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The Digital Laboratory

An exclusive collection featuring top-tier articles, visionary experts, and essential industry insights

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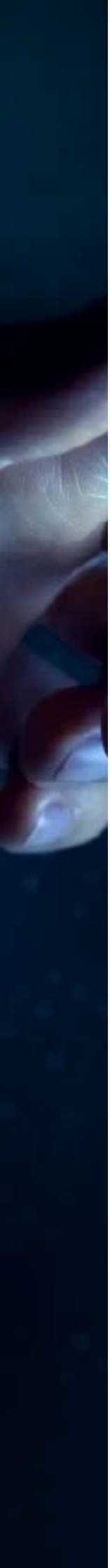


Foreword

Welcome to the latest edition of our Industry Focus eBook: The Digital Laboratory. In this volume, we explore how data, connectivity, and intelligent tools are redefining the scientific landscape, accelerating discovery, and streamlining operations in ways once thought to be years away. Across the life sciences, digital transformation is not just a trend — it's becoming the backbone of modern research and healthcare innovation.

As laboratories grapple with increasingly complex workflows and vast amounts of data, the need for streamlined digital infrastructure has never been more urgent. In **Why data platforms are key to scientific progress**, we examine how centralizing and standardizing data unlocks new potential for collaboration and insight. Meanwhile, **Say goodbye to LIMS headaches with SaaS solutions** presents a compelling case for flexible, cloud-based tools that reduce the friction of legacy systems.

The power of artificial intelligence and machine learning is on full display in **Breaking barriers in life science innovation with AI and connected data**, which highlights how integrated digital systems are accelerating breakthroughs from bench to bedside. This ties closely with **Proactive Health: The Shift Towards Preventative Healthcare**, a look at how data-driven tools are helping us move from treatment to prevention, shaping the future of personalized medicine.

Scientific discovery also advances in leaps, as seen in **New peptide antibiotic stops bacteria by binding where no drug has before** and **Researchers develop new approach to improve the accuracy of RNA sequencing**. These milestones are a testament to what's possible when innovation meets precision.

Looking ahead, **Pharma 4.0: Shaping the Future of Pharmaceutical Manufacturing** delves into how the pharmaceutical sector is evolving with smart technologies, while **Can AI Outperform Doctors in Diagnosing Infectious Diseases?** poses timely questions about the role of machine intelligence in clinical decision-making. Rounding out this collection is **Personalized vitamin D guidelines based on latitude and skin type could tackle deficiencies**, a compelling example of how digital tools can tailor health interventions to the individual.

We hope this eBook offers valuable insights into the digital laboratory's potential — a space where data, intelligence, and innovation converge to shape the future of science.

Why data platforms are key to scientific progress

It's widely acknowledged that innovation drives a company's growth and product development, and for organizations with research and development labs, these environments are central to that innovation.

Traditional laboratory software is built to manage workflows, but these systems often fail to address the modern challenge of enterprise data flows. Today, an organization's success increasingly depends on how effectively data moves across the enterprise to support informed decision-making.

Organizations that struggle to extract value from large volumes of data, or that aim to get more from their investments in data science and artificial intelligence (AI), can benefit from adopting a scientific data management platform as part of their digital infrastructure.

Integrating laboratory environments with the broader enterprise ecosystem enables organizations to better utilize the vast data lakes produced by labs.

Labs need to evolve from standalone units into strategic assets that are deeply connected to the organization's data architecture. A digitally native platform approach can help streamline this shift, making scientific data flow management more efficient and impactful.

This article looks at how adopting a platform-based approach to scientific data management, incorporating advanced analytics, semantic search, and lab automation, can enhance enterprise-level decision-making and lab efficiency, ultimately leading to more discoveries and stronger product pipelines.

Image Credit: LabVantage Solutions

Maximizing scientific data in business decision-making

Organizations aiming to make the most of digital transformation and to harness scientific data for business decision-making stand to gain from implementing a comprehensive scientific data management platform. This type of platform connects R&D labs, QA/QC in manufacturing, and more, while also providing access points for supply chain partners.

Unlike siloed software systems, a digitally native scientific data management platform fully leverages organizational and external data, builds AI-enabled digital labs, and enables enterprise-wide data flows that support the entire product lifecycle—from early-stage concepts to full-scale commercialization.

Whether the focus is on industrial chemicals, pharmaceuticals, fuels, or food, an integrated platform ensures optimal lab performance and unlocks advanced analytics. The result is sharper insights, more informed decisions, and, ultimately, greater innovation and sustained growth.

The disadvantages of siloed informatics

Key laboratory information has traditionally been housed in standalone systems, making it difficult for staff to locate, access, integrate, or reuse data effectively. These siloed solutions also restrict an organization's ability to enhance business processes across internal systems and supply chain partners.

At the same time, organizational data lakes hold immense potential for researchers aiming to drive new discoveries, extend product life cycles, or improve manufacturing efficiency.

However, when this data remains inaccessible, it can lead to missed opportunities. Researchers may be unaware of existing institutional knowledge, waste time and resources duplicating experiments, or find themselves manually piecing together data from multiple applications just to get a complete picture.

The impact of inaccessible data extends beyond R&D. QA scientists may lack access to crucial development data that could improve manufacturing outcomes and enhance product quality attributes. As a result, they often spend time on repetitive, low-value tasks instead of focusing on optimization and innovation.

Business leaders are also affected. Without visibility into lab activities and analytics, executives may struggle to gain clear insight into ongoing research, product pipelines, or the data needed to make informed investment decisions.

By reducing data fragmentation and implementing dashboards and other visualization tools, organizations can empower decision-makers at every level to better evaluate, validate, and analyze diverse data sources.

Achieving a seamless data flow

Organizations of all sizes pursue digital transformation to boost productivity, improve efficiency, and reduce costs, while maintaining a strong focus on innovation.

Industry observers such as Frost & Sullivan[1] argue that a platform approach to lab

informatics represents a solution to these challenges.

Frost & Sullivan's Frost Radar™ report on LIMS for the life sciences states that "users expect more from vendors, and vendors want to become end-to-end lab informatics solution providers rather than simply offering traditional laboratory information management systems [LIMS]."

Today's LIMS are far more advanced than earlier versions, often integrating features like electronic lab notebooks (ELN), scientific data management systems (SDMS), and lab execution systems (LES). Yet even with these expanded capabilities, they still fall short of fully supporting modern business processes.

Frost & Sullivan point out that organizations are demanding more—prompting a push for platforms that incorporate artificial intelligence, machine learning, and natural language processing.

These capabilities, they report, "would allow researchers and labs to better manage their data and extract insights at a faster pace to save time," while predicting that AI integrations with LIMS will increase "over the next few years."

Interest in these platforms is growing, as companies increasingly move away from fragmented solutions in favor of unified scientific data platforms that can seamlessly connect with broader enterprise systems.

By integrating lab data into the enterprise-wide digital ecosystem, organizations can streamline data flows, enabling leaders to bring products to market faster, reduce operational costs, and more effectively respond to customer needs.

The business case for a platform approach

The business case for a platform approach encompasses several areas.

Regulatory compliance

Regulated industries like pharmaceuticals can benefit from the implementation of automated compliance workflows, improving product quality, reducing failure rates, ensure data integrity, and facilitating robust audit trails.

Security and privacy risk

All data traffic is secure, protecting both business and customer privacy from data integrity issues, cyberattacks, and other safety concerns.

Efficiency and productivity

The elimination of data silos helps ensure smooth data exchange and collaboration across cross-functional teams throughout the enterprise. This streamlined approach can lead to stronger product pipelines, more discoveries, less repeat work, and improved adherence to quality parameters.

Moving away from time-consuming, low-value work to high-value science significantly boosts productivity, whether this is occurring in a single lab or across a global network of facilities.

Insights with AI

The integration of innovative AI technology improves data analysis, modeling, and predictions, helping to facilitate robust comparisons of different experiments while enabling deeper scientific insight and more rapid discovery.

Interoperability and standardization

Adhering to standardized protocols and data formats ensures data interoperability, simplifying data exchange and use across different platforms, software, and scientific disciplines.

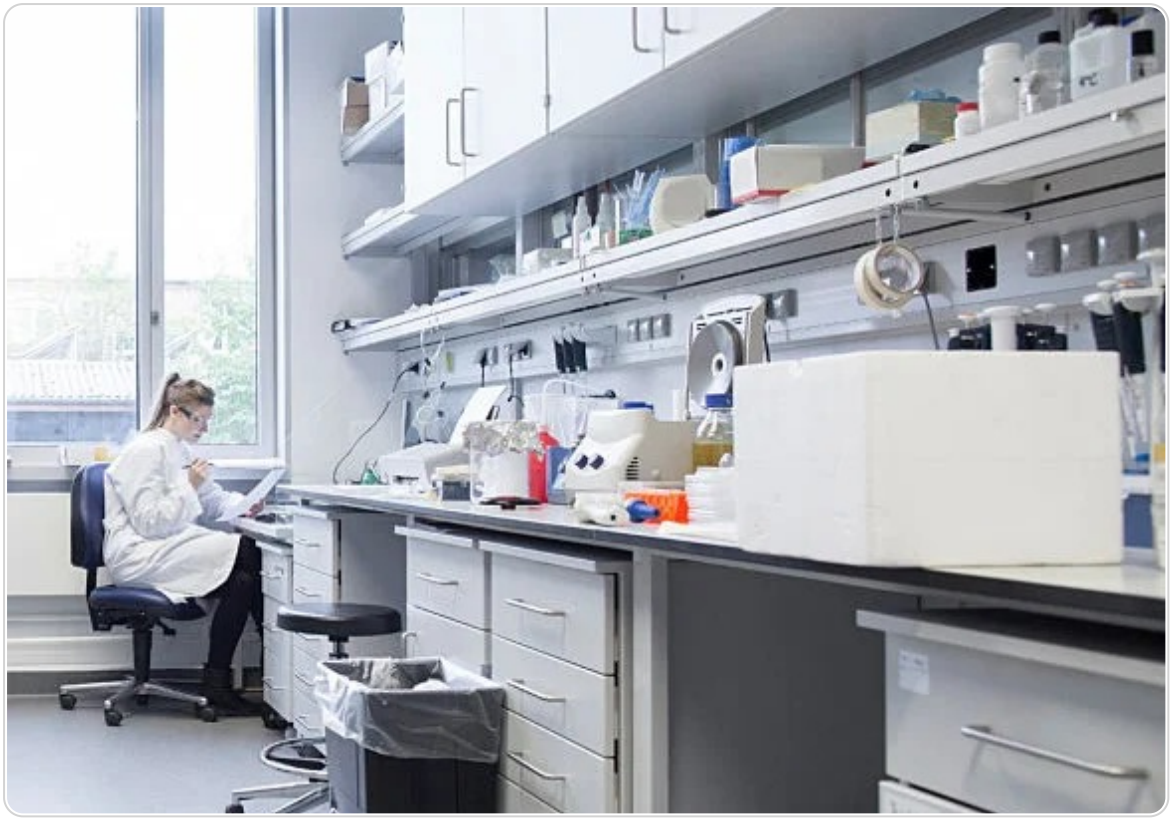


Image Credit: LabVantage Solutions

SAAS DELIVERY

LabVantage SaaS LIMS helps businesses:

- Reduce risk by improving data security, privacy, and regulatory compliance.
- Adapt to remote data management in response to the growth of work-from-home culture.
- Lower capital costs of cumbersome hardware and on-premises IT infrastructure.
- Stay up-to-date on the latest releases while avoiding disruptive product upgrades.

The LabVantage scientific data management platform

LabVantage pioneered one of the industry's first laboratory informatics platforms, incorporating this into its LIMS alongside an ELN for flexible R&D, an SDMS for automated data capture, and an LES for compliant workflows.

