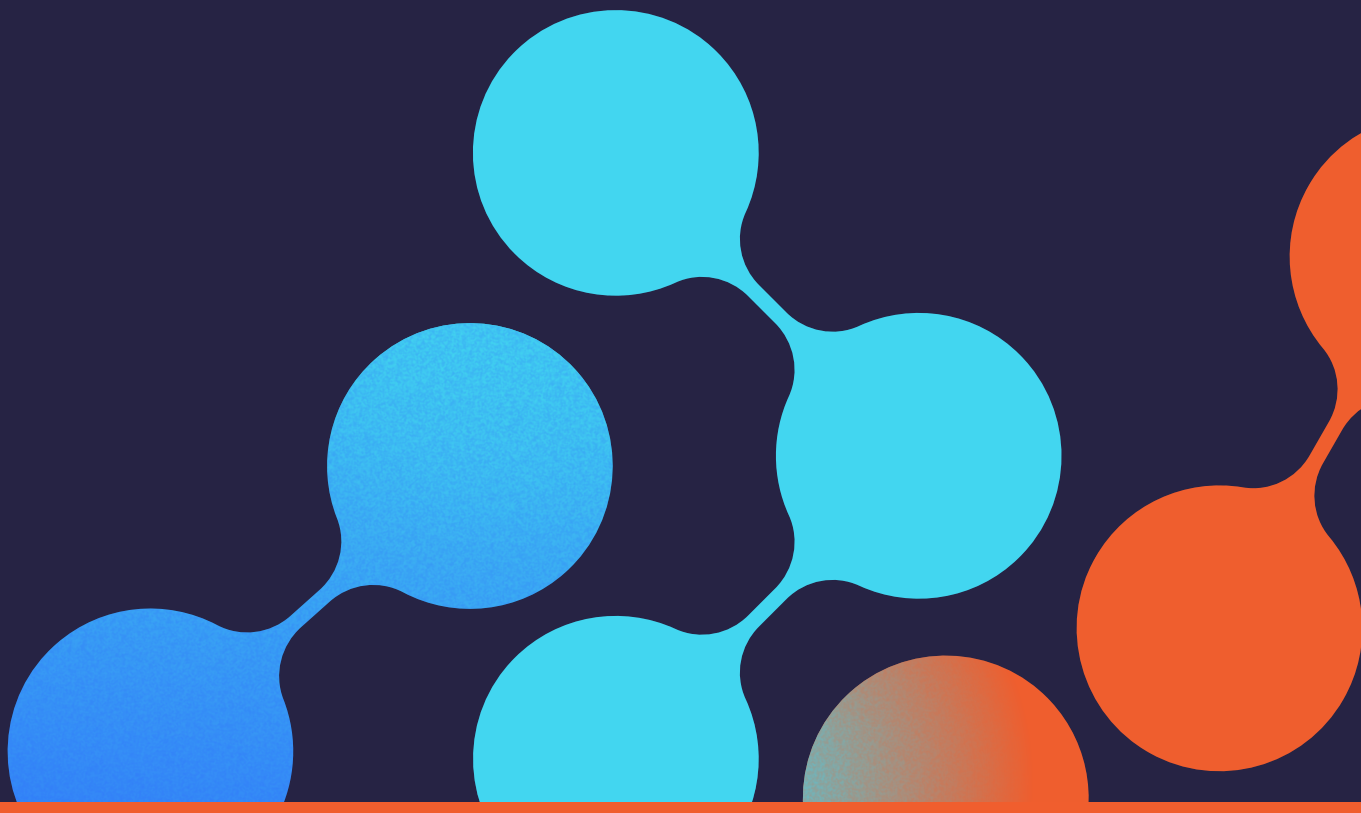
TITIAN SOFTWARE MOSAIC | Labguru

The Future of Digital Lab Operations

How AI and Technological Advancements Will Change the Lab of the Future



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The life sciences industry has long been an innovator for new technologies and ways of thinking, driven by a passion and need for accelerated drug discovery, higher throughput, and accurate, reproducible results. Today, lab operations are undergoing a profound transformation, driven by a combination of technological advancements — such as artificial intelligence (AI), robotics, and increasing volumes of data — alongside evolving research demands and industry funding challenges.

