrity of their work, the environmental impact of unsustainable lab practices can have a significant impact on the planet.

Manage Hazardous Materials

Effectively managing hazardous materials makes a difference and includes proper handling, storage, and disposal. Taking these steps can help reduce air pollution, preserve water quality, and conserve natural resources:

- Establish proper storage practices in designated areas
- Implement strategies to minimize the generation of hazardous waste
- Prioritize greener chemistry principles and select environmentally friendly alternatives
- Stay informed about regulations to ensure compliance

Reduce Waste Generation

When it comes to reducing waste and conserving resources in the lab, every small change helps solve a bigger problem. Worldwide, it's estimated that biological, medical, and agricultural research institutions produce about 5.5 million tons of lab plastic waste per year—around 2 percent of global plastic waste. Here are ways you can make conscious choices to reduce, reuse, and recycle:

- Conduct a waste audit to focus your efforts
- Implement a waste management plan
- Reuse and repurpose materials instead of disposing of them

Reduce Energy Consumption

Laboratories consume large amounts of energy to keep cold storage equipment, computers, and other technology running. This not only costs a lot of money, but it leaves a heavy carbon footprint. That said, there are still practical ways to operate more efficiently, reducing your energy usage without compromise:

- Upgrade equipment to help you replace outdated and energy-inefficient equipment
- Implement power management strategies through equipment settings
- Track and analyze energy usage patterns

Make Responsible Purchasing Decisions

As you make purchasing decisions, it's important to consider a product's life cycle—from warranty and maintenance to end-of-life disposal. This also includes finding products that are more sustainably made, helping you reduce hazardous waste and carbon emissions over time. You can do so in these ways:

- Look for equipment that supports waste reduction and recycling initiatives
- Consider products with longer warranties and easy equipment maintenance options
- Find equipment that meets or exceeds environmental standards and certifications

Choose a Transparent Partner

In addition to the Thermo Fisher Scientific greener products self-label program, we participate in the ACT label program. Created by the nonprofit organization My Green Lab to help consumers make smart, sustainable product choices, the ACT label provides environmental accountability, consistency, and transparency (ACT) for each labeled product. This helps:

- Provide you with the information needed to make more sustainable purchasing decisions
- Motivate product development professionals to introduce more sustainable products and packaging
- Encourage manufacturers to make process improvements and operate more sustainably
- Support customers in their efforts to reuse and recycle products whenever possible
- Demonstrate a commitment to invest in sustainable business practices