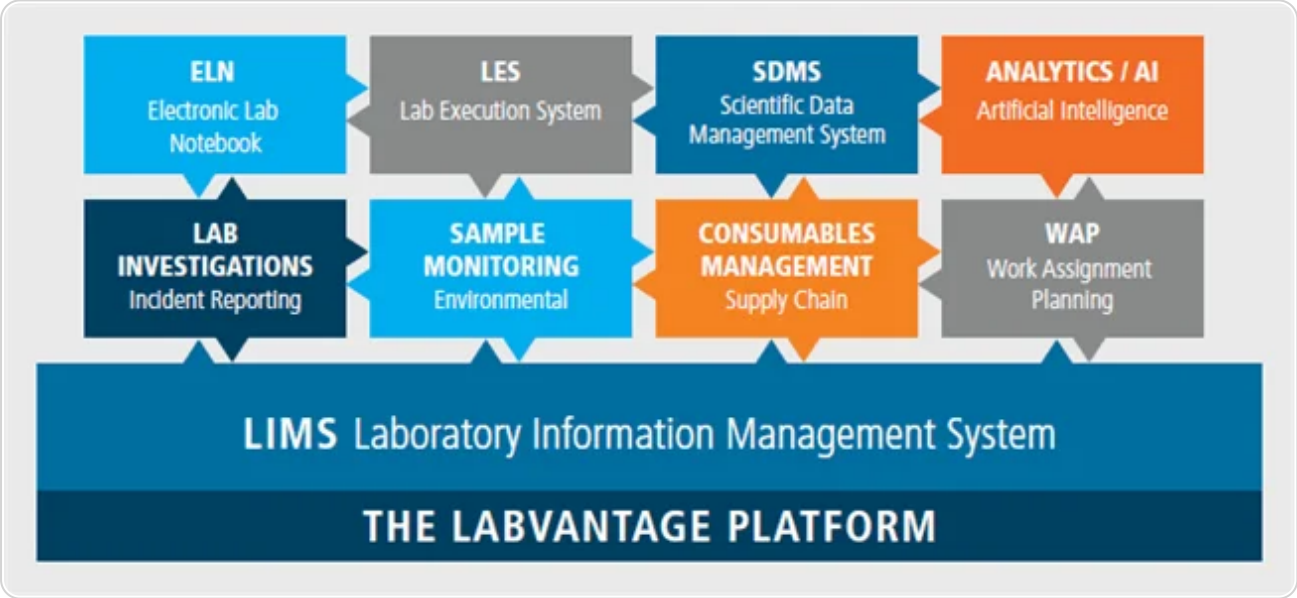
This platform acts as the hub of all labs across the organization and as a resource across the business. Thanks to its expanded capabilities, the platform can now be used to manage lab investigations, consumables management, sample monitoring, and work assignment planning.

The addition of AI-supported semantic search capabilities and advanced analytics has enabled a digitally native ecosystem that is able to serve the entire product lifecycle, from initial research and development to commercial manufacturing and QA/QC.

Its ability to manage both data flows and workflows allows this ecosystem to reduce operational costs while continuing to drive improvements in productivity, efficiency, decision-making, collaboration, and, eventually, time-to-market.

The entire scientific data platform is delivered with Software-as-a-Service (SaaS) technology, offering its users agility and scalability, and supporting innovation by meeting the FAIR data principles necessary for knowledge sharing and collaboration.

Scientists working in different types of laboratories and across multiple sites and geographies are empowered to do their jobs better, faster, and smarter, while business leaders are afforded the visibility to make more informed decisions on markets, products, and investments.



LabVantage's scientific data management platform, which integrates solutions within a single architecture, licensing model, and services contract, provides customers with the flexibility to select and activate specific components, and scale use as needed. Image Credit: LabVantage Solutions

Case study 1: Streamlining R&D and QC to develop a tasty non-alcoholic beer

Expanding a successful product line to meet evolving customer preferences can give

businesses a distinct competitive edge. A growing consumer interest in non-alcoholic beer is a timely example of this shift in demand.

For food and beverage manufacturers, adapting an existing recipe—or developing a new one—can be a costly and time-intensive process, often requiring multiple rounds of experimentation with various ingredient combinations.

Image Credit: LabVantage Solutions

One beer manufacturer addressed this challenge by using the LabVantage scientific data management platform, along with data from external sources, to identify the optimal formula for a new alcohol-free beer.

By tapping into its existing recipe database and applying AI-powered research, semantic search, advanced analytics, and automation, the company significantly reduced the number of experiments needed to achieve the desired flavor profile.

Once the product was developed, the platform continued to support quality assurance during commercial production. For instance, if a product sample fails quality checks, the issue can be logged directly into the Lab Investigations module. This enables rapid root-cause analysis and timely corrective action, well before the product reaches the customer.

In this case, the use of the LabVantage platform helped the company cut research and development costs, shorten time to market, lower risk, and reduce quality concerns.

The leading LIMS for growth and innovation

Frost & Sullivan named LabVantage the top growth and innovation leader in its LIMS report and Radar™, recognizing the company's strong position in a competitive landscape.[1]

Few vendors currently offer the level of integration LabVantage provides—combining LIMS with advanced scientific data management, analytics, and connections to enterprise systems beyond the lab.

LabVantage earned high marks for its "comprehensive portfolio" and "commitment to continued innovations." Frost & Sullivan also highlighted several of the company's key advancements.

Frost & Sullivan also highlighted a number of LabVantage's innovations.

One standout feature is LabVantage's application-specific solutions, which support particular industries and lab types with preconfigured workflows, enabling faster deployment and streamlined adoption.

The company's product portfolio continues to grow through a mix of internal development and external technology acquisitions, including investments in AI and natural language processing (NLP) that support scientific and unstructured data management.

A notable example is LabVantage's 2022 acquisition of Biomax Informatics, a knowledge management software provider.

Biomax Informatics' AILANI semantic search solution was recognized in the *Gartner® Hype Cycle™ for Life Science Discovery Research 2023*, where it was listed as a Sample Vendor in both the "Semantic Knowledge Graph Tools" and "Analytics Platforms for Research Informatics" categories.[3]

Case study 2: Optimizing raw materials inventory for $2 million annual savings

Laboratory managers and scientists need real-time visibility into stock levels and warehouse inventory to operate efficiently. A digitally native scientific data platform can deliver significant savings across large enterprises by enhancing the ability to detect waste

and automate inventory processes.

LabVantage's Consumables Management module offers a clear example of this impact. It helps identify expired chemicals before they're used in experiments and tracks ordering and consumption to promote optimal material usage.

Image Credit: LabVantage Solutions

One large paint manufacturer integrated this module into its LabVantage LIMS platform and saw a 90 % reduction in expired chemicals at a single site, translating into more than $2 million in annual savings from reduced chemical waste.

Increased inventory transparency also creates opportunities to share chemicals across labs, cutting down on redundant stockpiles of commonly used reagents. Additionally, the system can quickly pinpoint expired or compromised chemical lots and trace all affected experiments or tests, helping maintain quality and compliance.

Improving data flows from the laboratory to the boardroom

Digital transformation is essential for leaders planning for their organizations' growth and innovation. Laboratories can no longer operate as their own islands, equipped with

individual applications designed to support lab-specific workflows.

It is now a strategic imperative that organizations transition to integrated, digitally native solutions that are able to improve the flow of data across the entire ecosystem while effectively leveraging laboratory-centered data lakes. The choice of approach and partnerships in this endeavor are critical to its success.

LabVantage attributes its success in helping customers make this journey to its people, processes, and platform.

This article makes the case for a scientific data management platform approach to a digital enterprise, with case study examples bolstered by industry analysts like Frost & Sullivan.

It is important to work with only the best, most comprehensive, and integrative technologies as part of an organization's tech stack, with personnel trained and equipped to leverage these effectively.

It is also important to consider the people and processes within a potential scientific data advisor. For example, consider whether the advisor has global operations that can work in parallel with the organization's, and determine whether a potential advisor is skilled enough in the industry in question to offer appropriate solutions.

A potential scientific data advisor must be able to offer appropriate assistance as an organization evaluates, plans, and implements its transformation, supporting its client to understand and prepare for the change management required with novel and accessible solutions and processes.

LabVantage is uniquely positioned to deliver its modern scientific data platform to global organizations of all sizes and industries, thanks to its significant investments in its Customer Care and Professional Services Organization.

These advantages are key to supporting LabVantage's customers in making smarter, data-driven decisions that drive innovation and growth.

References and further reading

1. Frost & Sullivan (2023). *Life Sciences Industry Trends | Life Sciences LIMS Market Analysis*. (online) Available at: https://store.frost.com/frost-radartm-laboratory-information-management-systems-for-the-life-sciences-industry-2023.html (Accessed

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Acknowledgments

Produced from materials originally authored by LabVantage Solutions, Inc.

About LabVantage Solutions

LabVantage Solutions, Inc. is the leading global laboratory informatics provider. Our industry-leading LIMS and ELN solution and world-class services are the result of 35+ years of experience in laboratory informatics. LabVantage offers a comprehensive portfolio of products and services that enable companies to innovate faster in the R&D cycle, improve manufactured product quality, achieve accurate recordkeeping and comply with regulatory requirements.

LabVantage is a highly configurable, web-based LIMS/ELN that powers hundreds of laboratories globally, large and small. Built on a platform that is widely recognized as the best in the industry, LabVantage can support hundreds of concurrent users as well as interface with instruments and other enterprise systems. It is the best choice for industries ranging from pharmaceuticals and consumer goods to molecular diagnostics and bio banking. LabVantage domain experts advise customers on best practices and maximize their ROIs by optimizing LIMS implementation with a rapid and successful deployment.

Proactive Health: The Shift Towards Preventative Healthcare

Understanding preventative healthcare

The United States has the highest health expenditures of any developed country worldwide; however, only about 8% of Americans currently undergo routine preventive screenings. As a result, the US loses about $55 billion US dollars (USD) each year due to missed prevention opportunities, which amounts to about %body%.30 for every dollar spent on healthcare services.

Image Credit: Idutko/Shutterstock.com

Preventive medicine aims to reduce the risks of injury and disease through various primary, secondary, and tertiary prevention measures. For example, the United States Preventive Services Task Force (USPSTF) has offered several recommendations for clinical preventive medicine, which include education, screenings, counseling, preventive medications, and treatments to reduce the risks of noncommunicable and lifestyle-related diseases, as well as injuries.

Specialized clinics targeting communicable diseases like human immunodeficiency virus (HIV), sexually transmitted infections (STIs), and tuberculosis, as well as noncommunicable diseases like obesity and addiction, may also be incorporated into preventive health measures.

Key trends in preventative healthcare

Current estimates indicate that nearly 80% of chronic medical conditions could be prevented by healthy lifestyle behaviors, with about 63% of deaths likely caused by chronic diseases attributed to unhealthy lifestyle behaviors. Thus, lifestyle medicine has emerged as a crucial area within clinical preventive medicine.

Lifestyle medical interventions can be categorized into six basic pillars, which include whole

food, plant-based nutrition, physical activity, stress reduction, avoidance of toxic substances, sleep health, and healthy relationships. Taken together, these pillars aim to address the root causes of various chronic diseases, particularly cardiovascular diseases, diabetes, metabolic syndrome, and obesity, in an effort to significantly reduce their associated morbidity and mortality rates, as well as the financial burden associated with managing these chronic diseases.

Although lifestyle medicine interventions share numerous similarities in the prevention of various diseases, specific approaches can be implemented to target certain diseases. For example, dietary counseling and physical activity are crucial in many areas of disease prevention; however, these interventions have been shown to significantly reduce blood pressure levels and improve kidney function in individuals with chronic kidney diseases.

