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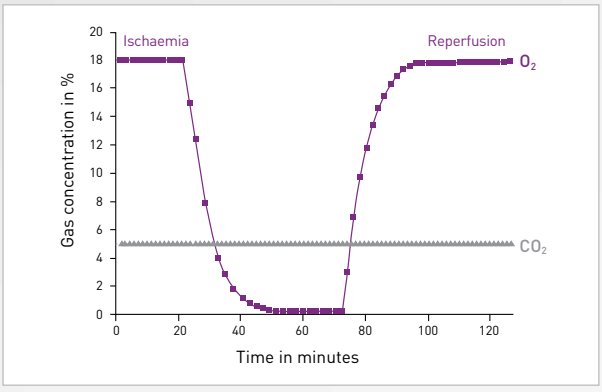

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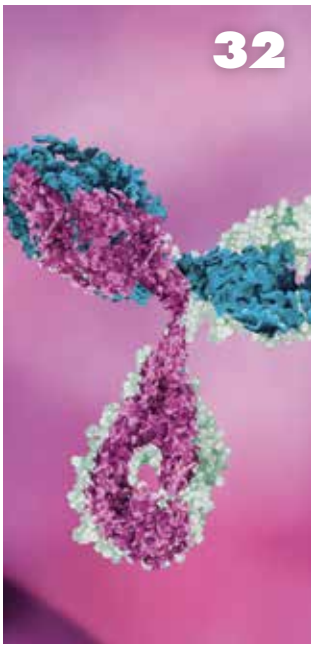

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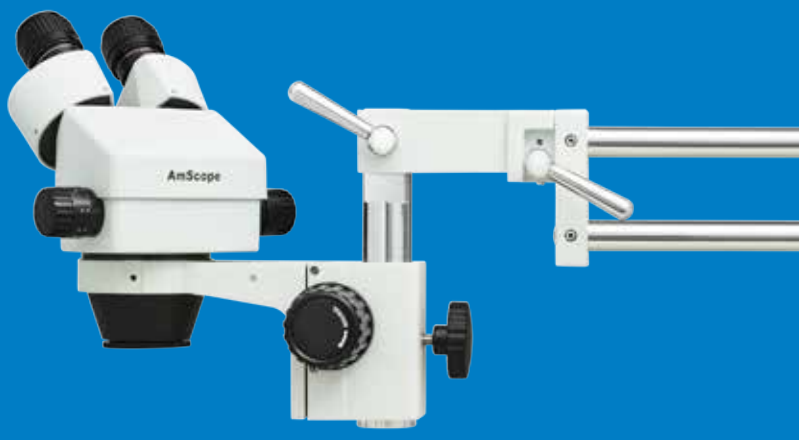

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For anyone who has put together and managed a work team, the most dreaded moment is when one of your staff gives notice. No matter the reason—better opportunity elsewhere, higher pay, less of a commute—for you, it's back to the beginning of a process that takes you away from your work, eats up an abundance of time, and is fraught with uncertainty. No matter the position to be filled, the same amount of effort is required.

In this month's issue, seasoned managers share some of their best practices for hiring and managing their staff. And the takeaway, as you'll find out, is that your best chance at making the right hire is to carefully and thoroughly attend to every detail of the hiring process. In addition, a new hire whose personality is compatible with that of the existing team trumps technical credentials in many cases.

"We work very hard on developing a team mentality where everyone has the same interests in doing their best," says Maya Murshak, chief executive officer at Merit Laboratories Inc. in East Lansing, Michigan, in this month's cover story.

Kim Rakoski, drinking water project manager at PDC Laboratories Inc. in Peoria, Illinois, evaluates not just the candidate's technical and scientific expertise, but also their softer and more nuanced qualities, including how they would fit into the culture of the organization.

Another important step is allowing the entire team to participate in the interview process. For Rakoski, once a candidate is deemed viable, more lab staff get involved to ensure that person is a good fit for all parties involved.

Author Scott Hanton, in this month's Leadership & Staffing article, "Hiring Right" (page 28), goes into even greater detail explaining his process for making the best hire. He also shares his methods for onboarding new employees. "There are many details that need to be taken care of before the new candidate even arrives for the first day. Preparation for his or her arrival is critical."

The shared message from both articles is clear: The responsibility for selecting and managing a laboratory staff falls squarely on the shoulders of lab management and not your organization's HR department.

Unrelated to hiring and managing but altogether fascinating, Anthony Atala, MD, director of the Wake Forest Institute for Regenerative Medicine, shares his institute's latest efforts "to develop cell therapies and replacement tissues and organs for more than 40 different areas of the body. Projects range from blood vessels to kidneys to cell therapies for both lung disease and hemophilia." Turn to page 50 to learn more.

Enjoy.

Best,
Pam

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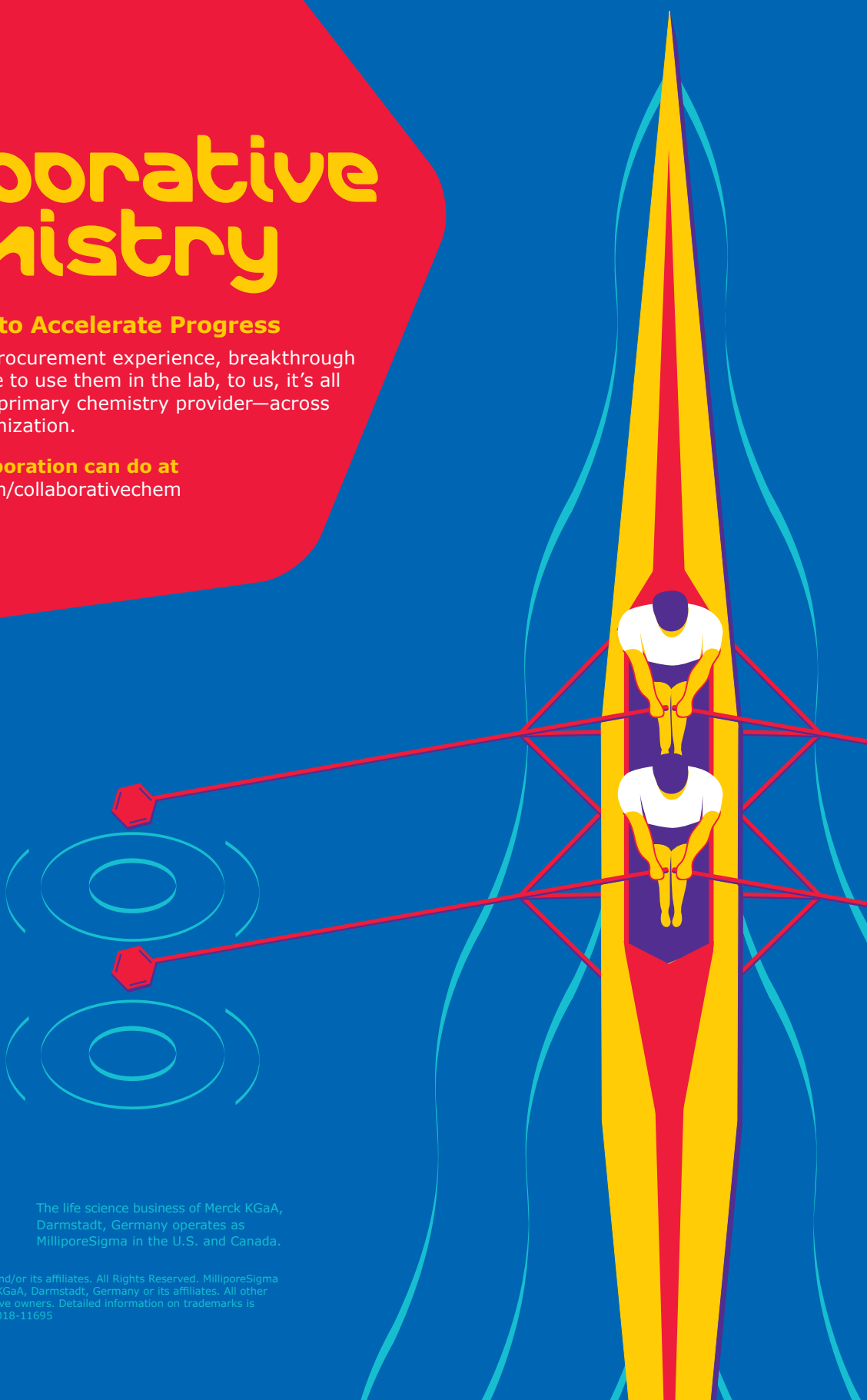

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HUMAN RESOURCES

A LAB MANAGER'S ROLE IN HIRING, SUPERVISING, AND EVALUATING LABORATORY STAFF

by Sara Goudarzi

Lab managers are tasked with running the day-to-day operations of their respective laboratories—from environmental and forensics to medical labs and everything else along the spectrum. To ensure that procedures are running at optimal levels, those in charge of labs need a knowledgeable and dedicated team that can handle the variety of tasks unique to each organization.

> "The cost of a bad hire is more than just an employee's salary."

Although much of the job of hiring is often left to the human resources (HR) departments of many organizations and independent labs, managers are key in assembling staff members who would be viable members of their laboratory community. Therefore, a manager's role cannot be understated when it comes to hiring, training, supervising, and evaluating employees. And it's important for those running labs to coordinate with the higher-ups and HR staff in finding and training team members who will enhance the work environment.

"We work very hard on developing a team mentality where everyone has the same interests in doing their best," says Maya Murshak, chief executive officer at Merit Laboratories Inc. in East Lansing, Michigan. Merit is a Women's Business Enterprise-certified and accredited environmental laboratory that's been serving clients for more than 30 years, with work that involves superfund sites and Resource Conservation and Recovery Act waste and permit monitoring for environmental analyses in drinking water, groundwater, wastewater, soil, waste, consumer products, and air.

Finding and evaluating the best fit

The cost of a bad hire is more than just an employee's salary—it also costs the lab training time, resources, and productivity, which, according to the U.S. Department of Labor, is an additional 30 percent of a hire's earnings.

To find competent and committed employees, lab managers look for candidates in every corner of the industry. "We are located very close to Michigan State University and have had great success hiring graduating students when we need new analysts or project managers," Murshak says.

Others might look for talent at networking events, such as during industry conferences and local training events, or use traditional or newer media to reach potential candidates.

Kim Rakoski, drinking water project manager at PDC Laboratories Inc. in Peoria, Illinois, explains that when a position opens up at her lab, it's first posted internally and on the PDC website. "We also use social media such as Indeed, Monster, and LinkedIn along with recruiting from local universities," she says.

Once a list of candidates is put together, managers typically evaluate potential hires on paper. As a candidate is deemed viable, he or she moves further up the list, and more lab staff often become involved in the hiring process to ensure that person is a good fit for all parties involved.

"Initially, we look at their resumes and make sure that the technical capabilities are there," Murshak says. "Once they have an interview with our human resources director, I meet with a potential candidate and ask about their wishes and what they are looking for. Then I tell them about our business and all the pros and cons. I try not to hold back. If, after the interview, both parties are still interested, we introduce them to the team that will work the closest with them. If that team approves, we make an offer."

Rakoski's process is similar in evaluating not just the candidate's technical and scientific expertise, but also their softer and more nuanced capabilities and qualities, including how they would fit into the culture of the organization.

"We sit and talk to the candidates during the interview versus [going through] the standard interview questions," she says of herself, the department manager, project managers, and department supervisors, all of whom are involved in the evaluation process. "We use those [interview questions] as well but as more of an opener for casual discussion." To ensure a candidate's viability, more than one department at her organization conducts many of the analyst interviews at the same time.

Balance of talent

Part of finding the right candidate is ensuring there's a balance of talent and point of view within the staff's composition. That means it's vital to provide opportunities to candidates from different backgrounds and to promote diversity, a task that many managers take seriously when it comes to hiring.

"PDC is an equal opportunity employer, and if a candidate is a right fit for the job they are hired," Rakoski says. "We did have an issue where the new hires in one

department were not blending well with the work group and it was suggested that maybe they should consider hiring someone of the opposite sex to balance things out a bit."

As fate would have it, the position's only applicants turned out to be of the suggested gender, she explains. However, for PDC, the ideal candidate is the one who "can keep up and do an excellent job."

Similarly, Murshak's team tries to find the best talent, a good example of which is their project management team. "For the first 20 years, it was all females," she says. "Then both of our females left to live outside East Lansing. Both left on very good terms and I consider them good friends. When the two positions opened up, the best two candidates were male. Our project management team was run for a few years by two fantastic guys."

"When analytical opportunities came up, one of the guys filled the laboratory position and the other, the marketing position," Murshak adds. "We hired two women to fill the project management spots, and they are working out excellently."

And though both labs have females in leadership roles, neither are a gender-oriented organization, meaning they make no extraordinary efforts to promote females or males within the laboratory and instead focus on finding the best person for every position.

"We value good character, education, and fit with our company views," Murshak says.

However, some of the highest positions—CEO and technical director, QA officer and safety officer, project managers, HR director, accountant, metals and inorganic senior analysts—within the laboratory happen to be filled by female employees. "They have all earned their positions and I am very proud of the work they do for Merit," she adds.

Boarding and training

The hiring of a new employee is just the beginning of the process of incorporating an individual into the culture and workflow of a lab. Depending on a lab's position and needs, every manager has his or her process of ensuring new hires feel comfortable with the work and values of the organization.

At PDC, all analysts and employees first receive training in ethics, general safety, chemical safety, and standard operating procedures (SOPs) from the operations and HR departments. New hires are also provided with, and asked to sign, confidentiality agreements.

"Once that's completed, then the department supervisor and fellow analysts train the new analyst on the day-to-day routines," Rakoski says. "For a project manager [PM], the outgoing PM will do as much training as possible before they leave the position, and training continues with SOPs, manuals, and help from fellow PMs."

Similarly, Murshak's lab starts the new hires with training in safety and industrial hygiene conducted by a safety officer. Next, new employees become familiar with the quality assurance (QA)/quality control manual and any SOPs that are applicable. They then are asked to read and sign a training statement attesting that they have read the documents provided by the QA officer.

The new analyst shadows a lead analyst for a week. Then the new analyst is shadowed by the training analyst and/or the director of the department and analyzes seven control samples to demonstrate his or her capability, which is reviewed by the director of the department and the QA officer. Finally, the QA officer gives the new hire a peer review and a 10 percent check on the analyzed raw data.

"We don't necessarily have a lot of hierarchy, but we have a lot of training and/or cross-training, and we welcome input and always are open to ideas and thoughts about how to make things more efficient and better," Murshak says.

Effective supervision

Once the right employee is integrated into a laboratory structure, each manager has his or her way of overseeing employee progress. For some, constant supervision works best; for others, it's trusting that all the training and initial scrutiny that went into picking a team member means that the manager can be more hands-off.

"Merit Laboratories is unique in that we try to not micromanage," Murshak says. "We are hands-on when they need us and hands-off when they are performing well."

PDC's style is more hands-on, but not in a way that feels like intervening. "Everyday supervision is more like a partnership," Rakoski explains. "We work hand in hand with each other and other departments."

Both teams find that a large part of effective supervision is evaluation. For PDC, every year, in addition to having a review by their supervisors, employees review their own performances. As it turns out, the employees are harder on themselves in evaluations than their supervisors are.

At Murshak's lab, all new employees are reviewed at the three-month mark and evaluated on performance and attention to detail. Furthermore, "We talk to their peers, and we ask for feedback from the new employee as well," Murshak says. "After that, we try to review everyone annually. These reviews are mostly informal. But formal reviews are done when needed."

For managers, assembling and training a strong crew is not just to ensure the company runs well, it's also to ensure the organization can continue to grow into a strong future. When a robust staff contributes to the organization and is invested to stay and work toward a common goal, the lab will have a strong skill set that will allow it to be on a path to growth even as other factors in the industry change.

An example of this is Murshak's lab, where much of her staff has been at the company for more than a decade and many senior staff members for more than 20 years.

"I was there when the company was born and have been with the lab through undergraduate and graduate school in chemical engineering," she says. "I came back to build and evolve our laboratory to have the best service and technically the best quality laboratory."

In business for more than three decades, Murshak's lab has had its share of hardships, but because of a solid staff—the organization's backbone—Merit always kept growing and is continually moving forward.

"We crawled out of bad economies by believing in what we are doing and working together through the tough times, and most of all, servicing our clients and their needs," Murshak says. "I am very fortunate to have a great team filled with smart, loyal, honest employees [who] care about our vision and are committed to what we do."

Sara Goudarzi *is a freelance writer based in New York City. Her website is www.saragoudarzi.com.*

The National High Magnetic Field Laboratory

RECORD-BREAKING 'MAGLAB' OFFERS UNPARALLELED RESEARCH ENVIRONMENT FOR THOUSANDS OF SCIENTISTS

by Lauren Scrudato

The National High Magnetic Field Laboratory (MagLab) has an impressive resume—it holds 16 world records, encompasses three facilities located throughout the US that are home to one-of-a-kind instruments and magnets, and attracts more than 1,400 visiting scientists each year. But as Gregory Boebinger, director of the MagLab, states, "This really is the kind of facility you have to see to believe. Everything is bigger than you could imagine."

The MagLab headquarters at Florida State University in Tallahassee features a 370,000-sq.-ft. complex with approximately 300 faculty, staff, and graduate and postdoctoral students who are constantly at work. The two other branches of the lab are located at the University of Florida in Gainesville and the Los Alamos National Lab in New Mexico.

The lab focuses on four main objectives: develop user facilities and services for magnet-related research; advance magnet technology in cooperation with industry; promote a multidisciplinary research environment and administer an in-house research program that uses and advances the facilities; and develop an educational outreach program.

"In order to run successfully, we need to have an in-house research component. We make sure our in-house expertise—whether it be engineering, technical, or scientific—is always dovetailing with the existing and future directions of new science that our users would like to pursue," explains Boebinger. And the unifying theme that attracts such a large number of scientists from all types of disciplines is high magnetic fields.

▲The MagLab headquarters in Tallahassee, Florida.

> "The breadth of science done here is exciting and continues to grow with time."

The MagLab is the only high magnetic field user facility with such a robust scope of magnets in the US. Having access to this type of facility is vital to pioneering new avenues of research across a variety of applications. The MagLab provides the extreme environments needed to better understand how materials will behave in more ordinary situations.

"High magnetic fields are an incredibly versatile tool throughout many of the physical sciences, from physics to engineering to biology to medicine, and we essentially provide unique high magnetic field facilities for research across all those disciplines," says Boebinger.

As Boebinger explains, high magnetic fields have been key in understanding so many new technologies, devices, and materials, such as commonly used LEDS as well as the ongoing development of next-generation LEDs. High magnetic fields were also imperative to understanding the fastest transistors in the world. "Even though you don't use these materials with high magnetic field[s], you need the high magnetic field to act as a microscope to understand how the properties work and how to improve the materials to develop the technology," says Boebinger.