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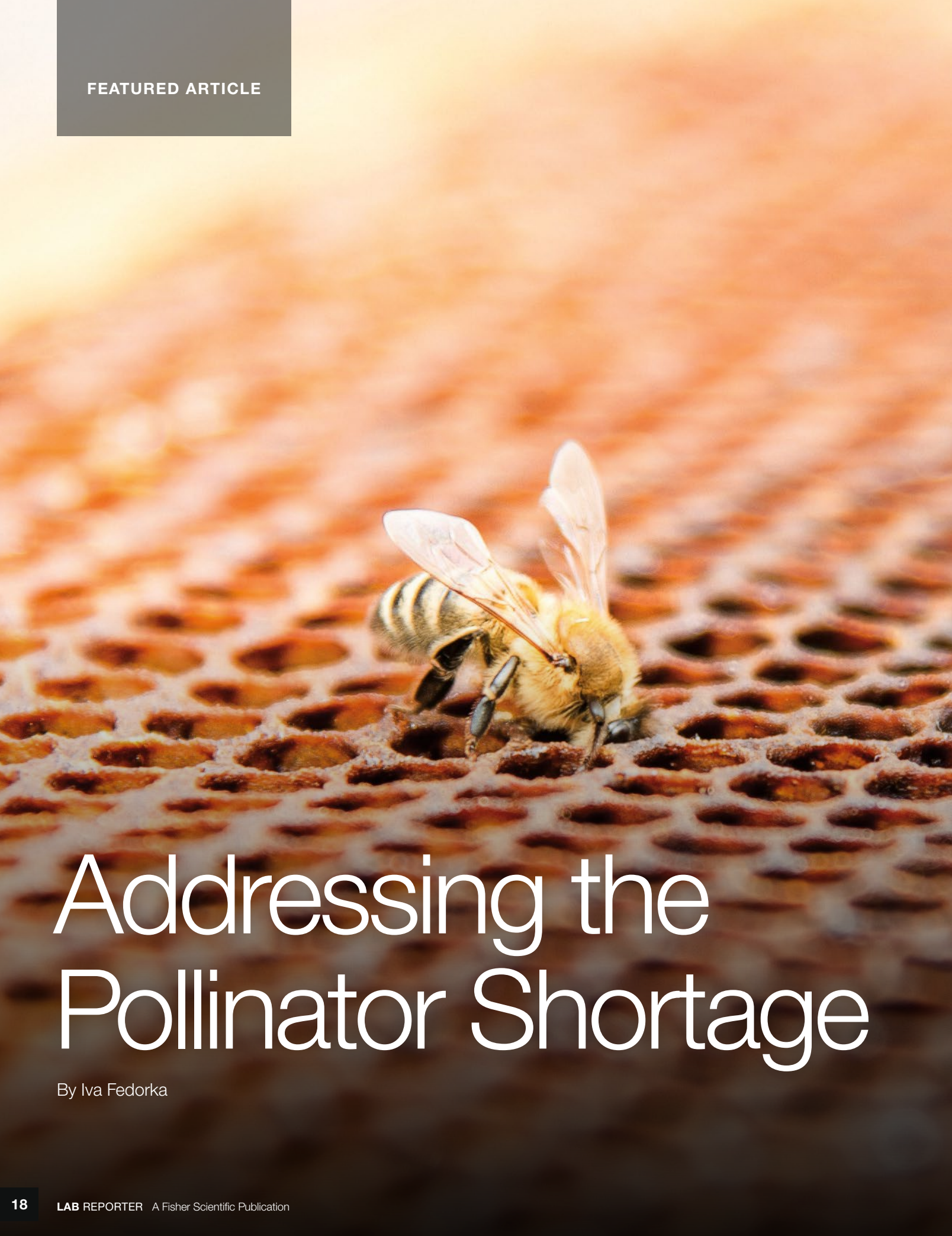

Addressing the Pollinator Shortage

By Iva Fedorka

The decline in bee and other natural pollinator populations has been well documented. Causes include climate and habitat change, pesticide and herbicide use, and many other factors that place global food production in jeopardy and make feeding the planet more challenging. According to the United States Department of Agriculture (USDA) Forest Service, roughly 80 percent of flowering plants must be pollinated to propagate.

It's now common for commercial beekeepers to rent colonies to farmers to support crop expansion or compensate for fewer wild pollinators. The USDA reports that the total value of these pollination services in 2022 was $441 million, an amount that has increased as much as 42 percent since 2017. Many scientists, academic institutions, and government agencies have been gathering data, conducting longitudinal studies, and even developing pollinating robots to mitigate the negative effects of pollinator loss.

However, manufacturing flying robots requires plastics, membranes, wires and foils, resins, carbon fibers, metal for electronics, and chemicals for batteries or solar panels. Damaged or unretrieved devices would create litter and pollution and could leach chemicals, produce microplastics, be consumed by birds, reptiles, and amphibians, and damage the engines of crop dusters.

Where Are the Pollinators?

In addition to bees, nocturnal insects, bats, birds, butterflies, flies, beetles, moths, wasps, ants, and other creatures can be active pollinators. A study published in *Proceedings of the National Academy of Sciences* looked at the relative contribution of non-bee pollinators globally by reviewing 39 studies conducted across five continents. Their survey found that insects other than bees provide 25 to 50 percent of total visits to crop flowers. Although some were less-effective pollinators than others per visit, they visited flowers more often, which made their performance about the same overall.

Non-bees are often active at different times of the day and may operate in larger geographies, function in weather that bees cannot tolerate, and be more efficient at pollen transfer under certain conditions or for greater distances. These non-bee pollinators may also visit different parts within a flower or flowers within a plant, increasing pollination effectiveness.

U.S. Government Efforts

In support of the 2014 presidential memorandum, "Creating a Federal Strategy to Promote the Health of Honey Bees and Other Pollinators," a multi-agency Pollinator Health Task Force was formed. The task force developed a national strategy, issued in May 2015, to promote honeybees and the nearly 4,000 species of native bees and other pollinating invertebrates in decline.