The role of technology in preventative care

Artificial intelligence (AI) encompasses a wide range of tools that have been increasingly applied within healthcare. Within preventative medicine, AI can be used to model how adolescents engage with adaptive technologies to acquire data for the development of effective and unique interventions for various health concerns.

For example, within a primary care clinic, an adolescent patient can be provided a tablet to complete an online screening tool to anonymously report their history with various health behaviors, including risky behaviors such as smoking and consuming alcohol.

Based on the patient's responses, the online screening tool can provide the patient with access to a personalized narrative game powered by an adaptive health behavior change system that addresses common scenarios such as peer pressure, social norms, and the consequences of alcohol use. By engaging with this AI-driven preventive health intervention, patients can receive specific support that enhances their ability to navigate real-world situations while simultaneously reducing their risk of participating in potentially life-threatening activities.

Benefits of a proactive health approach

In a study conducted by Trust for America's Health, researchers found that investing only $10 per person every year in community-based programs centered around increasing physical activity levels, improving nutrition practices, and preventing smoking and other tobacco use could lead to over $16 billion USD in saving every year. Of these annual savings, Medicare could save over $5 billion USD, Medicaid could save almost $2 billion USD, and private payers could

save over $9 billion USD, thus demonstrating the cost-effective benefits associated with community-based lifestyle interventions.

Image Credit: Drazen Zigic/Shutterstock.com

Challenges in implementing preventative healthcare

Currently, only about 27% of US medical schools provide the minimum required number of nutrition education hours. The lack of adequate lifestyle education incorporated into medical training has led several US residency programs to begin incorporating lifestyle medicine into their curricula. In fact, a recent resolution has required that medical training incorporate adequate clinical nutrition education to support widespread preventive care education.

Despite these efforts, only about 3.7% of funding for the National Institutes of Health is specifically allocated towards preventative medicine. Thus, there remains an urgent need to increase investment in preventive medicine training programs.

Case study: Successful preventative health programs

The coronavirus disease 2019 (COVID-19) pandemic exposed many of the limitations associated with curative medicine and emphasized the importance of adopting various

preventive measures to reduce one's vulnerability to infectious diseases. The widespread implementation of telemedicine during the COVID-19 pandemic is one way in which access to preventive care was expanded in order to reach more individuals and ensure their access to treatment.

In fact, the incorporation of data acquired from personal health devices and electronic health records has been shown to reduce the incidence of diabetes-promoting habits, thereby supporting diabetes and obesity prevention.

In addition to increasing patient access to healthcare providers, telemedicine has also reduced the burden on healthcare facilities and practitioners. Additionally, the ease of telemedicine visits can also allow patients to interact more frequently with their doctors, which allows physicians to monitor patient conditions more closely. In fact, telemedicine has been shown to significantly reduce readmission rates of patients with heart failure, as well as support the early detection of cardiovascular disease (CVD), thereby reducing costs.

Conclusions

Curative medicine remains a crucial aspect of healthcare; however, the prioritization of preventive medicine is imperative to promote health, prevent the spread of infectious diseases, as well as reduce the risk of developing preventable chronic health conditions. Although various technologies, ranging from AI, machine learning, and telemedicine, are currently being used to expand accessibility and adherence to preventive healthcare, there

remains an urgent need to increase public funding for community-based interventions and other innovative preventive medicine strategies.

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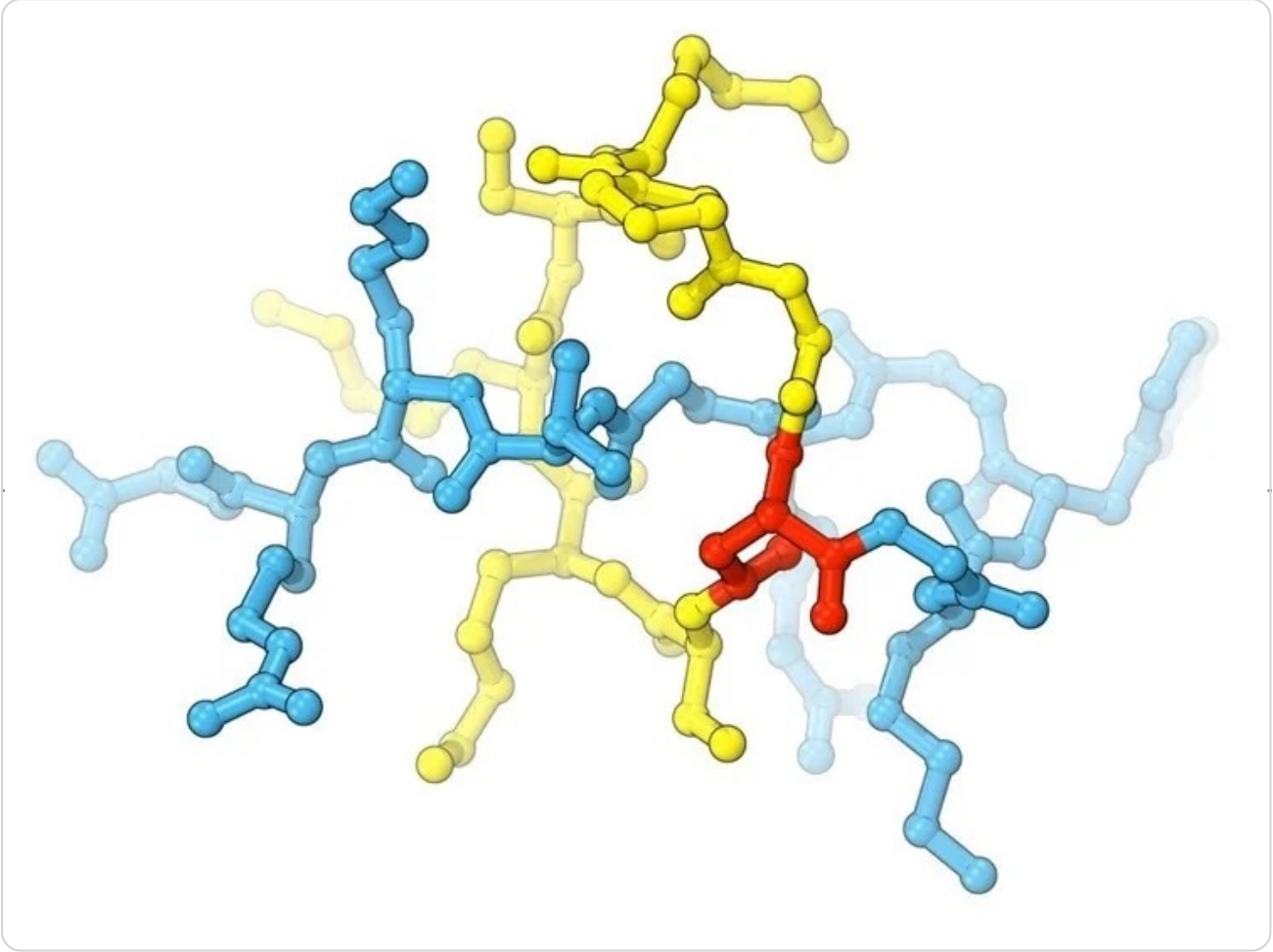
Further Reading

- All Healthcare Content
- The Concept of Human Health and Disease
- Medical Ethics and Health Policy
- Role of Real-Time Data in Healthcare
- Managing the Explosion of Healthcare Data to Harness its Power

More...

New peptide antibiotic stops bacteria by binding where no drug has before

Lariocidin hits drug-resistant bacteria where others fail — by hijacking the ribosome at a new site, bypassing defences, and opening the door to a new generation of antibiotics.



Lariocidin, a lasso-shaped peptide with promising antibiotic properties. (Graphic: Dmitrii Travin and Yury Polikanov). Research: A broad-spectrum lasso peptide antibiotic targeting the bacterial ribosome

Researchers at McMaster University, in collaboration with researchers from the University of Illinois at Chicago, have discovered a powerful candidate antibiotic that can kill a broad range of bacteria, including those resistant to existing antibiotics. They have published the findings in the journal ***Nature***.

Background

Antibiotic resistance occurs when bacteria evolve and develop resistance against existing antibiotics. It is a major public health crisis worldwide that makes the treatment of bacterial infections challenging. More than 4.5 million deaths occurred due to antibiotic resistance in 2019.

The World Health Organization (WHO) has designated Gram-negative bacteria as a critical threat because of their ability to develop and spread antibiotic resistance, making it a top priority to discover novel antibacterial drugs.

Various peptide-based antibiotics produced by microbes have shown high efficacy in treating bacterial infections. Most of these antibiotics are produced outside the ribosome, the cellular structure responsible for protein synthesis, by specialized peptide synthetases encoded in the genomes of antibiotic-producing microbes.

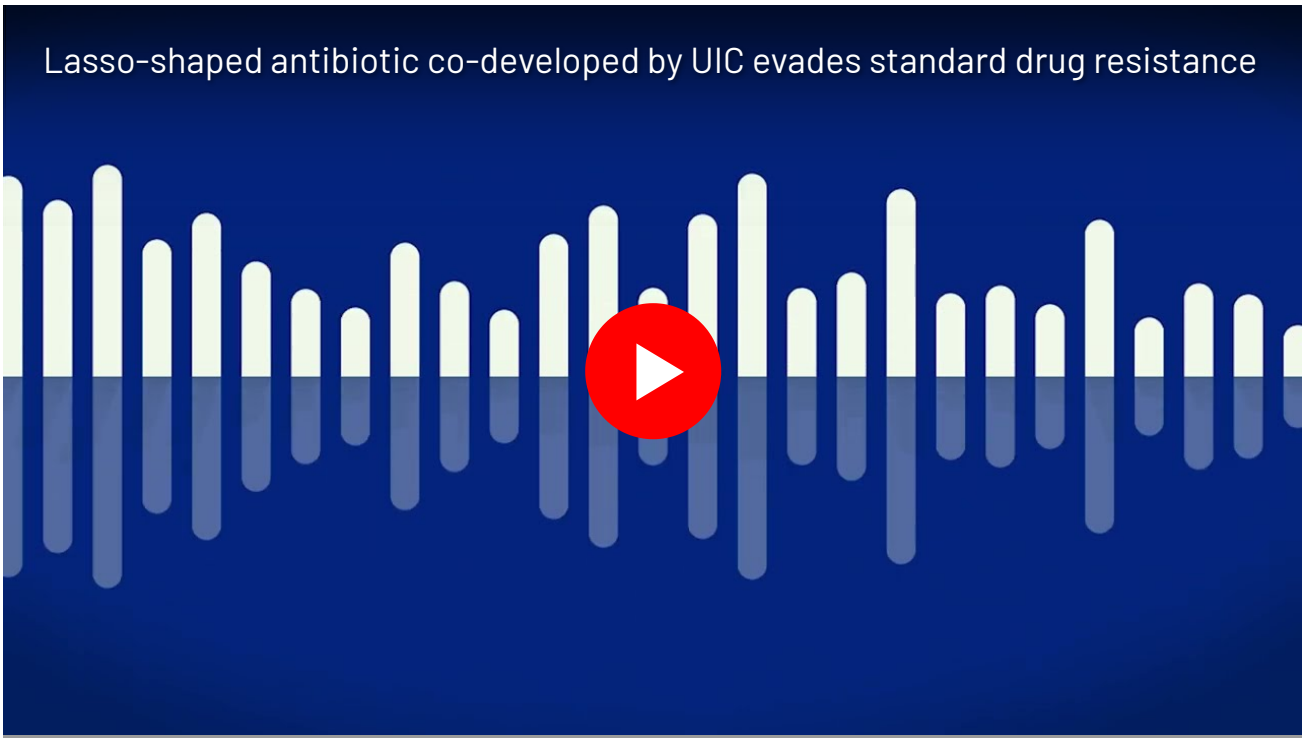
Ribosomally synthesized and post-translationally modified peptides are rapidly gaining popularity as a novel class of antibiotics. The post-translational modifications set the three-dimensional shape of these peptides, facilitating their interactions with the target proteins and protecting them from degradation by cellular peptidases.