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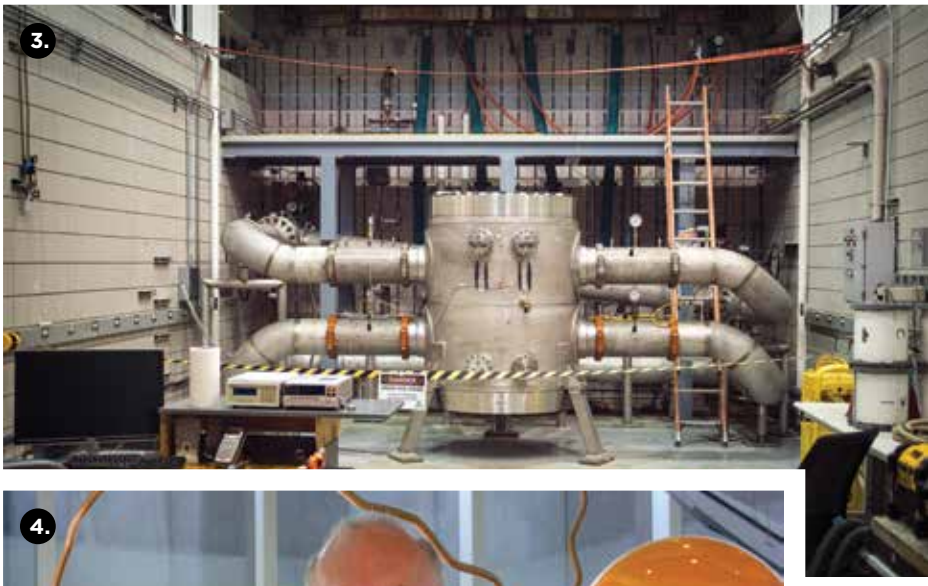
1. The 32 Tesla magnet is the world's most powerful superconducting magnet and 8.5 times stronger than the previous record holder. **2.** The 36 Tesla Series Connected Hybrid Magnet, now in operation, is designed to achieve high homogeneity while using half the power of a resistive magnet. **3.** The 41.4-tesla instrument, a world-record magnet, seen connected to cooling water pipes. **4.** Gregory Boebinger, director of MagLab. *Credit all photos: MagLab.*

One-of-a-kind equipment

The MagLab features dozens of different types of magnets, including permanent magnets, electromagnets, and resistive magnets. Among its 16 world records, the MagLab has the world's strongest magnet and the world's largest. The main facility at FSU uses 7 percent of the power of the city of Tallahassee to operate its resistive magnets. The lab uses 56 million watts to push 2,000 gallons of water through the lab's magnets every minute. Without the consistent cool water flow, the magnets would melt in a fraction of a second. Additionally, the Los Alamos branch of the lab is home to the largest motor in the country. It looks like any other motor, except it's 50 yards long, the shaft is one yard in diameter, and half a million pounds rotate at high speed to store energy. The motor generator, which is used to pulse a single magnet to create a high magnetic field for a fraction of a second, could generate 1.4 billion watts on its own if it were connected to the electrical power grid. For perspective, that equates to roughly two-thirds of the capacity of the Hoover Dam.

The lab's capabilities have roughly doubled since 2004, when Boebinger stepped into the role of director. He credits some of that growth to high magnetic field data becoming increasingly popular and essential in all types of research. Chemistry, biochemistry, and biomedicine are three areas where high magnetic field data has proved to be especially useful.

One example is within MRI technology. Researchers are developing new methods to better identify whether a certain type of chemotherapy will be effective in killing cancerous tumors while also limiting the side-effect damage to patients. Currently, MRIs have been exploited to image only hydrogen in the body. "But if you have high magnetic fields, you can start to look at sodium, chlorine, phosphorus, etc.," says Boebinger. With sodium, for example, you can tell whether cells are going to die because a cell takes up and accumulates sodium before it dies. So, imagine being able to give a patient a small dose of chemotherapy—enough to test whether it will work but not enough to cause side effects—and image the sodium to see if the tumor lights up. If so, then



a larger dose of chemotherapy will likely be effective in killing the tumor cells.

"This is one huge and obvious application for high-field magnetic resonance imaging. But you need higher-field magnets. So MagLab's materials and engineering groups are working to develop high-temperature superconducting magnets. These will revolutionize any application of high magnetic fields, and in particular, types of magnets used in doctors' offices and hospitals for MRIs," explains Boebinger. "We develop the materials that go into the next-generation magnets and the magnets themselves, and we pursue the science ranging all the way from physics to biomedicine."

Pushing science forward

Running a lab of this size and magnitude certainly comes with its own unique set of challenges. "The breadth of science done here is exciting and continues to grow with time. There's always a new frontier to explore," says Boebinger. But simply keeping track of all the work and experiments going on can be daunting. Boebinger's philosophy is to "hire the most talented people we can, give them the resources they need, and get out of their way." But each of these three steps can be a challenge on its own.

The MagLab has entered its 24th year as a user program facility, and with that length of operation time comes some major equipment upkeep. The facilities are primarily funded through the National Science Foundation, as well as through the Department of Energy and the state of Florida. Boebinger notes that the team plans to upgrade some of its aging instruments this year, as well as replace power supplies and some of the infrastructure that moves the cooling water around the magnets.

"I feel like we're moving from young-adult years to midlife, where we're really hitting our stride, but our joints are starting to creak and our hair is turning gray and falling out. Fortunately, we have folks stepping in to help update and rejuvenate that infrastructure."

***Lauren Scrudato**, associate editor for* Lab Manager*, can be reached at lscrudato@labmanager.com or 973-721-4070.*

Designing for Innovation

THE ROLE OF A LAB PLANNER IN DESIGNING SPACES THAT ENCOURAGE NEW WAYS OF THINKING **by Mark Paskanik, AIA, NCARB, LEED AP BD+C**

What is innovation science? Or rather, what makes labs capable of supporting innovation? If you look back at history, many famous lab inventions came about in nonconventional and even accidental ways.

Lab inventions

Thomas Edison is well known for his inventions and an amazing 1,093 patents, most of which were based on trial and error. He was once quoted as saying, "I have not failed. I've just found 10,000 ways that won't work." In June 1877, while working in the lab on an audio project, Edison and his assistants inadvertently scratched grooves into a disc. This unexpectedly produced a sound, which motivated Edison to create a rough sketch of a recording machine, the phonograph. By November of that year, Edison's assistants had created a working model. Incredibly, the device worked on the first try, a rare outcome for a new invention. This innovative idea made him famous.

How do you win a Nobel Prize? By sifting through your trash, of course. Eager to go on vacation, Alexander Fleming left a pile of dirty petri dishes stacked at his workstation before he left town. When he returned from holiday on September 3, 1928, he discovered that most of them had been contaminated—as you might expect would happen in a hospital bacteria lab. Fleming dumped most of the dishes in a vat of Lysol. But when he got to a dish containing staphylococcus, something odd caught his eye. The dish was covered in colonies of bacteria except in one area, where a blob of mold was growing. Around the mold was an area free of bacteria, as if the mold had blocked it from spreading. When he realized the mold could be used to kill a wide range of bacteria, penicillin was invented. To this day, is it one of the most widely used antibiotics.

University research

A few universities have taken a different approach. At the University of Michigan, there is a program called MCubed. This program stimulates innovative research and scholarship by distributing real-time seed funding to multiunit, faculty-led teams. Through this funding program, three faculty members from at least two different campus units can form a collaborative trio, or "cube," and request either $15K or $60K to advance their idea right away. As an example, one pediatrician and two mechanical engineering professors came together and developed a biochip that quickly measures immune status with only one drop of blood. Through their MCubed results, these cube collaborators secured a $3 million grant from the National Institutes of Health, and they are now one step closer to saving patients' lives. The MCubed program uses interdisciplinary methods to think about research by using nontraditional professions such as composer, artist, linguist, and more.

> "The MCubed program uses interdisciplinary methods to think about research by using nontraditional professions."

For the second consecutive year, Arizona State University (ASU) is the nation's most innovative school, according to *U.S. News & World Report* rankings (2015/2016). "We do things differently, and we constantly try new approaches," ASU president Michael M. Crow said. "Our students' paths to discovery don't have to stay within the boundaries of a single discipline. Our researchers team up with colleagues from disparate fields of expertise. We use technology to enhance the classroom and reach around the world. We partner with cities, nonprofits, and corporations to support our advances as the higher-education economy evolves. This ranking recognizes the new model we have created."

I have worked on projects for bioengineering, pharmacoengineering, and others. The programs that merge disciplines open up new ways of exploring research to discover innovation. This shift will continue to advance research.

STEM

Science, technology, engineering, and mathematics (STEM) have been at the forefront of education. The methods of teaching are still driving how space is configured. The innovation aspect that is changing how STEM is being taught is shifting toward industry. The education system is being challenged to have its students be better prepared for real-world experiences. Community colleges are looking at models to prepare their students for the next step: either the workforce or higher education. Higher-education systems are partnering more with industry to provide funding, and the industry partners are able to leverage the knowledge and brain power of the more highly educated personnel.

Lab design

Traditionally, laboratory design has been based on a rigid modular layout comprising rows of benches. In many cases, this can be a very effective and efficient approach, but integrating modular layouts with collaboration and workplace spaces can also have a very positive effect on the culture and environment of the research. To create an innovative layout, many of the following concepts apply:

- Relationship of the office to the lab
- Level of openness and flexibility
- Percentage and location of collaboration/interaction spaces
- Blurred lines of "territory"
- Technology

Modular layouts can also be set up to run in both east-west and north-south directions. If tour routes are being used, a hexagonal shape can create a unique way of displaying the science while increasing the linear footage of usable bench space.

In a lab, even the smallest details can have a big impact on efficiency. A good lab planner will listen to clients and researchers and design a workspace specific to their needs. If a researcher is struggling to perform a particular task, for example, making a change to the architectural details of the lab space can improve productivity.

Laboratory owners are constantly challenged to create new research environments with limited budgets and few resources. In addition, consideration has to be given to the "triple bottom line" (people, planet, and profit) within these strict budgetary constraints. Cost-conscious owners want facilities to meet their vision and business objectives while also including flexibility, efficiency, safety, and robust utility/engineering systems. Early in the process, strategies can be used that have no financial impact on the project. These strategies come from the lab planner's previous design experience and include options specific to the current project. Along with these strategies, incorporating initial and ongoing dashboards facilitates making informed decisions from the planning phase all the way through occupancy.

Laboratory projects can be extremely challenging and require a very thorough analysis. How do we as designers use our knowledge of past projects to work with clients to create their vision? In many cases, a high-level visioning process can be used in combination with practical approaches to create that vision in a day. With careful advance planning and use of very interactive and visual tools, the process itself can build consensus and can be fun for the groups involved.

So, what can we do today to make innovation science? We need to create spaces that promote the spark of genius, encourage new ways of thinking, and foster collaboration across disciplines.

***Mark Paskanik**, CRB senior architect & laboratory planner, has nearly 20 years of experience programming, planning, and designing research facilities worldwide. With a focus on tested planning principles, Mark uniquely adapts each lab design to support the client's vision to create a collaborative, efficient, and safe environment. He can be reached at mark.paskanik@crbusa.com.*

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Buying Used Chromatography Equipment

THESE HIGH-DEMAND USED INSTRUMENTS YIELD SUBSTANTIAL COST SAVINGS

by Erica Tennenhouse, PhD

With many laboratories experiencing funding challenges, and with a large portion of those funds typically devoted to instruments, it's no wonder that buying pre-owned equipment has become a popular option for certain labs—particularly start-ups and university labs. A wide range of instruments, including microscopes, thermocyclers, and flow cytometers, can be bought used.

According to Anthony Van Divner, head of sales and business development at BioSurplus (San Diego, CA), and Roger Gallo, CEO and president of EquipNet (Canton, MA), one of the most popular types of used instruments among their customers is a chromatography system.

"Chromatography instruments such as HPLCs and GCs are in constant demand," says Gallo. "If a dedicated research site doesn't have an immediate need for one, they may still buy one as a backup unit to be installed in the future or for parts in case their running system goes down." The popularity of these systems may be attributed to the fact that chromatography is performed in both R&D and quality control settings for a wide variety of industries.

The cost savings on a used chromatography system can be as much as 50 to 75 percent versus buying the same instrument new, says Van Divner. "Most of the customers we deal with take the opportunity for cost savings rather than buying [chromatography systems] new from the manufacturer."

Aside from the cost savings, Gallo notes that another key advantage to purchasing pre-owned chromatography equipment is the lead time for delivery. "Once a sale is consummated and payment has been collected, EquipNet will coordinate the earliest possible shipping or collection date, which would shave weeks, sometimes months, off the lead time promised by OEMs." This speed is advantageous for buyers who require the instrument immediately in order to keep their site's production afloat.

For BioSurplus, used chromatography systems are sourced primarily from working labs, including large pharma and biotech labs that have recently upgraded to the latest generation of instruments. "We really prioritize taking equipment out of working labs because that's where you have the best bet of getting quality equipment for the next end user," says Reid Hjalmarson, director of marketing at BioSurplus. For its part, EquipNet's chromatography equipment comes from exclusive contracts with multinational corporations, regional manufacturers, testing laboratories, clinical labs, and universities, says Gallo.

Before buying a piece of used chromatography equipment, there are several questions that customers should ask. When purchasing a gas chromatograph, Gallo recommends that customers make the following inquiries: Which type of inlets does it have? Which type of detectors does it have? Does it include software? For a liquid chromatograph, he suggests customers ask whether the solvent pump is isocratic, binary, or quaternary; whether multi-wavelength, ultraviolet visible, diode array, or fluorescence detectors are included; and whether software is included and, if so, which software revisions are needed. And they should inquire about the configuration.

Van Divner adds that the first question he believes customers should ask before purchasing a pre-owned chromatography instrument is how old it is. He also advises customers to get the serial numbers of all the components and to find out whether the instrument comes with software. Another useful question to ask, according to Hjalmarson, is whether the system is under a current performance maintenance plan, which can give the buyer confidence that the system has been properly maintained over time.

Erica Tennenhouse, *Scientific Content Editor for* Lab Manager*, can be reached at etennenhouse@labmanager.com or 647-500-7039.*

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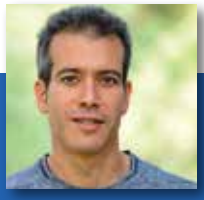

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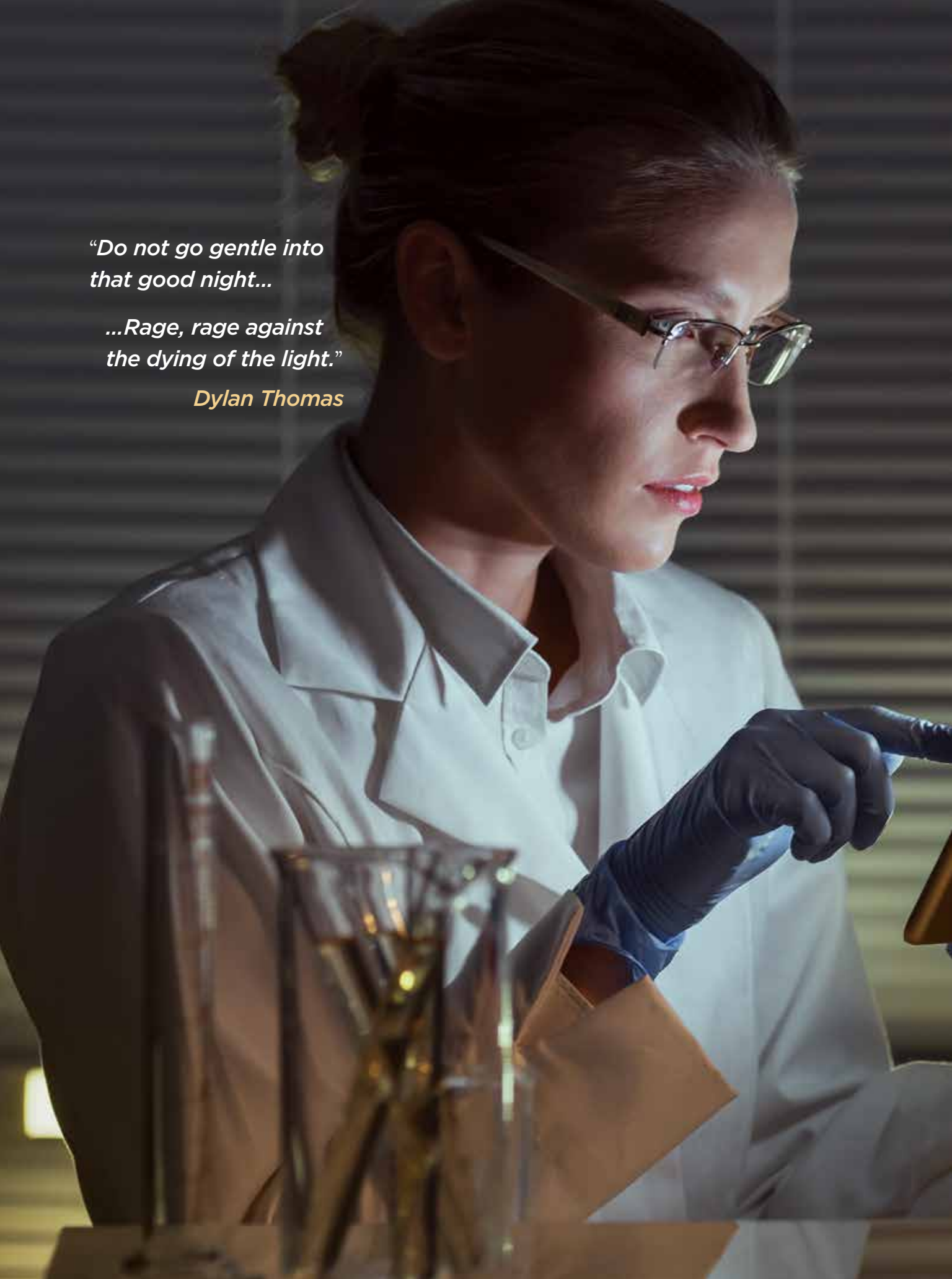

"Do not go gentle into
that good night...
...Rage, rage against
the dying of the light."
Dylan Thomas

LABORATORY EQUIPMENT MANUFACTURED WITH CARE AND ATTENTION TO DETAIL LETS SCIENTISTS FOCUS ON WHAT MATTERS MOST

Why good manufacturing practices are the foundation for great science

SUPPORTING SCIENTISTS IN PURSUIT OF A BETTER WORLD

The words from Dylan Thomas implore us to strive for more, take on challenges, to live boldly and with conviction. This sentiment is especially evident in the scientific community, where the fight against disease is fraught with challenges. Take, for example, the emergence of antibiotic-resistant bacteria that do not respond to any available treatment and necessitate ongoing drug development. Or cancer therapies that need to be designed to destroy cancer cells without damaging healthy cells. For every step forward, new challenges arise. It is because of tireless effort and bold new ideas that scientists create cures and improve countless lives. This drive and motivation, however, is not limited to the life sciences. It extends even further into our daily lives, as scientists and researchers work to overcome challenges facing society, including ensuring production of safe and nutritious food, as well as improving materials that make up our homes, medical devices, and personal technology.

Chemical, industrial, and life science research advancing new concepts begins in the lab, where countless fundamental processes set the foundation for future discoveries. Using reliable equipment, manufactured in a way that adheres to the highest quality standards, ensures accurate, consistent results. It also enhances productivity by allowing scientists to spend time and resources on their research. Companies like Heidolph North America make it their mission to use good manufacturing practices and provide quality individual support, allowing scientists to put their research first.

BE PREPARED FOR YOUR CHALLENGE

New innovations and cures often stem from the latest, most advanced techniques. These techniques rely heavily on basic preparatory steps such as vortexing and heating samples and autoclaving surgical tools and glassware. While these steps seem mundane, they are essential to the success of the experiment. For example, ensuring a drug is properly dissolved in a solution by vortexing or heating can be essential to its

Research advancing new concepts begins in the lab, where countless fundamental processes set the foundation for future discoveries.

in vivo efficacy. Having easy to use, reliable heating platforms and vortexes makes this task seem like second nature. Similarly, powerful techniques such as gas or liquid chromatography and mass spectrometry produce enormous amounts of data identifying thousands of metabolites in a single sample. Sample preparation involves evaporating solvents out of the sample, often using rotary evaporators. Heidolph rotary evaporators are made with high quality German engineered motors. They are designed and manufactured in German-based research, development, and production facilities, and are backed by guaranteed quality standards. This ensures scientists can process thousands of samples worry free.