With the advent of AI in more publicly accessible tools, such as ChatGPT, the prominence of a once behind-the-scenes technology is driving new conversations and ideas for how it can be used in the life sciences industry. For example, specialist large language models (LLMs) are being developed to meet the needs of discovery research.

While some scientists yearn for 24/7 lab operations, made possible by robotics and smart automation where AI takes the night shift, others are simply looking for methods to speed up analysis and provide more in-depth data on results.

In this survey-based white paper, we will explore how forward-thinking labs are starting to embrace next-generation technologies, AI-powered efficiency, seamless data automation and integration to move toward smarter, faster, and more scalable science—and why those that don't may risk falling behind.

In January 2025, Titian Software and Labguru surveyed the life sciences industry to understand the trends and innovations that matter most in digital lab operations. 155 people completed the survey. These findings represent the current state of automation and data management, the evolution of AI in life science and its potential impact in lab operations.

KEY FINDINGS

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DATA OVERLOAD THE BIGGEST CHALLENGE FOR LABS

When asked to select the three challenges in lab operations that are most likely to drive change in the lab: 54% of respondents chose data overload / data management, representing a potential challenge around how data is managed today. 53% of respondents selected funding and cost pressures, highlighting a key challenge across the industry, regardless of organization size. 49% of respondents picked automation of manual processes, reflecting on a challenge that the industry has faced for some time.

PROCESS AUTOMATION WILL DRIVE CHANGE

When asked to select the three trends that will drive the most change in lab operations, 77% of those surveyed believe automation will drive change by 2026, echoing the challenge of manual process automation. 75% of those surveyed stated AI / Machine Learning will play a big role in driving change by 2026.

TECHNOLOGY ADOPTION: INVENTORY MANAGEMENT FIRST

Aligning with the challenges being faced in the industry today, automation and AI continue to be leading catalysts for change. However, while AI and automation are seen to be driving change in the industry, fixing inventory management is the highest priority with 65% of respondents stating that inventory (reagents and supplies) management is the top technology they're interested in adopting.

KEY FINDINGS

LABS STILL NOT DIGITAL-READY

As it stands, only 15% of labs are fully digitized, while 50% still have significant manual processes, reflecting the challenges that come with adopting digital processes and automation.

AI FOR MANAGING MASSIVE DATA GENERATION

When asked about the most significant role AI will play in lab operations, the top choice, selected by around a quarter of respondents (24%) was managing the massive volumes of data generated from experiments, instruments, and other sources. This was followed by accelerated drug discovery (19%) and improving data documentation and integration (17%).

THE TIMELINE FOR AI AND NEXT-GENERATION TECHNOLOGIES

While 45% of survey respondents plan to implement next-generation lab technologies such as AI and advanced robotics within 2 years, 25% stated that they either have no current plans or expect it to be longer than 5 years to implement next-generation lab technologies.

CONTENT

DEFINING DIGITAL LAB OPERATIONS

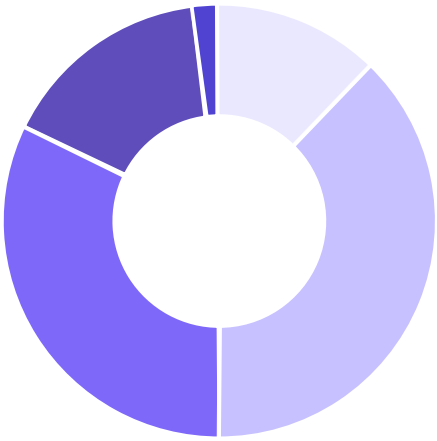
Lab operations refer to the day-to-day activities, systems, and processes that support the efficient, compliant, and safe functioning of a biopharma lab. This includes all manner of processes from inventory management, sample management and experimental workflows to equipment maintenance and regulatory compliance.

It's all about ensuring that research, development, and quality control activities are carried out with the proper controls required to deliver reliable and reproducible results.

Digital lab operations build on the above by using technology to enhance the quality and speed of research, while still delivering the required results.

DIGITAL LAB MATURITY

Despite the growing trend toward digital transformation in the life sciences sector, our findings reveal a significant gap in implementation. Just 15% of respondents reported that their labs are fully digitized, leveraging advanced automation technologies and sophisticated data analytics to streamline operations and enhance decision-making. In contrast, more than a third (35%) of labs are still heavily dependent on manual processes, suggesting that many participants remain in the early stages of their digital maturity journey.