As part of a year-long Pollinator Protection Initiative, the U.S. General Services Administration (GSA) placed beehives at 11 locations throughout the country. The pilot was successful: increasing public awareness and providing beekeeping lessons while pollinating nearby crops. Responsibility for the individual locations was then transferred to the local GSA organizations, but the knowledge gained is intended to help advance the science underpinning the government's land management and regulatory decisions.

The U.S. government is committed to increasing and improving pollinator habitats directly through land management and indirectly through interactions between federal and state governments, localities, the private sector, and citizens. These actions range from planting pollinator gardens and improving land management practices at federal facilities to advancing the availability and use of pollinator-friendly seed mixes in land management, restoration, and rehabilitation projects nationwide.

Reasons for Robots

The need to simulate natural pollination occurred in part from the growth of vertical farming, a method that uses artificial intelligence (AI) and artificial lights to grow plants indoors. Although the concept is attractive, many vertical farms can produce only lettuce and herbs, which can be grown hydroponically with relatively little water.

> To expand profitability of vertical farms by offering a greater variety of crops, pollination is needed.

Nearly a third of the crops we consume must be pollinated to grow, but domesticated honeybees cannot easily navigate in artificial light. Hand pollination is expensive and time intensive, so the use of robotic pollinators is a potential option.

continued from page 19

Addressing the Pollinator Shortage

The StickBug

WVU Today reported that researchers at West Virginia University have successfully designed a robot that pollinates. Led by Yu Gu, associate professor in the Department of Mechanical and Aerospace Engineering, the team created StickBug, a six-armed robot. Gu, along with Jason Gross, associate professor and associate chair for research, mechanical, and aerospace engineering, and Nicole Waterland, associate professor of horticulture and director of controlled environments, received $750,000 in USDA funding.

The robot assesses the area and creates a detailed map of the flowers and pollination-dependent plants, Gu said in the article. The multiple arms help to improve efficiency and effectiveness for flowers growing in hard-to-reach places. The robot can use one arm to grab a branch and the other to pollinate. By performing flower inspections, mapping, pollination, development tracking, and other time-consuming tasks, growers are free to focus on planting, irrigation, pest control, and other necessary duties.

StickBug's effectiveness will be evaluated with blackberry and tomato crops grown in a greenhouse. These plants were chosen because of their popularity, economic value, and production in high tunnels and greenhouses. "Greenhouse tomatoes can be produced for 11 months out of the year, so there's a continual need for [pollinators]," Waterland said in the article.

Gu hopes that this robotic pollination technology can help more people in the state have their own agricultural ventures. For WVU specifically, the robot pollinator also provides educational opportunities for students. "WVU allows us to do cutting-edge research," Gu said. "[This project] provides an opportunity for students to do both hands-on and theoretical research in robotics as well."

Are Robots the Answer?

Alan Dorin, an associate professor in the Faculty of Information Technology at Monash University in Australia, disagrees with the robotics approach in his article "No, 'robobees' are not the answer to pollinator decline." Although the idea of robots has captured media attention, and the notion of insect suffering is not disputed, the concept does not "fly" with many ecologists and biologists.

Available statistics suggest that approximately 16 trillion honeybees were managed worldwide in 2016, a number that was deemed insufficient to meet global agricultural demand. This number does not include the trillions of wild honeybees or the tens of thousands of other species of bees, flies, butterflies, moths, beetles, wasps, and other insect pollinators that would also need to be "replaced." Furthermore, the world's small and subsistence farms that comprise 75 percent of growers are unlikely to be able to afford a swarm of robotic bees.

The robots may even displace existing wild and managed pollinators, escalating their decline and increasing our dependence on alternative solutions. Their abilities are unlikely to include wildflower pollination, a waste of resources from a grower's perspective and too broad of a design consideration.

A Better Solution

Exploring a more ecologically sound approach, while still incorporating technology, may be a better alternative than focusing on replacements.

- Digital technology can help facilitate pollination of crops and wildflowers
- Machine learning and computer vision techniques can survey and capture insect activity
- Beehives connected to the internet could help monitor colony health
- App-controlled pheromone lures might be used to attract and orchestrate pollinator movement

The pursuit of a natural and conservation-based support, like the GSA and other habitat-preserving programs, may ultimately be a more effective approach to successfully addressing this serious global concern for all pollinators.