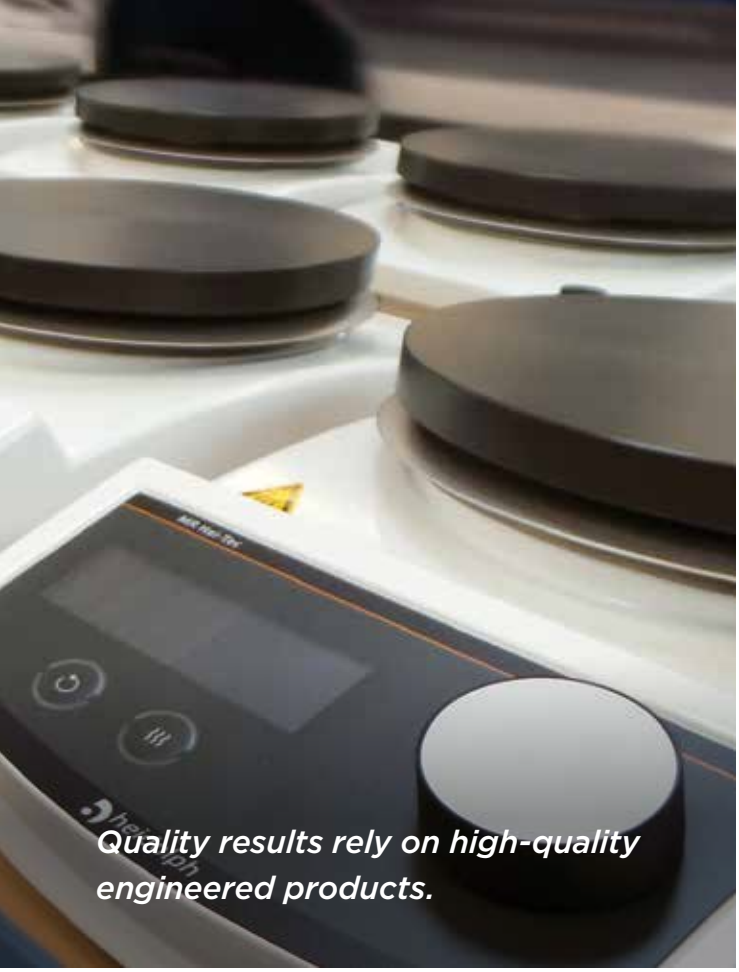
When exploring new ideas in the lab, it is also necessary to ensure appropriate safety measures are in place. When working with vapors, fumes, gas, and particulate, properly functioning hoods and workstations protect individuals from exposure to hazardous substances.

Preparation not only leads to better research, it can save money over the course of experiments. Investing in tools to reduce waste, such as distillation systems for recycling, adds up to significant savings over time. This may be done on a small scale in a laboratory to recycle frequently used solvents, or on a larger scale in industry. Processes like cleaning auto parts produces liters of waste fluid daily, and recycling these fluids creates long-term cost savings and increases sustainability.

Being prepared with the right tools makes daily tasks safer and more efficient, accelerating discovery and innovation.

ALIGN YOURSELF WITH THOSE WHO SHARE YOUR VALUES

With laboratory equipment, routine maintenance and the associated downtime can be costly. Similarly, malfunctions that occur during an experiment seriously hinder research, especially when equipment needs to be shipped off-site for service or repair. By adhering to good manufacturing practices, and providing longer warranty periods, scientists can be guaranteed reliable, high quality equipment that is made to last. Heidolph laboratory equipment is manufactured in Germany, with the "Made in Germany" seal signifying premium, high quality products. Using German-made components that do not require routine maintenance, and the high standards of quality control applied to each individual unit increases product longevity.



Quality results rely on high-quality engineered products.

Caring for the needs of researchers accelerates science and discovery.

The reason so much care goes into each piece of equipment is because Heidolph understands that regardless of the field of research, scientists are working toward a common goal of improving human health and living conditions. The company's core values lie in supporting scientists so that they can produce their best work. When high quality products are coupled with best in class service and support, the result is exciting innovation and solutions.

SUPPORT THE RESEARCHER- SUPPORT THE CAUSE

Ideas may be born in an instant but translating them into real life solutions takes years of effort, trials, and failures. These solutions are the work of those who, in the words of Thomas, "rage against the dying of the light," continuing to work despite setbacks. Recent advances in biotechnology, such as gene editing, targeted cancer therapies, and stem cells, are changing the way we think of disease. The development of new pharmacologic agents to target pathways in chronic illnesses such as hypertension and diabetes enables patients to effectively manage these conditions. These solutions stemmed from bold ideas and the search for better solutions. Heidolph is passionate about providing researchers products engineered and manufactured to the highest quality standards along with outstanding support. They are working behind the scenes along every step of the way on the path to new discovery. In caring for the researchers' needs, Heidolph accelerates great science for a better world.

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Hiring Right

REQUIREMENTS FOR FINDING AND KEEPING THE BEST CANDIDATES FOR YOUR LAB **by Scott D. Hanton**

People are the most important aspect of any organization or business. The organization can accomplish only what the individuals within the organization contribute. As a laboratory leader, it is vital for us to sponsor and develop a strong sense of community in our staff. Developing a strong sense of community begins with the recruiting and hiring processes. To contribute positively to our community, we are looking for candidates who can bring the following attributes to the organization:

- Maturity
- Personal accountability
- Intrinsic motivation[1]
- An interest in collaboration
- Critical thinking[2]
- Safety consciousness
- A willingness to give[3]
- Leadership[4]

Our recruiting and hiring philosophy is to hire attitude and train skill.[5]

Recruiting process

Today, there are multiple paths to finding qualified candidates. It is no longer enough to simply post an open position on the company website and expect the candidates to find us. We try to use a multifaceted recruiting approach that includes:

- Company career website
- Referrals from current employees
- Social media, such as LinkedIn
- Local professional societies
- Internet job boards
- Leadership team's personal networks
- Professional recruiters

As we search for candidates, we are actively seeking the following characteristics:

- Technical excellence
- Critical thinking
- Communication skills
- Creativity
- Flexibility
- Teamwork[6]
- Leadership[7]

Of these, technical excellence is the easiest to find and the easiest to evaluate. However, we want to consider all candidates who demonstrate at least the minimum technical skill required for the position. Additional technical skill is largely irrelevant.[8] The other characteristics will drive the hiring decision.

Candidates who can demonstrate the following characteristics during interviews and other interactions will usually be the most successful candidates:

- Emotional maturity
- Passion[9]
- Energy
- A giving attitude

Resume review is a critical skill for all hiring managers. In some cases, so many candidates apply for a position that many resumes need to be rapidly and effectively screened. In other cases, few candidates are available, and

patient scrutiny of the existing resumes is required. In any situation, clear decisiveness is required in resume review. When we screen resumes, we are looking for leadership and innovation indicators, and we are cautious about time gaps, lists, and errors.

Once the best resumes percolate to the top, we conduct brief telephone interviews to further evaluate the candidates. For a typical open position, we are screening 50 to 100 resumes to pick five to 10 candidates to call with the goal of inviting three candidates for in-person interviews. Phone-screen interviews typically take 15 to 30 minutes and focus on the details of the resume. Telephone interviews require careful listening. Successful candidates are those with whom we wish more conversation.

Interview process

Ideally, we want three candidates for in-person interviews. Our interview teams are effective at comparing candidates with each other and differentiating between their opportunities and challenges. It is often difficult to interview a single candidate for a position, for it is hard to avoid comparing a single candidate with our ideal candidate.

The primary reason to interview candidates is to seek one who fits the position. Fit is both with the job that needs to be done and with the rest of the current team. Evaluating technical skills is a secondary portion of the interview. That should have been accomplished during the telephone interview.

The first step of the interview process is selecting a 360-degree interview team. The 360-degree team includes interviewers from staff above, equal to, and below the open position in the organizational hierarchy. Since community is so important, we want to obtain a clear view of how the candidate interacts with staff at all levels of the organization. Poor candidates will work hard to impress leaders but not treat lower-level staff well. Our desire is to screen out these candidates.

Our approach to in-person interviewing is to focus on behavior-based questions. Here are examples of our typical interview questions:

- Tell me about a time you had conflict with a co-worker and how you resolved it.
- Tell me about a time you faced a priority issue and how you solved it.

- Tell me about a time you made an important mistake and how you communicated it.
- What are you most proud of?
- What personal attributes make you the best person for this position?

"Our recruiting and hiring philosophy is to hire attitude and train skill."

While the stock market states that previous performance is not an indicator of future performance for any specific stock, the opposite is true for people; past performance is an excellent indicator of future performance. We want to create scenario questions that probe past actions and behaviors and predict how those actions and behaviors will work in our environment. We probe attitudes about safety, quality, teamwork, and communication.

Once the formal interviews are complete, we start to make decisions. We convene the interview team and obtain feedback from each member. It is important to hear each interview team member and explore any issues discovered during the interviews. Our strategy is for any leaders on the interview team to express their opinions last so we receive unbiased feedback from the team.

Once we have candidates we are interested in hiring, we look for any additional information we can find to prevent any unpleasant surprises later. This is a good time to check in with the personal references provided. Typical questions for references include information about personality, behavior, and areas for improvement.

Once a first-choice candidate is selected, it is time for the offer process. It is also time to remind the candidate of all the positive reasons for him or her to accept the imminent offer. We will start notifying all the candidates in whom we are no longer interested. We will, however, hold off notifying other good candidates until we have an accepted offer from the first-choice candidate.

Onboarding

There is only one chance to make a first impression. Planning the onboarding of a new employee is critical. It is important to meet the expectations of the new employee with respect to readiness, desire to have him or her aboard, and commitment to his or her early success. Our onboarding process has four phases:

- Before the first day
- The first day
- The first week
- The first month

There are many details that need to be taken care of before the new candidate even arrives for the first day. Preparation for his or her arrival is critical. It is important to work with the supervisor to establish a clear "roles and responsibilities" document establishing the new role.[10] It is also important to establish expectations with the supervisor about the milestones that are expected to indicate whether the new employee is progressing as needed. Key deliverables before the first day include:

- 30-, 60-, and 90-day goals
- Computer
- Workstation/desk
- Nameplate
- Office supplies
- Personal safety protective equipment
- Identification of a mentor

On the first day, we want to introduce the new person to our community and ensure he or she can find vital things such as coffee and restrooms. Here is a typical day-one checklist:

- Introductions to everyone in the organization
- Lunch with the supervisor
- Tour of the facility
- Safety indoctrination
- Check that computer and network ID work
- Meet the mentor
- Get company ID
- Start safety training

During the first week, the goal is to complete safety training and start introducing the new staff member to the science conducted in the lab. Here is a typical week-one checklist:

- Complete safety training
- Do ethics training
- Complete general quality SOPs
- Begin lab-specific SOPs
- Understand expectations
    - Review roles and responsibilities
    - Review 30-, 60-, and 90-day objectives
    - Review annual objectives
- Begin introduction to internal work processes, such as timesheets

- Provide introduction to the company

Over the course of the first month, the goal is to complete initial lab training and have the new person start to contribute in the laboratory. Here is a typical month-one checklist:

- Complete initial lab-specific training
- Start making contributions to the lab work
- Build working relationships with other lab members
- Be introduced to how the business works
- Be introduced to key customers/clients
- Obtain feedback from supervisor on 30-day objectives
- Identify further training needs
- Have lunch with managers

Retention of new employees rests largely on five things:

1. Integrating them into the work community[11]
2. Providing them with the tools and knowledge they need (technical, safety, quality)
3. Engaging them with appropriate technical challenges
4. Enabling them to have real job satisfaction[12]
5. Providing them the connections needed to ask questions, obtain more information, and grow in their role[13]

Summary

Recruiting and hiring is a process that must be owned by the managers/leaders of the organization. Ensuring the right people come into the organization is a high-priority activity. Setting up a process for careful selection of the right people is a key responsibility of managers. Utilizing all the talents of the organization and following a behavior-based process can enable high-quality hiring decisions. Once the right candidates are selected, managers can drive a detailed onboarding process that makes a good first impression and ensures that the new member of the team is guided and encouraged to be successful.

***Scott D. Hanton**, PhD, is the general manager of Intertek Allentown. Prior to working for Intertek, he was a manager and analytical scientist at Air Products and Chemicals for 20 years. During his time at Air Products, he worked closely with the knowledge management and continuous improvement teams. Hanton is also on the board of directors for the Laboratory Managers Association (ALMA). Hanton received his BS from Michigan State University and his PhD from the University of Wisconsin–Madison, both in chemistry. Dr. Hanton can be reached at scott.hanton@intertek.com.*

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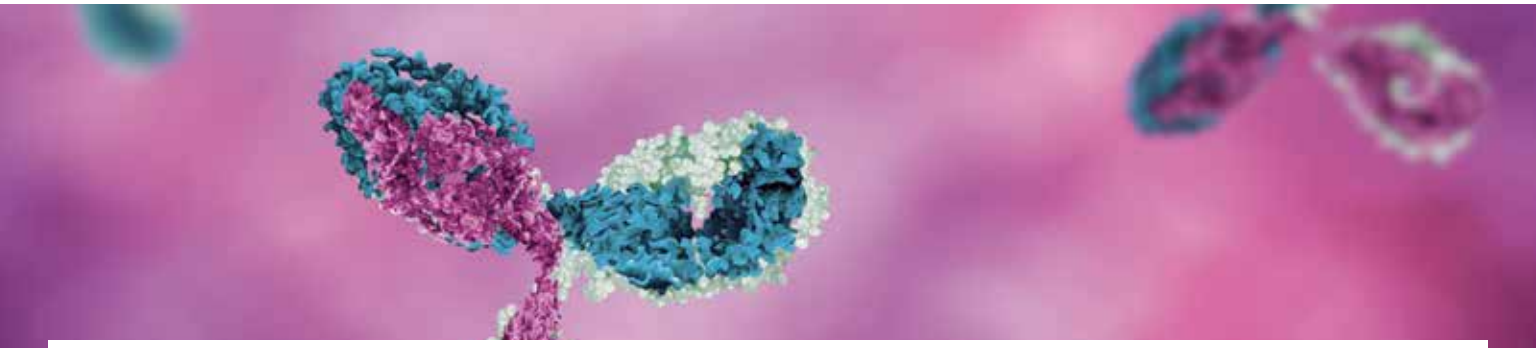

Computer Modeling and Simulation

APPLICATIONS IN CHEMISTRY, CLINICAL, AND PHARMACEUTICAL LABS HOLD PROMISE—WITH RESERVATION

by John Joyce, PhD

According to one author, modeling and simulation "live at the intersection between theory and experiment."[1] The model is an interpretation of current theory, while the execution of that model is a simulation of what the model designer expects to happen. This simulation can be extremely useful, because how well its predicted results compare with actual experimental results is a good test of whether you have accurately taken all factors relevant to the experiment into account.

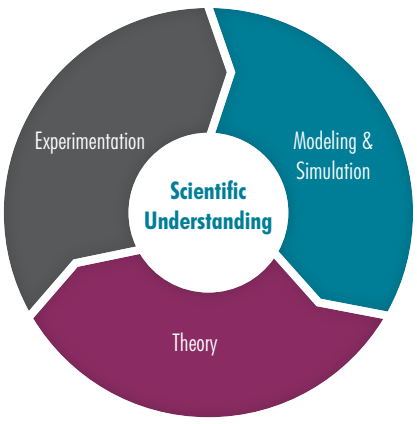

Illustration 1: Role of Modeling and Simulation in Scientific Discovery - Office of Nuclear Energy.

To help visualize the potential problems in designing and using models, consider the management of your laboratory. A good case can be made that you are not managing a laboratory, but rather the visualization, or model, of the laboratory that you hold in your mind. How well your management of this model works is a function of how well this simulation corresponds to reality and the criticality of any discrepancies.

It is very entertaining, in a schadenfreude sense, listening to group managers in informatics requirement-gathering meetings confidently describe how the analyses in their group are performed, only to have an analyst hesitantly interrupt, stating that the described process is not the procedure they actually follow. Predictive models used in the laboratory are vulnerable to this same effect. These models can be very helpful, but it is imperative that you continually question their accuracy. The following sections illustrate some of the critical roles of modeling and simulation in the modern laboratory.

Chemistry laboratories

Among the simplest models that you are likely to encounter is the lowly calibration curve, particularly those in which the relationship between the value actually being measured and the concentration is linear. However, you are liable to encounter much more complex models and simulations even in a chemistry lab performing organic analysis. What has become almost a classic example is the modeling of a high-performance liquid chromatography (HPLC) system. It is not uncommon to have to develop a new analytical method to separate and quantify new organic compounds that the laboratory deals with. The classic way would be to run a plethora of experiments under all of the potential conditions, but there are obvious drawbacks to this. Principally, consider how many experiments you would have to run to cover all of the potential analytical conditions and the corresponding time and money involved.

To list just a few, your potential variables include the type of separation column, the solvent used, whether the

nature of the solvent varies over time, whether the temperature of the solvent varies over time, the rate of flow of the solvent, sample injection size, and identifying the optimal detector and potentially the optimal optical frequency of the detector. Because the group of samples you would need to run would increase factorially, it should be obvious that developing this new method would require a significant investment of time, patience, and, oh yes, money!

Illustration 2: Android HPLC Simulator - Regents of the University of Minnesota.

Fortunately, due to the significant research on how HPLC systems work, it has been possible to develop models of their operations, and it is feasible to run multiple computer simulations to identify the optimal set of analysis conditions. This will still require the analysis of samples under different conditions, but only a handful, compared with what you would otherwise have to run. A good caveat to keep in mind is that there are multiple ways of modeling for HPLC optimization. For those interested in getting a feel for the history and approaches for HPLC modeling, this paper from *Chromatography Today*[2] would probably be a good place to start.

While many HPLC system and column manufacturers have developed their own proprietary software for analysis optimization, there are a number of free programs available on the internet to perform this optimization. To emphasize that you do *NOT* require access to a supercomputer to perform these optimization calculations, HPLCsimulator.org, a designer of simulator and training tools, has an app version, *HPLC Simulator for Android.*[3]

Clinical laboratories

Clinical laboratories, whether freestanding or integrated within a hospital or clinic, can also profit from simulation and modeling. Researchers at Stanford University have recently (July 10, 2018) announced the development of a computer program, Decagon, which uses graph convolutional neural networks to predict potential side effects when two drugs are taken at the same time.[4] The concerning thing is that in many cases, these drugs have never been administered together, so no one knows which side effects, if any, might occur due to their interaction. The scary thing is that the drugs might be prescribed by different doctors who have no idea that the patient is on another medication.

According to this research group, the number of known side effects is currently around 1,000, while the number of drugs on the market is currently approximately 5,000. From simple statistics, this means that there are over 125 billion possible side effects among possible pairs of drugs.

Decagon uses a database of all known side effects for each drug, all known protein-protein interactions in the body, and all known drug-protein interactions as a starting point to feed its deep-learning algorithm into a supercomputer. Once this knowledge base is generated, Decagon can project potential side effects from binary drug interactions on a much simpler computer, even if those drugs have never been used together or if a specific side effect has not been observed with either drug. As a test of the accuracy of the system, its top 10 predictions, which had not been entered into its database, were cross-checked against the literature and, so far, at least five of them have been confirmed. Unfortunately, Decagon can make projections for only binary drug combinations, while the United States Centers for Disease Control estimates that 23 percent of all Americans took at least two prescription drugs in the last month and that 39 percent of those over 65 years of age took five or more.

