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Strategies for a More Sustainable Lab

By Kevin Ritchart

While many people have adopted a more sustainable lifestyle at home, the practice of creating and maintaining sustainable habits in the lab is still a work in progress.

Studies have found that laboratory buildings consume 10 times more energy and about four times more water than office spaces. Along with the increased power and water needs, the prevalence of single-use plastics also contributes to lab waste.

Scientists worldwide have become more aware of this growing problem in recent years, and they're taking a closer look at how they work in the lab and what can be done to reduce their environmental impact. Lab personnel are engaged in efforts to become more sustainable and join the "green lab" movement.

By making sustainable big-picture decisions, lab managers can help ensure their facility is doing its part to have a positive impact on the environment.

Check the Label

In North America, the process of identifying more sustainable products for your lab is made easier by the Energy Star and ACT labels. Energy Star is an energy-efficiency designation that was created by the U.S. Environmental Protection Agency and the U.S. Department of Energy to highlight equipment that meets certain standards.

While most people are familiar with purchasing Energy Star-certified appliances for their homes, these designations have now reached the lab. Products like ultra-low-temperature freezers now carry Energy Star ratings to aid lab managers in their purchasing decisions.

The ACT label is an econutrition designation that compares laboratory products based on the environmental impact of their manufacturing, daily use, and disposal. The ACT label is independently verified and designed to help scientists make more informed purchasing decisions based on their sustainability goals.

Sustainable Strategies

In addition to using sustainable products, there are a number of strategies for making labs more sustainable. By increasing awareness of their lab's environmental impact and identifying conservation opportunities, lab managers can shift the culture of their lab toward a more sustainable approach. And a straightforward place to start is with waste.

While the general definition of waste is anything that's left after recycling, reuse, and composting, the lab definition includes items that are not being used to their full potential. This can mean purchasing unnecessary products, holding on to products that aren't being used, and using existing resources in a wasteful manner.

By following these strategies, labs can reduce the amount of waste they're creating:

Consider shared equipment. Consider whether it's possible to share equipment between labs, and do so when possible. The University of Colorado-Boulder has created two such programs that have been very successful, one for sharing ultra-low-temperature freezer space and another for the common use of biosafety cabinets.

Learn to let go. Identify items that are no longer needed and consider donating them. Some nonprofit organizations will donate to scientists in need or to high school chemistry labs.

Use only what's absolutely necessary. Unless a piece of equipment needs to run overnight, turn it off when you're done using it. If your lab has adequate ambient light, consider turning off some or all of the overhead lights. Consider whether alternative methods of cooling your reactions that use less water are right for you. Many labs don't need to use as much electricity or water as they routinely consume.

Recycle what you can. Consider reusable apparel. For products that can't be reused, consider recycling. Recycling programs for personal protective equipment and pipette tip boxes are available.

These are just a few examples of strategies that can help make your lab more sustainable.

Ideas for the content in this article were drawn from multiple sources, including "Building a Culture of Sustainability," Lab Manager, March 20, 2019; and "Making Sustainable Labs a Reality," Lab Manager, April 1, 2020.

Kevin Ritchart is a Fisher Scientific staff writer.

The Promise of Oligos in Medicine

Oligonucleotides are short DNA or RNA molecules that can be chemically synthesized in quantities from micrograms to metric tons. Due to their ability to bind to complementary sequences through Watson-Crick base pairing, they are being used in therapeutics, diagnostic testing, DNA sequencing, and vaccine production. Recent development of mRNA vaccine candidates for use against SARS-Cov-2, the virus that causes COVID-19, has increased public awareness of oligonucleotide technologies.

Therapeutics

Oligonucleotides used as a novel class of therapeutics are attracting much attention. Numerous oligonucleotides are being evaluated in clinical trials for the treatment of a variety of diseases, especially those that cannot be effectively treated by conventional small-molecule drugs or protein therapeutics. Oligo-based therapeutics are promising because they have high specificity. Several therapeutic treatments based on oligonucleotides have already been approved in the United States, and many more are currently being evaluated for treatment of cancer, infectious diseases, metabolic disorders, genetic disorders, and other diseases.

Oligonucleotide therapeutics are quite diverse, using antisense oligonucleotides (ASOs), small interfering RNAs (siRNA), microRNA (miRNA), or aptamers. They can inhibit gene expression or impede protein function by interacting with a specific sequence of a target gene or protein.

Vaccines

Vaccines have contributed to the eradication or control of infectious diseases and subsequently increased life expectancy in human populations. The lack of effective vaccines against infectious diseases like HIV/AIDS and malaria, along with the appearance of new infectious diseases like COVID-19, has stimulated research on vaccines and vaccine components, including new adjuvants.

Vaccines typically contain one or more adjuvants to improve vaccine efficacy by boosting the immune response to produce more antibodies for longer-lasting immunity. Recently, there has been growing interest in the use of ASOs as adjuvants. Studies have demonstrated that vaccine efficacy can be improved by either inducing antigen modification with enhanced expression of immunogenic molecules or targeting specific components of the immune system to achieve the desired immune response.

Diagnostics

The molecular diagnostics market is growing steadily and is accompanied by the increasing need for oligonucleotides. Oligonucleotides are used as primers and probes for polymerase chain reactions (PCR), and they are also used in microarrays, in situ hybridizations, and antisense analyses. The reverse transcription (RT)-PCR test can detect the presence of a specific virus, such as the coronavirus, by amplifying viral RNA in a patient sample.

High-Quality Oligonucleotide Production

Regardless of the final use of a chemically synthesized oligonucleotide, purity and yield are crucial for oligo manufacturers. To obtain the desired oligonucleotide, phosphoramidite building blocks are sequentially coupled according to the sequence of the desired product. The solid-supported phosphoramidite synthesis cycle has been the mainstay of oligonucleotide synthesis since the late 1970s. Once the oligonucleotide is the appropriate length, the oligo is cleaved from the solid support, deprotected, and purified. The occurrence of side reactions must be minimized because errors can accumulate as the oligonucleotide is synthesized.

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Operating with Confidence in the Face of Uncertainty

By Kylie Wolfe

In the event of an emergency, it's important to be prepared. Having a plan in place for your laboratory not only protects your colleagues, it also protects their work.

Whether it's a fire, severe storm, or global pandemic, acting with efficiency can be essential. One way to prepare your team for the unexpected is by implementing a continuity of operations plan (COOP). While it's difficult to create a perfect plan for every scenario, you can help minimize disruptions and avoid losing valuable progress.

Get Started

A COOP gives your lab the opportunity to outline various steps that, with proper training, can be executed at a moment's notice. This plan helps to keep your lab running as smoothly as possible when the unexpected happens. To make sure your COOP works and remains effective, you'll want to:

- Design and document your plan
- Test and train employees often
- Review and maintain your plan regularly

Draft a Plan

Start by developing a small planning committee. The members can help identify essential functions and the amount of effort it would take to maintain each. Decide how many employees you need to keep research moving and supplies in stock. This list can then be prioritized to focus on critical areas, like protecting precious samples and equipment.