Iva Fedorka is a Thermo Fisher Scientific staff writer.

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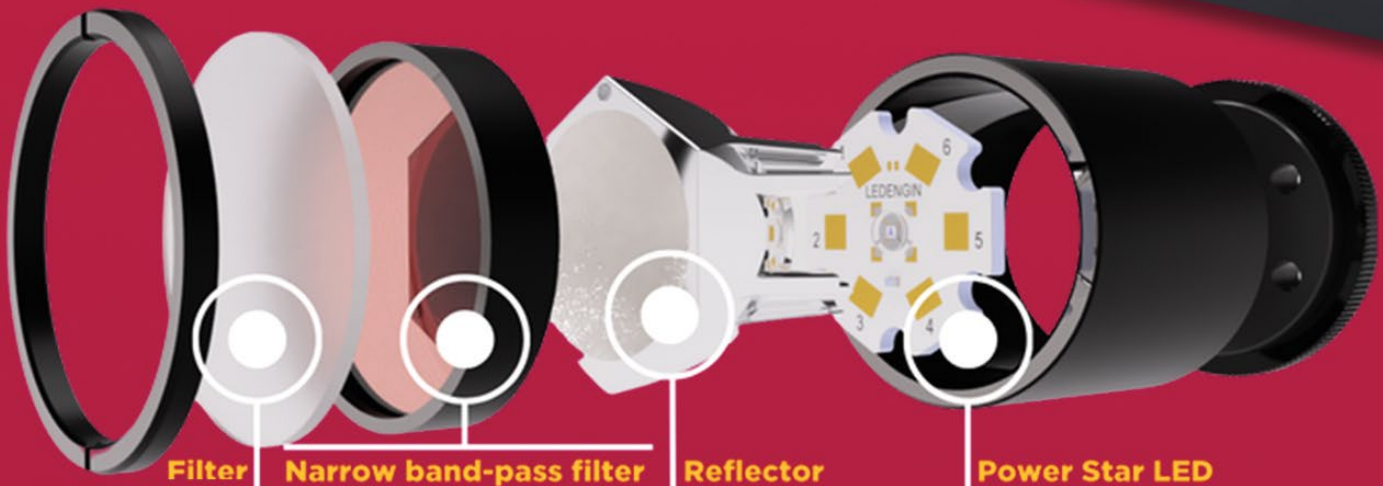

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MY-PCR, W:32 in.	MY-PCR32	15-338-366
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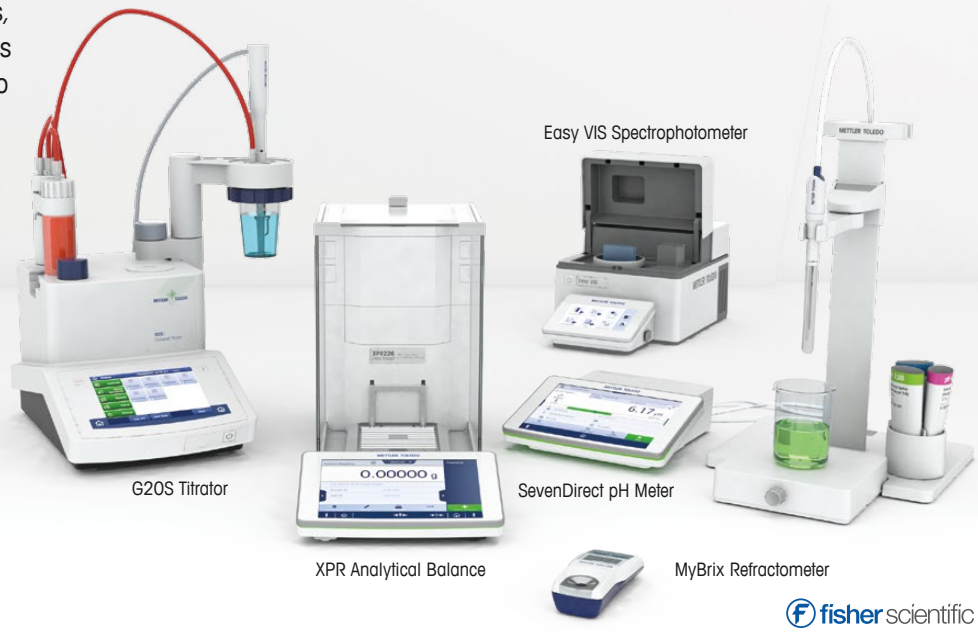