Lasso peptides are biologically active molecules with a distinct, structurally constrained knotted fold that belong to the class of ribosomally synthesized and post-translationally modified peptides. Lasso peptides act on several bacterial targets; however, none of them has been identified as targeting the bacterial ribosome.

In this *Nature* article, Professor Gerry Wright from McMaster University and his team reported the identification of a new lasso peptide named lariocidin that acts as a broad-spectrum antibiotic by targeting the bacterial ribosome at a unique site.

Importantly, lariocidin not only inhibits protein synthesis by interfering with translocation but also induces translation errors (miscoding), giving it a dual mechanism of action.

The researchers note that lariocidin meets three key criteria for a next-generation antibiotic: a novel structure, a new binding site, and a distinct mechanism of action.



The study

Researchers generated a collection of environmental bacterial strains by culturing them in the laboratory for approximately one year. Such a long-term culture allowed the growth of even the slowest-growing bacteria that could have otherwise been missed.

They prepared methanolic extracts of individual bacterial colonies and tested them against a multidrug-resistant bacterium. This led to the identification of a novel lasso peptide, lariocidin, which was produced by a type of soil bacterium called *Paenibacillus*.

By conducting a series of biochemical and structural experiments, they found that lariocidin is capable of killing a wide range of bacteria, including multidrug-resistant strains, by inhibiting ribosomal protein synthesis.

They also found that lariocidin binds to a unique site in the small ribosomal subunit of bacteria, which is clearly distinct from the sites of action of existing antibiotics that target the small ribosomal subunit. This unique binding site enabled lariocidin to circumvent the defense mechanisms that bacteria have evolved to resist other drugs.

This ribosomal binding mode relies primarily on interactions with the RNA backbone rather than the nucleobases, making it less susceptible to resistance caused by mutations at the binding site.

In lab-adapted bacterial strains with a single ribosomal RNA operon, researchers identified rare spontaneous mutations in the 16S rRNA that reduced lariocidin susceptibility—further validating the ribosome as its target.

The team emphasized that developing antibiotics that act at previously untapped ribosomal sites offers a way to bypass common resistance mechanisms.

As observed by researchers, the unique structure of lariocidin enabled it to overcome the challenges that other antibiotics typically face when targeting the bacterial ribosome. Mechanistically, antibiotics initially enter the bacterial cell through transporters in order to inhibit protein synthesis, specifically the ribosome. However, bacteria can change or remove these transporters to block the entry of antibiotics.

The strong positive charge of lariocidin, on the other hand, enabled it to enter the bacterial cell directly through the membrane without the need for transporters. This specific feature made lariocidin a broad-spectrum antibiotic.

Because lariocidin bypasses the need for specific transporters, it can enter a wide range of bacterial species, reducing the likelihood of resistance developing through transporter-related mechanisms.

Using a mouse model of *Acinetobacter baumannii* infection, researchers demonstrated that lariocidin is capable of significantly reducing the bacterial burden in various organs. They further found that the peptide has a low propensity for generating spontaneous resistance and has no cytotoxic effects on human cells.

Its antimicrobial activity was even stronger in nutrient-limited media that mimic host environments, suggesting improved clinical potential compared to standard susceptibility tests in rich media.

This enhanced potency was linked in part to the presence of bicarbonate, which increases bacterial membrane potential and promotes uptake of the positively charged lariocidin.

All these features made lariocidin a promising candidate for further development into a clinical antibiotic for the treatment of serious bacterial multidrug-resistant infections.

The study also identified a structurally related isoform, lariocidin B (LAR-B), which contains an additional isopeptide bond, forming a double-lariat structure. This may improve the stability of the molecule and marks LAR-B as the founder of a proposed new class (class V) of lasso

peptides.

By conducting bioinformatic analysis of available bacterial genomes, researchers suggested that there could be other ribosome-targeting lasso peptides still to be discovered in nature.

They identified dozens of lariocidin-like biosynthetic gene clusters (BGCs) across multiple bacterial phyla, including Actinomycetota, Bacilliota, and Proteobacteria, suggesting a wide evolutionary distribution of this antibiotic scaffold.

The researchers describe lariocidin as the first member of a previously unrecognized family of ribosome-targeting lasso peptides, with the potential for even more potent analogs to be discovered.

The researchers are now working on developing strategies to modify the lasso peptide and produce it in large quantities for clinical development.

Source:

- Lasso-shaped antibiotic co-developed by UIC evades standard drug resistance

Journal reference:

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Say goodbye to LIMS headaches with SaaS solutions

As today's laboratories evolve, the software solutions supporting them must keep pace with their changing needs. This also requires leadership, both in the lab and across the organization, to recognize and embrace the advantages modern technologies can offer.

Laboratory Information Management Systems (LIMS) delivered as Software-as-a-Service (SaaS) are playing a key role in enabling the lab of the future. By integrating digital labs into the broader data ecosystem, these solutions help bridge the gap between lab operations and enterprise strategy.

Choosing to upgrade to a SaaS-based LIMS is a strategic move that delivers wide-ranging benefits—from improved efficiency at the lab bench to better-informed decisions in the boardroom.

Organizations working with older on-premises LIMS releases can benefit by upgrading to a current SaaS version, including:

- Automatic updates and patches ensure access to the most up-to-date productivity-enhancing functionality.
- Access to innovative artificial intelligence (AI) features.
- Guaranteed uptime.
- Automated backups.
- Current cybersecurity protections and ongoing scans.
- More time for science instead of IT setup and troubleshooting.

Today's LIMS capabilities enable users to work at their fullest potential. In contrast, labs still relying on legacy systems often face significant obstacles—limited system visibility, duplicated efforts across departments, dependence on printed spreadsheets and paper notebooks, and manual data entry without the support of automated SOPs to uphold data integrity and regulatory compliance.

These challenges are often compounded by the need to coordinate with internal administrators, third-party consultants, or shadow IT teams. The result can be a patchwork of customizations, add-ons, and workarounds that are costly to maintain and difficult to upgrade, diverting focus from core organizational goals.

Deploying a SaaS-based LIMS backed by modern technology and expert support addresses

these issues head-on. This article explores how a SaaS LIMS modernization program streamlines data management, enhances decision-making, and promotes collaboration, helping laboratories stay competitive and innovative in a rapidly evolving scientific landscape.

Image Credit: LabVantage Solutions

Why work with SaaS?

SaaS is a software delivery method that leverages secure cloud services to deliver software applications over the internet. These packages are offered as paid monthly or annual subscriptions, rather than on-premises perpetual licensing.

SaaS enables the adaptability, scalability, and cost efficiencies required for laboratories seeking to navigate the complex landscape of data-centered scientific research and manufacturing confidently.

The SaaS Academy states that: "The SaaS industry is experiencing an unprecedented surge, cementing its position as a cornerstone for businesses worldwide. From tech to healthcare, SaaS has penetrated every sector, and now many companies are transitioning to a fully SaaS-

based model, fueling the demand for SaaS solutions."

The global software as a service market was valued at USD 261.15 billion in 2022. From 2023 to 2030, it is anticipated that it will grow at a compound annual growth rate (CAGR) of 13.7 %.

"In today's era where growth is not merely a choice but a necessity for organizations, the significance of cloud computing or SaaS migration cannot be overstated," states one expert.

"Software-as-a-Service (SaaS) migration has emerged as a transformative force, empowering businesses to enhance customer experiences, lessen overhead expenses, and embrace unparalleled growth."

SaaS eliminates the need for complex infrastructure, costly maintenance, and manual upgrades that are often delayed and disruptive to operations. By removing the burden of on-site hardware and servers, organizations can reduce overhead and redirect those resources toward other strategic growth initiatives.

Accenture estimates that migrating to the cloud can lead to a 30–40 % reduction in total cost of ownership (TCO), underscoring the financial benefits of this shift. At the same time, demand for scalable, flexible solutions continues to rise, driving increased adoption of SaaS across industries.

As CIO Dive highlights, SaaS is becoming central to IT strategy. "IT leaders have a profound opportunity to drive digital disruption with SaaS applications, which are easy to consume and enable business users to bypass IT," states Manjunath Bhat, VP analyst at Gartner.

SaaS in the lab

SaaS deployments are a strategic decision, and as organizations continue to recognize this, business leaders are increasingly able to focus on their primary missions while experts manage and maintain systems and applications.

This is an especially important consideration for laboratories, where work is often mission-critical, highly specialized, regulated, and process-intensive. The laboratory workforce tends to be passionate about science, discovery, and problem solving, preferring not to engage with manual workflows or IT management.

Deploying an updated LIMS via SaaS and supporting it via expert services frees teams from managing non-lab-related issues such as hardware, infrastructure, backups, routine maintenance, and security.

As a result, scientists and lab technicians can concentrate on the work that drives meaningful outcomes. They no longer need to worry about whether data is properly encrypted to protect patient privacy, whether research is secure, if quality standards are being upheld, or if cyber threats are being effectively managed.

Transferring responsibility

Shifting laboratory operations to SaaS transfers the responsibility of LIMS platform maintenance to the vendor, allowing laboratory staff to better focus on science.

The table below highlights the responsibilities of the vendor and laboratory when comparing on-premises deployments to SaaS.

Source: LabVantage Solutions

	On-Premises	On-Premises
Daily maintenance and backups	Lab/IT	Vendor
Encryption and security	Lab/IT	Vendor
Disaster recovery	Lab/IT	Vendor
Upgrades	Lab must pay to install each upgrade and is responsible for all supporting activities	Vendor sends updates. Lab decides which features to engage
Customer Care	Pay for support level	Comes with subscription; tiered levels of support for every budget

Leveraging a LIMS modernization program

Implementing, upgrading, or migrating a LIMS can feel overwhelming, but the risks of sticking with outdated software or manual processes make it increasingly difficult to justify delay. The longer organizations wait, the more they risk falling behind in efficiency, compliance, and innovation.

A modern LIMS from a trusted, experienced vendor helps reduce many of the typical implementation hurdles. It enables labs to tap into the full value of analytics, automation, cybersecurity, data integrity, and more, without the complications of legacy systems.

LabVantage's LIMS modernization program is designed to make that transition worthwhile,

providing the features, functionality, and support needed to break free from systems that limit adaptability and growth.

A closer look at what's included in a SaaS upgrade reveals the clear advantages of modernizing and moving to the cloud, showing that the long-term benefits far outweigh the initial time and effort required for a successful implementation.

New functionality

SaaS deployment means updates are automatically applied. The software solution is always up-to-date and equipped with the latest features and functionality, without the need to perform manual upgrades.

Subscription model

The SaaS model reduces LIMS-related costs into predictable ongoing operational expenses rather than one potentially disruptive large capital expense. This helps organizations better manage cash flow while avoiding unanticipated or hidden costs. A typical subscription has a fixed monthly cost, with organizations able to scale up as required.

High-value services

A SaaS subscription allows its users to take advantage of zero-touch maintenance. Infrastructure and hardware are provided, and applications are managed daily. There is no need to worry about maintenance, servers, backups, or protection against cyber threats, because these are all managed by the SaaS solution provider's team of highly qualified experts.

Reliability

LabVantage delivers highly stable, reliable systems due to its partnerships with top-tier hosting providers. Connectivity is seldom interrupted, and the use of multiple data storage facilities ensures that data is always safe in case of natural disasters or other issues. Should issues occur, however, disaster recovery is rapid and straightforward.