How would you assess your laboratory's current level of digital maturity?

Just beginning to adopt digital tools	15%
Partially digitized, with significant manual processes	35%
Moderately digitized, with integrated digital workflows	34%
Fully digitized, featuring advanced automation and analytics	15%
Other	1%

The overall breakdown of digital lab maturity might not come as a surprise with large pharma and biotechs leading the way in terms of full and moderately digitized labs.

Nearly half (48%) of those that said their lab was fully digitized represented labs in large pharma/biotech.

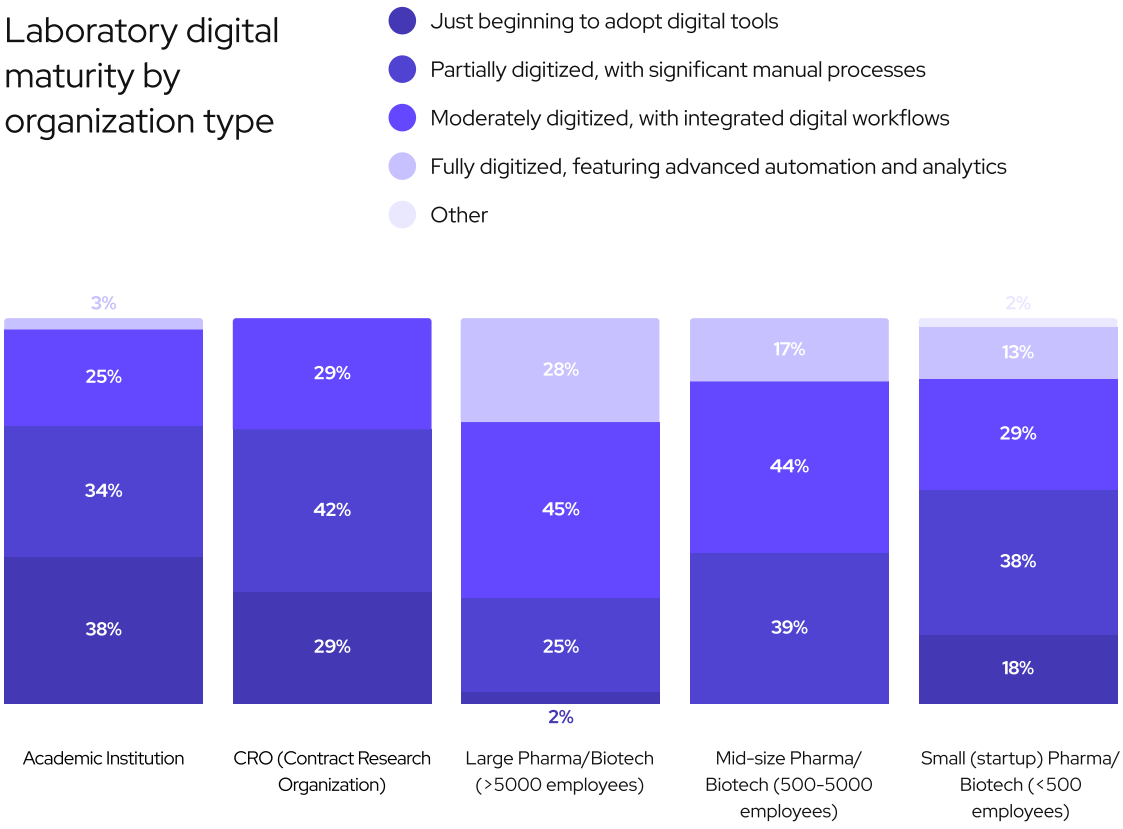
At the other end of the scale, academic institutions, small / start-up pharma and biotechs accounted for the majority (83%) of labs that are only just beginning to adopt digital tools.

DIGITAL LAB MATURITY

Among labs that are still heavily reliant on manual processes, those categorized as partially digitized or just beginning to adopt digital tools, pharma and biotech companies of all sizes are well represented. Notably, small to mid-sized organizations account for 50% of this group, with 38% of small pharma/biotech and 39% of mid-sized pharma/biotech still navigating high levels of manual workflows.