"[Predictive] models can be very helpful, but it is imperative that you continually question their accuracy."

Pharmaceutical laboratories

Pharma labs may actually benefit the most from modeling and simulation, as they attack both ends of the labs' product streams. As we gather more information as to how and why a particular drug works, we can build models to predict the behavior of new molecules, allowing lab staff to design new drugs with potentially fewer side effects and increased effectiveness. At the same time, as we learn more about how cancerous cells evade the body's immune system, it is possible to design drugs to neutralize this capability. Recent research has allowed the design of molecules that block the sites on some cancer cells that tell the immune system not to attack them. While this approach is highly specific, it can also be extremely effective. In one promising trial, the experimental drug did nothing for 80 percent of the test population, but the other 20 percent underwent a complete remission, with *no* residual cancer cells detected in their bodies.

Also accelerating the delivery of new drugs is a greater willingness of regulatory agencies worldwide to allow, and even encourage, a more prominent role

for modeling and simulation in clinical trials, potentially reducing the number of trials and/or the number of people involved in the trials. Some of this willingness is due to ethical concerns, while some is due to increasing faith in the accuracy of the models and resulting simulations.

Ending caveat

From these examples, it is clear that modeling and simulation do have a strong role to play in terms of scientific discovery. However, there are potential hazards to relying too strongly on modeling and simulation without confirmatory experiments. It is the nature of models to reflect the assumptions and factors that go into their design. While many models have been shown to work well, often the models are built on observed physical characteristics, rather than a full scientific understanding of why those properties behave as they do. Frequently, this potential failure point is amplified by a belief that we know more about how a process works than we actually do. This can occur in any field, but is particularly discernible in relation to medicine, in which new layers of subtle interaction are continually being discovered. Without that fundamental knowledge, it is easy to encounter an unseen trip wire consequent to a factor unconsidered in the model, as an outcome of it happening to remain constant in the samples used to build or train the model.

As others have stated, "Modeling and simulation should never be viewed as a substitute for real-world experimentation."[1]

As a final thought, it is worth keeping in mind this quote from Nobel physicist Richard P. Feynman: "If you thought that science was certain—well, that is just an error on your part!"

Dr. John Joyce *is a laboratory informatics architect based in Richmond, Virginia. His background includes extensive work in instrument design and automation for industry as well as engineering the data flows from instruments to and between data systems. He can be reached via email at jrj_sci@yahoo.com or by phone at 804-601-0211.*

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Keep Your Hands to Yourself

SAFE USE OF AUTOCLAVE STERILIZERS

by Vince McLeod

Autoclaves are so common and familiar in labs today that it is easy to overlook the associated hazards. Consider these recent incidents reported by the Lab Health & Safety Committee of the American Industrial Hygiene Association.[1]

A sudden explosion rocked a laboratory building one morning. A search by lab personnel found that an autoclave had ruptured, blowing its 80-lb door off its hinges, across the room, and into the opposite wall. Luckily, no one was in the room when the door blew off. With racks of test tubes, stacks of culture media, and trays of equipment (including needles) awaiting sterilization prior to disposal splattered across the room, it looked as if a bomb had gone off. Further investigation was unable to determine the cause of the failure. Not very reassuring, to say the least.

In another incident, a post-doc was severely scalded while removing a load from a tower-style autoclave. She was attempting to remove a Nalgene tub containing one-liter bottles of media in water when the tub buckled and spilled near-boiling water onto her torso and thighs. She was not aware of the contents of the Nalgene tub because the autoclave log had not been filled out for the load.

And in a third incident, two steam releases occurred in an autoclave room. One was due to a lack of a backflow preventer, which allowed steam to backflow into a DI water feed made of PVC. The PVC melted, releasing boiling-hot steam into the room. The second release occurred in the same room when the automatic overpressure safety valve switch failed. It was found that the electrical safety switch had been damaged during the previous release.

It is easy to get hurt when you are dealing with pressurized steam, but you can avoid mishaps and potential significant damage or injury by following a few basic safety precautions.

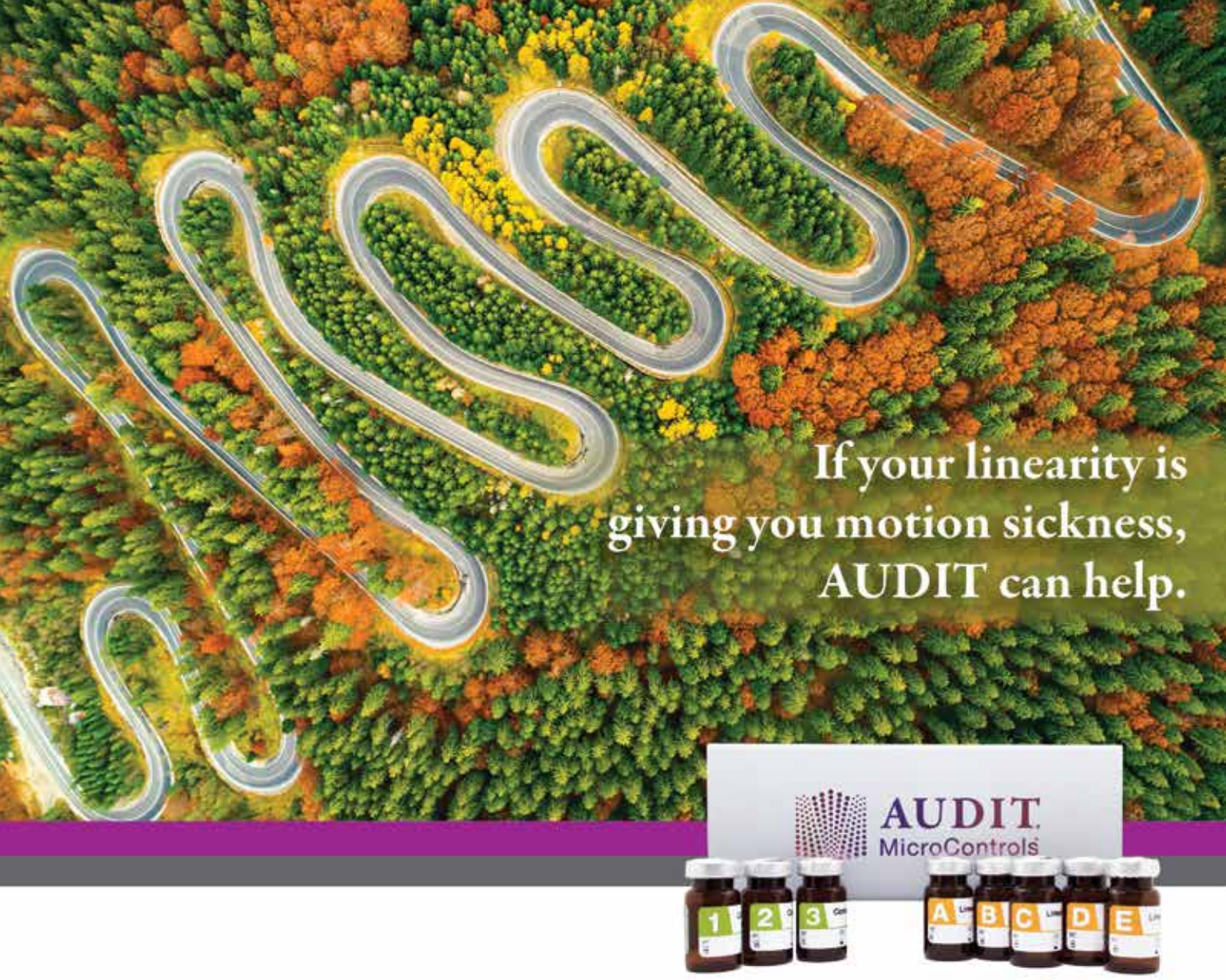
Recognizing the hazards

As a start, always think of autoclaves as large specialized pressure cookers. Do you remember all the warnings and stories your mother and grandmother told you about using pressure cookers? If not, consider that autoclaves use heat and pressure with water to create superheated steam. Therefore, they can pose significant hazards to untrained or careless employees.

Autoclaves are basically used for two main purposes—either to steam-sterilize media, instruments, or lab equipment such as glassware and specialized implements or to inactivate biological waste materials.[2] As we have indicated, the primary hazards are physical ones presented by high temperatures, steam, and pressure. Effective sterilization requires steam temperatures in excess of 250°F (121°C). Typical autoclave pressurization is at least 20 pounds per square inch. Depending on the use, additional concerns may include biological hazards such as infectious materials or physical hazards from sharps.

First—train, train, train

Loading and running an autoclave may seem as simple as using your dishwasher at home, but some planning is required to operate the autoclave safely and efficiently. All operators should be thoroughly familiar with the owner/operator's manual and controls. Controls vary between manufacturers, and every machine has unique loading characteristics, load-sizing requirements, cycle settings, and cycle types.[3] The size of the load and types



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of materials requiring sterilization or inactivation/decontamination will determine the cycle needed. It is highly recommended that the manufacturer's operation manual be copied and waterproofed/laminated and kept in the room with the autoclave.

Adopt a policy in which all users must be trained prior to operating any autoclave. Principal investigators or laboratory supervisors must bear the responsibility of ensuring this is done. Ensure all training is documented, and maintain the records in the lab. Make sure your training addresses proper use of appropriate personal protective equipment.

At a minimum, training should cover:

- Location, function, and use of controls
- Proper loading and unloading (including packaging, sizing, and testing protocols)
- Required personal protective equipment (heat-resistant gloves, lab coats, eye protection, and closed-toe shoes)
- Incident and maintenance reporting and record keeping
- Emergency procedures

Second—develop and enforce a monitoring and testing protocol

To ensure the autoclave is functioning properly and sterilization/inactivation is effective, we should monitor the operation of the autoclave and routinely test sterilization cycles. In fact, in Florida, this is mandated by the Florida Administrative Code for handling biomedical wastes, FAC 64E-1.[4] Under this law, autoclaves must be tested before being placed into service and routinely afterward. For autoclaves used to inactivate substances such as human pathogens, blood, tissues, and clinical samples, testing is required after every 40 hours of use. Autoclaves used to sterilize other materials must be tested every six months. We believe this is a reasonable testing schedule for research laboratories. Other institutions recommend testing with biological indicators at least once per month.[3]

Testing an autoclave's sterilization effectiveness requires the use of biological indicators. These are available in commercially prepared test kits containing bacterial spores, usually *Bacillus stearothermophilus* (e.g., ProSpore2). Most spore vial test kits require incubation of the autoclaved test vial along with a nonautoclaved control vial. Incubation will allow surviving spores to grow. We recommend that test loads, if used, approximate the weight and density of actual waste or materials normally autoclaved. For best results, test vials should be placed at the bottom, top, front, rear, and center of the autoclave chamber by placing vials in those positions of the test load or by making a number of smaller test packs with vials in the center and placing the packs appropriately in the chamber. In this way, the correct parameters for sterilization (time, temperature, and pressure) can be determined.

Third and final step—record keeping

A good autoclave safety program must include documentation. Principal investigators and supervisors are responsible for ensuring proper records are kept up to date. Autoclave users should be responsible for recording autoclave run information.

In addition, we recommend keeping records of all on-site maintenance. Only contractors approved by the manufacturer should perform maintenance. Keep maintenance contractor contact information conveniently posted.

Log each load processed in the autoclave. Record the date, time, and operator's name and contact information (e.g., lab, room number, and phone number). Indicate whether the load is biohazardous material and record the temperature, pressure, and time length for the cycle. If the autoclave provides

printed data or if data is recorded on a cycle wheel, save the printout or disk. Finally, include information in the log sheet for all efficiency tests performed and the results of each test.

Summing up

Additional information and technical assistance are always available from manufacturers as well as from NIOSH, OSHA, and many academic websites. The key to working with autoclaves is first recognizing the hazards, followed by training, testing, and record keeping. Whenever possible, we recommend autoclaves be located in dedicated rooms with proper and sufficient facility supply and exhaust ventilation.

Vince McLeod *is an American Board of Industrial Hygiene-certified industrial hygienist and the senior industrial hygienist with Ascend Environmental + Health Hygiene LLC in Winter Garden, Florida. He has more than 35 years' experience in industrial hygiene and environmental engineering services, including 28 years with the University of Florida's Environmental Health & Safety Division. His consulting experience includes comprehensive industrial hygiene assessments of major power-generation, manufacturing, production, and distribution facilities. Vince can be reached at vmcleodcih@gmail.com.*

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Breathing Easier

IMPROVED AIR-QUALITY SENSORS AND COLLABORATIONS COULD SAVE LIVES

by Mike May, PhD

On Friday, August 3, 2018, the Texas Commission on Environmental Quality issued another Ozone Action Day in Houston, Texas—the fourth-largest city in the United States. People with respiratory issues were encouraged to stay inside as much as possible. Limiting driving, especially idling, was also recommended, although the latter is almost impossible in one of the top 10 cities for traffic congestion in the country, according to INRIX, a company that collects traffic data. But it's not just this southern hot box that needs to think about air quality. Fighting for clean air is an international issue.

> "Even very low concentrations of air pollutants have been shown to have serious health effects."

According to the World Health Organization (WHO), outdoor air pollution kills 4.2 million people every year. Ninety-one percent of "the world's population lives in places where air quality exceeds WHO guideline limits."

Other organizations have published related findings. In the *Annals of the American Thoracic Society* in 2018, Kevin Cromar, director of the air-quality program at New York University's Marron Institute of Urban Management, and his colleagues published data from the *Health of the Air* report, which is produced by the Marron Institute of Urban Management and the American Thoracic Society (ATS). The results revealed that ozone levels surpassed ATS recommendations in more than 80 percent of the counties with validated air-quality monitors. The report estimated that poor air quality accounts for about 6,270 added deaths in the United States every year. The Health of the Air team also developed an online tool (HealthoftheAir.org) that provides air-quality data on specific areas of the United States.

To improve the quality of the air that we breathe, many scientists have the same goal: to produce more accurate measurements. As it turns out, that's not such an easy task.

PARTICLES IN THE PROBLEM

When discussing air quality, scientists typically mention ozone and particulate matter (PM). Ozone is a gas made up of three oxygen atoms, and it's not always bad. In the upper atmosphere, ozone can absorb almost all of the carcinogenic ultraviolet rays from sunlight, but at ground level, breathing ozone constricts airways, which can cause problems from a cough to chronic obstructive pulmonary disease.

The PM in air that impacts the quality is defined by the U.S. Environmental Protection Agency (EPA) as "a complex mixture of extremely small particles and liquid droplets that get into the air." The EPA adds, "Once inhaled, these particles can affect the heart and lungs and cause serious health effects."

The PM in air-quality measurements reflects the size of the particles. For example, $PM_{2.5}$ represents particles that are less than 2.5 micrometers in diameter. That makes the

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biggest of those particles about one-twentieth the diameter of an average human hair. Scientists also study other particle sizes, such as PM_{10} and $PM_{0.1}$, which are less than 10 and 0.1 micrometers in diameter, respectively.

When asked about the top priorities in air-quality monitoring, Anthony Wexler, director of the air-quality research center at the University of California, Davis, says one is "measuring $PM_{0.1}$, which may be more related to health effects than PM_{10} or $PM_{2.5}$." He adds that this is a challenge because there are currently no suitable instruments on the market.

In addition to the size of the particles in the air, the chemicals that make up those particles also matter. That's why Wexler says that one need is "real-time sensors for PM chemical composition."

To better measure smaller particles and determine what they are, scientists require new tools and techniques.

HEALTHY MONITORING

Protecting human health is a top objective for monitoring the quality of air. It requires knowing sources of danger and how they cause damage.

Even very low concentrations of air pollutants have been shown to have serious health effects, Wexler explains. Human health can be in jeopardy from gases in the tens of parts-per-billion range and particles in the range of tens of micrograms per cubic meter. "These low concentrations are difficult to sense," he says.

To monitor air quality as effectively as possible, scientists need tools that can provide the desired data and do so economically. So it would be useful, Wexler says, to be able to measure PM composition "without spending hundreds of thousands of dollars."

Other experts agree that better technology is needed to improve our ability to monitor air quality. For example, Julian Marshall, Kiely Professor of Civil and Environmental Engineering at the University of Washington in Seattle, says, "Top priorities are low cost, accuracy, portability, durability, and avoiding—or knowing about—measurement artifacts." He adds, "For some measurements, meeting regulatory standards is important."

Today's instrumentation lacks some of the crucial features that scientists desire for better air-quality monitoring. Sometimes, for instance, an instrument doesn't work long enough where it's needed. As Marshall says, "Many instruments that are portable have short battery lives or otherwise are difficult to use for longer-term measurements."

Even with enough battery power, today's instrumentation often lacks capabilities that scientists need. One of the key shortcomings is lack of reliability. "Getting reliable measurements—for example, reproducible measurements—from reasonably priced devices can be challenging," Marshall explains. "This aspect is something that colleagues and I struggle with each day." As a result, many scientists are on the hunt for low-cost sensors that are sufficiently reliable.

NEW APPROACHES

Several approaches are under way to analyze air quality in new ways. Some of those projects are taking place in the lab of Aydogan Ozcan, Chancellor's Professor at the University of California, Los Angeles (UCLA), and leader of UCLA's bio- and nano-photonics laboratory. In *Light: Science & Applications* in 2017, Ozcan and his colleagues reported on a new technique for measuring air quality with a mobile microscope and machine learning. The scientists described this platform, called c-Air, as a "field-portable cost-effective platform for high-throughput quantification of particulate matter." This platform includes a micropump, an air sampler, and a lens-free holographic microscope on a chip, and a custom machine-learning algorithm analyzes the data. In 30 seconds, c-Air screens 6.5 liters of air and determines the PM size distribution down to 1.74-micrometer particles. The scientists noted that the resolution could be improved to 0.5 micrometers, if needed, with a different sensor that uses smaller pixels or by applying computational techniques that "digitally synthesize smaller pixel sizes." Ozcan and his colleagues concluded, "We believe that the c-Air platform, with its microscopic imaging and machine-learning interface, has a wide range of applications in air-quality regulation and improvement."

Networking technology might also provide more information. Here, inexpensive and reliable sensors have the potential to transform air-quality research. They would enable data to be collected from more locations and more frequently. Wexler points out that this could allow citizens and communities to get involved. He hopes to see sensors improve to the point that measuring common air pollutants, like ozone and $PM_{2.5}$, can be done with inexpensive, accurate, and real-time sensors "so that everyday citizens can measure the quality of the air that they breathe." Wexler notes that the number and quality of sensors that are affordable to consumers and have reasonable accuracy is growing rapidly.

Teamwork in monitoring air quality could be practiced in many ways, including a project called MegaSense, which is coordinated by the University of Helsinki in Finland. MegaSense aims to combine many inexpensive and low-quality sensors with advanced machine learning and very accurate measurement stations.

Sasu Tarkoma, professor of computer science at the University of Helsinki and head of MegaSense, says that the MegaSense project reached a major milestone at the Mobile World Congress Shanghai with a live demonstration of wireless air-quality sensors calibrated with artificial intelligence techniques. This collaboration of the University of Helsinki, Nokia Shanghai Bell, China Mobile, and Vaisala demonstrated "live air-quality measurement and calibration with industry-grade and low-cost air-quality sensors," Tarkoma explains.

