avantor™

Digitizing Lab Operations

Digital innovation driving lab operations

The lab of the future is a continuous development process — a transformation of how labs leverage technology and evolve operations, enabling scientists to move science forward and deliver vital innovations faster. Technology alone cannot deliver the acceleration science needs; digital technology needs to be effectively integrated into how life sciences labs operate. To take full advantage of what these digital technologies offer, existing workflows may need to be "disrupted" and transformed to leverage the digital tools of tomorrow that can make labs more efficient, productive and environmentally sustainable.

Current state of digital technology in global labs

It is estimated that a total of $1.97 trillion will be spent on digital transformation across all industries around the world in 2022 alone,[1] with substantial investments being made in digital transformation and automation life sciences research. However, effectively utilizing these investments presents an ongoing challenge for many life sciences organizations. Recent industry research highlights some of the challenges:

- In a recent report by Accenture, when 128 leaders in the life sciences industry were surveyed about their digital transformation efforts, 40% replied that they had not embarked on applying digital to R&D or QC labs, and 37% more were still in pilot mode. The same survey reported that 70% of respondents who have scaled up are achieving or exceeding expected business value.[2] So, although there are clear benefits to implementing digital transformation, progress remains limited.
- 77% of respondents in a 2021 Forrester survey of global decision-makers in R&D strategy confirmed that intelligent, connected Internet of Things (IoT) technology supports some portion of their lab environment. Over two-thirds of survey respondents supported the use of robotics and IoT in their labs, and 37% indicated that they use automated analysis of experimental results.[3]
- In a 2021 survey of scientists by The Science Advisory Board, most researchers reported that they currently use liquid handling systems, microplate readers and, to a lesser degree (around 49%), multiplex and high-throughput systems. Far fewer scientists reported using advanced robots, but around 45% did note that they would like to use robotics in the future.[4]

The automation and digital technology already present in labs has led manual experimentation to be relegated to the earliest parts of the discovery phase. Once a target has been identified, automated sample preparation, testing and analysis tools in later discovery phases are tasked with high-throughput, highly repetitive tasks. This has led to a major increase in throughput for those specific operations or experimental steps. This also aligns with the growing use of large experimental datasets to facilitate more sophisticated analysis and exploration of new approaches for developing solutions to life sciences challenges.

The availability and growing use of these large datasets is critical to the growing importance of OMICS in life sciences research. Broadly speaking, OMICS encompasses various disciplines in biology, such as genomics, proteomics, metabolomics, metagenomics and others. Through rapid advances in biotechnology and computing, increasing amounts of data can be extracted faster and more accurately than ever before. It is enabling greater understanding about what happens when information from DNA is passed down to different molecules in cells, while the various layers are examined at unprecedented spatial or temporal resolution, depth and thoroughness with the help of the OMICS universe.[5]

There is enormous transformative potential from building more and more research around large datasets and OMICS-based systems biology. However, one of the most persistent challenges labs face is that, while high-throughput machines generate data and results much more quickly and efficiently, the data they collect is not yet easily connected or integrated.

Instead, data from processes and tools is often manually moved into spreadsheets or other data collection and analysis tools, step by step, adding time to research workflows and running the risk of data entry errors.

It can also complicate efforts to accurately document chain of custody of experimental results, a crucial requirement for both productive reuse of research information and meeting increasingly stringent regulatory requirements. Manual data entry can also make it difficult for collaboration and results-sharing with research colleagues, especially teams working in different locations.

Fragmentation in information and process flows

One of the most persistent challenges labs face is that, while these high-throughput experimentation platforms generate data and results much more quickly and efficiently, the data they collect is not yet easily connected or integrated. In other industries, such as automated manufacturing, production machines have sensors and controls automatically generate reams of production data. That data is efficiently captured, filtered and packaged and passed via gateways to cloud-computing analytical platforms that generate real-time actionable data.

That kind of IoT capability is still in the development stages for many labs. Many automated research tools are stand-alone systems with no established protocols for formatting and moving data from the tools to analytical platforms and research records. Instead, data is manually moved into spreadsheets or other data collection and analysis tools, adding time to research workflows and running the risk of data entry errors.

That same fragmentation and manual movement of data also affects the informatics that guide all the critical supply chain forecasting and management of day-to-day lab operations. Whether it is supplies, consumables or equipment, having all the right tools and materials in the right place at the right time to conduct science still requires significant amounts of manual activity and coordination.