A trusted advisor

The responsibility for maintaining the system is transferred from an organization's internal staff to LabVantage's experts. These experts work closely with an organization's team, regularly checking in to discuss requirements, issues, and innovative ways to maximize performance.

LabVantage's team gets to know a client's business model and workflows, proactively

supporting them to find new ways to optimize efficiency.

Product expertise

With deep product knowledge, LabVantage Customer Care and Product Support are the best resources to offer advice on capabilities, how to leverage specific features, when to turn modules on or off, or the best way to set up a specific desired workflow or use case.

Getting and staying ahead with SaaS conversion

The future of technology and science remains unknown. Laboratories and their solutions providers, like LabVantage, must closely work alongside one another to be prepared and respond to the sector's changing needs.

LabVantage is committed to supporting its customers with reliable, easy-to-use, next-generation technology that meets all industry mandates and regulations, from 21 CFR Part 11 to HIPPA, GMP, and ISO to SOPs.

LabVantage's on-premises customers are offered the opportunity to shift to SaaS and expedite an upgrade to the latest LabVantage LIMS release via the company's modernization program, allowing its customers to take advantage of LabVantage's investments in product development and enterprise SaaS.

Smooth upgrade, support, and continued services

LabVantage develops an implementation plan to expedite the move to the new LIMS environment. This plan includes steps for migrating existing data and any data clean-up required before it can be stored in the cloud.

This process is mapped out as part of the transition and is completed in phases, ensuring minimal impact on day-to-day functions. Users are trained on any new functionality or processes during the implementation stage.

LabVantage's SaaS customers are able to choose between various levels of service packages, ranging from basic escalation to zero-touch. Customers can select their ideal option, whether this includes 24/7/365 support for round-the-clock operations or local time-zone support during conventional working hours.

A support team member is assigned to each account. This team member maintains regular contact with the customer and schedules management review calls quarterly or as required.

Their role lies in supporting the customer to get the full value out of the LabVantage LIMS, and this proactive interaction ensures that customers are informed about best practices, new functionality, and ways to optimize features for best results.

Organizations work closely with LabVantage to improve the user experience, whether this involves working with users at the bench to eliminate tedious steps or working with managers looking to improve their team's productivity.

The current generation of early-career personnel expects easy-to-use technology that anticipates their needs. LabVantage works with its customers to ensure that bench users have the experience they want.

The company's customer care service offers advice and support with a range of use cases, helping its customers personalize the solution without risking data security or system integrity.

Organizations can save money because there is no need to hire consultants for small projects or outsource day-to-day tasks such as backups. Transferring responsibilities via a SaaS deployment regularly offsets these third-party fees and other hidden costs.

LabVantage's product development teams focus on innovation and bringing new technology to its customers, continually driving customer value via improved user experiences and ongoing product enhancements. Updates are rolled out semi-annually, with users benefiting from full documentation and training.

The close support relationship afforded by working with the Customer Care team means customers are updated on LabVantage's product roadmap, with regular updates on the release windows for major innovations.

This communication is two-way, with laboratories able to make enhancement requests, share the types of issues emerging in the market with LabVantage, and outline how they would like the technology to develop. Organizations can also provide feedback on release updates.

This closed loop of timely, strategic-level communication is highly advantageous for the organization, affording company leaders a position of respect and influence.

Advantages for everyone: From benchtop to boardroom

Priorities vary among different people in organizations, but everyone can benefit from the deployment of a SaaS LIMS.

CEO

As the leaders guiding an organization's growth, CEOs rely on access to timely, actionable information. Laboratories are often at the core of an organization's intellectual property, yet lab data is frequently siloed or disconnected from enterprise systems.

A modern SaaS LIMS bridges this gap by bringing the lab into the digital-native enterprise, integrating it with the broader digital ecosystem to unlock insights and analytics that extend well beyond the lab.

By doing so, a SaaS LIMS not only enhances lab productivity and performance—it also drives better insights, supports more informed decision-making, and helps accelerate time-to-market for new products.

CFO

SaaS shifts an organization's LIMS costs from a capital to an operational expense.

The subscription model associated with SaaS means that budgeting and planning are scalable and straightforward, with organizations only paying for what they need. Multiple contracts with third-party consultants are no longer required, because an organization works with one preferred vendor as its trusted partner.

CIO

Responsibility for the LIMS environment is shifted to LIMS experts. The SaaS solution's zero-touch, zero-maintenance nature means that daily maintenance, automatic backups, cybersecurity, disaster relief, daily management, and routine maintenance are all managed by the LIMS vendor.

Users benefit from highly reliable uptime with minimal risk.

Lab managers

Get the most out of your LIMS platform—and your scientific team. With an always-up-to-date LIMS managed by the vendor, your scientists can focus on running experiments, analyzing data, generating reports, and staying compliant.

The system is automatically patched, updated, and backed up; processes are automated; oversight is simplified; and both accuracy and data integrity are maintained.

You also gain access to real-time analytics and visualization dashboards, giving you a clear

view of lab performance and productivity to quickly adapt to changing business needs.

Bench users

Bench users benefit from working with the newest features and the latest technology, whether this is in terms of R&D or QA/QC. The SaaS LIMS gives all users access to up-to-date workflows and features, reducing repetitive work, automating processes, ensuring accuracy and data integrity, enforcing SOPs, and streamlining scientific work while limiting the impact of IT issues.

Image Credit: LabVantage Solutions

The next steps

Adopting SaaS for LIMS modernization is a strategic necessity for today's laboratories. With access to greater scalability, adaptability, and cost efficiency, lab-centered organizations can optimize data management, foster essential collaboration, and enable faster, more informed decision-making.

Deploying the latest technologies through SaaS is critical to staying competitive and driving scientific innovation forward.

Organizations currently operating LabVantage's LIMS on-premises should consider evaluating a SaaS modernization path without delay. Postponing this decision means postponing key benefits, and increases the risk of falling behind competitors or eroding customer trust.

There's also the potential risk to data if existing backup systems are unreliable or cybersecurity measures are not sufficiently robust.

Choosing to modernize with a SaaS LIMS addresses these concerns and prepares the organization for the future, no matter what challenges lie ahead.

Acknowledgments

Produced from materials originally authored by LabVantage Solutions, Inc.

About LabVantage Solutions

LabVantage Solutions, Inc. is the leading global laboratory informatics provider. Our industry-leading LIMS and ELN solution and world-class services are the result of 35+ years of experience in laboratory informatics. LabVantage offers a comprehensive portfolio of products and services that enable companies to innovate faster in the R&D cycle, improve manufactured product quality, achieve accurate recordkeeping and comply with regulatory requirements.

LabVantage is a highly configurable, web-based LIMS/ELN that powers hundreds of laboratories globally, large and small. Built on a platform that is widely recognized as the best in the industry, LabVantage can support hundreds of concurrent users as well as interface with instruments and other enterprise systems. It is the best choice for industries ranging from pharmaceuticals and consumer goods to molecular diagnostics and bio banking. LabVantage domain experts advise customers on best practices and maximize their ROIs by optimizing LIMS implementation with a rapid and successful deployment.


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Pharma 4.0: Shaping the Future of Pharmaceutical Manufacturing

Over time, drug manufacturing has evolved significantly, moving from small-scale manual production with basic tools to large-scale operations in today's multimillion-dollar pharmaceutical industry.

The emergence of Pharma 4.0 is a result of technological advancements like robotics, artificial intelligence (AI), and the Internet of Things (IoT), which have greatly improved the efficiency, quality, speed, and adaptability of pharmaceutical manufacturing processes.[2]

Image Credit: BRKH-STUDIO/Shutterstock.com

What is Pharma 4.0?

The term Industry 4.0 refers to the fourth industrial revolution, associated with the application of advanced technologies that have dramatically changed the landscape of manufacturing. Pharma 4.0 has considerably challenged the traditional batch approaches and old business models of drug development. As stated above, Pharma 4.0 involves the implementation of technologies, such as AI, robotics, automation, and computational modeling, that enable the manufacturing of pharmaceutical products with minimal human intervention.[3]

Pharma 4.0 has enabled a significant reduction in resource utilization. A higher data density inspired the pharma industry to develop customized medicinal products suitable for individualistic treatment instead of the current one-size-fits-all" strategy.[4] Pharma 4.0 promotes sustainable values and better quality control.

Core components of Pharma 4.0

Some of the key components of Pharma 4.0 are discussed below:

Digitalization

Digitalization with proper cybersecurity is one of the core components of Pharma 4.0.[4] Smart factories implement IoT, which is a cyber-physical system comprising well-interconnected computing devices, instruments, sensors, and equipment integrated with an organized network.[5]

Data digitalization is considered the backbone of IoT, which involves the conversion of previously manually generated data to digital format. In pharmaceutical industries, data related to supply chain (e.g., raw materials variability), operation procedures, operator work instructions, video-based training, and real-time monitoring have significantly improved decision-making.

Digital integration into an IoT has enabled real-time monitoring and has revolutionized biosensor diagnostics. It has also paved the way for the production of personalized medicine with optimal dosage.

A usable IoT requires the capacity for each unit to be connected to the cloud to send and store information. Cloud storage enables pharmaceutical companies to manage different data types, including manufacturing, clinical, genomic, patient, and supply chain.[6]

This data can be easily obtained and analyzed in real time through authorized devices with an internet connection.

Artificial intelligence

AI is used in pharmaceutical manufacturing to predict equipment maintenance and prevent production disturbances, manufacturing risks, and production downtime.[7] It improves and optimizes manufacturing processes in the pharmaceutical industry.

Specific AI algorithms enable handling large and disparate datasets. Machine learning (ML) and artificial neural networks (ANN) are two subdivisions of AI that play important roles in risk prediction and management.

ML utilizes the ability of computers to learn a task from data monitoring and uses statistical tools to derive general knowledge from these data without external prompts.

Based on how input data is utilized, ML algorithms are categorized as supervised learning, unsupervised learning, and reinforcement learning, and each of these approaches is used in pharmaceutical manufacturing operations. For example, the ANN model is used in the risk-based analysis of the biomanufacturing process.[8]

This approach enables fault detection for complex dynamic processes and predicts therapeutic drug pharmacokinetics.

Robotics and automation

Robotics and automation enabled the streamlining of the manufacturing process.[7] Complete process automation has been possible due to the ability to capture all process performance data through cloud-connected process analytical technology (PAT).

Subsequently, big data can be converted into knowledge via AI algorithms, and this information provides insights into the process and how the production, quality, and safety of pharmaceutical products can be improved.

Robotics and automation have effectively decreased the need for human intervention and, thereby, reduced errors in the manufacturing process.

Benefits of Pharma 4.0

Pharma 4.0 offers several benefits to pharmaceutical companies.[4] Some key benefits are listed below:

- **Production efficiency:** Pharma 4.0 focuses on implementing technologies that offer real-time monitoring of pharmaceutical manufacturing processes. This strategy improves production efficiency by enabling quick detection and resolution of manufacturing issues.
- **Product quality:** Pharma 4.0 offers early identification of quality issues in the manufacturing process. Technologies support consistent product quality.
- **Personalized medicine:** Pharma 4.0 offers the collection and analysis of large-scale medical records of individuals, and this data enables the development of tailored or personalized treatment of patients.
- **Supply chain management:** Pharma 4.0 technologies enable real-time monitoring of the supply chain that helps better track and maintain inventory and distribution of pharmaceutical products.
- **Safety:** Pharma 4.0 helps produce safer, stable, and high-quality products.
- **Time to market**: Pharma 4.0 uses advanced analytics and ML approaches that help accelerate the drug discovery and manufacturing process. Therefore, it reduces the time for a drug to reach the market.