Interestingly, 25% of large pharma and biotech companies also fall into the partially digitized category. This highlights that even well-resourced organizations are not immune to these hurdles. As AI and emerging technologies continue to evolve, they may play a critical role in accelerating this transition and reducing reliance on manual processes.

Laboratory digital maturity by organization type

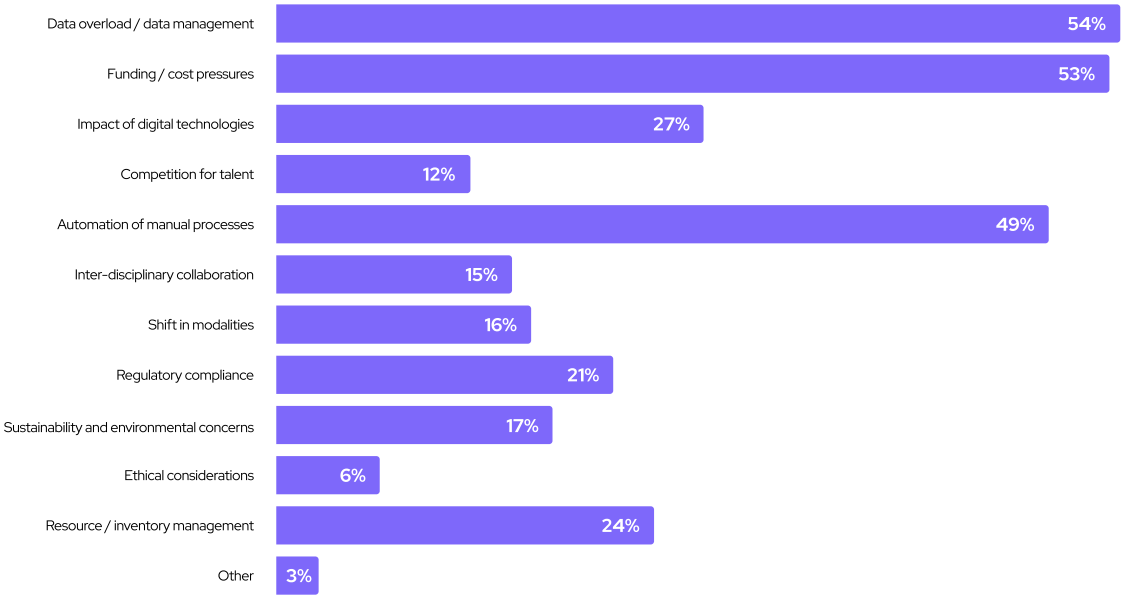


THE CHALLENGES DRIVING CHANGE

When survey respondents were asked about the lab operation challenges that are most likely to drive change, three distinct challenges came out on top:

- Data overload / data management (54%)
- Funding / cost pressures (53%)
- Automation of manual processes (49%)

What challenges in lab operations are most likely to drive change in your lab? (Choose three)



THE CHALLENGES DRIVING CHANGE

The survey responses clearly spotlight an issue with how labs are going to manage the increasing volume of data produced. While it's an area that new AI technologies could play a pivotal role in, organizations will need learn how to navigate around siloed systems and disconnected data to make it meaningful for AI.

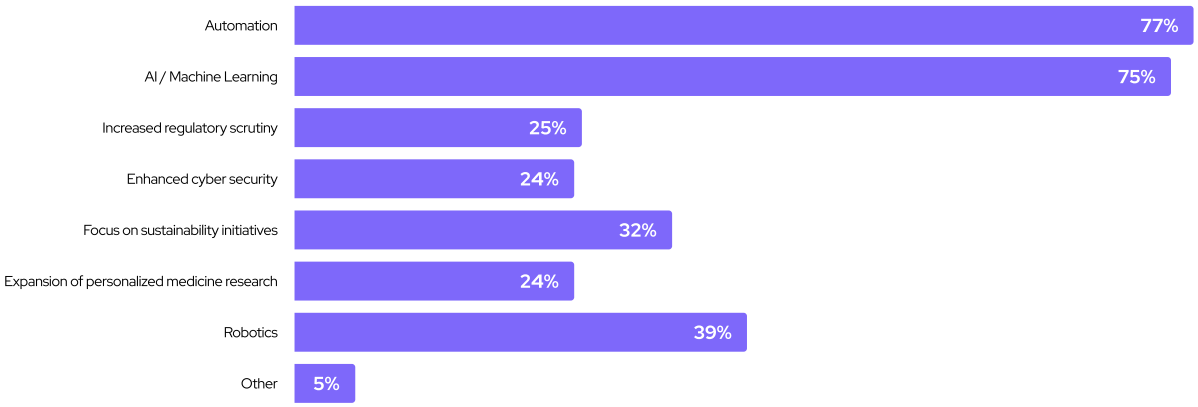
AI could also help solve both the funding and automation challenges highlighted, as it takes on the role of optimising lab efficiency and ensuring the output of data is usable. This could save a lot of time for those working in the lab, providing time back to the scientists to concentrate on the work that matters, rather than sifting through data and running processes that could be automated.