A Safer, Eco-Friendly Biosafety Cabinet That Covers All Applications

By Elizabeth Dille, PhD,
Product Manager, Labconco

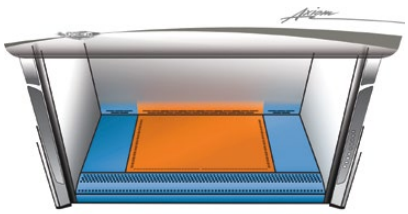
A Simple Choice

The Axiom Class II, Type C1 Biosafety Cabinet (BSC) is considered a significant advancement in biosafety technology, offering a robust solution to streamline operations and elevate safety standards. It removes any confusion around the type of BSC that's required for your research, provides added safety, and decreases the costs that would accrue with other cabinets. The Axiom BSC can function as a recirculating cabinet, or it can be connected to an exhaust system from the Chem-Zone or central work area. This flexibility gives your laboratory the ability to change to or from an exhausted cabinet should your research requirements change. After a quick connection to ductwork and a re-certification, you have a cabinet that meets your changing needs.

Advanced Safety

Although rare, in the event of a remote exhaust failure in a vented Class II, Type A2, or B2 cabinet, users face the risk of chemical and/or biological exposure. Without sufficient building exhaust, there is a chance that contaminated air may escape the canopy of a Class II, Type A2 cabinet or exit the sash area on a Class II, Type B2 cabinet.

If a remote exhaust failure is detected in the Axiom BSC, users are immediately protected through the initiation of an Active Protection Protocol (APP). APP swiftly adjusts the Axiom's internal exhaust blower to improve containment while simultaneously alerting the user of an exhaust failure. A five-minute countdown timer activates to allow time to finish work and clean up the cabinet safely.



The Axiom BSC features a dual ECM blower system that helps it respond appropriately during an exhaust failure. This system requires minimal static pressure from the general exhaust system which is very helpful when trying to retrofit new BSCs into existing and older laboratories.

Energy Conservation

Exhausting BSCs requires moving air through the cabinet and out of the building via the exhaust system. On average, Class II, Type B2 units exhaust two to three times the amount of air as Class II, Type A2 units. From an energy conservation standpoint, Type A2 BSCs offer significant advantages. However, Type A2 BSCs are not recommended for applications involving larger volumes of chemicals. In the past, users have opted for Type B2 cabinets with safer single-pass exhaust, but the Axiom BSC achieves this in the Chem-Zone work area at a similar exhaust volume and static pressure to that of Type A2 cabinets. The Axiom BSC can also connect to a general exhaust system, unlike Type B2 cabinets that require dedicated ductwork.

The Axiom Class II, Type C1 BSC is changing the way scientists approach lab design, combining unparalleled versatility and sustainability with unmatched safety. With the Axiom BSC, the dilemma of choosing between Type A2 or Type B2 cabinets, or the need for multiple units to fulfill various requirements is no longer necessary. Now any application can be handled with ease and efficiency.

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PCR Workstation	Cat. No.
AC632LFUVC 32 in. PCR Workstation	**36-101-8894**
AC648LFUVC 48 in. PCR Workstation	**36-101-8897**

Endeavour Ductless Fume Hood

The Endeavour Ductless Fume Hood is designed to protect the operator from potential toxic fumes, vapors, and particulates. AirSafe NXT provides simple and effective user interaction, and fume hood operational parameters.

Standard Features:
- Microprocessor controller with audible and visible alarms for both airflow velocity and filter change
- Bonded carbon filters—no dust
- Polypropylene construction for excellent chemical resistance

Endeavour Ductless Fume Hood	Cat. No.
ACPT4000 48 in. Ductless Fume Hood	**36-100-0063**
ACPT6000 72 in. Ductless Fume Hood	**36-100-0069**

Filters sold separately; application worksheet required.

AC600 Series Ductless Chemical Workstation

The AC600 Series Ductless Chemical Workstation is an economical solution for protecting the operator and environment from toxic vapors, gases, fumes, and particulates. It ships fully assembled and can be configured for a variety of common applications.