For example, it is still quite common for labs to follow manual procedures for scheduling equipment, setting up and confirming calibrations and documenting which scientist or research team is using a particular device. The same manual processes are also commonly followed for requesting and delivering supplies or preparing samples.

The potential risk with these manual processes is wasted time and wasted materials.

- **Stock-outs of needed products, interfering or forcing cancellation of research work:** This can happen when a rarely used product is suddenly needed and hasn't been reordered, or when available stock of high-demand products used by multiple research teams in one lab are used up.
- **Overordering and slow inventory turnover:** Many labs end up protecting themselves from stock-outs by overordering and maintaining supplies of products that are stored for months or longer, until they expire and need to be disposed of.

This waste impacts one of the most fundamental goals life sciences laboratories are pursuing: to become more sustainable, environmentally sensitive organizations by significantly reducing excess energy use, wasted consumables like research chemicals and wasted materials such as paper and plastic.

Vision: digital connectivity and optimization

Digital transformation and the intelligent integration of digital information systems into lab workflows can make a major contribution to these critical sustainability goals.

Connectivity is key: the disparate automated research tools and the lab management tools used to manage inventory, equipment, chemicals and other systems need to connect and exchange information more seamlessly. Labs that are more connected can experience improvements in predictive and prescriptive analytics, which can enhance scientific outcomes.

Digital transformation also envisions incorporating IoT-type systems into labs — smart shelves, RFID tracking of materials, smart buttons — so that manual data capture and entry are replaced with automated data exchange.

Improving information flow can help lab managers and process operators identify bottlenecks and outdated operational procedures that can be amended, because the right kind of actionable data about the lab's needs are more readily available in real time. It can also help improve communication and interaction with scientists and research staffs.

Digitizing the lab creates an open ecosystem that optimizes lab workflows. This technology is also critical to the move by some major life sciences companies to create large-scale "centers of excellence" that can rationalize their footprint and create the framework for significantly more efficient resource utilization.

One leading biopharmaceutical company has established multiple centers of excellence designed and equipped from the ground up to maximize every square inch of space. Their approach has been to tailor the lab space to be more flexible by understanding how assets are being used, based on higher-quality data.

The centers for excellence also include platforms that support increased amounts of remote working, including being able to access digital lab tools during off-hours for greater convenience and to enable near round-the-clock lab workflows.

Most importantly, this approach enhances collaboration by scientists in the facility, helping to promote innovation and more productive scientific results. This shared model also supports better data on the total needs of the organization, providing data on things like tool utilization and scheduling that can help guide longer-term decisions on equipment maintenance schedules and procurement of new tools.

Tools to advance lab digitalization

There are several digital innovations that are being adopted to improve the flow of information in labs and provide the information needed to reduce error, improve supply chain efficiencies and deliver a broader range of IoT-type enhancements to lab operations:

Smart shelves: Rather than having stockroom personnel deliver materials to individual labs, smart shelves are installed in storage rooms located near labs. They incorporate sensors that can detect when materials stored in them are getting low and, through linkages with inventory management tools, initiate timely restocking — a simple yet valuable way to reduce stock-outs and prevent overordering of materials.

Smart buttons: Avantor Services has implemented a pilot version of this tool at Avantor's Bridgewater Innovation Center research lab. Buttons are located at various workstations; researchers use the tool to request services such as medical waste removal or glass wash service, as well as request replenishment of materials or consumables, tied directly to the specific research being done at that workstation.

This simplifies and streamlines these kinds of services for more efficient scheduling. Like other kinds of IoT technology, this

simple device can change lab culture and workflows around routine services and stocking, digitizing a step previously handled by having personnel perform periodic manual surveys of lab supplies.

Smart cameras: This is a newer tool used in sensitive clean room and controlled environments where personal protective equipment is required for entry. Deep lens technology can help document and ensure that proper safety and environmental protocols are followed to protect the integrity of any clean room and provide critical documentation of compliance for regulatory purposes. It's also more efficient: it automatically documents and records the compliance rather than requiring manual data entry.

Digital "twins": This powerful tool builds on the automated data capture and integration of IoT-type sensors like smart shelves and electronic lab notebooks, as well as advanced inventory, chemical and equipment management databases that are all tied together and provide information about resources as they are being used.