Make note of instruments you rely on, including those that are temperature sensitive. Document the brand, model, and serial number of each, as well as information about warranties, maintenance, power supply, and any other crucial details. Also consider storage options with backup features, like liquid nitrogen backup systems for ultra-low-temperature freezers, to keep your samples safe.

Outline remote work practices and determine which tasks, like planning experiments, can be conducted off site. In some cases, limiting the number of researchers in the physical lab space may be necessary.

It's helpful to inventory your chemicals and reagents often so that hazardous materials are secured and acknowledged during an emergency.

Keep a contact list handy, too. This should include employees, as well as public safety, environmental health and radiation safety (EHRS) contacts, and others who are relevant to your work. Make sure your list is always up to date and accurate.

Test Your Ideas

While the creation of this plan tends to rest in the hands of lab leaders, every member of the team plays a role in implementing it.

COOPs are considered living documents and should be tested, discussed, and revised regularly. Schedule exercises often and remind employees of important procedures.

With that said, communication is critical. Routine meetings with your planning committee can help keep your COOP current while trainings with staff members can prepare employees to act.

Back up important files and keep a list of these documents. Test remote connections and initiate security measures for all data and shared files. It's not just your physical space that matters, your digital space does, too.

Compare Notes and Make Revisions

It's hard to anticipate every type of emergency, but a plan can make a dramatic difference. Even if your needs vary from the lab next door, comparing ideas can help ensure your document is complete.

Your planning committee can offer suggestions for improvement based on various tests and trainings. Feedback from all employees is important.

As we learned in 2020, things can turn upside down in an instant. If you experience a scenario that requires you to activate your COOP, you'll know how to tailor your plan and support your process. Most importantly, always keep lines of communication open with your personnel.

Establishing a plan ahead of time can help minimize disruptions to lab operations and promote safety. Turn education into action and begin preparing your team now for the unexpected later.

This content was inspired, in part, by "Research Continuity Planning," University of Pennsylvania, March 12, 2020; "Continuity Planning and Recovery Guide," University of Texas at Dallas, March 2020; and "Research Continuity Guidance For Laboratories And Research Facilities," Massachusetts Institute of Technology, March 2020.

Kylie Wolfe is a Fisher Scientific staff writer.

Staying Agile During COVID-19: A Manufacturer's Perspective

As case numbers increased during the first three months of the COVID-19 pandemic, governments acted swiftly but focused on their own country's best interests. Despite its start in late 2019, the pandemic's global impact on supply chains was not fully appreciated until February 2020, when Chinese authorities declared workforce movement controls that halted manufacturing in China.

As the pandemic spread across the world, other producers of key raw materials and finished personal protective equipment (PPE) reacted similarly, severely impacting global supply. An unprecedented increase in demand and the simultaneous disruption of logistics and transportation only added to the situation.

While many countries advocated for local production of PPE, this was often not feasible in the short term. Manufacturing plant changes required additional time and money, and secondary suppliers of raw materials were also experiencing significant demands. As the pandemic progressed, governments began to consider long-term effects and started planning on more collaborative levels.

Successful Strategies and Lessons Learned

For Ansell, one successful strategy for supplying PPE during the pandemic was using numerous warehouses to quickly access local markets. However, this strategy requires significant product stock to absorb peaks in demand. This is not only expensive but also may be impractical for some products.

A second strategy was deploying manufacturing and production and diversifying sourcing. This increases the ability to manufacture PPE in multiple countries and to make the same product in multiple locations. Sourcing diversification provided options for acquiring key raw components to cope with disruptions in other parts of the supply chain.

While this ensures agility, there are difficulties with manufacturing a completely identical product using different suppliers, so consumers must accept small differences in product appearance and performance. This strategy may not work for products like surgical gloves, which are subject to medical device regulations that may restrict the use of alternate components.

A third strategy, process automation, has proven helpful in adjusting response plans to include manufacturing runs with fewer people and social distancing measures.

Overall, a combination of these strategies helped us successfully mitigate some of the issues during this pandemic. Along the way, more lessons will be learned and greater improvements made to ensure that we continue to protect supply chains in our industry.

Preparing for a Second Wave

In late April 2020, Dr. Anthony Fauci, director of the National Institute of Allergy and Infectious Diseases at the

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National Institutes of Health (NIH), was already talking about the inevitability of the virus' return and how our handling would determine our fate.[1] In spite of having successfully controlled the spread of the virus, Director Jung Eun-kyeong of South Korea's Centers for Disease Control and Prevention reported that the second wave had already been detected in the country by late June of 2020.[2]

Countries, businesses, and hospitals have started to lift restrictions on elective surgeries. At the same time, some centers are stockpiling PPE in anticipation of a second wave of the virus. For some healthcare providers, this has increased concern that a second wave will create more pressure on the supply chain. Will Lange, chief of Honeywell's PPE business, said the supply chain is not yet fully prepared for a second wave of significant PPE demand and that it will "probably take about nine months to get to a good spot."[3]

Working Together

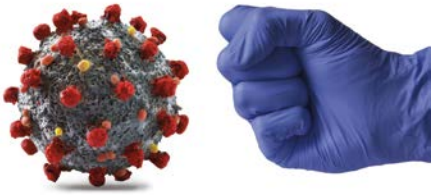
Unfortunately, stockpiled product is not necessarily available to frontline workers and the healthcare industry, where it is most needed. As governments and other industries become familiar with the importance of appropriate protection and the value of PPE, demand may exceed supply and drive prices up. Market imbalances may leave some developing countries struggling to procure enough PPE to protect their healthcare and frontline workers.

The coronavirus pandemic may have demonstrated the importance of an open, rules-based global trading program that requires nations to eliminate some trade barriers. In an open letter to the Australian British Chamber of Commerce, several trade ministers

said this outbreak should "lead us to deepen our commitment to shared rules for the governance of global trade and investment."[4] No country is entirely self-sufficient in the supply of medicines, medical supplies, or PPE, and free-flowing trade plays a key role in crises like these.

As World Health Organization (WHO) Director General Tedros Adhanom Ghebreyesus recently said, "no organization and no country can fight this pandemic alone. Only by working together will we overcome this global threat. The greatest threat we face now is not the virus itself, it's the lack of global solidarity and global leadership. We cannot defeat this pandemic with a divided world."[5]

Extensively reshoring our essential capabilities can help minimize short-term supply risks for local business communities as economies stabilize. However, those taking advantage of the crisis should not be able to undo the decades of progress that the global community has accomplished.