▲ *The MegaSense project combines sensors and networks—such as ones using SMEAR towers, like the one shown here—to track air quality in real time. (Image courtesy of Susan Heikkinen, University of Helsinki.)*

MegaSense is already running a pilot project in the Helsinki area, and another is being developed in Beijing, China. As Tarkoma points out, MegaSense "builds on the scientific SMEAR measurement station network that operates in three countries at the moment: Finland, Estonia, and China." Larger-scale trials are expected in late 2018 and early 2019.

"Getting reliable measurements—for example, reproducible measurements—from reasonably priced devices can be challenging."

MegaSense relies on a combination of high-quality sensors that calibrate low-quality ones. "The system is supported by a highly accurate measurement tower in each city that provides the ground truth data, a dispersion model designed for the urban environment, and a distributed mesh network of low-cost and very low-cost air-quality sensors that are calibrated based on validated sensor data," Tarkoma explains. Although today's inexpensive air-quality sensors suffer from drift in their measurement and exhibit high error rates, the MegaSense approach deals with that through what Tarkoma calls "a calibration scheme that detects drift and corrects it." He adds that MegaSense integrates with the 5G cellular network and leverages mobile edge computing for sensor management.

With this technology, Tarkoma and his colleagues envision benefits to air-quality monitoring. The key objectives, according to Tarkoma, include near-real-time air-pollution monitoring with high spatiotemporal accuracy and fine-grained air-quality maps that enable a new generation of environmental services for personal health, city planning, and pinpointing air-quality problems.

Given the negative health impacts of poor air quality and the huge number of people impacted, almost no effort is too extreme or over the top. Making better use of existing sensors and developing better ones should be a high priority for countries, organizations, and labs around the world. Working together, both as scientists and citizens, could be the key to improving the air that we breathe.

Mike May *is a freelance writer and editor living in Texas. You can reach him at mike@techtyper.com.*

Jeffrey Abels

ASK THE EXPERT

OVERCOMING SAMPLE PREPARATION CHALLENGES by Lauren Scrudato

Jeffrey Abels has more than 40 years of experience in lot sampling, inspection, grading and testing of dried fruits, tree nuts, peanuts, spices, edible seed, pulses, fruit concentrates, green coffee, and cocoa. He attended Rutgers University for undergraduate and graduate studies in food science and entomology. Abels has conducted inspections of processing facilities throughout the Middle East and Asia, and has expertise in the investigation of stored product insect infestations, insect identification, and microanalytical entomology. He is the owner of the Foreign Trade Service Corporation, with offices in Houston, TX, and ISO 17025 accredited laboratories in Newark, NJ and Chesapeake, VA. Abels is the Chairman of the Food Science Section of the American Council of Independent Laboratories.

Q: There seems to be an increasing awareness on food safety and consumers wanting to know what exactly is in their food products. Can you comment on the overall importance of proper sample preparation within food testing specifically?

A: You cannot separate the importance of unbiased sampling and proper sample preparation from the analysis. A laboratory might have the finest scientists, state-of-the-art scientific instruments, and validated methods with very low detection limits. However, if the sample is not representative of the lot or if it has not been properly prepared, the test data is irrelative.

Q: What are some of the common challenges encountered with sample preparation methods? Do you face any unique obstacles specific to your work?

A: At FTS Laboratories our goal is to become a much "greener" laboratory—one that uses fewer hazardous reagents and smaller volumes. As a laboratory that primarily serves importers and processors of tree nuts, peanuts, and edible seed, we run a high volume of indicator tests for rancidity. Standard methods for sample preparation involve isolation of the lipids by Soxhlet extraction. This takes considerable time and uses more solvent than we would like.

> "If the sample is not representative of the lot or if it has not been properly prepared, the test data is irrelative"

Q: How do you overcome these challenges? What type of instrumentation are you using to ensure proper sample prep practices?

A: We were introduced to the CEM Edge at a trade show, and requested a demonstration at our laboratory. The Edge extracts the oil from the sample in a very short amount of time using a very small volume of solvent. The Edge system then goes through a programmed clean-up procedure. The total process usually takes about 12-15 minutes. We then use a nitrogen evaporator to remove the residual solvent, and that takes about 40 minutes. In contrast, the Soxhlet method takes many hours. We have also found in our laboratory that the extracted portion is much cleaner.

Q: How has the introduction of automated sample prep affected prep practices?

A: In an age when your thumbs can instantly connect you to the world via your smart phone, clients expect test results yesterday. Any technology that can prepare samples and test samples faster is indispensable in the modern laboratory. The CEM Edge is now an integral part of our sample preparation procedures. We can also use the Edge to prepare samples for pesticide residue testing and other analyses.

Q: Any advice for those who find sample prep complicated or overwhelming?

A: Consider implementing innovative instruments into your lab. FTS Laboratories is in the business of testing food, but the Edge is used in environmental, pharmaceutical, and other types of laboratories.

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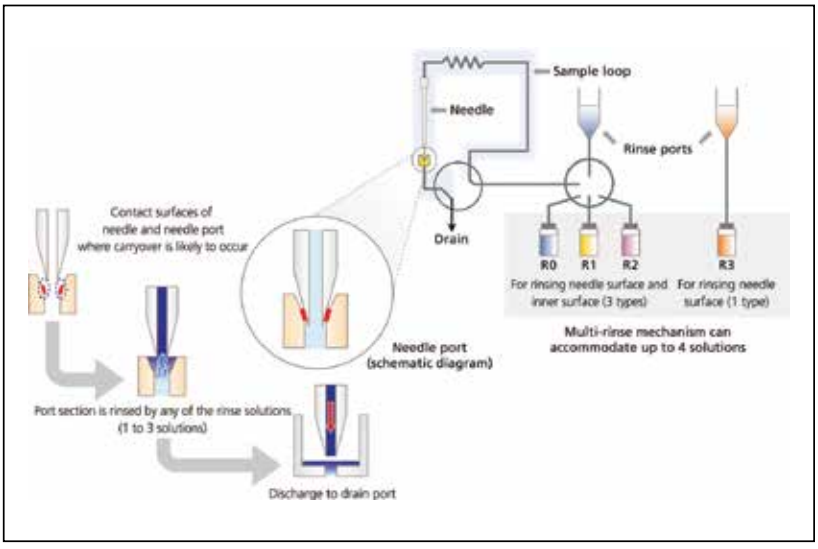
CHROMATOGRAPHY

MINIMIZING HPLC CARRYOVER

by Angelo DePalma, PhD

In a recent presentation, scientists from Waters (Milford, MA) defined HPLC carryover as "sample left over from a previous injection that may interfere or co-elute with analytes of interest, often interfering with accurate quantitation." Carryover has always been a problem in HPLC, but its significance increases with today's sensitive detection methods, specifically mass spectrometry (MS), as "carryover that would otherwise be undetected by UV [ultraviolet detection] will often be evident with mass detection."



Carryover is one example of ghost peaks, which have always plagued chromatographers. Ghost peaks arise from impurities in the mobile phase, sample, or instrument. Mobile phase contamination is relatively easy to identify and correct: Inject pure mobile phase. If the ghost peak appears, investigate organic and aqueous phases independently.

Shimadzu (Columbia, MD), in collaboration with Daiichi Sankyo, has developed its line of Ghost Trap DS (for HPLC) and Ghost Trap DS-HP (for UHPLC), which, when installed between the gradient mixer and the autosampler in reverse-phase LC, traps mobile phase impurities.

Sample impurities are trickier to deal with. First, eliminate mobile phase as a source, then prepare the sample in a way that eliminates the undesired peak. When the impurity arises from target analyte degradation, the solution involves eliminating the degradation source (e.g., oxygen) or trying to understand the time course over which degradation occurs.

Instrument effects—principally carryover—are the most common source of ghost peaks. Carryover, particularly in this age of autoinjectors and highly parallel experimentation, may occur when sample components adhere to or adsorb onto the outside of the needle that aspirates sample from a vial or microwell. Highly absorbing materials are the worst offenders, as they may persist in subsequent chromatograms even after several blank injections, suggesting perhaps a nonexistent mobile phase issue.

In his review article on carryover, William Letter, an LC/MS expert at Chiralizer Services (Hillsborough, NC), notes that carryover originates from four main sources: poor HPLC system maintenance, sample overloading, wash/sample vials, and poor technique.

According to Letter, "Most auto-injector valves rely on a rotary seal to move the sample from the needle loop to the flow path of the system. The components within these valves wear out and should be inspected at least every six months and replaced when needed." Other things to look for are wear on the needle or needle seat, leaks, and a worn injector valve rotary seal. Worn seals allow sample retention between injections within spaces and grooves. "Additionally, buffer salts can lodge between the seals, causing leaks or carryover."

Sample overloading is another common mistake chromatographers make, which can result in spurious peaks appearing out of nowhere and is related to proper

maintenance. Overloaded columns leak sample, often unpredictably, over many injections. Gas chromatographers have the option of baking out the column at high temperature, replacing the guard column, or snipping a few centimeters off of a capillary column.

Letter recommends avoiding column overload by first undertaking a loading study to determine a column's capacity for a particular sample and method, then flushing columns regularly. The wash method should employ a stronger-eluting solvent or buffer, typically one incorporating a gradient. Flushing is particularly important for isocratic methods, which tend to retain materials even when chromatographs appear pristine.

Technique and training are inseparable components of successful LC operation. According to Letter, "Good chromatography requires a complete understanding of the hardware used and the fundamentals of HPLC. You must be able to troubleshoot the complete flow path of the system and concepts of chromatography as used in method development. This is not a technique best learned by trial and error but rather through mentoring using logical steps."

An operator's ability to troubleshoot a carryover problem therefore reduces to the skill set they bring to HPLC. Letter stresses hands-on training, practical experience, and professional education on the actual instrument to be read, as a supplement to books and articles. "You will learn far faster this way and spend less time troubleshooting problems and more time running samples, accurately, in less overall time."

System maintenance

Proper HPLC system maintenance is important for a variety of reasons, says Jennifer Simeone, principal scientist at Waters (Milford, MA), including the minimization of carryover. "LC systems contain parts that wear over time, including valves, needles, and fittings. Excessive wear or damage to any of these parts may lead to the creation of dead volumes where sample can remain after an injection and show up as carryover in subsequent injections."

All LC instrument vendors recommend periodic preventive maintenance to address routine system wear. Simeone also recommends that users flush the system after using aggressive solvents or buffers that can corrode LC system components, which is another source of carryover.

Dr. Andreas Otto, product manager at Agilent Technologies (Santa Clara, CA), notes that poor HPLC maintenance can lead to contaminated or spoiled solvents. "Leaving HPLC capillaries filled with water for long periods can promote algae growth, which may lead to system clogging or sample-independent effects, which are observed as carryover."

Carryover is particularly troublesome with autosamplers, which use needles to draw samples from vials or multiwell plates into the sample loop. Inadequate rinsing and cleaning of needles is a major source of carryover in consecutive runs.

Some carryover involves just one or several components of multicomponent samples that may be interacting, unexpectedly, with system materials such as metals. "Ferrous metals may bind to specific biological analytes, leading to carryover or selective irreversible sequestration in HPLC runs," Otto adds. Potential workarounds include assessing the compatibilities of known analytes with HPLC systems, passivation, and using bioinert HPLC components.

HPLC vendors have introduced features that minimize carryover through dual needle usage, which increases washing time between analytical runs. On this point, Curtis Campbell, PhD, OEM/VAR business development manager at Shimadzu Scientific Instruments (Columbia, MD), advises users to use a wash solvent appropriate for the sample and diluent. "When analyzing ionic samples, a wash solution containing counterions provides effective adsorption suppression. When analyzing hydrophobic samples, using an organic solvent as the needle wash solution can reduce carryover because it acts to solubilize and wash away the adsorbed sample components. The needle wash solution should be treated like the mobile phase. It should be changed regularly, and moreover, the wash solution reservoir bottles should periodically be replaced or thoroughly washed to prevent the growth of microorganisms."

When components of complex samples have significantly different chemical or physical properties, a single rinse solution is often insufficient for adequate rinsing. Shimadzu autosamplers incorporate a flow path and materials that resist adsorption and rinse options that minimize carryover. "The needle's outer surface can be rinsed by multiple solvents, while the inner surface can be rinsed by up to three rinse solutions," says Campbell.

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Mass spectrometers, measuring the mass-to-charge ratio of charged particles to determine their molecular weight, have not quite become a routine acquisition for every lab that might benefit from them. Four parts are standard in all mass spectrometers: a sample inlet, an ionization source, a mass analyzer, and an ion detector.

Sample types analyzed by survey respondents	
Blood, body fluids, and cultures	30%
Pharmaceuticals	28%
Waste water	24%
Drinking water	24%
Human blood and body fluids	23%
Animal tissue	20%
Rocks and minerals	18%
Food and food related products	17%
Clinical samples	16%
Soils	15%
Oils	14%
Gases	12%
Metals	11%
Plants	10%
Petroleum and related products	10%
Polymers	9%
Air	6%
Controlled substances/narcotics	6%
Cosmetics	3%
Other	16%

Some of the most exciting applications of mass spectrometry, as reported by survey respondents:

- 2-D mapping of metabolites in tissue
- Developing proxies for paleotemperatures
- Proteomic biomarker discovery
- Drug development and discovery
- PFCs in drinking water
- Pesticide analysis
- Metabolite identification

TOP 6 QUESTIONS

You Should Ask When Buying a Mass Spectrometer

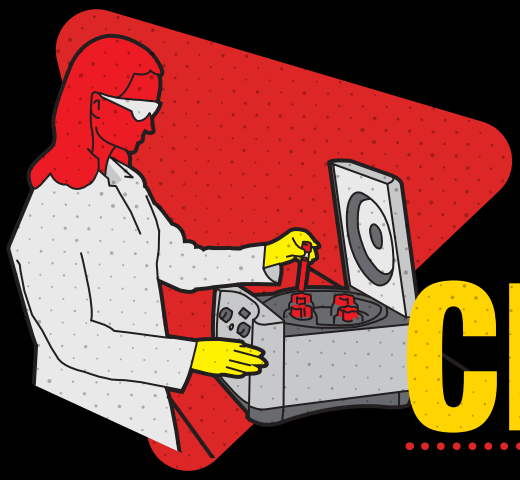
1. What factors come into play when determining the MS specifications you require in terms of throughput, sensitivity, robustness, software control, ease of use, and ease of maintenance?
2. What differentiates the vendor's MS from others offered, in terms of performance and how easy it would be to upgrade?
3. How do you validate the specification claims presented by the vendor?
4. Has the data processing software been designed for enhanced analytics, with lab workflow in mind and does it support critical compliance requirements?
5. What are important price points to keep in mind when selecting an MS?
6. Laboratories need fast and effective services, including an effective distribution of spare parts, instruments, service personnel, and education/ training. How does the company serve these needs globally?

PRIMARY APPLICATION

for Mass Spectrometer Use as Reported by Survey Respondents:

TEST WATER QUALITY OR FOOD CONTAMINATION	30%
DETERMINE STRUCTURES OF DRUGS AND METABOLITES	26%
SCREEN FOR METABOLITES IN BIOLOGICAL SYSTEMS	25%
DETERMINE PROTEIN STRUCTURE, FUNCTION, FOLDING, AND INTERACTIONS	20%
QUANTITATE (RELATIVE OR ABSOLUTE) PROTEINS IN A GIVEN SAMPLE	13%
DETECT SPECIFIC POST-TRANSLATIONAL MODIFICATIONS THROUGHOUT COMPLEX BIOLOGICAL MIXTURES	13%
PERFORM FORENSIC ANALYSES	13%
DETECT DISEASE BIOMARKERS	9%
SEQUENCE OLIGONUCLEOTIDES	1%
OTHER	40%

For more information on mass spectrometers, including useful articles and a list of manufacturers, visit www.labmanager.com/mass-spectrometers



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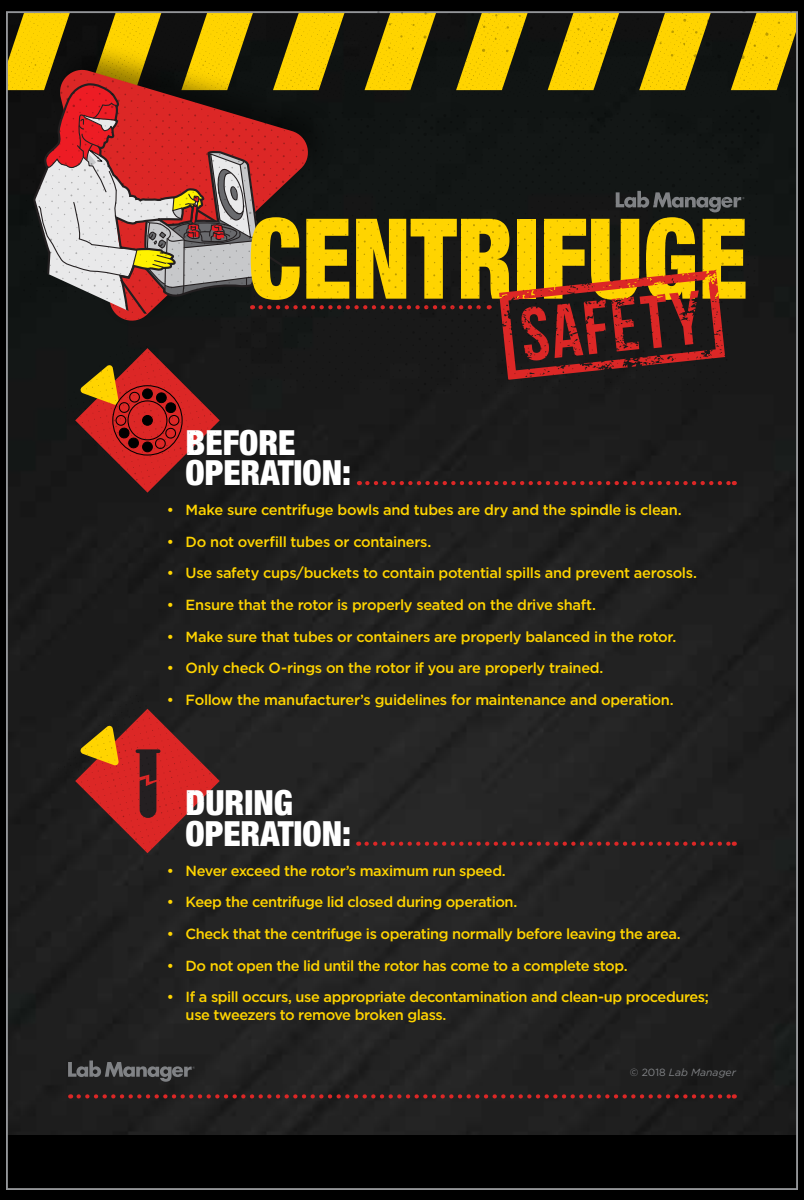
CENTRIFUGE SAFETY



LabManager.com/centrifuge-safety

Anthony Atala, MD

ASK THE EXPERT

NEXT FRONTIER IN 3-D BIOPRINTING AND TISSUE ENGINEERING

by Tanuja Koppal, PhD

Anthony Atala, MD, director of the Wake Forest Institute for Regenerative Medicine (WFIRM), talks to contributing editor Tanuja Koppal, PhD, about the possibilities regarding the recent advances in 3-D bioprinting. He discusses some of the existing challenges while elaborating on the diverse applications that are being served using this ground-breaking technology.

Q: Can you provide some perspective on the progress that has been made in 3-D bioprinting in recent years?