Challenges of Pharma 4.0

Pharma 4.0 requires the implementation of many advanced technologies and overcoming regulatory and logistical challenges. The majority of the changes are associated with

establishing technologies that support autonomous manufacturing systems with elevated process controls and quality management. Automation offers reduced product variability and ensures consistent product availability.

The key barriers that inhibit or delay the implementation of advanced technologies include the lack of precedent in the industry, the high cost of adopting advanced technologies, and perceived regulatory uncertainties. Furthermore, significant institutional knowledge of existing platform technologies induces hesitancy to embrace a new one.[4]

Lack of regulatory precedence often leads industries to follow conventional processes even when technological advances could improve quality over the long run. Multiple global jurisdictions have differential regulatory expectations, making them tricky to file; however, the international regulatory convergence on advanced manufacturing technologies has significantly reduced these regulatory uncertainties for manufacturers.

At present, the majority of pharmaceutical industries have just begun navigating the world of "big data." Conversion of large amounts of unstructured data into organized information requires solid AI models. Determining and communicating data's purpose is a key technical challenge of Pharma 4.0.[2]

Insufficient expertise and lack of proper training may hinder sustainable development in the pharmaceutical supply chain. The replacement of the workforce by automation might impact job opportunities.

Conclusion

In conclusion, technological advancements have driven the evolution of pharmaceutical manufacturing, transforming the industry from manual, small-scale production to large-scale, automated processes. Pharma 4.0, an extension of Industry 4.0, integrates technologies such as AI, IoT, robotics, and automation to revolutionize drug development and manufacturing.

This shift has resulted in enhanced efficiency, improved product quality, and the development of personalized medicine. However, the adoption of Pharma 4.0 faces challenges, including regulatory complexities, high costs, and the need for expertise. Despite these hurdles, Pharma 4.0 holds great promise for the future of pharmaceutical manufacturing.

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Further Reading

- All Pharmaceutical Manufacturing Content
- The Role of Process Validation in Ensuring Consistent Drug Quality
- Pharmaceutical Continuous Manufacturing vs. Batch Manufacturing: What's the Difference?
- Advantages of x-ray fluorescence in pharmaceutical elemental analysis
- How Process Development Enhances Drug Discovery Outcomes

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Can AI Outperform Doctors in Diagnosing Infectious Diseases?

Artificial Intelligence (AI) is revolutionizing medicine by enhancing diagnosis, treatment, drug development, and healthcare management. In diagnostics, AI-powered tools improve accuracy in radiology, pathology, and endoscopy, enabling faster and more precise disease detection.

AI-assisted surgical systems enhance precision and minimally invasive procedures. In drug discovery, AI accelerates development by analyzing large datasets, predicting molecular interactions, and optimizing drug design.

Additionally, AI-driven virtual reality (VR) and augmented reality (AR) are transforming medical education and surgical training. During the coronavirus disease 2019 (COVID-19) pandemic, AI contributed to early diagnosis, vaccine development, and drug repurposing.

While AI enhances efficiency and decision-making, it complements rather than replaces human expertise. As AI advances, its integration with medicine promises improved patient care, personalized treatments, and innovative healthcare solutions.[1]

This article explores AI's capabilities and limitations in medical diagnostics, comparing AI-driven tools with human doctors. It highlights AI's strengths in speed, accuracy, and pattern recognition while addressing challenges like data bias, ethical concerns, and interoperability.

Image Credit: CHIEW/Shutterstock.com

AI Capabilities and Limitations

AI is revolutionizing medical diagnostics by enhancing accuracy, efficiency, and speed in disease detection and analysis. AI-powered systems can process and interpret vast amounts of complex medical data, including medical imaging scans such as X-rays, Magnetic Resonance Imaging (MRI), and Computed Tomography (CT) scans, as well as biosignals like Electrocardiogram (ECG), Electroencephalogram (EEG), and Electromyography (EMG).

Additionally, AI can analyze patient records, including Electronic Health Records (EHRs), aiding healthcare professionals in early disease detection and treatment planning.[1,2]

A major advantage of AI in diagnostics is its capability to handle multimodal medical data, integrating text, images, and physiological signals to provide a comprehensive view of a patient's health. Explainable Artificial Intelligence (XAI) plays a crucial role in making AI-driven diagnoses transparent and interpretable, enabling medical professionals to validate AI-generated predictions.

AI-driven Clinical Decision Support Systems (CDSSs) further assist in real-time decision-making, improving patient management and reducing diagnostic errors.[1,2]

Despite its advancements, AI in medical diagnostics faces several limitations. The quality and availability of medical data remain a significant challenge, as AI algorithms require large, high-quality, and well-labeled datasets for training. Data bias can lead to inaccurate or unfair diagnoses, especially when models are trained on non-representative populations.

Ethical concerns surrounding data privacy, transparency, and accountability also pose hurdles to widespread AI adoption. Additionally, interoperability issues between AI-based diagnostic tools developed by different organizations hinder seamless integration into existing healthcare systems.[1,2]

Further, emerging technologies such as Quantum Artificial Intelligence (QAI) and General Artificial Intelligence (GAI) are expected to enhance diagnostic accuracy and speed. Quantum computing has the potential to accelerate data processing, enabling real-time analysis of vast medical datasets, while GAI aims to replicate human-like cognitive abilities in diagnosis.

However, for AI to reach its full potential in clinical practice, regulatory frameworks, ethical considerations, and data standardization must be addressed to ensure trust, reliability, and fairness in AI-driven medical diagnostics.[1,2]

Comparison with Human Doctors

AI-powered virtual assistants are revolutionizing healthcare by providing triage and diagnostic support. Compared to human doctors, AI systems demonstrate notable strengths and limitations across three key dimensions:

Accuracy

Studies indicate that AI-driven symptom checkers achieve diagnostic precision and recall rates comparable to human doctors. AI models, such as Bayesian networks, effectively match symptoms with diseases by leveraging vast datasets. However, human doctors possess contextual understanding, intuition, and the ability to interpret non-verbal cues, which AI lacks.[2,3]

Speed

AI systems provide instant responses, significantly reducing wait times for initial assessments. Unlike human doctors, who require consultations and physical examinations, AI-powered tools analyze symptoms and generate probable diagnoses within seconds, improving healthcare accessibility.[2,3]

Diagnostic Outcomes

AI tools exhibit high safety levels in triage decisions, often going wrong on the side of caution. While AI ensures consistency and scalability, human doctors offer personalized care and adaptability in complex cases. AI systems excel in recognizing patterns across large datasets, but doctors remain superior in handling rare conditions and ambiguous cases.[2,3]

Case Studies: Notable examples and recent studies

Machine learning models, such as extreme gradient boosting (XGBoost), have been successfully used to predict antimicrobial resistance (AMR) in nontyphoidal *Salmonella*, demonstrating high accuracy in forecasting minimum inhibitory concentration (MIC) values.

Deep learning models, including recurrent neural networks (RNNs) and convolutional neural networks (CNNs), are utilized for rapid blood culture diagnostics in intensive care units (ICUs). A long short-term memory (LSTM) model accurately predicted bloodstream infections based on ICU patient parameters.[4]

A decision-support algorithm was developed to optimize outpatient antibiotic prescriptions for uncomplicated urinary tract infections (UTIs). The model, trained on electronic health records, reduced second-line antibiotic use by 67%. AI-driven molecular screening identified novel antimicrobial peptides (AMPs) from microbial genomes.

Researchers used generative AI models to discover over a million new antibiotic molecules, many of which exhibited strong efficacy in preclinical trials. AI models trained on mass spectrometry data efficiently detected antimicrobial resistance in bacterial strains. CNNs were also applied to classify Gram-stain morphologies with 95% accuracy.[4]

Similarly, oncological imaging applies AI to detect and classify tumors, predict treatment responses, and track patient outcomes across multiple cancer types. In cardiology, AI improves detection, segmentation, and diagnosis of coronary artery disease, heart failure, and vascular anomalies.

Abdominal imaging uses AI to optimize liver, pancreatic, and renal lesion identification. Radiomics-driven analytics integrate imaging features, clinical data, and outcomes to predict disease risk, survival, and therapeutic efficacy.

Across these diverse studies, AI consistently enhances diagnostic accuracy and workflow efficiency, indicating profound potential for personalized medicine and better patient management overall.[5]

Ethical and Practical Considerations

The integration of AI in healthcare presents significant ethical and practical challenges, particularly in clinical decision-making, patient care, and data security. While AI enhances diagnostic accuracy, predictive analytics, and personalized treatments, its reliance on large volumes of sensitive health data raises concerns regarding patient privacy, data protection, and informed consent.

The risk of algorithmic bias, often due to the underrepresentation of marginalized populations in training datasets, can exacerbate disparities in healthcare access and treatment outcomes.[6,7]

To address these concerns, regulatory frameworks such as the General Data Protection Regulation (GDPR), Medical Device Regulation (MDR), and AI Act have been established to ensure transparency, accountability, and fairness.

These laws mandate data protection, ethical AI deployment, and patient safety. Compliance prevents biases, safeguards privacy, and ensures AI complements doctors rather than replacing them, maintaining ethical and practical medical standards.[6,7]

The European Union (EU) AI Act categorizes AI-based medical technologies as high-risk, requiring stringent compliance measures to guarantee reliability and patient safety. Liability issues also arise, particularly in determining whether responsibility for AI-related errors should fall on physicians, developers, or healthcare institutions. The Artificial Intelligence Liability

Directive (AILD) seeks to provide legal clarity on this matter.[6,7]

Moreover, AI's impact on the doctor-patient relationship is crucial. Automation should support, not replace, human decision-making to preserve trust, empathy, and ethical medical practice. Future governance should prioritize human oversight, inclusivity, and equity to ensure AI-driven healthcare remains patient-centered and ethically sound.[6,7]

Conclusion: Balanced Evaluation and Future Potential

AI is transforming medical diagnostics, offering greater accuracy, efficiency, and speed in disease detection. AI-driven tools enhance imaging interpretation, biosignal analysis, and decision support, improving patient outcomes. Its strengths include rapid diagnosis, scalability, and consistency, but human doctors remain essential for contextual understanding, intuition, and complex case management.

Despite AI's advancements, challenges such as data bias, ethical concerns, and interoperability issues hinder full integration. Regulatory frameworks like GDPR, MDR, and the EU AI Act aim to ensure transparency, accountability, and fairness.

Future developments, including Quantum AI and General AI, hold promise for enhanced diagnostics but require robust ethical and legal guidelines.

Ultimately, AI complements rather than replaces medical professionals. A balanced approach that leverages AI for efficiency while maintaining human oversight is key to maximizing its potential in healthcare. Future research should focus on improving AI's reliability, inclusivity, and integration into clinical practice.

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- The Pros and Cons of Healthcare Chatbots
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Breaking barriers in life science innovation with AI and connected data

Research and development teams rely on high-quality data to guide their decisions. They also stand to benefit from the use of generative AI to speed up discovery, along with more streamlined workflows that better connect research with manufacturing.

This article explores practical ways to achieve these goals.

When organizations move too slowly, the market moves on

Companies across every industry rely on the speed of their internal innovation cycles to stay competitive in markets driven by constant change and continuous improvement. But moving quickly from discovery to development to commercialization is no easy task.

Many organizations find themselves held back by unmanageable data silos, overly complex workflows, and fragmented infrastructures that prevent R&D and manufacturing teams from operating in sync.

To overcome these hurdles, innovators need closer collaboration between internal functions, such as manufacturing, labs, and quality teams, and external forces like customer demands and commercial partnerships.

At the heart of effective collaboration is one critical component: data. Whether collaboration is embedded in company culture or driven by strategic goals, access to real-time, high-quality scientific data and analytics is essential for building productive internal and external relationships.