We need to continue to share the challenges and diversify our supply chains to become more resilient in the face of future shocks. Combating this global problem necessitates a global response, and we all have a part to play. It is not the first pandemic and it won't be the last, but we hope to have learned how to be better prepared for and reduce the impact of future adverse events.

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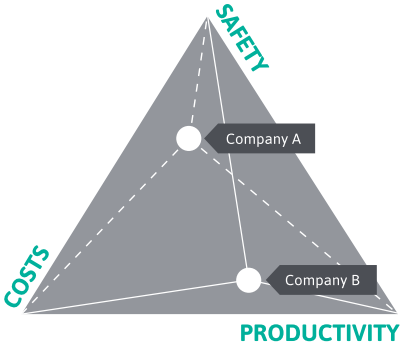

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Three Pillars of Glove Safety: Protection, Precision, and Comfort

By Anita McLean, Kimberly-Clark Professional Category Manager

Gloves are one of the most critical types of personal protective equipment (PPE), particularly in the laboratory. But finding the right gloves can be challenging. According to *Health & Safety International*, "even small deficiencies in glove design may reduce grip, strength, and manual dexterity."[1]

Gloves must be suited for the task at hand without compromising precision, protection, or comfort. For example, bulky gloves may provide the right chemical protection but reduce dexterity and increase the time it takes to complete a task. So scientists might choose thinner gloves to maintain dexterity, sacrificing chemical protection and requiring frequent changes. Worse, some may choose to not wear gloves at all, risking injury or chemical exposure.

Consider these statistics:

- 30 percent of people who experienced a hand injury were wearing the wrong type of glove[2]
- The indirect costs of a worker injury can be four to 10 times the amount of direct medical costs[3]
- The average work time lost for a hand injury is six days[4]

The right gloves provide adequate protection while delivering precision and comfort, protecting the science as well as the scientist. These attributes may be hard to find in a single glove, but without them scientists face higher risk of injury and contamination.

Finding the Right Gloves

Here are some things to keep in mind when selecting gloves.

Protection
Laboratory workers are routinely exposed to chemical agents. According to an international safety study, 21 percent of respondents had been injured in the lab more than once.[5] And in a recent laboratory PPE poll, 85 percent of respondents said that getting people to consistently wear gloves is their biggest challenge.[6]

Protection is important in glove selection, but it can vary from one glove to another. These questions can help you identify the level of protection gloves provide:

- Do the gloves resist a wide range of chemicals, including cytotoxic drugs?
- Do they offer chemical splash protection?
- Do the materials reduce the risk of allergic reaction?
- Can the gloves protect against punctures, lacerations, and other risks?

Search for a glove that offers the right protection for your specific needs first. Then think about precision and comfort.

Precision
Good ergonomics are crucial to meeting user needs. Pipetting, microscopy, operating microtomes, and other routine procedures can put researchers at risk for repetitive motion injuries that result in inflamed tendons, pinched nerves, and restricted blood flow.[7]

Gloves with gripping surfaces can help prevent tendonitis and other injuries by requiring less force from the fingers.[8] Select gloves with the right characteristics to reduce the risk of muscle fatigue and injury while providing good wet and dry grip. For lab environments, look for thin, protective gloves that offer tactile sensitivity and enhanced dexterity through textured fingertips or other features.

Comfort
Uncomfortable gloves have been linked to reduced compliance and increased risk of injury, according to *Health & Safety International*. The article states that "uncomfortable glove materials may reduce blood circulation, cause numbness, limit finger and hand motion, cause muscle fatigue, and reduce work performance."[9]

Choose gloves that enhance comfort and deliver the right level of protection. This may include materials that protect while reducing overall thickness, accelerator-free polymers that reduce the potential for skin irritation, and more. And look for certified ergonomic comfort to ensure comfort in use without compromising protection.

Product Sustainability

Gloves that offer protection, precision, and comfort are more likely to last longer, reducing glove waste.

Labs and cleanrooms can reduce glove waste even further by diverting used gloves from landfills through The RightCycle Program. This groundbreaking service from Kimberly-Clark Professional lets labs turn their used nitrile gloves, safety glasses, and single-use apparel items into new plastic products and other consumer goods.

Since 2011, The RightCycle Program has helped research facilities, universities, nonprofits, and other businesses divert more than 1,200 metric tons of PPE from landfills. With this program, safety and sustainability truly go hand in hand.

For more information about choosing hand protection that provides precision, protection, comfort, and sustainability, contact your Fisher Scientific representative.

Content provided by:

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Filtered Fume Hoods: A Simple Solution for Complex Labs

Although ducted hoods are traditionally considered the best way to protect users from harmful chemical vapors, innovations in carbon filtration technology have paved the way for filtered fume hoods. In an ongoing search to improve lab experience and operations, filtered fume hoods meet all requirements. The new Echo and Airo filtered fume hoods from Labconco have many advantages over ducted models, including energy efficiency, environmental friendliness, and flexibility.

Energy Efficiency

When trying to increase lab efficiency, fume hoods may be some of the first equipment of interest. Ducted fume hoods have a high impact on a lab's yearly heating, ventilation, and air conditioning (HVAC) costs. The HVAC system exerts a sizable amount of energy to move air into the lab and maintain it at desirable temperature and humidity levels. When exhausting to the outside environment, that valuable tempered air is removed from the building and any new air supply must be tempered in an endless repeating cycle.

Ducted hoods typically require a significant volume of airflow to work properly. Airflow costs an estimated $8 USD per cubic foot per minute (CFM) on average, with a range from $5 to $13 USD depending on the climate of the lab's location. A ducted fume hood that requires 500 CFM could cost as much as $4,000 USD per year to operate.

The Labconco Echo and Airo filtered fume hoods eliminate HVAC costs entirely. Valuable tempered air is no longer lost but is instead run through carbon filtration and returned to the lab space. By conserving air, filtered fume hoods offer labs an excellent way to improve energy efficiency.

Environmentally Friendly

In addition to improving operational efficiency, environmental friendliness is another area of ongoing exploration. The Echo and Airo filtered fume hoods are an excellent way to reduce environmental impact. As ducted fume hoods expel air outside of the building, harmful fumes or vapors are also exhausted into the environment. The chemicals are diluted by the air, which make this a generally safe and common practice, but pollutants are still added to the atmosphere.

With filtered fume hoods, chemicals bind to the carbon in the filters and clean air is recirculated. The harmful fumes or vapors are captured and contained in the filters, which can be safely discarded when full. This process, plus the efficiency gained by eliminating exhausted air, makes filtered fume hoods an excellent option for your lab space.

Flexibility

The Echo and Airo hoods also offer flexibility when compared to ducted fume hoods. Ducted hoods require significant infrastructure and planning for installation, including the ductwork

Content provided by:

that must be in place for the airflow and exhaust. Because of this, ducted hoods are difficult to relocate once they are in place.