A: The field of 3-D bioprinting has really advanced over the past few years as the need for these technologies increases. For example, we have implanted a variety of lab-engineered tissues and organs into patients, but we know that to make these treatments more widely available, we must scale up the manufacturing process. We turned to 3-D bioprinting about 15 years ago as one way to accomplish this, and we then spent a 13-year period developing what we call an Integrated Tissue and Organ Printing System (ITOP). In early 2016, our research published in *Nature Biotechnology* showed that we could engineer tissues that developed a system of nerves and blood vessels when implanted in experimental models. We showed that these structures had the correct size, strength, and function for use in humans, proving the feasibility of printing living tissue structures to replace injured or diseased tissue in patients.

> "These systems will have a great impact on choosing the best potential therapies for patients."

Q: What were some of the early challenges in using the technology and what remains to be addressed?

A: An early challenge was to produce human-scale tissues because larger tissues require additional nutrition. We have optimized the water-based "ink" that holds the cells so that it promotes cell health and growth, and we have printed a lattice of micro-channels throughout the structures that allow nutrients and oxygen from the body to diffuse into the structures and keep them alive while they develop a system of blood vessels. Solid organs, such as the liver, kidney, and heart, are the most difficult to print and still remain a challenge. Solid organs require billions of cells, and because they have high oxygen requirements, we must find ways to supply them with oxygen until they integrate with the body.

Q: Can you offer some details on how 3-D bioprinting is advancing drug discovery and therapeutics?

A: We have used the 3-D printing technology to successfully engineer micro-sized 3-D organs, known as organoids, and connected them together on a single platform in order to monitor their function. Known as body-on-a-chip, we are using micro hearts, lungs, and livers to mimic how the human body responds to medications. Body-on-a chip is basically a miniaturized system of human organs to model the body's response to harmful agents and develop potential therapies. Human cells are used to create tiny organ-like structures that mimic the function of the heart, liver, lung, blood vessels, etc. Placed on a two-inch chip, these structures are connected to a system of fluid channels and sensors to provide online monitoring of individual organs and the overall organ system.

Q: How reliable and reproducible is the data obtained using these 3-D models and organoids? Are there some limitations or caveats that people need to know about?

A: 3-D models for personalized medicine, such as body-on-a-chip systems, are now being used for drug and toxicity testing, but it is important to realize that although these models are vastly better than 2-D cultures, they are still not fully equivalent to the human response. We still have to

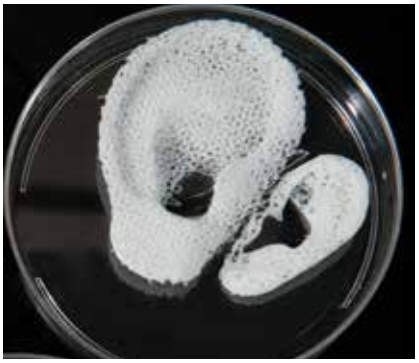
exercise caution and not assume that the outcomes will be exactly the same in humans. Nonetheless, these systems will have a great impact on choosing the best potential therapies for patients.

Q: What are the applications of 3-D bioprinting in regenerative medicine?

A: The applications of 3-D bioprinting in regenerative medicine are promising. Currently, there are simply not enough donor tissues and organs to meet demand. Regenerative medicine offers the hope of engineering replacement organs in the lab to solve this shortage. And because these organs would be made with the patient's own cells, there would be no issues with rejection as there are with organs from donors. At our institute, we are working to develop cell therapies and replacement tissues and organs for more than 40 different areas of the body. Projects range from blood vessels to kidneys to cell therapies for both lung disease and hemophilia. We are pursuing multiple strategies, including 3-D bioprinting, to move our projects forward to meet our ultimate goal—making patients' lives better.

Q: Are there new trends and technologies that you are excited about or that you consider to be game-changers in the field?

A: One of the major trends in 3-D bioprinting involves the need to standardize and automate manufacturing, like Henry Ford did with the automobile assembly line. Last year, Wake Forest Institute for Regenerative Medicine announced the launch of a five-year, $20 million effort involving a public-private partnership with the goal of improving the additive manufacturing processes to hopefully speed up the availability of replacement tissues and organs for patients. The partnership involves the Regenerative Medicine Manufacturing Innovation Consortium, comprising more than 80 industry and academic partners; the Regenerative Medicine Development Organization, a nonprofit that manages the consortium; the U.S. Army Medical Research and Materiel Command; and the U.S. Army Medical Technology Enterprise Consortium (MTEC).



▲ *Ear scaffolds created by WFIRM's Integrated Tissue-Organ Printing System in cell culture medium.*

▶ *A bladder scaffold is "seeded" with cells and supports them as they grow and develop. Scaffolds are the essential components of tissue engineering efforts.*

Photo Credit: Wake Forest Institute for Regenerative Medicine

Dr. Anthony Atala is the director of the Institute for Regenerative Medicine, and chair of Urology at Wake Forest School of Medicine. Dr. Atala is a recipient of the U.S. Congress-funded Christopher Columbus Award, the World Technology Award in Medicine, the Samuel Gross Prize, the Innovation Award from the Society of Manufacturing Engineers, and the Edison Science/Medical Award. He was elected to the National Academy of Medicine in 2011, and to the National Academy of Inventors in 2014. His work was listed twice in *Time* magazine's top 10 medical breakthroughs of the year. He was named by *Scientific American* as one of the world's most influential people in biotechnology in 2015. He also received the Innovator of the Year award from *R&D* magazine in 2016. Dr. Atala has led several NIH working groups and is the founder of the Regenerative Medicine Foundation. He heads a team of over 450 researchers, and 12 applications of technologies developed in his laboratory have been used clinically. He is editor-in-chief of *Stem Cells Translational Medicine and BioPrinting*. He is editor of 14 books, has published over 500 articles, and has applied for or received over 250 national and international patents.

Tanuja Koppal, PhD, is a freelance science writer and consultant based in Randolph, New Jersey. She can be reached at tkoppal@gmail.com.

qPCR

SPEED AND SENSITIVITY GIVE QPCR THE LEG UP IN CERTAIN CLINICAL CASES

by Brandoch Cook, PhD

Although the polymerase chain reaction (PCR) is credited to the work of Kary Mullis, the history of its discovery and refinement is quite a bit more complicated. However, the combination over 30 years ago by his research team of repeated thermal cycling with a heat-stable polymerase unleashed the intrinsic power of the technique to exponentially replicate target DNA. Thus, it became a ubiquitous tool in genetics and molecular biology laboratories. It was nonetheless limited in that it could identify the presence of a gene or sequence, but not the extent to which it was expressed. This state of affairs continued until the advent of real-time PCR (or qPCR), which allows the detection of amplicons as they arise during the exponential phase of DNA replication, via probes

> "Wouldn't it be nice to know whether the cruise ship buffet has norovirus before you decide to get on the boat?"

that fluoresce in proportion to the total product of amplified DNA. This procedure allows demarcation of the exact moment a DNA sequence becomes detectable, making it a real-time, rather than an endpoint, assay. With this information, one can calculate relative gene expression using internal standards or quantify absolute levels in molecular weight or copy number. Additionally, the design of instrumentation and reagents make it naturally suited to automation and high throughput. Continual upgrades in materials that are available from major manufacturers, and improvements in complex data analysis software, have driven increased efficiency and sensitivity of detection of small amounts of nucleic acids within large samples. Therefore, it is potentially a powerful technique to diagnose and validate the presence of microbial infection or contamination in blood and tissue samples and in the food supply.

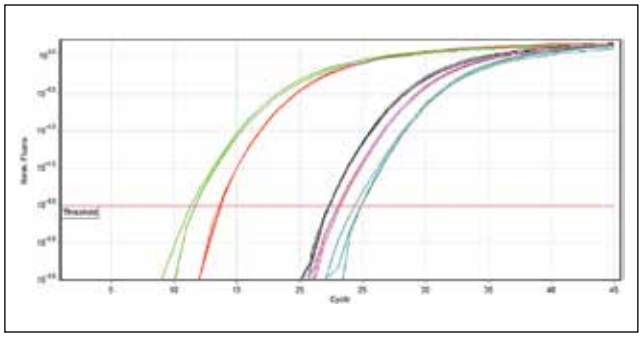
Fast detection, small samples

One major advantage of qPCR in microbial diagnostics is the speed with which samples can be assessed. For instance, bloodstream bacterial infections account for approximately 40 percent of sepsis, a systemic inflammatory response in which the risks of death and morbidity increase drastically with time. The current gold standard for positive detection requires culturing of blood samples, which can take two to four days. In contrast, qPCR analysis can be resolved in as little as six hours, so there is an inherent advantage to bypassing the culture step if possible. Procedures can also be executed in multiplex format so that the presence of multiple pathogenic species can be assessed simultaneously. Additionally, because of the large blood samples required for culturing analyses, qPCR is intrinsically well-suited to diagnostics in cases of neonatal and childhood infection, in which blood draws are necessarily low-volume. Because of the power of this technique, there is a burgeoning array of tests, protocols, and instrumentation tailored to different target genes of different microbial species. Detection typically proceeds in one of two ways: 1) amplification of the 16S ribosomal RNA gene, coupled with a species-specific fluorescent probe oligonucleotide; or 2) amplification of a unique region of a virulence or antibiotic resistance gene. Commercially available systems include Roche's SeptiFast, which can identify 25 different pathogenic bacterial and fungal species; and Seegene's MagicPlex, distributed through Thermo Fisher, which detects more than 80 species accounting for 90 percent of sepsis.

Infectious and emerging diseases

Equally important to detecting pathogenic bacteria in clinical cases of sepsis, the capabilities of qPCR extend to infectious and emerging diseases. A partial list of rapidly evolving research-based and clinical diagnostic approaches includes efforts to understand and detect urinary tract infections, respiratory infections such as pneumonia and influenza, agents of bio- and agro-terrorism such as in the Amerithrax crisis following the 9/11 attacks, and outbreaks of emerging viral infectious diseases such as Zika and Ebola. In fact,

qPCR techniques have become the most valuable tool in early identification of several outbreaks due to the ability to directly test urine samples, which are easy to collect from travelers before they leave or move throughout developing countries that lack the resources to maintain biocontainment facilities needed to isolate and culture virus-infected samples. Variations on Seegene's detection platform include AnyPlex and AllPlex, which offer diagnostic panels for multiple respiratory, intestinal, and sexually transmitted pathogens. Additionally, Roche's cobas analyzer series allows a high degree of automation in detection of emerging infectious diseases.



Food safety

Another rapidly growing focus of qPCR-based diagnostics is food safety. There are approximately 250 different known vectors for foodborne illness, resulting annually in over 48 million individual cases, 128,000 hospitalizations, and more than 3,000 deaths from food poisoning. Wouldn't it be nice to know whether the cruise ship buffet has norovirus before you decide to get on the boat? Again, qPCR has the potential to slash identification times from several days to a matter of hours. Similar to bloodstream infections, culture protocols are still the standard accepted method of detection for bacterial contamination such as *salmonella* or *E. coli*; however, in cases of viral or protozoan species, qPCR has become the method of choice. Among the reagents, kits, and instruments available are the SureTect system from Thermo Fisher and the DNeasy *mericon* kit series from Qiagen, which can be automated using the QIAcube.

Limitations relegate qPCR to a supportive technology

Generally, qPCR diagnostics bring a striking increase in sensitivity, especially in multiplex protocols for identification of multiple genes or species and for slow-growing or latent microbes that persist at low copy numbers. However, there is also a greater risk of false positives and less negative predictive value than in more established tests. The potential for contamination with extraneous nucleic acids is very high during sample collection and processing. Moreover, the presence of nucleic acids in dead cells and in species that remain at low levels after antimicrobial treatment regimes are in place can confound test results. Therefore, in sepsis and other diagnoses, qPCR is broadly considered a supportive technology that can shape understanding of, and response to, infection, rather than a diagnostic one reliable enough to replace blood culture-driven identification methods. Additionally, because the kits and reagents specific to each pathogen are often proprietary and unique to the instrumentation of the manufacturer, there is a great deal of cost, specialization, and expertise inherent in these techniques. As laboratories and facilities continue to elevate their technology and training, however, it is clear that qPCR will help push microbial diagnostics into new and fertile territory.

"qPCR diagnostics bring a striking increase in sensitivity, especially in multiplex protocols for identification of multiple genes or species."

***Brandoch Cook**, PhD is an assistant professor in the Weill Cornell Medicine Department of Surgery in New York, NY. He can be reached at brandoch.cook@gmail.com.*

FOR ADDITIONAL RESOURCES ON qPCR AND PROTEIN BIOLOGY, INCLUDING USEFUL ARTICLES AND A LIST OF MANUFACTURERS, VISIT WWW.LABMANAGER.COM/PROTEIN-BIOLOGY

ARE YOU IN THE MARKET FOR A BIOLOGICAL SAFETY CABINET?

Biological safety cabinets (BSCs) are enclosures that protect users and the environment from biohazards by removing particulates and aerosolized pathogens from the work area through HEPA filtration, then recirculate or exhaust the purified air, hence cleansing the workspace air.

Biological safety cabinet types used by survey respondents:

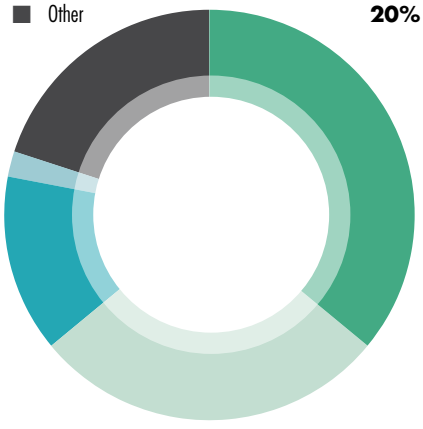
Class II biological safety cabinet	78%
Class I biological safety cabinet	23%
Class I biological safety cabinet	8%
Other	4%

Application conducted in biological safety cabinets as reported by survey respondents:

Cell / tissue culture	52%
Microbiology plating / specimens	52%
PCR/qPCR	25%
Sample and reagent storage	19%
Pathogen handling	35%
Mycology	15%
Gross dissection	10%
Laboratory animal handling	10%
Other	12%

Of those respondents interested in purchasing a new biological safety cabinet, the reasons for these purchases are as follows:

Replacement of an aging system	36%
Addition to existing systems, increase capacity	28%
Setting up a new lab	14%
First time purchase	2%
Other	20%



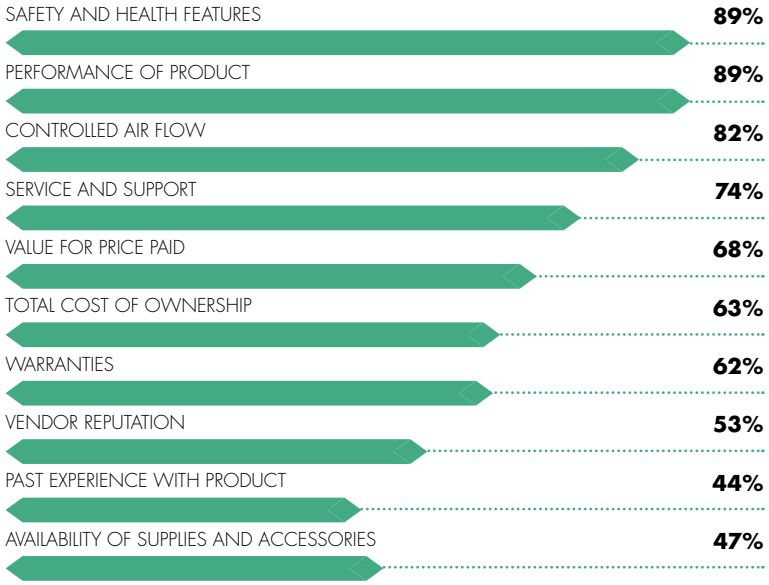
TOP 5 QUESTIONS

You Should Ask When Purchasing a Biological Safety Cabinet

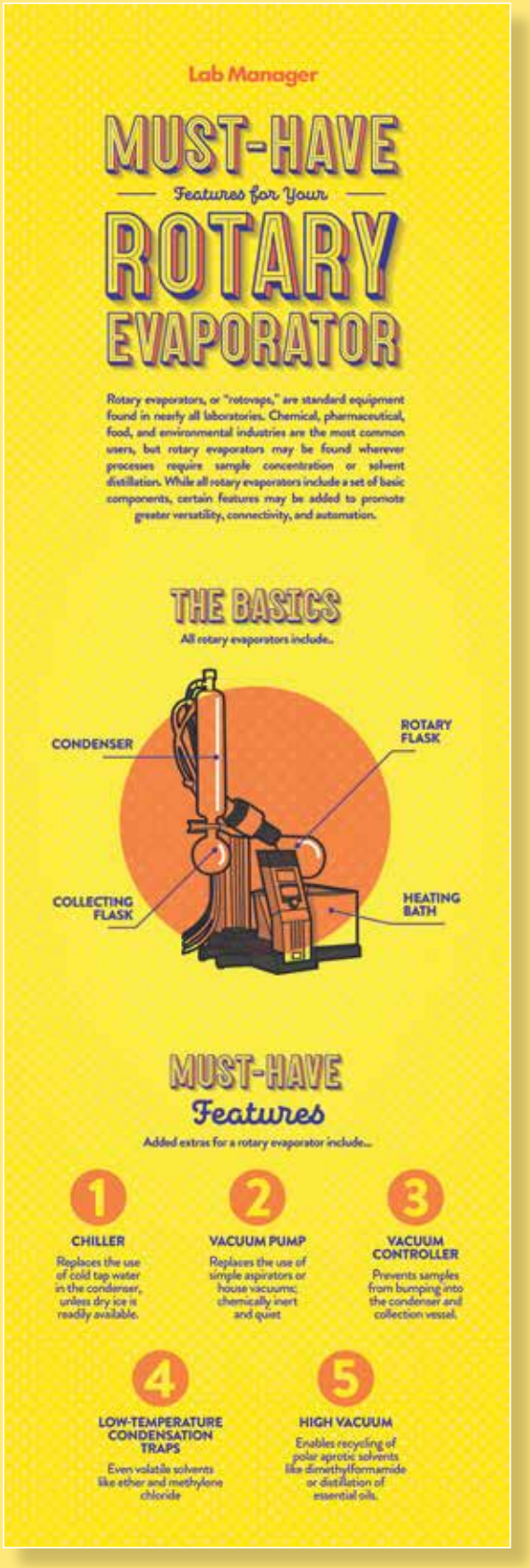
1. Do the samples/specimens/cultures need to be protected from environmental particulates? Answering this question determines what type of BSC you require.
2. Are chemicals involved in your application? Hazardous (toxic or volatile) vapors are not filtered by the HEPA/ ULPA filters found in BSCs. Different BSC designs are available.
3. What are your size limits? Know what the maximum space allotment is so that you don't end up with equipment that is too big for your lab, or so small that you can't work.
4. Does your procedure require modifications to the equipment that are uncommon? BSCs should be built to an appropriate standard and listed by a testing agency. Some modifications can lead to the equipment being unsafe; reputable manufacturers will not provide such alterations.
5. Cost is always a concern. Avoid looking at the sticker price of a BSC; inquire instead about the lifetime cost of each BSC. This includes energy savings, service life, and a proven product track record.

TOP 10 FEATURES/FACTORS

Respondents Look for When Purchasing a Biological Safety Cabinet:



For more information www.labmanager.com/BSCs



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AUTOCLAVES

STERILIZING WITH STEAM VS. DRY HEAT

by Erica Tennenhouse, PhD

Effective sterilization of equipment and supplies is a necessity for any laboratory, as insufficient cleaning can lead to severe consequences for both experiments and lab personnel. Several sterilization methods are available, including solvents, radiation, filtration, steam, and dry heat, with the latter two being the most common. While steam sterilization remains the method of choice for the majority of applications, there are some cases in which dry heat is the preferred method. To get the most out of either dry heat or steam sterilization, it is crucial to understand the key differences between the two.