THE TRENDS DRIVING CHANGE: AUTOMATION AND AI

As labs continue to navigate the complexities of digital transformation, automation and intelligent technologies are emerging as critical enablers of progress. A significant 77% of those surveyed believe automation will be a key driver for change, echoing the ongoing challenge of reducing reliance on manual processes and the urgent need to adopt more efficient, forward-thinking approaches.

This is reinforced by the 75% of respondents who expect AI and machine learning to play a transformative role in lab operations by 2026.

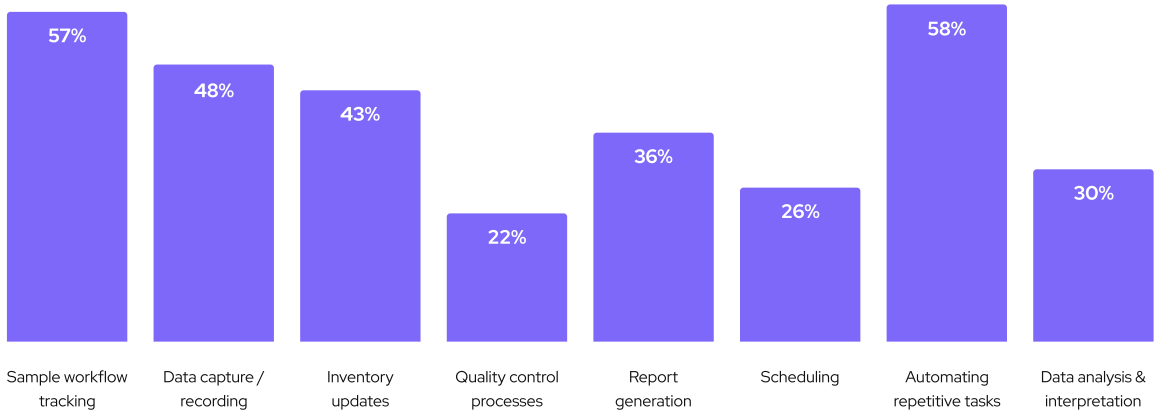
Which of the following trends do you believe will drive the most change in lab operations by 2026? (Choose three)



THE TRENDS DRIVING CHANGE: AUTOMATION AND AI

Turning to the lab processes that respondents felt would benefit most from automation, there was a heavy weighting towards automating repetitive tasks (58%), sample workflow tracking (57%), and data capture / recording (48%).

Which lab processes would benefit the most from automation? (Choose three)