The placement of filtered fume hoods is not restricted, which gives the lab more flexibility. Filtered hoods require virtually no ducting, so hoods can be repurposed for changing applications by simple moving and recertification. And because the Echo and Airo fume hoods are not ducted, they can be placed in locations where ducted hoods are impractical, like the basements of tall buildings or in older structures where adding a new ducting network would be both difficult and expensive.

Filtration Technology

Erlab, a company with over 50 years of experience in carbon filtration, has formed a business partnership with Labconco that combines their innovative Neutrodine Unisorb filtration technology with Labconco's well-established hood performance. The Erlab technology produces comprehensive molecular filters that simultaneously capture solvents, acids, bases, ammonia, formaldehyde, and other chemicals. A unique filter frame prevents carbon shifting and channeling to provide high retention capacity and extends the filter lifetime for better safety and longevity.

Labconco Filtered Fume Hoods

The Echo is a full-sized benchtop hood that can be used for many applications. Similar in size to ducted hoods, it can house similar equipment and is available with optional side and back windows for increased visibility. Also available in a floor-mounted version and multiple depths, Echo hoods can accommodate larger equipment and instruments.

The Airo filtered fume hood is a compact version that's shorter and narrower. Airo models can be used in labs with low ceiling height clearance or those with less space available for new equipment.

Scientist to Scientist: Sustainability in Lab Plastics

An Interview with Emelia DeForce, PhD, Senior Scientist at Thermo Fisher Scientific

What strategies or "sustainability wins" are you implementing to make consumable products more green or sustainable?

Thermo Scientific Nalgene products were the first ACT labeled laboratory consumables. The ACT label is a virtual label that provides an environmental impact score for each product to help users make informed and sustainable product choices. Created by the nonprofit My Green Lab, the scores are based on the product's environmental impact of manufacturing practices, energy and water use, and end-of-life disposal.

Although many lab consumables are single use and have a bad reputation for sustainability, we want to ensure that the quality of our products remains the same, so the need to implement sustainability surrounding the manufacturing and end of life of the product is crucial. The ACT label helps address this issue by incentivizing changes to the manufacturing process and providing transparency to our customers.

Are researchers demanding greener products?

Yes. In a recent survey, more than 70 percent of respondents told us that they'd like their labs to go "greener." Scientists are demanding more sustainable products. They understand global climate change and know that inherent wastefulness in research is part of the problem. Many are frustrated by the lack of attention to this issue by manufacturers and the industry as a whole.

What systematic progress is being made?

Regulatory measures to address the issue of plastic waste are increasing. For example, in 2022 the UK will implement a tax on packaging that does not contain 30% or more recycled material. The U.S. is following suit with the Break Free from Plastic Pollution Act of 2020. When passed, it will address waste, recycling, manufacturing, and the export of plastic waste. This is good news — it will bring more green practices into laboratory products.

How do we need to change our mindset to support sustainability?

We're going to have to shift our culture as a society and more specifically as manufacturers in order to implement change. We need better technology to address municipal sorting, recycling, and reuse of plastic material. Companies must adopt better strategies and provide transparency in the product manufacturing process. Most importantly, consumers must make purchasing decisions based on best environmental practices to create demand for these changes.

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How to read an ACT label:
Most categories are rated on a scale of 1 to 10, with a lower score indicating less impact on the environment. Visit specific product pages to see the digital ACT labels.

Ergonomics Foster Effective Cleaning

Content provided by:

Micronova®

Although controlled environments are continually evolving in scope, they may be smaller or more modular in scale. Maintaining clean spaces in a safe and ergonomic manner — along with effective cleaning and sanitization — is key.

When making changes, consider integrated systems that address technician needs, safety, quality, and other concerns. Identify ergonomic issues, like the weight of the mop head at the end of a long lever, the required reach, the ability to hold equipment in ergonomically desirable stances, and control of excess liquid to avoid potential slip and fall hazards.

A collaborative review with technicians and quality team members can help you identify the best overall system. Some issues may be best addressed with training while others may require new equipment or refinements to standard operating procedures. In some situations, you may need a combination of all three approaches.

Training

Standardized training, with specific do's and don'ts for the use of equipment and the cleaning process, makes staff improvisation or equipment adaptation less likely. Demonstrations of body balance and cleaning positions that reduce repetitive awkward postures, stretching, leaning, or twisting to reach high ceilings or below equipment are as important as specific cleaning routines. Training will also increase staff confidence in best practices and promote consistency in cleaning and disinfection.

Tools and Equipment

When the process review uncovers equipment limitations that cannot be overcome by training, evaluate the cleaning tools. Mop heads and handles are one possible focus.

- Keep multiple handles on hand to accommodate all people regardless of height
- Choose lightweight and sturdy extendable handles that properly support wet mop heads
- Minimize the need for step stools to provide the best access

Ergonomic experts recommend adjusting mop handle length to the height of the forehead to guard against unnecessary bending when mopping floors. In contrast, workers wearing small hoods, isolators, or RABS may require smaller or more modular handles that still allow optimum reach.

Mop head shape, size, and weight can also influence cleaning efficiency and ease, and the mop material or fabric is another factor that is often overlooked. Does the fabric need to move smoothly over textured non-slip floors or minimize grab on a high ceiling? Is extra absorbance needed to prevent slipping or disinfectant buildup in wet areas? Compatibility with disinfectants is equally important, along with the ability to evenly disperse the agent.

Accessories

In addition to basic cleaning materials, mops, wipes, handles, and specialty tools, the right carts, wringers, and other accessories can also be critical. Would a better wringer reduce dripping and the potential for slips? Do you have tools that offer sufficiently easy wringing while allowing for proper disinfectant contact time? Is the current wringer a comfortable height for wringing? Personnel should be able to effectively operate a downward press wringer without bending at the waist.

The Micronova MegaWringer Flat Head Mop Wringer and BucketBinder Multi Bucket Kit with NovaSnap Mops is a complete system that addresses your demands and makes the disinfection process simpler, more ergonomic, and more cost effective. Its unique core system includes a one-step, snap-on mop assembly and buckets without bulky carts and frames. The wringer consistently minimizes residual liquid without the ergonomic challenges of repetitive bending and twisting motions.