This real-time resource can then be tied to supplier networks to significantly rationalize purchasing and supply distribution throughout the organization. It can also help make the lab more sustainable — by reducing or even preventing duplicate material purchases — improve demand planning and help keep costs under control.

Combined with the use of state-of-the-art predictive analytics and visualization tools, this information ecosystem's data can be applied to a virtual model of the lab — its assets, research teams, resource requirements and workflows are incorporated into the model. As new data is applied, sophisticated simulations can be run to help determine future needs, adjustments to resources based on new research assignments being brought into the facility, or other major events. It can also help identify potential areas for improvements in workflows and digital tools to enhance the twin's ability to accurately track the lab's needs.

Moving digitalization forward

Realizing the potential benefits of lab digitalization can be more effectively accomplished through a systematic approach that blends hardware, software and workflow redesign. Avantor has recently launched their SmartScience initiative that clusters all their digital offerings and innovations to provide scalable digital solutions to lab digitalization challenges.

The SmartScience approach is designed to create an innovative digital ecosystem where access to data and real-time insights power lab productivity, foster enhanced collaboration and propel life-changing science. It is built on Avantor's well-established portfolio of digital tools and capabilities, including:

- Digital software tools encompassing lab inventory management, chemical management, equipment management and life sciences sample management;
- Lab hardware solutions such as self-checkout supplies kiosks and vending machines, hand-held scanners and IoT-type technologies like smart buttons;
- An industry-leading global e-commerce system supporting over 6 million SKUs, multiple languages and an integrated platform where all points from procurement to purchasing to point-of-use are unified within a shared ecosystem;
- And AI-driven product recommendation engine and KPI Insights analytical tools to provide a comprehensive view of inventory use and performance, based on product and point-of-use (POU) metrics.

Combined with Avantor's focus on innovation and driving the digitalization of the lab, SmartScience solutions are designed to adapt to how existing labs work — creating a customized, science-enabling experience that can be scaled according to the needs of individual locations, budgets and both immediate and long-term research goals.

The critical value of openness

The Lab of the Future is not an end state but a continuous development process. This ongoing effort is focused on finding the best way to use each new digital technology to improve lab efficiency and enable scientists to accomplish the vital task of bringing life-changing therapies to the world faster.

But to truly reap the benefits of the automation already present in many labs and incorporate the real-time data advantages that smart sensors and advanced analytics tools offer, it is critically important to be open to change on multiple levels.

This includes working to create open information ecosystems that improve the ability of siloed tools and management systems to share information. It calls for openness by scientists and lab operations personnel to look at existing workflows with a critical eye and use the data generated by IoT-type tools to improve operations.

Improved collaboration between technology and service providers will play an important part in these efforts. Developing more common, open communications and data formatting protocols will play a critical role in enabling real-time data exchange between lab automation tools from different providers, similar to the kinds of protocols in wide use in other industries.

To support this, Avantor is an active participant and sponsor of the Lab of the Future conferences, working with our partners and customers within life sciences to share ideas and promote the technologies that can move the industry closer to the Lab of the Future vision.

Through its SmartScience solutions, Avantor is leveraging its expertise in customer workflow optimization, digital commerce, data informatics and digital services to enable a cohesive path to scientific breakthrough and more environmentally conscious, less wasteful life sciences research.

Avantor is ready to help labs worldwide pursue their unique journey to the Lab of the Future. By applying our unique expertise, our digital software and hardware offerings and our commitment to collaboration and innovation with our life sciences partners, we can help deliver the right mix of digital technology and data-driven lab optimization that will create sustainable workflows and solutions for every lab, scale-up and production environment.

Notes:

1. IDC Worldwide Digital Transformation Spending Guide
2. Digital Transformation in the Lab: Bridging Analog Islands in a Digital Ocean — **Accenture Life Sciences Report**
3. Digital Labs: AI, IoT, and Robotics Offer Better Efficiency and Insights — **LabMinds blog**
4. Survey: Scientists want to boost use of lab automation — **The Science Advisory Board**
5. The OMICS Universe and Its Future — **The Medical Futurist**

AVANTORSCIENCES.COM

36601-MN-RB

0122 Lit. No. 010269W ZPROAVTR36601-EN