Steam sterilization

Steam sterilization is carried out in an autoclave. The pressurized steam produced has a high latent heat. This intense heat leads to hydrolysis and coagulation of proteins, which kills off microbes, spores, and viruses. Steam sterilization typically involves exposing an item to steam at a temperature of 121°C for 15 to 30 minutes. As the temperature and pressure are increased, the time required to sterilize items can be greatly reduced.

Compared with dry heat sterilization, steam sterilization is the more efficient method because the moisture in steam is a good conductor of heat and is superior at penetrating the load. With less energy needed, steam sterilization offers increased productivity with lower energy expenditure, resulting in cost savings. Steam is a widely accepted method for items that can accept both heat and moisture; thus, most materials are conducive to sterilization with steam, save for a few key exceptions listed below.

Dry heat sterilization

In contrast to steam sterilization, dry heat sterilization—which was actually the first sterilization method developed—does not involve water. Dry heat sterilization typically involves exposing an item to a temperature of 170°C under normal air pressure for around an hour. That time period ensures that even the most resistant spores get killed off via oxidation of their cellular components.

Dry heat often yields similar results to steam sterilization, but with less efficiency, making it a less attractive option for most labs. However, certain situations call specifically for dry heat sterilization. For example, dry heat is required for hydrophobic items, such as fats and oils; items that will be damaged by moisture, such as powders; and instruments that may become corroded. Liquids, on the other hand, are not compatible with dry heat sterilization because they will boil off if exposed to dry heat. Growth media, flammable materials, and dense loads are similarly poorly suited to dry heat sterilization. While the greater efficiency of steam sterilization results in cost savings, dry heat sterilizers have a lower initial cost, lower maintenance cost, and lower operation cost than an autoclave.

Which method to use?

The following is a general guide to the laboratory items that should be sterilized using steam, dry heat, or both. However, you should consult with the manufacturer if you are uncertain of the best sterilization method for a particular product.

Use steam sterilization for:
- Culture media
- Flammable and heat-sensitive items
- Liquids
- Dense loads

Use dry heat sterilization for:
- Fats
- Oils
- Powders
- Metal instruments at risk of corrosion

Use either dry heat or steam sterilization for:
- Glassware
- Most metal instruments

Erica Tennenhouse, *Scientific Content Editor for* Lab Manager*, can be reached at etennenhouse@labmanager.com or 647-500-7039.*

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ELECTROPHORESIS

OVERCOMING THE CHALLENGES OF SINGLE-CELL ANALYSIS

by Angelo DePalma, PhD

Since cells are the smallest indivisible units of life, single cells are the smallest platform through which we can study living things. Most cellular responses are measured in aggregate, as the average response of a large number of cells to a stimulus; single-cell analysis examines the mechanisms and pathways responsible for that response.

The value of single-cell analysis products and services exceeds $1.5 billion annually and is expected to surpass $3.5 billion by 2022.

Working with single cells raises immediate concerns about analyte quantities and concentrations. Although standard analytical methods are routinely applied to single-cell analysis, they require tweaking. Flow cytometry has been the go-to method of single-cell analysis, but competition is heating up from next-generation sequencing, polymerase chain reaction, microscopy, spectrometry, fluorescence, and automated capillary electrophoresis (CE).

Overcoming heterogeneity

"Single-cell analysis is key to probing cell heterogeneity, especially in cancer research," says Rawi Ramautar, PhD, principal investigator at Leiden University (Leiden, the Netherlands). Scientists analyze single cells to understand how metabolic processes at the single-cell level translate to cell growth and division.

CE, in particular capillary zone electrophoresis, is well-suited to profiling metabolites in very small samples due to its nanoliter sample requirements. Moreover, CE separations are complementary to chromatographic-based analysis.

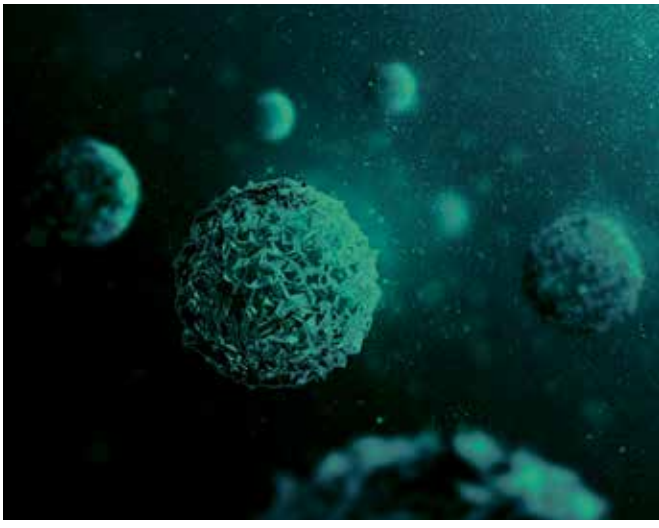
"Next to CE, nano-LC and capillary LC are also very strong techniques for profiling compounds in single cells," Ramautar tells *Lab Manager*. "Direct injection electrospray ionization mass spectrometry has also been used for single-cell analysis. However, ion suppression may be an issue, and often no information can be provided on isobaric and isomeric compounds by this approach."

Sensitivity becomes the major challenge when analyzing endogenous metabolites in a single cell, particularly considering the wide range of metabolite molecular classes and concentration dynamic ranges from picomolar to millimolar—all in a volume of one nanoliter or less. "Metabolic profiling of millions of cells, while easier, is unsuited for obtaining insight into biochemical processes at the microscale and single-cell level," Ramautar adds.

Single-cell tweaks

CE-MS is no exception to the general rule that analytic methods must be adapted to the special needs of single-cell analysis.

In conventional CE-MS, a coaxial sheath-liquid interface couples CE to MS. In this configuration, electrospray ionization (ESI) operation is confined by the sheath-liquid flow rate, typically between two and 10 microliters per minute. With conventional CE-MS, using standard ESI-MS conditions, the electrophoretic



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effluent ranges between 10 and 100 nanoliters per minute, which is significantly diluted, thus compromising detection sensitivity.

To circumvent this limitation, Ramautar's group coupled CE to MS via a sheathless, porous tip interface designed to utilize the intrinsically low-flow property of CE.

"With this approach, and by employing nanoliter injection volumes, we obtain low-nanomolar detection limits, suitable for single-cell analysis, for a wide range of acidic and basic metabolites," he says. "The remaining challenge is efficient extraction of charged metabolites from a single cell and injecting that volume into the CE-MS system without loss of relevant metabolites."

One well, one cell

"Bulk analysis gives mean results of a population, which does not correspond to the heterogeneity found in nature. Thus, bulk-cell analysis misses low frequency signals that might actually be significant," says Dr. Guilhem Tourniaire of Cellenion (Lyon, France). "The main limitations of single-cell analyses are that they typically take longer, cost more, and generate huge data set[s], which must then be interpreted using complex bioinformatics."

Analysis of single cells requires a means of reliably limiting samples to just one cell. Various dilution methods have been used for decades, for example, in the generation of monoclonal antibodies from polyclonal cell cultures.

Cellenion's approach, cellenONE, overcomes these issues. CellenOne is an acoustic dispenser mounted on a high-precision x-y-z linear magnetic stage, coupled with high-resolution optics and associated computing to provide real-time monitoring of cell and particle travel inside the dispenser. Cells emerge in droplets. By monitoring cells' positions inside the lower portion of the dispenser (using automated image processing), it is possible to know whether a single cell will be present within the next droplet before it is actually formed.

The system works under a "single-cell condition," whereby droplets containing zero or more than one cell are rejected.

"With dilution approaches, the highest percentage of samples containing single cells is 35 percent, meaning that 65 percent of your plate[s] are useless. Thus the need, when developing a monoclonal culture, for multiple cloning steps, each taking several weeks," Tournaire explains. "CellenOne ensures that all wells contain a single cell the first time, so there is no need to repeat the cloning process."

Angelo DePalma *is a freelance writer living in Newton, New Jersey. You can reach him at angelo@angelodepalma.com.*

ARE YOU IN THE MARKET FOR A GAS GENERATOR?

In many laboratories, gas generators are quickly replacing traditional tanks, offering greater flexibility, convenience, safety, and cost-effectiveness. Gas generators offer the ability to produce on-demand supply and specialty blends of highly pure gases for various applications.

Gas generator types used by survey respondents:

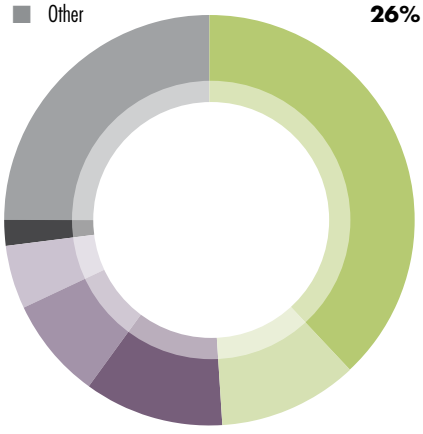
Nitrogen	46%
Hydrogen	35%
Zero Air	26%
Calibration	5%
Purge	3%
TOC	2%
Other	32%

Of those respondents interested in purchasing a new gas generator, the reasons for these purchases are as follows:

Cheaper than gas cylinders	38%
Increase safety	11%
Upgrading old system	11%
Starting a new lab process	8%
Switching from helium to hydrogen	5%
Building/renovating lab	2%
Other	26%

Of those respondents interested in purchasing a new gas generator, the reasons for these purchases are as follows:

- Cheaper than gas cylinders 38%
- Increase safety 11%
- Upgrading old system 11%
- Starting a new lab process 8%
- Switching from helium to hydrogen 5%
- Building/renovating lab 2%
- Other 26%



TOP 6 QUESTIONS

You Should Ask When Buying a Gas Generator

1. What is your application? As the range of available gas generators continues to expand, consider what it will be used for. For example, Fourier transform infrared spectroscopy operates best in the absence of carbon dioxide, so users will require a generator that creates CO2-free gas
2. Do you require high quality gas? In many cases, gas generators can produce a superior product both in purity and consistency without the risk of contamination during gas-line changing.
3. What volume of gas do you require? Many instruments now require higher volumes of gas. If your space is small, or you expect your needs to increase over time, you may wish to consider a gas generator that will take up much less space than storing tanks of gas.
4. Are long-term cost savings important to your project? Beyond convenience, gas generators save on shipping costs, time-related costs for changing tanks, and managerial costs for managing the safety and supply of tanks.
5. Is noise a factor in your lab? Noise can be both bothersome and present a real health concern for those exposed. If low-noise is desirable, consider a gas generator with detachable or low-noise compressors.
6. What sorts of service agreements are available? Is training in self-maintenance sufficient, or are service representatives available?

TOP 10 FEATURES/FACTORS

Respondents Look for When Purchasing a Gas Generator:

PERFORMANCE OF PRODUCT	78%
LOW MAINTENANCE / EASY TO CLEAN	71%
SAFETY AND HEALTH FEATURES	68%
VALUE FOR PRICE PAID	64%
AVAILABILITY OF SUPPLIES AND ACCESSORIES	62%
TOTAL COST OF OWNERSHIP	60%
LOW OPERATING COSTS	60%
WARRANTIES	59%
SERVICE AND SUPPORT	58%
FOOTPRINT/SIZE	46%

For more information on gas generators, including useful articles and a list of manufacturers, visit www.labmanager.com/gas-generators

Raising the bar with what's under the bench

Introducing the most advanced nitrogen gas generator for your laboratory

Built upon decades of innovation in gas generation for the lab, Genius XE has been designed with superior performance and user experience in mind. With increasingly sensitive applications and productivity demands, the quality of instrument gas is more important than ever. This is why Genius XE features **Multi-Stage Purification™** and innovative ECO technology, defining **a new benchmark in gas quality and usability.**

www.peakscientific.com/genius

*Your local **gas generation** partner*

ARE YOU IN THE MARKET FOR A BATH OR CHILLER?

Water baths and circulators are used in a variety of settings including industrial and clinical laboratories, academic institutions, government research laboratories, environmental research applications, and food technology. Despite their maturity as a product category, laboratory baths continue their slow evolution, particularly in the areas of controls and user interface.

How many water baths and/or chillers are currently in place in your lab:

1	14%
2	18%
3	20%
4	8%
5 or more	34&
None	5%

How survey respondents repair their baths or chillers:

Our department	56%
Manufacturer service agreement	22%
Third party service agreement	17%
Multi-vendor service agreement	4%
Other	2%

Nearly 55 percent of respondents are planning to purchase a new bath or chiller. The reasons for these purchases are as follows:

Replacement of aging system	55%
Addition to existing systems, increase capacity	27%
Setting up a new lab	7%
First time purchase	2%
Other	9%

TOP 7 QUESTIONS

You Should Ask When Buying a Bath or Chiller

1. Does the product have any exclusive features? What sets it apart from other vendors' chillers or baths?
2. Is it important for your lab that the vendor have ISO 9001 certification?
3. What is the warranty period? What does it cover?
4. Are service plans available? If so, is there an on-site option?
5. Does the unit have the appropriate cooling or heating capacity for the application? Is there enough reserve capacity to account for environmental cooling or heating losses?
6. Does the manufacturer offer the necessary accessories for the application? (Tubing, fluid, adapters, electronic interfaces, etc.)
7. Does the manufacturer understand the application and provide a thorough explanation of calculations to recommend the proper instrument?

TYPES

Of Water Bath or Chiller Used by Survey Respondents:

STANDARD (GENERAL PURPOSE) WATER BATHS	58%
CIRCULATING WATER BATHS	55%
SHAKING WATER BATHS	25%
COOLED WATER BATHS	22%
BOILING WATER BATHS	10%
WATERLESS BEAD BATHS	8%
STIRRED WATER BATHS	7%
STEAMING WATER BATHS	3%
OTHER	12%

For more information www.labmanager.com/baths-chillers

SELECTING THE RIGHT NMR TUBES

Problem: An NMR tube is a thin glass walled, closed bottomed tube used to contain NMR solution samples. Its purpose is to confine a liquid sample in a perfectly cylindrical volume in a magnetic field. There are a variety of NMR tubes available on the market from a number of different manufacturers, however, it cannot be overlooked how important correct tube selection is for ensuring quality and reliability of your experimental results. It is possible to select NMR tubes from a huge variety of qualities, with an equally significant difference in price between the cheapest and the most expensive. They are rated according to many parameters and not in a conventional way—but what is the difference between these different NMR tubes? How varied is the effect on the quality of the spectra and how do you know the right tube to pick for your experimental requirements?

Solution: Historically, it had been the norm to pick tubes based on factors such as thickness, concentricity, and camber. However, the key to purchasing the right NMR tube for your needs is to keep focused on the application being carried out and pick the most suitable tube for your application. A shift in thinking is needed to start with the application and system configuration rather than with the tube properties. The industry is supporting this focus on application and experimental need by offering a service to scientists that helps them to determine the most appropriate tubes rather than simply offering the tubes by properties alone.

NMR tubes can be split into three different application approaches:

1. For day-to-day use in an environment of low to medium throughput, providing the best balance between quality and price

2. For medium to high throughput with use of a sample loader, these tubes are designed to support the user in achieving reliable, repeatable results

3. For high quality and high precision work, best for achieving repeatable, reliable results with very limited impact of background noise

Once the user has established their application into one of the above three categories they can move forward to the right standard tube for their requirements. Therefore, they need to keep in mind the application, sample requirements, and hardware. Once this is completed, the specific structural properties of the tubes can be evaluated in how they impact experiments. The table below provides an initial guide:

NMR instrument performance/application	Structural specs
Experimental Temperature	Glass Type
Spinning Sample	Camber
Resolution	Concentricity

In addition to standard NMR tubes, specific sample/applications require specialized tubes. One example is Microscale NMR tubes for specialized NMR experiments. These are most appropriate where only a small sample is available; for example, for protein experiments on high field NMR spectrometers. Microscale NMR tubes are available with their construction optimized for various solvents including D20, CDCI3, DMSO-d6, and CD3OD and for probe type, RT probes or Cryoprobe™. These tubes allow for the restriction of the active volume and hence reduce the amount of solvent used without causing line shape problems. Another example is NMR microscopy tubes. Here, samples are not solution, but objects, typically live objects such as animals and plants and inanimate material samples for application in many different fields of research. These can include physics, chemistry, biochemistry, biology, medicine, food technology, materials science, chemical engineering, among others.

All scientists are seeking accurate, reproducible results and the effect of choosing the correct NMR tube cannot be overstated.

For more information, please visit: https://www.bruker.com/service/service-units/labscape-service-and-life-cycle-support/consumables.html

▲*NMR tubes. Credit: Bruker*

TECHNOLOGYNEWS

ANALYTICAL

Nitrogen Gas Generator

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- Specifically engineered for MP-AES instruments to supply the high purity nitrogen required for plasma support gas or monochromator purge
- Produces 25 LPM of 99.5% or 10 LPM of 99.95% pure nitrogen with a supporting air supply of up to 36.5 LPM
- Nitrogen purity is guaranteed with real-time measurement of oxygen content in the gas stream

Peak Scientific www.peakscientific.com

Ion Mobility Device

FAIMS Pro Interface

- Designed to increase the breadth and depth of proteins scientists can identify while reducing time-consuming sample preparation steps
- Provides faster, higher-quality results through its next-generation design, further enhancing instrument selectivity and detection limits through gas phase fractionation and reduced matrix interference
- Reduces sample fractionation steps, which can help save time, long-term costs, and maintenance through increased productivity

Thermo Fisher Scientific www.thermofisher.com/FAIMSPro

AUTOMATION PRODUCT SPOTLIGHT

PUSHING THE BOUNDARIES IN AUTOMATION

A NEW GENERATION OF AUTOMATED ENDOTOXIN DETECTION

Lonza is revealing its next-generation endotoxin automation solution, PyroTec™ Pro Robotic Solution. Consistent with the FDA's Process Analytical Technology (PAT) initiative, Lonza is introducing a new generation of automated endotoxin detection driven by its market leading WinKQCL™ Endotoxin Detection Software. The need for accurate and dependable endotoxin testing technology is greater than ever, with the pharmaceutical industry increasingly focusing on the development of innovative biotherapeutics that carry a higher risk of endotoxin contamination. However, endotoxin testing traditionally involves a number of manual data entry and test template creation steps, which are inherently prone to human error. As a consequence, confidence in results is reduced, the retest rate is increased and the potential for proper second person review of the methods is reduced. Furthermore, the lack of metadata to be associated with manual steps has a negative impact on traceability and the laboratory's audit capability. As an add-on to Lonza's industry-leading WinKQCL™ Endotoxin Detection Software, the automation module in version 6.0 simplifies the process of setting up an automated endotoxin testing run and requires minimal human intervention while enhancing assay performance. The simplicity of the WinKQCL™ Endotoxin Automation Software Module means that no programming or robotic scripting knowledge is required. Results are automatically read and saved, and can be easily transferred into and out of LIMS, CAPA, MODA, or other database systems.