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Description	Size	Cat. No.
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AquaPur	5 gal.	**04-355-125**
AquaPur	55 gal.	**04-355-126**
AquaPur ST	4 x 1 gal.	**22-281-500**

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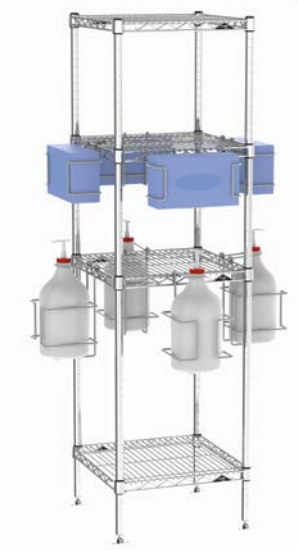

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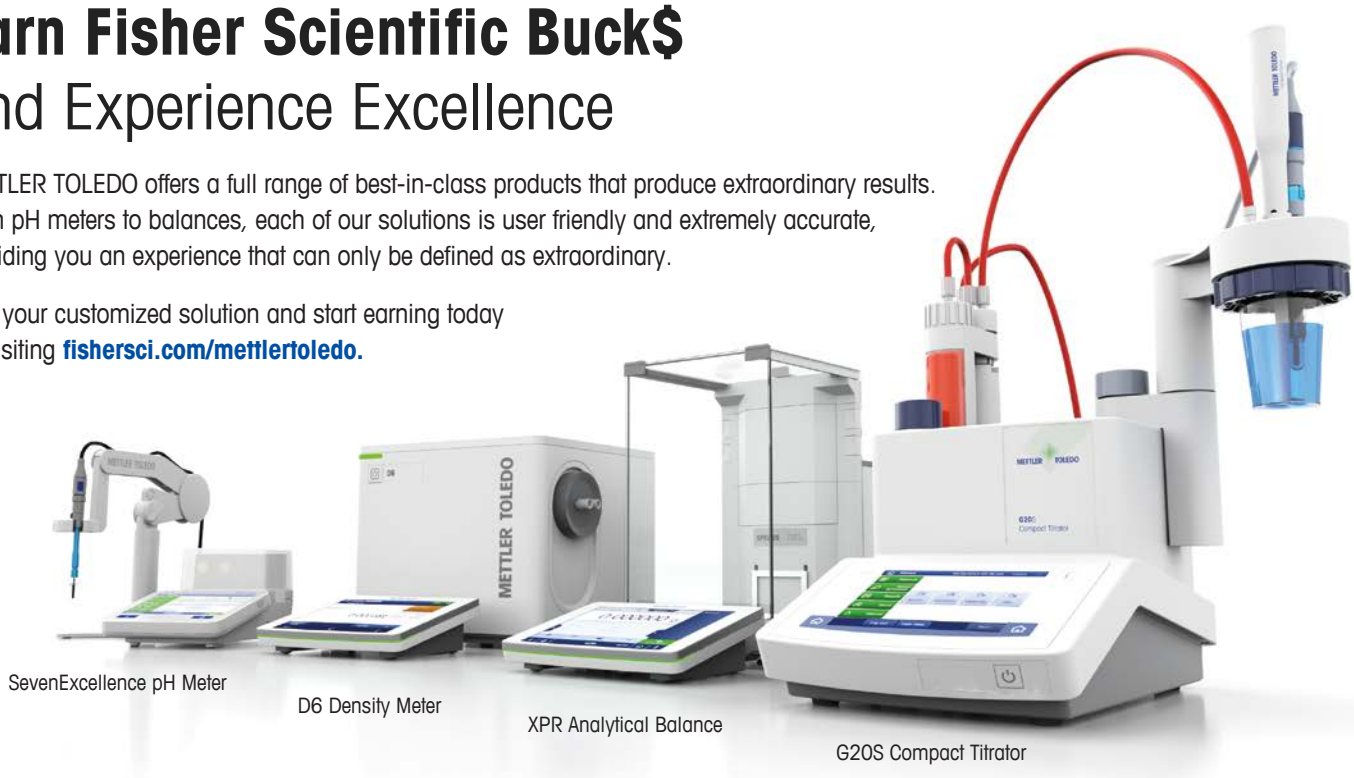

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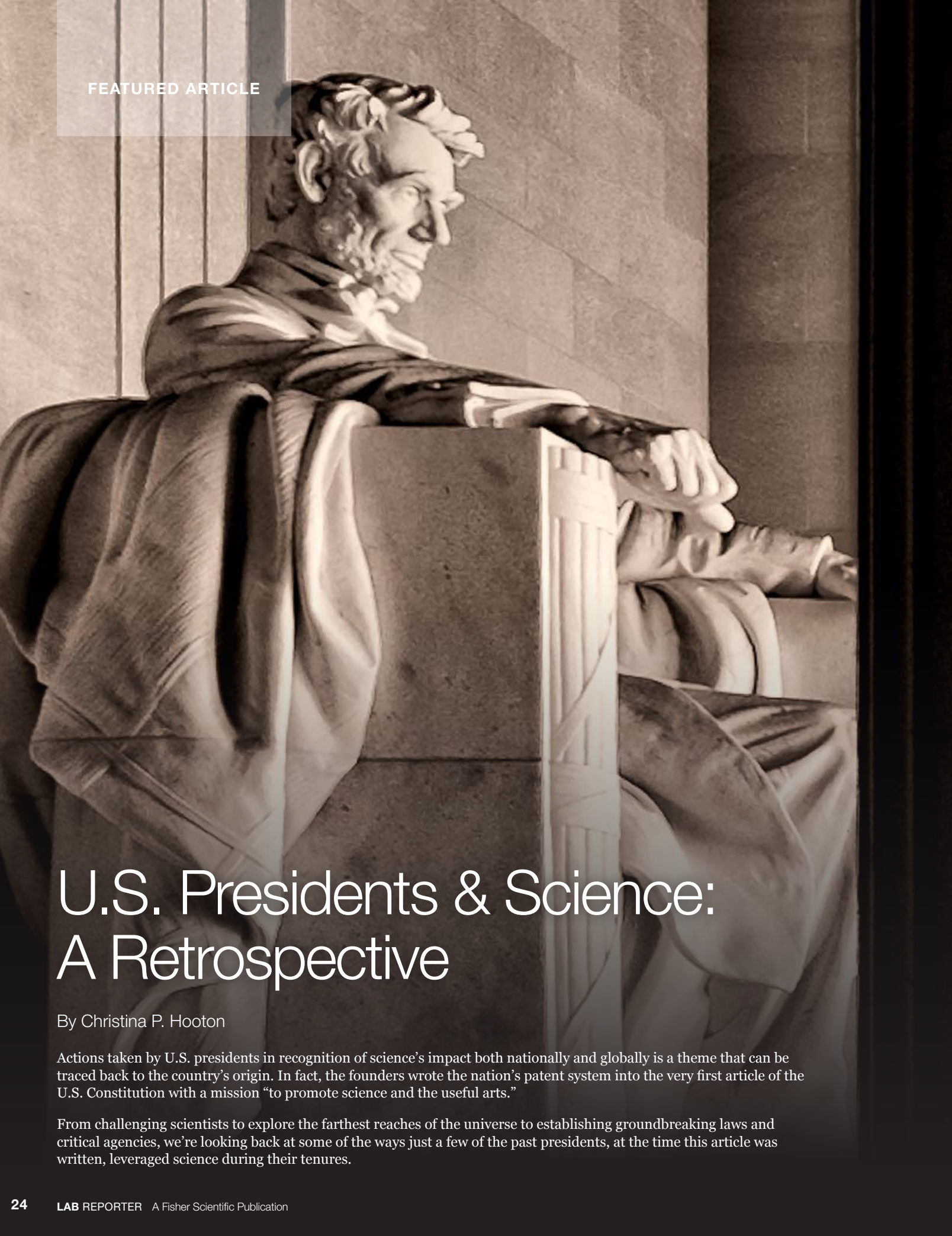

U.S. Presidents & Science: A Retrospective

By Christina P. Hooton

Actions taken by U.S. presidents in recognition of science's impact both nationally and globally is a theme that can be traced back to the country's origin. In fact, the founders wrote the nation's patent system into the very first article of the U.S. Constitution with a mission "to promote science and the useful arts."