These relationships are what enable faster decisions and better, more agile outcomes across the research and manufacturing value chain.

To make this possible, companies need an integrated data analysis environment, along with a dependable connection to accurate, contextualized internal and external data. The life sciences industry, in particular, has laid out a strong roadmap for achieving these goals.

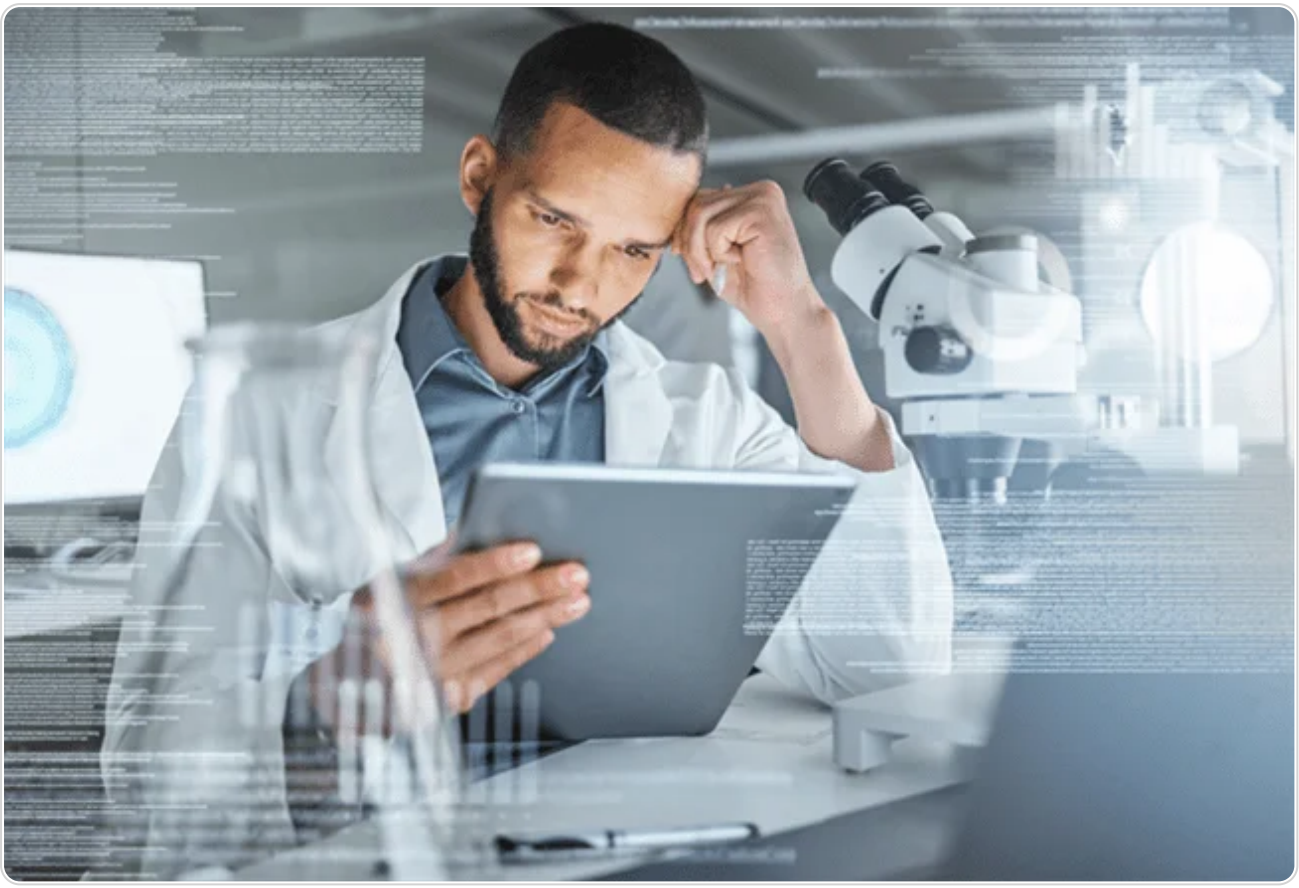


Image Credit: LabVantage Solutions

Lessons from the life sciences: Putting R&D on the fast track

Patients rely on life science companies to bring new drugs to market quickly, but doing so remains a significant challenge in an industry long constrained by breakdowns between R&D and manufacturing, supply chain issues, scale-up difficulties, complex development pathways, and strict regulatory requirements.

Despite these longstanding obstacles, the industry successfully discovered, approved, and deployed COVID-related therapies in just two years. This remarkable acceleration was made possible through the use of high-quality, real-time scientific data that compressed innovation timelines from years into months.

Traditional, time-consuming methods of experiment design were replaced by digitally enabled workflows that provided immediate access to critical clinical data.

Beyond just accessing data, success hinged on the ability to analyze it effectively.

Predictive AI models were used to contextualize trial data and identify vaccine candidates with a high likelihood of success. AI-driven platforms also helped detect and resolve potential

supply chain and manufacturing bottlenecks early, supporting faster, more confident downstream decisions and enabling rapid commercial scale-up once approvals were granted.

Image Credit: LabVantage Solutions

This collaborative, data-first model has reshaped the life sciences landscape—but its value extends beyond healthcare. Organizations across industries can apply these same principles to remove operational barriers, maximize returns on innovation investments, and accelerate the delivery of meaningful products to market.

Rapid innovation starts with combining the right solutions in the right way

The LabVantage suite of AI-powered solutions was initially designed to accelerate drug discovery and clear the go-to-market pathway for precision medications. This advanced toolset now enables product innovators across a range of industries to work in a much more rapid and streamlined manner.

The LabVantage suite of technologies has enabled R&D labs in its customers' organizations to achieve:

- 50 % reduction in analysis effort.
- 60 % reduction in validation effort.
- $1 million reduction in cost per laboratory.

LabVantage supports its customers in removing potential R&D barriers, developing streamlined organization-wide workflows, and implementing an integrated data environment designed to drive rapid and forward-looking decisions via a range of fit-for-purpose solutions.

The LabVantage LIMS platform

The LabVantage LIMS platform has been designed to fit seamlessly into customers' existing workflows.

It's a fully integrated, code-free laboratory informatics platform that affords users a single, scalable, user-friendly interface for accessing LabVantage's Laboratory Information

Management System (LIMS), Lab Execution System (LES), Scientific Data Management System (SDMS), Electronic Lab Notebook (ELN), and advanced analytics.

LabVantage Analytics, powered by tcgmcube™

Discovery can be accelerated, lab throughput can be increased, and downtime can be reduced, thanks to LabVantage Analytics' AI-powered predictive analytics tools designed to connect users to actionable business insights.

LabVantage Analytics provides innovators a range of benefits, including:

- A single source of truth for all internally generated unstructured and structured data.
- Interactive dashboards and visualizations with powerful drill-down features.
- A comprehensive library of more than 1000 statistical and AI/ML models designed to support low-code AI workflows.

AILANI for semantic integration and search

The AILANI deep learning platform provides R&D teams with the analytical skills of a data scientist alongside the super-intelligence and efficiency of advanced AI-driven algorithms. The AILANI platform provides an intuitive interface able to answer users' R&D questions across proprietary and public sources. The system can:

- Recognize users' initial intentions and search for relevant insights across a range of disparate data sources.
- Facilitate groundbreaking research, discover hidden relationships, and promote interdisciplinary collaboration.
- Allow teams to access the data lake: a new data architecture able to meet today's need for the rapid analysis of diverse internal and external data types

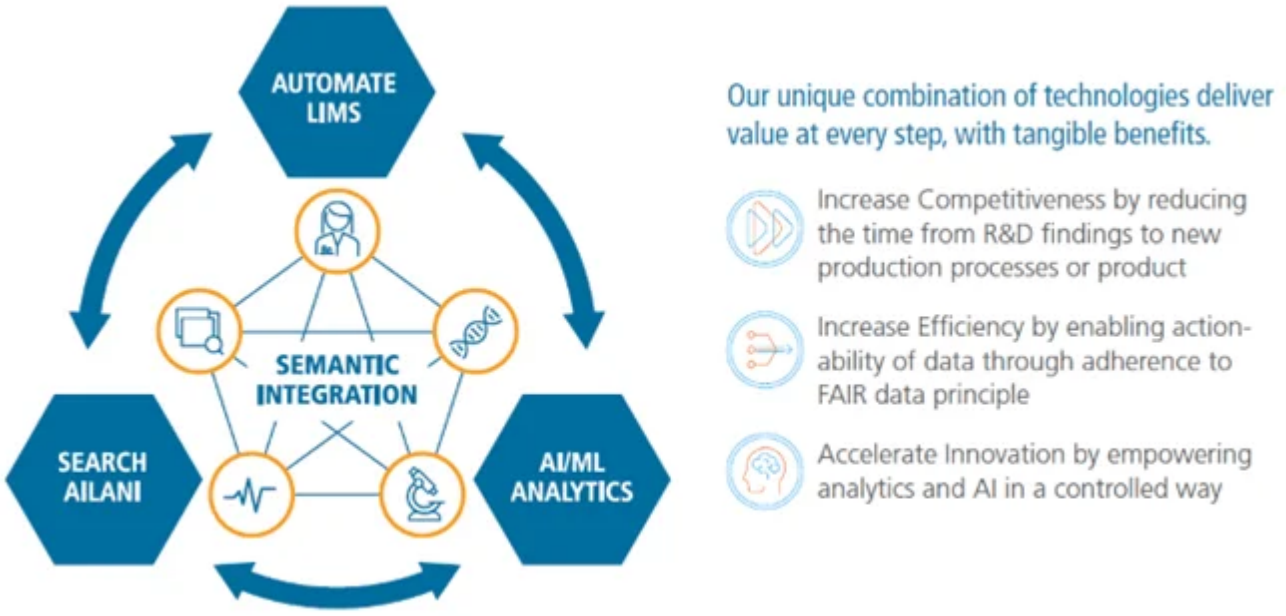


Image Credit: LabVantage Solutions

Summary

LabVantage provides an ideal solution for organizations whose growth is limited by the absence of a focused, efficient research funnel that integrates seamlessly with manufacturing operations.

Designed with these challenges in mind, LabVantage technologies enable users to respond quickly and collaboratively to new discoveries, shifts in market demand, and the evolving needs of customers and partners.

Acknowledgments

Produced from materials originally authored by LabVantage Solutions, Inc.

About LabVantage Solutions

LabVantage Solutions, Inc. is the leading global laboratory informatics provider. Our industry-leading LIMS and ELN solution and world-class services are the result of 35+ years of experience in laboratory informatics. LabVantage offers a comprehensive portfolio of products and services that enable companies to innovate faster in the R&D cycle, improve manufactured product quality, achieve accurate recordkeeping and comply with regulatory requirements.

LabVantage is a highly configurable, web-based LIMS/ELN that powers hundreds of laboratories globally, large and small. Built on a platform that is widely recognized as the best in the industry, LabVantage can support hundreds of concurrent users as well as interface with instruments and other enterprise systems. It is the best choice for industries ranging from pharmaceuticals and consumer goods to molecular diagnostics and bio banking. LabVantage domain experts advise customers on best practices and maximize their ROIs by optimizing LIMS implementation with a rapid and successful deployment.

Researchers develop new approach to improve the accuracy of RNA sequencing

A team at NDORMS, University of Oxford has developed a new approach to significantly improve the accuracy of RNA sequencing. They pinpoint the primary source of inaccurate quantification in both short and long-read RNA sequencing, and have introduced the concept of "majority vote" error correction leading to a substantial improvement in RNA molecular counting.