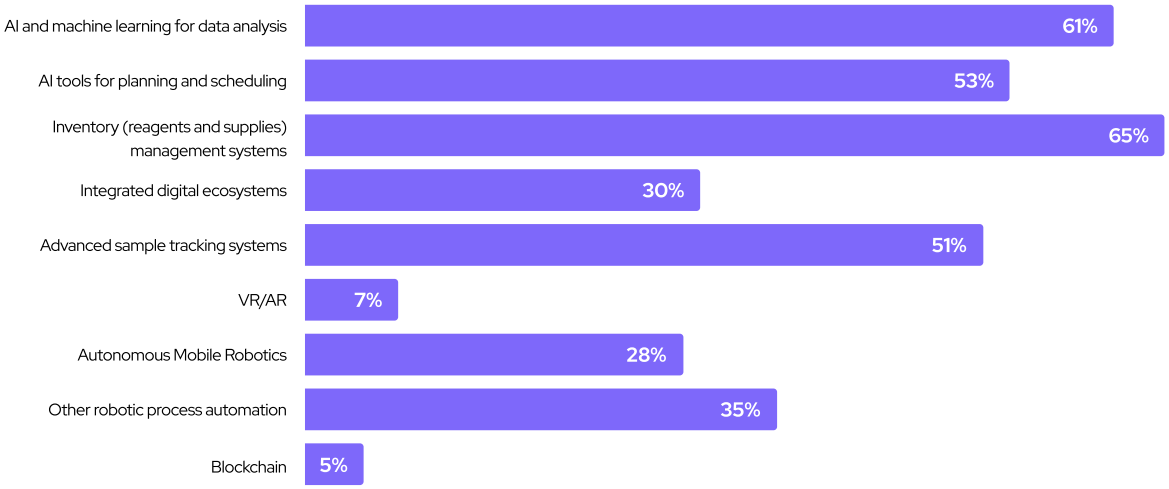
Although automation isn't new to labs, some of the drivers for automation are changing as AI begins to play a larger role in both lab automation and data management.

While today's use cases of lab automation may commonly include automated stores, liquid handling and robotic arms, tomorrow's lab will augment their automation capabilities with AI and machine learning. These new tools will revolutionize data workflow automation, supporting the integration of instruments in the lab, while orchestrating data to ensure it is usable and accurate.

TECHNOLOGY ADOPTION: INVENTORY FIRST

AI and automation might be trend-setters for upcoming change, but inventory management is still seen to be the highest priority with 65% of respondents stating that inventory (reagents and supplies) management is a technology they're interested in adopting.

Which emerging technologies are you most interested in adopting? (Choose three)



Interestingly, AI tools for data analysis (61%) and planning and scheduling (53%) were also high up the list of emerging technologies that respondents would adopt, proving more popular than autonomous mobile robots (28%) and other robotic process automation (35%).

WHERE AI FITS INTO THE LAB

It might not yet come in the form of a robot assistant (at least for most labs), but AI is set to play a fundamental role in optimizing digital lab operations. With access to massive data sets available from the varying digital lab platforms, AI can:

- Enable predictive insights
- Improve sample tracking and scheduling
- Reduce human error
- Accelerate data interpretation and decision-making
- Design experiments
- Generate hypotheses

This is to name but a few. The focus on automating work that is time consuming and takes away from the science is recognized by over 60% of respondents who are keen to adopt AI and machine learning for data analysis, while over 50% also see the potential that AI tools have for planning and scheduling.

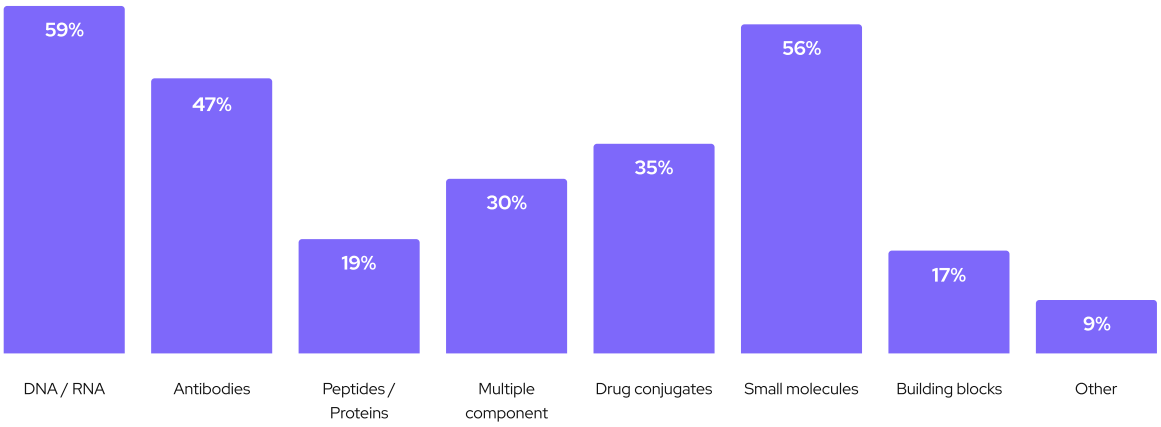
If lab technology solution providers choose to take this into account, we'll likely start seeing more AI-based automation coming into play, helping to unify and integrate data across platforms.