From challenging scientists to explore the farthest reaches of the universe to establishing groundbreaking laws and critical agencies, we're looking back at some of the ways just a few of the past presidents, at the time this article was written, leveraged science during their tenures.

Establishing a Young Nation

John Adams – Public Health

One of the earliest U.S. presidents showed his appreciation for the pursuit of knowledge by writing public support of science and the arts into the Massachusetts Constitution. Additionally, President Adams proposed the establishment of the American Academy for Arts and Sciences, which still exists today as an independent research center. Perhaps one of his most lasting contributions, though, is signing into law the Act for the Relief of Sick and Disabled Seamen. This authorized the creation of a government-operated Marine Hospital Service, one of the first public health institutions of its kind and one that led the way for the present-day Department of Health and Human Services, National Institutes of Health (NIH), and other federal health programs. Today, the NIH is the largest public funder of biomedical research in the world.

Abraham Lincoln — Science Education

A need emerged for accessible higher education and training after the Industrial Revolution. In 1862, President Lincoln signed the Morrill Act, which paved the way for creating a system of land-grant colleges and universities. These institutions were to focus on the teaching of practical agriculture and science. Some of the first institutions to carry this designation were Kansas State University, Iowa State University, and Rutgers University. In 1890, a second Morrill Act was passed and led to the establishment of 19 historically Black colleges and universities, including Alabama A&M University and Tuskegee University. The program was expanded again in 1994 to include tribal colleges and universities. Today, there are over 112 land-grant institutions.

Inspiring Innovation

Franklin D. Roosevelt — Government-Funded Research

It took nearly three decades to establish the United States' role in cancer research. The National Cancer Act of 1937, signed into law by President Roosevelt, led to the creation of the National Cancer Institute (NCI) and was the first time Congress provided funding for a non-communicable disease. Exactly 20 years later, the first malignancy was cured with chemotherapy at the NCI. Today, it is still the federal agency responsible for conducting research and training on the cause, diagnosis, and treatment of cancer. The Institute also assists with and promotes cancer research and training at other public and private institutions, supporting 71 NCI-designated cancer centers, 5,000 grantees, and 2,500 clinical trial sites.

Dwight D. Eisenhower — DARPA

In 1957, the Soviet Union launched Sputnik, the world's first artificial satellite, ushering in a new era of space exploration. Wishing to "prevent technological surprise" in the future, President Eisenhower created the Defense Advanced Research Projects Agency (DARPA). DARPA helped the National Aeronautics and Space Administration (NASA) get off the ground and went on to perform many other research projects, including ARPANET, an experimental computer network that was a precursor to the internet. Still in existence today, its mission is to make pivotal investments in breakthrough technologies for national security.

John F. Kennedy — Moon Landing

Building on the progress of his predecessor and in response to further pressure from Soviet Union achievements, President Kennedy asked Congress for an additional $7 to $9 billion over a five-year period for Project Mercury, the space program initiated by President Eisenhower. He also set the goal of landing a man on the Moon and returning him safely to Earth by the end of the 1960s. Although his dream wasn't realized until after his death, President Kennedy's leadership inspired an array of people — from aerospace engineers to production workers — and set the stage for a number of successful space expeditions, including one giant leap for mankind with Apollo 11.

Looking to the Future

Richard Nixon – Environmental Legislation

By the late 1960s, the environmental decay that naturalists had warned about was coming to fruition. Smog filled the air and pollutants traversed waterways. President Nixon signed into law a slew of environmental bills during his time in office, including the Clean Water Act, Clean Air Act, National Environmental Policy Act, Endangered Species Act, and the Marine Mammal Protection Act. He also proposed the establishment of the Environmental Protection Agency, a move he hoped would further shrink the federal government through consolidation of various offices.

George H.W. Bush — Clean Air Act

In 1990 President Bush made amendments to the Clean Air Act established by President Nixon. At this point, scientists had linked acid rain to coal-fired power plants. Prior bills had been introduced to address the issue but failed because they would have required, at great cost, for every coal-fired plant to meet pollution limits based on uniform clean-up technologies. Instead, President Bush proposed a bill that would take a "cap and trade" approach. In this scenario, a pollution "budget" cap is set, and pollution permits are sold and traded between power plants. Low-cost pollution reducers would make the most cuts and sell their permits to high-cost reducers. His bill gained bipartisan support and proved even more effective than many of its proponents had anticipated, achieving greater reductions in pollution than regulations required and doing so at lower costs than had been estimated, according to Harvard Law School's CleanLaw Podcast article "What Environmental Protection Owes George H.W. Bush" by Joe Goffman.

Barack Obama — Medical Initiatives

In addition to furthering the work of his predecessors in curbing U.S. greenhouse gas emissions, President Obama proposed and implemented initiatives for emerging medical technologies. The BRAIN (Brain Research Through Innovative Neurotechnologies) Initiative is meant to revolutionize understanding of the human brain. The Precision Medicine Initiative aims to improve disease treatments by tailoring them to the unique characteristics of each individual's genes, environment, and lifestyle. To further this work, the All of Us research program seeks to build a diverse health database with the help of one million U.S. citizens.

As we look back at U.S. history, it is clear that the ideals of scientific exploration and innovation are intertwined with the nation's evolution.

We hope you enjoyed this journey through time — and sometimes space — as much as we did!

Christina P. Hooton is a Fisher Scientific staff writer.

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N 840 G	Rotary Evaporation, Filtration, Centrifugal Concentration, Vacuum Oven	4.5 torr, 6 mbar	34 L/min.	Yes	Yes	**13-880-906**

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FB-11207	12.75 L	(3.3 gal.)	**FB11207**
FB-11209	18 L	(4.75 gal.)	**FB11209**
FB-11211	29 L	(7.4 gal.)	**FB11211**

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In Support of Reproducibility

By Iva Fedorka

Testing and data are foundations of the scientific process. As theories are developed and experiments conducted, the new information discovered will be verified as it becomes accepted by other scientists. Consensus and the adoption of new concepts and paradigms occur when experimental results can be reproduced and thereby validated. For this, test results must be accurate and reproducible.