Standard Features:
- Microprocessor controller has audible and visible alarms for both airflow velocity and filter change
- 360° visibility
- Well suited for low-volume chemical applications

Description	Cat. No.
AC632A 32 in. Workstation	**36-100-4271**
AC632TA 32 in. Workstation, Tall Version	**36-100-4272**
AC648A 48 in. Workstation	**36-100-4274**
AAC648TA 48 in. Workstation, Tall Version	**36-100-4275**

Filters sold separately; application worksheet required.

Genome Editing Could One Day Help Treat Diseases

By Kylie Wolfe

What if scientists could unleash the potential of genome editing on diseases that affect the heart or muscles? That may soon be possible. Genome editing technologies have evolved over the last several decades, leading to faster and more accurate methods. These techniques make it possible to cut and replace sections of DNA, changing their expression.

One new approach is being explored at Rice University in Houston, Texas. Researchers in the Xue Sherry Gao laboratory found a way to correct dozens of genetic errors at once. And they think their CRISPR-based approach could help treat diseases that are triggered by mistakes in multiple genes. Their work was published in *Nature Communications*.

Bringing Simplicity to the Field

To create a more advanced gene editing tool, the team used drive-and-process (DAP) arrays instead of the more common CRSIPR-Cas12a or CRISPR-Cas9. DAP arrays are unique because they use transfer RNA (tRNA) molecules, which typically play a key role in protein synthesis. In this case, tRNA serves as a promoter of and driver for guide RNA (gRNA) expression.

With this in mind, the team engineered a 75-nucleotide tRNA molecule capable of making DAP arrays. Those arrays were then able to complete "up to 31 edits with the base editor and three edits with the prime editor," as mentioned in a *Rice News* article.

"Previously, if we wanted to edit multiple genes in the same cell, we would have to do them one after another, which is very time consuming and low efficiency," said graduate student Qichen Yuan in the article.

When gRNAs are released at genomic sites, they can recognize regions of interest, sending editors toward specific DNA targets. This results in fewer off-target edits, making it a very effective tool.

"Since we are introducing multiple gene edits at once, one could imagine it might lead to more off-target edits," said Xue Sherry Gao, principal investigator, in the same article. "But our experimental data is very impressive. We actually observed fewer off-target activities while maintaining the same level of on-target editing with DAP arrays."

Fixing Errors Efficiently

The new genome-editing strategy could make it easier to fix errors with efficiency and precision. The team tested various DAP arrays and determined that they can make disease-suppressing changes in human cells. Although some attempts were more successful than others, the gRNAs performed well and caused very few unwanted edits.

Some existing methods, like CRISPR-Cas9, can't process gRNA in the same way, while other strategies have less success avoiding off-target changes, an advantage of the team's new approach.

The DAP arrays may be more useful because they release the right number of gRNAs to complete the edits. They also don't require long DNA promoter sequences to set gRNAs in motion, reaching a range of targets.

Making Advancements in New Ways

The team's use of DAP arrays could bring simplicity to an otherwise complex field and has the potential to positively impact biology research, engineering, and disease treatment.

> The new genome editing strategy could make it easier to fix errors with efficiency and precision.

"We anticipate we could pair DAP arrays with base editors, prime editors and other emerging CRISPR technologies, such as multiplex CRISPR screening and studying of polygenic diseases in vivo," Gao said in the *Rice News* article. "Our lab has a current focus using these technologies for the disease modeling and treatment of cystic fibrosis."

As more experiments get underway, scientists will continue to close in on an answer—one that may bring the power of genome editing to disease treatment.

Kylie Wolfe is a Thermo Fisher Scientific staff writer.

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UFEM1.10KT.18S2	1 to 100	1 to 999	PP	PTFE-Coated	FFKM	**13-880-919**
UFEM1.10FT.18S2	1 to 100	1 to 999	PTFE	PTFE-Coated	FFKM	**13-880-921**