For more information, visit www.lonza.com

BASIC

Viscometer

Gel Timer DV2T

- Features a unique magnetic compression-fit coupling to easily attach/detach the glass rod to instrument
- Test method can be run manually or automatically, using the time-to-torque program stored in instrument memory
- Provides continuous torque sensing capability with live display of real-time data

AMETEK Brookfield www.brookfieldengineering.com

High Pressure Parallel Reactors

- Configured to optimally suit applications including homogeneous and heterogeneous catalysis, hydrogenation, carbonylation, and corrosion testing
- Easy to set up with one simple closure, and has a fail-safe mechanism to protect operators
- Conform to a wide range of national and international safety standards

Asynt www.asynt.com

Eye Wash Station

Aero Emergency Solution

- Combines sterile saline with a buffered, pH neutralizing solution to rinse impurities and irritants from the eyes
- Available in 16 or 32 oz bottles with unique eye-opener that allows used fluids and contaminants to flow away from the eye
- Meets all FDA requirements for eye wash as per 21 CFR part 349 and also meets ANSI Z358.1-2009 (as a personal eye wash only)

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Data Loggers

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- Equipped with TraceableGO Bluetooth capability to track reagents, clinical samples, vaccines, and food items during transport
- Compact size and strong durability allow loggers to fit almost anywhere, including the inside of a small cooler
- Capabale of storing up to 90 alarm events
- NIST traceable calibration is included to ensure accurate, reliable measurements

Cole Parmer www.coleparmer.com

Evaporator

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- Accommodates many more samples and can be operated entirely unattended
- Can dry samples without cross-contamination and sample loss due to solvent bumping commonly experienced with rotary evaporator systems
- EZ-2 temperature control and Auto Stop systems protect samples during operation

Genevac Ltd. www.genevac.com

Magnetic Induction Stirrer

- Uses advanced coil technology that produces the strongest magnetic coupling for mixing viscous solutions
- Significantly reduces the chance of magnet spin-outs at higher stirring speeds
- Quiet operation helps users stay focused in the laboratory
- Digital control assures a constant continuous speed for reproducible results

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Fume Hoods

EcoFlow

- Offered in 24", 30", 36" & 48" wide models, and are an economical solution for laboratories where space is limited
- Ideal for additional hood space applications and student workstations
- "Easy-Touch" operation allows for precise positioning
- Full selection of accessories and components, including work surfaces, base cabinets, plumbing, and electrical services are available

HEMCO www.HEMCOCorp.com

Perchloric Acid Fume Hoods

- Engineered for the safe handling of perchloric acids in laboratory procedures
- Come in 48", 60", & 72" widths and include a dedicated wash down and exhaust system
- Features dedicated wash down with integral piping spray nozzles & remote control on right column

HEMCO www.HEMCOCorp.com

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- Provides an intuitive smart phone-like interface
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INTEGRA www.integra-biosciences.com

Titrator

OMNIS

- Includes a fully integrated solution for moisture analysis and water content determination with volumetric Karl Fischer titration
- Chemicals are handled in a closed system, eliminating contact with reagents and solvents
- Water content determination starts automatically with sample injection and the fully automated system discards used sample after measurement

Metrohm omnis.metrohm.com

Electronic Pipette Filler

UltraJet

- Perfect for use even in confined spaces such as safety cabinets and fume hoods
- Ergonomic design ensures you can use it for extended periods of time without discomfort
- Includes a disposable syringe filter inside to protect it from over-filling and a snug neoprene collar to firmly grip the pipette and ensure good directional control

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Refrigerator

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- Developed to address the need of clinical laboratories and patient care facilities
- Enables secure and energy-efficient storage of vaccines, medicines, lab kits, and breast milk
- Offers whisper quiet operation at less than 35 dbA, meaning they won't disrupt the work environment and patient comfort
- Uses environmentally-friendly refrigerants in line with global initiatives aimed at minimizing greenhouse gas emissions

Thermo Fisher Scientific www.thermofisher.com/whisperquiet

INFORMATICS

NGS Analysis Software

SureSeq™ Interpret

- Updated version designed to help researchers effortlessly translate NGS data into meaningful results
- Can be used with SureSeq NGS panels, facilitating analysis and visualization of a wide range of mutation types and structural variants
- Rapidly processes sequencing data and delivers accurate mutation calling with 100% sensitivity and 99.9% specificity at >1% variant allele frequency (VAF)

Oxford Gene Technology (OGT) www.ogt.com

Mass Spectrometry Software

SCIEX OS 1.4

- Provides new tools for full regulatory compliance and updated calculation algorithms
- Acts as the central processing application for data produced by Analyst® and Analyst® TF Software applications
- Supports 21 CFR Part 11 Compliance with the incorporation of electronic audit trails, electronic signatures, and detailed security configurations

SCIEX www.sciex.com

KITS

Gene Editing system

TUNR

- Allows users to precisely control the expression of their gene of interest
- Custom-designed for specific projects and includes everything needed to tune gene expression in the user's favorite cell line
- Enable users to precisely tune gene expression from 100% all the way down to complete knockout

AMSBIO www.amsbio.com

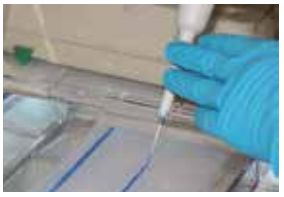
Conversion Kit

- Combined with the symphony 7100 bathless dissolution tester, the small volume conversion kit offers the advantages of both bathless instruments and small sample volumes
- Extends the symphony 7100's unique ability to run up to three different temperatures and agitation speeds to much lower volumes ranging from 30-100 mL
- Compatible with conventional manual or semi-automated sampling techniques as well as in-situ UV Fiber Optics

Distek, Inc. www.distekinc.com

Gel Extraction Kit

EB Pure Agarose



- Designed to quickly isolate small DNA fragments (70 bp to 20 kb) from Agarose Gel in just 15 minutes
- Enhanced filtration provides researchers with better resolution and allows them to recover more delicate molecules
- Extracted DNA is suitable for use in most applications including ligations, PCR, sequencing, restriction digestion, or various labeling reactions

Empirical Bioscience www.empiricalbioscience.com

Antibody Labeling Kit

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- Five new labels added to the Lightning-Link® antibody labeling kits offer customers increased choice and flexibility for common fluorescence detection-based applications
- Enables easy, direct conjugation of the label to primary antibodies in less than 20 minutes
- Lightning-Link protocol is free of separation steps, saving researchers time and precious materials

Expedeon www.expedeon.com

Immunoassay Kit

Gyrolab CHO-HCP E3G

- Designed for impurity analysis in the CMC (chemistry manufacturing and controls)—bioprocess workflow of biotherapeutics
- Quantifies residual host cell proteins from Chinese hamster ovary cells used in bioprocessing of biotherapeutics
- Provides consistent and sensitive assay performance without the need for extensive assay development

Gyros Protein Technologies www.gyrosproteintechnologies.com

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SureFlo™

- Prevents tips from sealing off and liquid "popping" into tips, filters, or pipettes
- Enhanced with a specially formulated inert, hydrophilic surface treatment that stops liquid from pooling and results in the lowest dead volume on the market
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VECTASHIELD® Vibrance™

- Delivers significant improvements to the immunofluorescence workflow
- Produces increased brightness over the entire visible spectrum, including far-red fluorophores
- Can be stored at room temperature, providing increased flexibility and options for archiving
- Offered in 2 ml and 10 ml formats with a minimum one-year expiration date from the date of manufacture

Vector Laboratories www.vectorlabs.com

LIFE SCIENCE

Assay

AbSeq

- Analyzes protein expression at the single-cell level using high-throughput sequencing
- Brings together high-quality antibodies from the BD Pharmingen™ portfolio with oligonucleotides
- Helps develop a more complete picture of the role genes and proteins play in biological systems

Becton, Dickinson and Company www.bd.com/genomics

Mycoplasma pneumoniae Antigens

- Availability of these two antigens will benefit the needs of biopharmaceutical, clinical, drug-discovery, and life science researchers, as well as manufacturers of IVD test kits
- Both a native and a recombinant version of the antigen are available, with each exhibiting exceptional purity levels as a result of chromatographic manufacturing techniques
- Demonstrate exceptional lot-to-lot consistencies and feature an outstanding shelf life stability claim of 10 years from the date of manufacture

Binding Site www.immunologicals.com

DNA Reference Standard

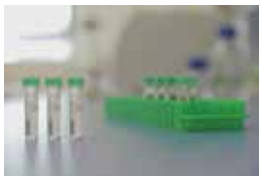
- First-to-market cell line-derived reference standard for myeloid blood cancers
- Largest cell-line derived reference standard available, contains 22 mutations across 19 oncology-relevant genes
- Enables faster, more reliable, and more cost-effective assay validation

Horizon Discovery Group www.horizondiscovery.com

Antibodies

Recombinant monoclonal anti-ranibizumab antibodies

- Highly specific for the monoclonal antibody drug ranibizumab (Lucentis) or the complex of ranibizumab with its target, vascular endothelial growth factor A (VEGF-A)
- Designed for use in pharmacokinetic (PK) and immunogenicity assays for ranibizumab and biosimilars
- Approved for *in vitro* research and for commercial applications of *in vitro* services that support preclinical and clinical drug and biosimilar development and patient monitoring



Bio-Rad, Inc. www.bio-rad-antibodies.com

Electromagnetic Flow Meter

FLEXMAG 4050 C

- Includes biocompatible disposable flow tube specifically developed for single use biopharmaceutical applications, including filtration processes, chromatography, or buffer and media preparation
- Provides a completely stable, direct, and accurate volumetric flow measurement, unaffected by fluid properties such as color or density
- Uses a single barb fitting that meets biopharmaceutical requirements for adaptation to single use systems

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Isolation Valves

- Use a flexible diaphragm to isolate the actuation mechanism from the fluid path
- All wetted areas of the valve are PTFE, making this series ideal for use with corrosive media
- One-piece valve stem functions as a sealing membrane while also supporting and centralizing the poppet in the seating area

Clippard www.clippard.com

Microplates

BactiGrowth

- Enable high yield growth of bacteria, yeast, mammalian, or insect cell lines
- Manufactured to conform to the automation-friendly ANSI/SBS format
- Produced under class 10,000 clean room conditions from ultra-pure grade polypropylene
- Supplied in packs of 5 plates with tight fitting lids sealed in a sterile polymer bag

Porvair Sciences www.porvair-sciences.com

VAPOR RELEASE PREVENTION

Problem: In most laboratories, a variety of automated analysis equipment can be found running almost all the time. Some of these systems use hazardous organic chemicals—reagents with noxious and/or dangerous fumes that can have a detrimental impact on the analysts using those systems. The negative impacts of exposure can range from developed sensitivities to specific chemicals, to cancer and other diseases—not to mention the inherent fire and explosion risk that can occur with volatile vapors present in the air. Unfortunately, with many of these analytical systems, the release of these fumes into the laboratory atmosphere—from the bottles and containers holding them—occurs all too often. Frequently, the bottles holding the reagents on the inlet side of the systems are not sealed correctly, often only loosely covered with a thermoplastic film or aluminum foil—neither of which properly contain vapors emanating from the bottles' contents. On the waste side, where used and contaminated reagents are collected, the situation is similar. Flow path tubing often passes through an open, unsealed hole on a large container. As the vapors are released from these open vessels, it forces scientists to be regularly exposed to hazardous chemical vapors. This creates an unsafe work environment for thousands of laboratory personnel and violates numerous governmental regulations in place around the world.

Solution: As highlighted above, there are two primary sources in most automated systems where harmful vapors are regularly released into the laboratory—the reagent bottles found at the inlet of a system and the waste containers into which spent reagents are collected. By addressing both vapor sources with innovative and cost-effective solutions, the Cole-Parmer VapLock family of modular products works to help create true "closed systems" and limit scientists' exposure to dangerous reagent fumes. On the solvent inlet side, VapLock engineers have developed unique threaded caps for most of the commonly found reagent bottles in the laboratory. Available in a variety of useful configurations, the VapLock brand bottle caps incorporate key features to ensure maximum functionality in today's laboratories. These features include ¼-28 flat-bottom threaded ports to which flow path tubing can be connected, an integrated one-way check valve that allows air into the bottle but prevents the release of vapors, an integrated large-porosity filter to prevent particulate contamination of the reagents inside the bottle, and a special design that allows the cap to seal naturally against the bottle without the use of O-rings or gaskets.

On the waste containment side, at the heart of the VapLock product line, is a highly functional, adaptable, and easily expandable manifold, engineered with flexibility in mind. This manifold system can be connected to virtually any commonly used waste container, and it is equipped with a variety of threaded ports to which waste lines can be attached or that can be plugged if unused. If additional ports are needed to accommodate multiple systems or complex fluidics, the manifolds can be easily stacked to increase connection options. An activated carbon filter is attached to each VapLock system to adsorb organic vapors and prevent their release into the laboratory environment.

Through these primary products—as well as a host of accessories that support their use—the VapLock solution successfully and economically addresses the problem of vapor release in laboratories, provides a safer environment for workers, and helps organizations comply with government regulations.

For more information, please visit www.coleparmer.com/VapLock

▲*VapLock closed systems make it easy to improve laboratory safety by reducing exposure to vapors and hazardous solvent waste*

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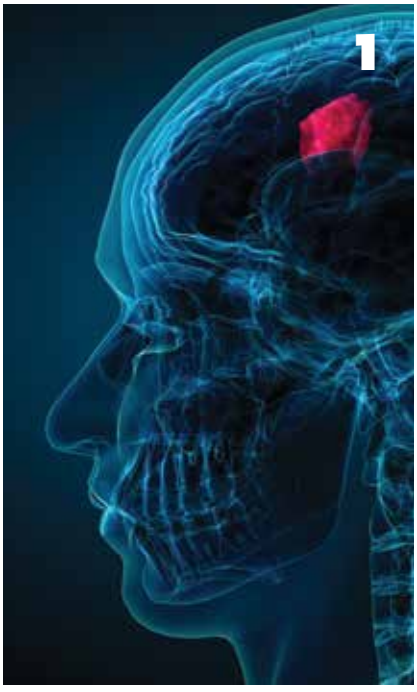


LAB MANAGER ONLINE

We look back at our web content since the September issue and look forward to what's in store for the upcoming November issue.

1 The Search for New Targets and Treatments for Pediatric Brain Cancer

Brain tumors have become the leading cause of mortality in pediatric cancer patients. Although prospects are relatively better for pediatric patients with low-grade gliomas (pLGG) and progress has been made toward medulloblastomas, conventional therapies remain essentially ineffective against pediatric high-grade gliomas (pHGG).

Read more at **LabManager.com/pediatric-cancer**

2 Trending on Social Media: Salary and Employee Survey

As of Sept. 17, *Lab Manager*'s top September issue article posted to social media was The Twelfth Annual Salary and Employee Satisfaction Survey. After reviewing close to 1,000 responses, some of the key points we observed in this year's survey results included slight changes in the types of labs where respondents work, the baby boomer generation still dominates much of the workforce, and employee loyalty remains strong.

Read more at **LabManager.com/12th-survey**

3 Most Popular Webinar

Our most recent top webinar on LabManager.com with 328 registrants was "How to Create a More Effective Chemical Hygiene Plan." In this Safety First webinar, Dr. James Kaufman drew from nearly 30 years of writing and reviewing CHPs to help guide attendees into creating the most effective plan. He also covered the most common pitfalls, and how to avoid them when building a customized plan. Though it ran on August 22, you can still register to watch on-demand.

Read more at **LabManager.com/CHP**

LabManager.com

NEXT ISSUE ➡ Marketing Your Lab

As budgets tighten and grant money shrinks, it is increasingly important for labs to draw in new business to increase revenue. While there is no quick fix, labs must figure out who their potential clients are before trying to market their services. By identifying these clients, labs can target their marketing to these clients.

ASK LINDA
STAFF TRAINING

QUESTION:

Dear Linda,

Some members of my staff have gone almost two years without any training. While I recognize the vital importance of training, I have very limited resources available for that purpose. The training my team requires is general laboratory safety, cleaning of lab equipment, routine maintenance and calibration of laboratory equipment, report writing on lab-based activities, and the like.

I'm writing to see if you can point me in the direction of alternative and cost-effective training programs that my staff might be able to take advantage of.

Thanks in advance.

Gordon

HAVE A QUESTION FOR LINDA?
EMAIL HER AT: *LINDA@labmanager.com*

ANSWER:

Dear Gordon,

You are quite right to be putting your attention to staff training, as that investment will help your lab strengthen its competitive position and demonstrate your commitment to your team.

While I can't recommend any one training program in particular, below are some types you might consider:

Online programs involve self study with learners proceeding at their own pace and taking tests at the end of the course. Often a minimum score is required to certify that the student has passed the course.

Live remote broadcasts are increasingly being used to eliminate the costs of long-distance travel to attend training. The software used usually allows workshop participants to ask questions.

Some suppliers offer DVD courses that lab managers can purchase and make available to their staff members.

Consultants can be brought in to present training programs, which are recorded so other employees can view the workshop later. For these you'll need approval from the presenter in advance.

Some consultants charge for training workshops by the number of attendees. Lab managers can limit spending by controlling enrollment and making sure only those staff members who can benefit most actually attend the workshop.

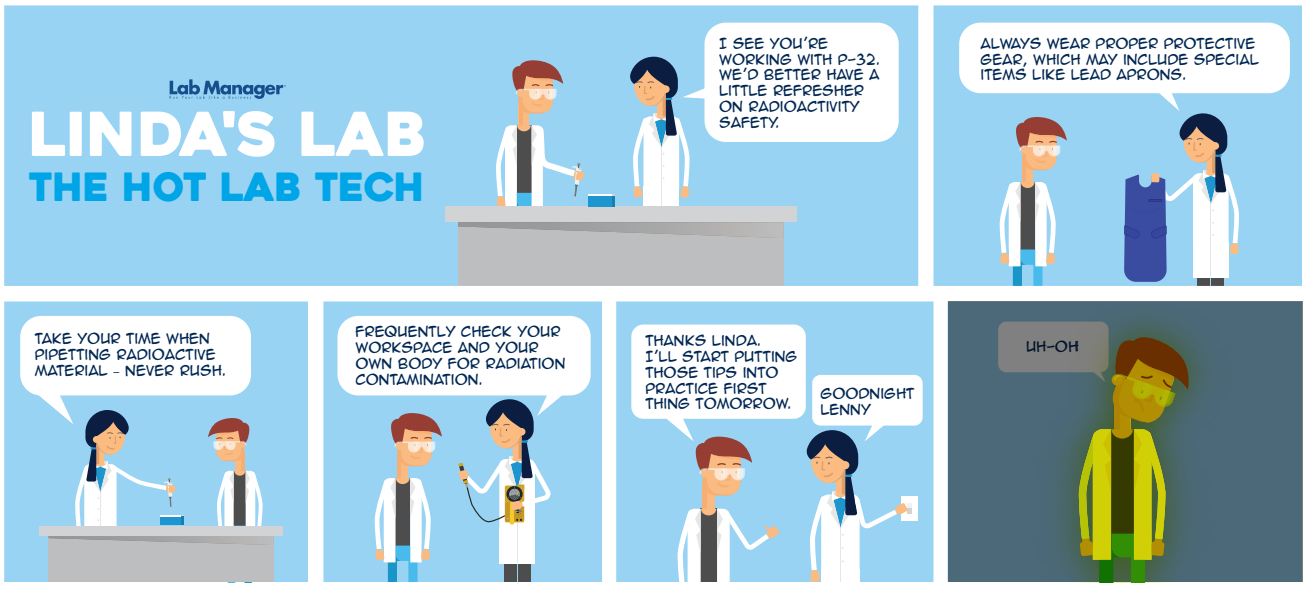
Cross-training, in which a more experienced member of the team trains another less experienced one, is another possibility. Managed right, this can be very productive and cost effective.

All of these options need to be considered before deciding on a training program that can best improve the quality of your existing workforce.

Good luck.

Cheers, Linda

FOR MORE INFO: LABMANAGER.COM/LAB-TRAINING



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