Reproducibility Defined

The National Academy of Sciences defines reproducibility as the ability to produce consistent results when using the same input data, calculations, methods, code, and other analytical processes. Since random elements may impact results, outcomes do not have to be identical to be reproducible. Reproducibility is also different from replication, which is simply repeating the steps in an experiment or process.

In science, statistical methods are used to help answer questions or to make appropriate inferences about reproducibility based on the data. Today's experiments are increasingly analytically complex, which places a greater importance on statistical review. Controversies about interpretation may threaten the value of some data, so it's important to understand how inferences may be made.

Barriers to Reproducibility

It is well known that specific published results cannot always be reproduced by other scientists, but the specific reasons for such failures and ways to correct them are not. Along with other issues, common complaints include data and model availability, publication pressures, and industry standards.

Some barriers, like a lack of access to resources or insufficient data storage, may be significant but straightforward. Others may be more nuanced, like professional pressure to publish research about specific topics or the lack of a suitable audience. A poor understanding of multiple and disparate science topics can also unexpectedly and negatively affect outcomes.

Quality and Reproducibility

Different or inconclusive results can be caused by poor quality technique or materials. One example of how quality issues can affect results can be found in the evaluation of erythropoiesis-stimulating agents used to treat anemia in cancer patients. Some believe that these treatments can also stimulate erythropoietin (EPO) receptors on tumor cells (the EPO receptor-cancer hypothesis). Many articles have been published on this topic, but their data and conclusions conflict.

One search[1] found 280 relevant articles related to the topic. These were reviewed for potential relationships between quality and reproducibility. Many conflicts existed between and within articles, caused by quality deficits, including:

- Faulty quality parameters like a lack of appropriate controls (90%)
- Inadequate reagent and method validation (87%)
- Choice of inappropriate statistical methods (84%)
- False-positive or -negative test results (81%)

Producing Reproducible Results

Laboratory managers can establish practices and procedures to support the production of high-quality and reproducible technical results in a number of ways.

Set high expectations

Clearly establish the required levels of competency and compliance for all laboratory personnel, including principal investigators.

Validate methods[2]

Evaluate all test methods to determine the accuracy, precision, replication, and repeatability of specific steps and the viability of the method over time. In addition, determine specificity, detection and quantitation limits, and the linearity and range of the assay.

Understand measurement uncertainty[3]

Determine whether observed differences in experiments are "significant." Does the variation represent real differences?

Establish training

Provide on-the-job training for all employees, regardless of previous educational background or work experience. Training can help improve flexibility, innovation, and agility, and is a vital part of most lab audits.

Effectively document

Most labs use Standard Operating Procedures (SOPs) as "how-to" manuals for all technical and operational laboratory processes. Include further explanations to help staff understand the reasons for maintaining important aspects of the operation, which can help with compliance.

Follow good lab practices

Lab cleanliness, equipment calibration, environmental controls, and documented observations and results are typical good lab practices. More specific practices, like triplicate experiments or specific standard deviation ranges, may be needed as demanded by the science.

Share results

Round-robin testing is a common way to compare results when the same methods are used with identical samples in different labs. These results can provide data about reproducibility and provide feedback to the lab about its ability to reproduce results.

Reproducible results are key to good science. They help verify new discoveries, demonstrate competency, and clearly communicate technical outcomes to others. By creating reproducible data, others may build upon findings and advance scientific discovery.

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Iva Fedorka is a Fisher Scientific staff writer.

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Selecting the Best Transfection Method

When to Use Transfection Reagents, Viral Transduction, or Electroporation

The uses of nucleic acid delivery have expanded from recombinant gene expression to a diversity of other experimental applications, including gene knockdown with small interfering RNAs (siRNA) and genome editing with CRISPR ribonuclear protein complexes (RNPs).

With these advances, three approaches have become a mainstay for delivering nucleic acid cargo into mammalian and insect cells: chemical transfection, viral transduction, and electroporation (**Table 1**). We will highlight the primary benefit associated with each method to help you identify the best approach for a given experimental application and available laboratory resources.

No single delivery method is ideal for all situations, but researchers may routinely employ a suboptimal approach for the sake of familiarity or to avoid any start-up costs associated with new methods. In addition to describing these three methods, we will introduce the Mirus Bio *Trans*IT transfection reagents and Ingenio EZporator Electroporation System, which are both easy to use and cost effective.

Convenience: Chemical Transfection

Complexing nucleic acids with chemical transfection reagents to deliver them into cells is generally the quickest method of delivery. For many common cell types, chemical transfection is highly efficient and nontoxic. No specialized materials are required aside from the chemical transfection reagent itself. Chemical transfection is often the most convenient delivery method for plasmids and oligonucleotides for gene expression and knockdown studies.

Some formulations, like the *Trans*IT-X2 Dynamic Delivery System, can also be used to complex with Cas9 RNPs for CRISPR-mediated gene editing (**Figure 1**). Mirus Bio also offers turnkey solutions for cell type-specific transfections, transfection of mRNA and oligos, and reagents for protein production in high-density suspension CHO and HEK 293 cell cultures. Depending on the cell type, chemical transfection may be the most convenient nucleic acid delivery method.

Table 1. Features of Common Nucleic Acid Delivery Techniques

	Chemical Transfection	Viral Transduction	Electroporation
Related Materials	Chemical reagents, e.g. *Trans*IT reagents, calcium phosphate, cationic lipids and polymers, nanoparticles	Viral vector-producing or packaging cell line	Electroporator, cuvettes, electroporation buffer
Mechanism of Action	Condensation and complexation of cargo, mediation of charge interactions between cargo and cell surface, endocytosis	Depends on viral vector, entry of packaged cargo via viral infection of cells	Permeabilization of cell membrane via applied electrical field
Process	Add transfection complex mixture to cells	Transfect cells to produce viral vectors, harvest and purify vectors, infect cells	Suspend cells in buffer and apply electrical pulse
Time Required	Minimal	Several days	Minimal
Primary Cost	Chemical reagents	Time, chemical reagents	Up-front purchase of electroporator
Primary Benefit	Convenience	Efficient, targeted delivery to both *in vitro* and *in vivo* systems, including quiescent cells	Delivery of diverse cargo to hard-to-transfect cell types

Targeted Efficiency: Viral Transduction

Virus-mediated expression via transduction with lentivirus (LV) or adeno-associated virus (AAV) is a valuable solution for some non-dividing cells and cells refractory to chemical transfection. Additionally, recombinant viruses can be pseudotyped for cell-type specific infection and gene expression.