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FB-11206	6.9 L (1.8 gal.)	FB11205
FB-11207	12.75 L (3.3 gal.)	FB11207
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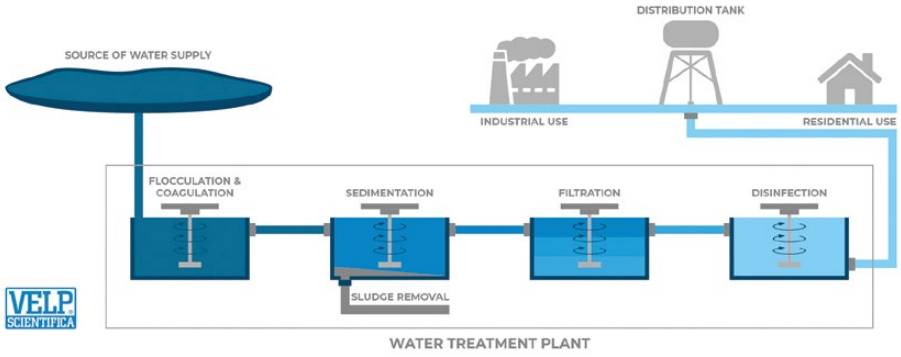
The Importance of Jar Testing in Water and Wastewater Analysis

A jar test is a pilot-scale laboratory test that simulates coagulation or flocculation with different chemical doses. The purpose of this test is to estimate the minimum coagulant dose required to achieve certain water quality goals. The jar test helps determine the right amount of treatment chemicals, or the lowest dose of chemicals needed to provide satisfactory settling.

Flocculation or coagulation is fundamental in every water treatment process and it is a propaedeutic step for sedimentation, filtration, and disinfection before distributing water for residential and industrial use.



Jar Testing and Flocculation

Jar testing helps you choose the correct chemical coagulants and dosage to remove suspended matter and pollutants from water treated in wastewater treatment plants.

The choice and dosage of chemical coagulants comes from the laboratory jar test results, which mimic the full-scale operation of a water treatment plant.

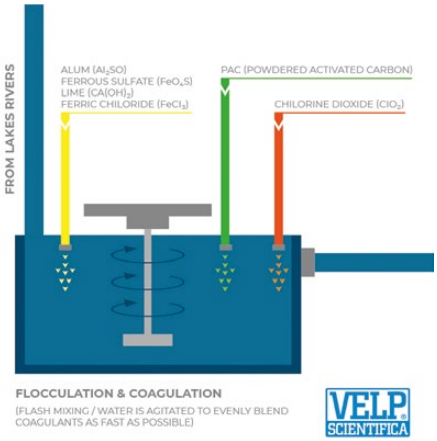
The most used coagulants are lime (calcium hydroxide), alum (aluminum sulphate), and iron salts (ferric or ferrous).

How It Works

Using a flocculator, the coagulant substance is added to the water sample beakers. The chemical coagulant starts to precipitate, trapping all the impurities and forming flocs that will deposit on the bottom of the beaker.

The sample is continuously stirred so the formation, development, and settlement of floc occurs like it would at a full-scale plant and can be observed.

The operator then performs a series of tests to compare the effects of different amounts of flocculation agents at different pH values to determine the right size floc.



The most common analytical conditions using a flocculator are:

- 1,000 mL glass beakers (jars), tall form, Ø 105 mm
- 600 mL wastewater samples and coagulants
- Paddles at the middle height of the sample
- Turbulent stirring at 120 rpm for 120 seconds
- Slow speed flocculation at 30 rpm for 25 minutes
- First evaluation of results after 5 minutes of sedimentation

Results Evaluation for Optimizing Performance

The results of a jar test can be evaluated based on different criteria:

- Floc dimension evaluation with a numerical degree
- Time from the addition of chemicals to the first appearance of flocs

- Time from the addition of chemicals to the first appearance of flocs
- Evaluation of residual turbidity of the supernatant after a determined sedimentation time by turbidimeter
- Measurement of the electro-kinetic potential of suspended particles on a sample taken immediately after the addition and mixing of chemicals
- Determination of filterability of clarified water by standardized membrane filters under pressure (the reduction of water flow is related to clogged filters and residual, unsettled suspended matters)

VELP-Dedicated Solutions for Flocculation

The jar test helps water treatment plant operators avoid overfeeding or overdosing, especially with coagulants, saving resources and optimizing processes. VELP offers robust solutions for jar tests with strong resistance to chemical and mechanical corrosion. For example, VELP JLT and FCS Series Flocculators feature multiple stirrers and consistent speeds, a basic requirement for reliable results. An illuminated back panel enables simple and clear floc observation and evaluation for maximum reproducibility. These products also offer a digital display and timer, helping to meet the requirements of every lab.

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