Image Credit: NDORMS, University of Oxford

Accurate sequencing of genetic material is crucial in modern biology, particularly for comprehending and addressing diseases linked to genetic anomalies. However, current methodologies encounter substantial constraints. In a landmark study, an international consortium of researchers, led by Adam Cribbs, Associate Prof in Computational Biology, and Jianfeng Sun, Postdoctoral Research Associate at the Botnar Institute, University of Oxford, have developed an innovative method to correct errors in PCR amplification – a widely used technique used in high-throughput sequencing. By pinpointing PCR artefacts as the primary source of inaccurate quantification, the research, published in Nature Methods, addresses a long-standing challenge in generating accurate absolute counts of RNA molecules, which is crucial for various applications in genomics research.

The researchers focused on Unique Molecular Identifiers (UMIs), which are random oligonucleotide sequences used to remove biases introduced during PCR amplification. While UMIs have been widely adopted in sequencing methods, the study reveals that PCR errors can undermine the accuracy of molecular quantification, particularly across different sequencing platforms.

> *PCR amplification, essential for most RNA sequencing techniques, can introduce errors, compromising data integrity. We tackled this by synthesizing UMI barcodes using homotrimer nucleotide blocks, enhancing error correction and enabling near-absolute RNA molecule quantification, markedly improving molecular counting accuracy."*
>
> *Jianfeng Sun, Postdoctoral Research Associate, Botnar Institute*

Homotrimers are nucleotide sequences consisting of three identical bases, for example AAA, CCC, GGG. By evaluating homotrimers nucleotide similarity, errors are detected and corrected through a "majority vote" method.

The study demonstrates that homotrimer UMIs significantly outperform traditional monomer UMIs in reducing false positive fold enrichment during the analysis of differentially expressed genes and transcripts (DEGs and DETs). This enhancement is vital for the accurate identification and quantification of DEGs or DETs, particularly in bulk sequencing approaches. Additionally, in single-cell sequencing, where extensive PCR amplification is often required, homotrimer UMIs have proven effective in mitigating the effects of PCR artefacts, thereby substantially improving the reliability of sequencing data.

'By constructing UMIs from homogenous blocks of nucleosides, we aimed to improve error correction in both short- and long-read sequencing, showcasing our commitment to enhancing sequencing technology applications,' says Associate Professor Adam Cribbs, senior author of the paper and Group Leader in computational biology.

This research has profound implications. By rectifying PCR errors in UMIs, it greatly boosts molecular quantification accuracy in various sequencing applications. It's a vital tool for researchers in bulk RNA, single-cell RNA, and DNA sequencing, enabling accurate gene expression and molecular profile analyses. Enhanced UMI error correction not only reduces

the incidence of false positives but also offers multiple diagnostic applications, especially in scenarios necessitating longitudinal analysis of samples.

Source:

NDORMS, University of Oxford

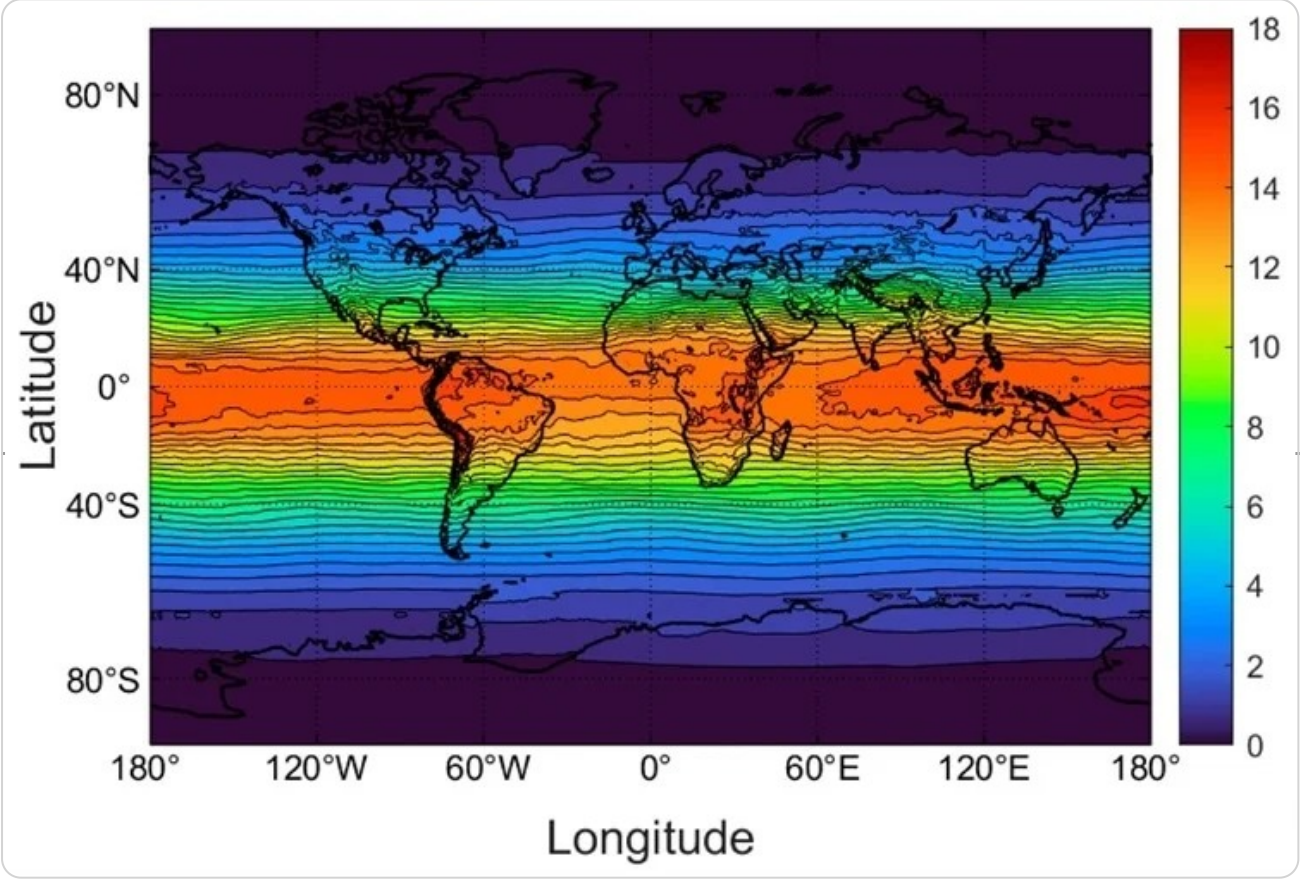
Journal reference:

Sun, J., *et al*. (2024). Correcting PCR amplification errors in unique molecular identifiers to generate accurate numbers of sequencing molecules. *Nature Methods*.
doi.org/10.1038/s41592-024-02168-y

Personalized vitamin D guidelines based on latitude and skin type could tackle deficiencies

In a recent study published in the journal *Nutrients*, researchers calculated indicative exposure times for maintaining vitamin D status as a function of latitude, month, and skin type, considering clear-sky and all-sky conditions for an ambulatory person in modest clothing.

The study underscores the importance of personalized approaches to assessing nutritional needs. It highlights the interplay between oral intake, sunlight exposure, and geographical factors, which can inform strategies for addressing widespread vitamin D deficiencies across diverse populations.



Midday mean clear-sky UVI values averaged over the days of March 2004–2020. While generally latitude-dependent, the UVI is also influenced by column ozone (less in the Southern Hemisphere, especially at high latitudes) and altitude (most noticeable with the Andes on the west coast of South America). Study: Globally Estimated UVB Exposure Times Required to Maintain Sufficiency in Vitamin D Levels

Background

Vitamin D is crucial for musculoskeletal health and has various other health benefits, but deficiencies are prevalent, partly due to inadequate dietary sources and limited sunlight exposure. Public health strategies often involve food fortification or supplementation, yet the challenge lies in balancing vitamin D synthesis with the risks of excessive sun exposure.

About the study

The study aims to provide nuanced guidance by considering factors like latitude, skin type, and time of year to inform national policies regarding food fortification, supplementation, and sun exposure. Thus, it addresses the complexity of maintaining optimal vitamin D levels while minimizing health risks.

Researchers utilized global surface ultraviolet (UV) irradiance data obtained from the Global Ozone Monitoring Experiment (GOME). This data was initially quantified as the UV index (UVI) and later converted to Vitamin D effective UV irradiance.

These data were sourced from instruments attached to European Space Agency (ESA) satellites, providing continuous coverage from 2002 to the present via the TEMIS portal. The study focused on clear-sky UVI and all-sky data, incorporating cloud data where available, to determine UV levels.

To estimate the change in vitamin D status, the study employed calculations from a previous study, which relates exposure to UV in terms of standard vitamin D dose (SDD) to the change in circulating 25-hydroxyvitamin D (25OHD) levels.

The study considered one month for analysis. Initially, a simplified scenario of full-body exposure at noon under clear skies was assessed to calculate the dose required to maintain vitamin D levels.

The analysis involved several adjustments to this baseline calculation, including considerations for skin surface area, skin type (ranging from I to VI with higher numbers indicating darker skin), orientation, and potential variations in UV exposure due to clouds.

These adjustments were made to provide more realistic and applicable exposure times for different scenarios, such as standing upright and wearing modest clothing. Additionally, corrections were applied for darker skin types at higher latitudes and seasonal variations in UV levels due to clouds.

Overall, the methodology aimed to provide tailored exposure recommendations, considering

various environmental and personal factors that affect vitamin D synthesis.

Findings

The analysis revealed distinct exposure times required for maintaining vitamin D levels under clear-sky and cloudy-sky conditions.

Under clear skies, exposure times for white skin types ranged from 3 to 15 minutes at every 10 degrees of latitude, with longer durations needed at higher latitudes due to lower sun angles and Antarctic ozone depletion.

Skin type V individuals required increased exposure times at all latitudes compared to skin types I–IV, while skin type VI individuals faced even longer exposure times, especially at higher latitudes.

In contrast, under cloudy skies, the impact of cloud cover varied across latitudes and seasons, extending exposure times by about 15% in equatorial regions and up to an additional 60% at high latitudes.

Despite this, maintenance doses remained achievable for white skin types, even at high latitudes outside the Vitamin D Winter period. However, for skin type VI individuals, exposure times exceeding 15 minutes in equatorial regions and well over an hour at higher latitudes were necessary under all-sky conditions.

Overall, the study underscores the complex interplay between environmental factors, skin type, and UV exposure in maintaining vitamin D levels, highlighting the need for personalized recommendations to account for diverse population needs and local climatic conditions.

Conclusions

The results of this study highlight the importance of balancing oral intake with cutaneous synthesis of vitamin D, particularly through sunlight exposure, to address deficiency effectively. They also provide valuable insights into the feasibility of maintaining vitamin D levels through sun exposure, considering latitude and skin type variations.

Maintaining vitamin D status is challenging during winter due to reduced sunlight availability, especially at higher latitudes. This underscores the need for alternative strategies such as increased sun exposure during summer months or dietary supplementation. Changing lifestyles and occupational habits may impact vitamin D synthesis, particularly for individuals

with deeply pigmented skin at higher latitudes.

The study's strengths include its comprehensive approach, which provides guidance on sun exposure durations for different skin types and latitudes. However, limitations such as assumptions about skin area exposure and lack of consideration for cultural practices are acknowledged.

Future research could explore additional factors influencing vitamin D synthesis, such as age and ethnicity, and refine exposure recommendations based on a more nuanced understanding of individual needs and behaviors. Overall, the study's findings contribute valuable insights to guide public health strategies for addressing vitamin D deficiency worldwide.

Journal reference:

- Globally estimated UVB exposure times required to maintain sufficiency in vitamin D levels. Kift, R.C., Webb, A.R. *Nutrients* (2024). DOI: 10.3390/nu16101489, https://www.mdpi.com/2072-6643/16/10/1489