Though AAV and LV can both be used for *in vivo* and *in vitro* experiments, the small size of AAV (~20 nm) allows for more efficient spread in tissue than LV (>100 nm). However, the small size of AAV also limits its packaging capacity to 4.7 kb compared to LV (~10.2 kb). Expression of AAV can persist for weeks in non-dividing cells, while integration of lentiviral genomes can be used to generate stable cell lines.

Vectors are usually produced via transient co-transfection of packaging plasmids with a plasmid encoding the gene of interest. As shown in **Figure 2**, high titer production of LV or AAV with the *Trans*IT-VirusGEN Transfection Reagent provides large quantities of virus for multiple viral transductions and difficult-to-transfect cells.

Flexibility: Electroporation

Establishing a platform for viral vector production may be too time-consuming for some experimental applications. Electroporation is a quick, non-viral alternative for delivering diverse molecular cargo to difficult-to-transfect cells. Unlike the other two methods, efficient delivery is less limited by the size of the gene of interest or payload. For studies in difficult-to-transfect cells like primary T cells (**Figure 3**), consider an electroporation delivery approach. The Ingenio Electroporation product line offers a universal solution for multiple cell types and cuvettes compatible with most conventional electroporators. Or, choose the cost-effective Ingenio EZporator to support your entire

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Figure 1.*Trans*IT-X2 Outperforms Lipofectamine for Multiple Applications. (A) In a head-to-head comparison of plasmid DNA expression in 41 different cell types, the *Trans*IT-X2 Dynamic Delivery System outperformed Thermo Scientific Lipofectamine 2000 for most of the cell types tested. (B) Greater knockdown with siRNAs was also observed in some cell lines, like primary normal human dermal fibroblasts (NHDF). (C) In addition to plasmid and oligonucleotide delivery, the *Trans*IT-X2 Dynamic Delivery System can also complex with Cas9 RNPs for CRISPR-mediated gene editing studies. The *Trans*IT-X2 Dynamic Delivery System was used to deliver Cas9 RNPs into U2OS cells, and a T7E1 mismatch assay was used to measure cleavage efficiency at 48 hours post-transfection.

Figure 2.*Trans*IT-VirusGEN Transfection Reagent for Higher LV and AAV Titers. Transfection with *Trans*IT-VirusGEN Transfection Reagent yields higher titers per transfection compared to other reagents, which saves time and resources, eliminating the need for multiple transfections to produce the required amounts of LV or AAV in both suspension (A, C) and adherent (B, D) HEK 293 cells.

Figure 3. The Ingenio Electroporation System Balances Efficiency and Viability. Primary human T cells were electroporated with an eGFP reporter plasmid and assessed after electroporation by flow cytometry.

Figure 1. *Trans*IT-X2 Outperforms Lipofectamine for Multiple Applications.

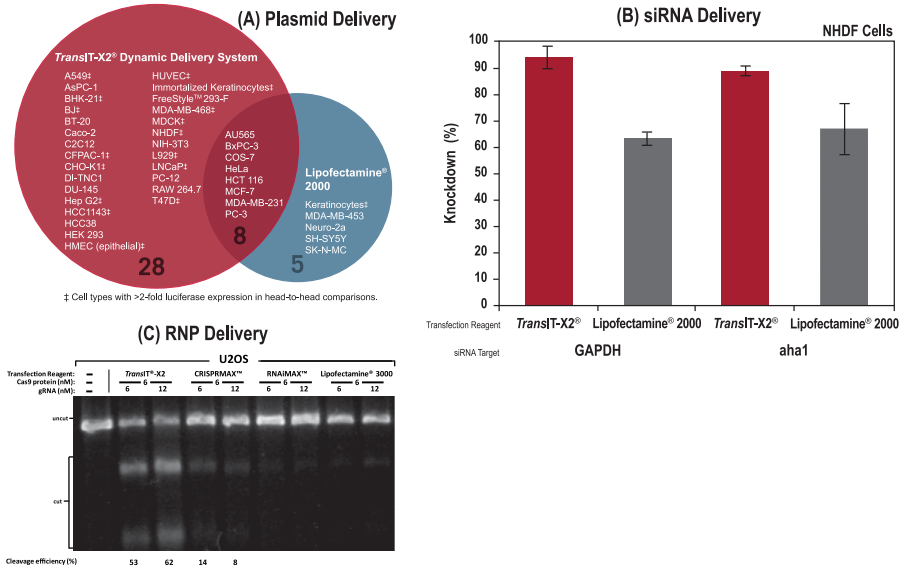


Figure 2. *Trans*IT-VirusGEN Transfection Reagent for Higher LV and AAV Titers.

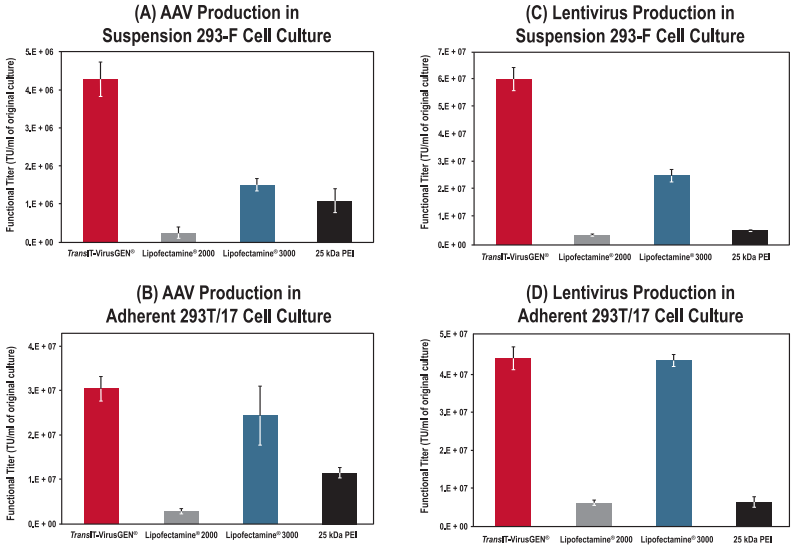
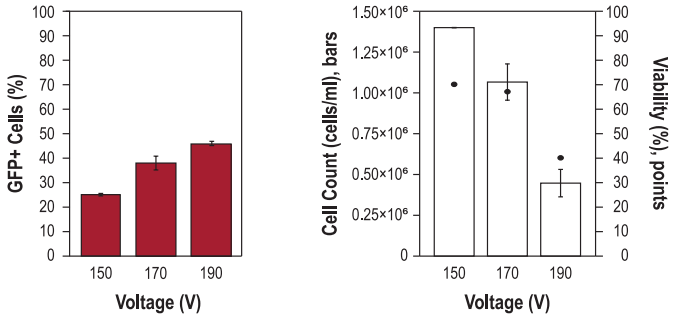


Figure 3. The Ingenio Electroporation System Balances Efficiency and Viability.



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