DATA MANAGEMENT: MULTIPLE MODALITIES AND PLATFORMS

Data is one of the things that many labs have in abundance, with 54% of survey respondents stating that data overload and management is one of the most likely challenges to drive change in their lab.

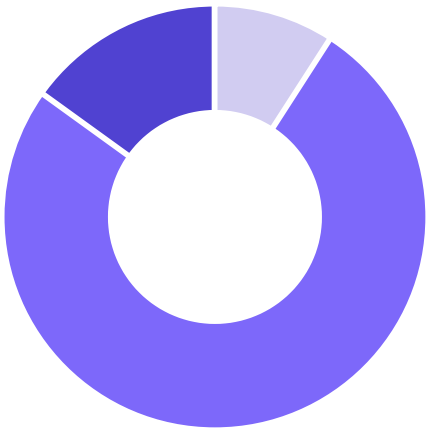
It's not just the volumes of data that causes challenges; it's also the complexity and diverse range of modalities that need to be considered, as this creates new challenges around storage, automation, data acquisition, and compliance and regulation.

What modalities does or will your lab manage? (Select all that apply)



DATA MANAGEMENT: MULTIPLE MODALITIES AND PLATFORMS

What we can see from the data is that while small molecules are still present, additional modalities are making the management challenges ever more complex, and 76% of those surveyed stated they are only somewhat prepared to handle this increase in sample types.



How prepared is your lab to handle this increase in sample types?

Not prepared, urgently need solutions	9%
Somewhat prepared, but facing challenges	76%
Very well-prepared with dedicated systems in place	15%

Currently, 55% of labs utilize Inventory Management Software, while 65% express interest in adopting new Inventory Management Systems. This signals a rising demand for more sophisticated and integrated solutions.

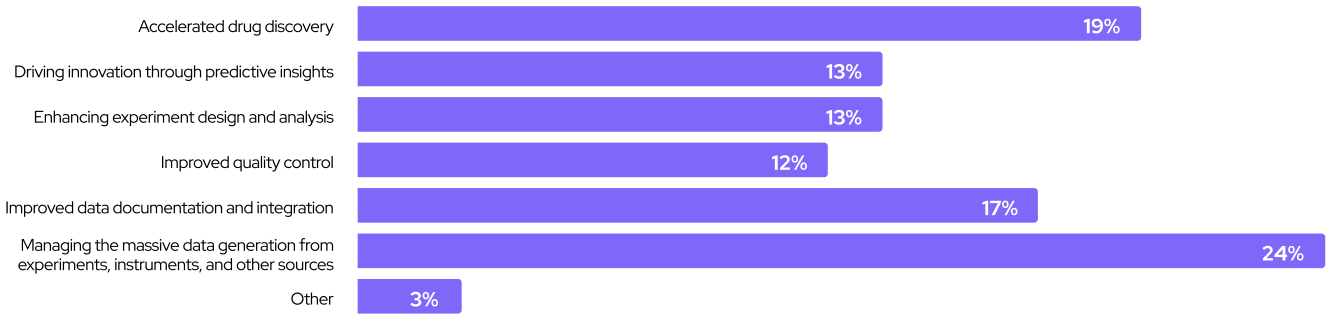
If we recognize data as being the fuel for AI, and the precursor to AI adoption, then a significant challenge that labs of all sizes need to address is the disconnect of platforms that they have in place today. A lab might have any combination of platforms and tools including (but not limited to): LIMS, ELNs, inventory management tools, screening data analysis, substance registration software, workflow management, and specific lab equipment automation software.

Consequently, this disconnect severely limits automation opportunities, complicates analyses, and prevents the intelligent use of information, potentially compromising lab efficiency, productivity, and quality.

For AI, fragmented datasets can lead to a lack of proper context and understanding of the data, and if you don't have the experimental protocol, the instrument logs, and proper metadata, AI tools can reach wrong conclusions.

FOUNDATIONAL ROLE OF DATA FOR AI

What do you believe will be the most significant role of AI in lab operations over the next five years? (Pick one)



When asked about the most significant role of AI in lab operations over the next five years, respondents echoed the sentiment for efficiency, with managing the massive data generation from lab experiments being the top choice (24%), followed by accelerated drug discovery (19%), and improving data documentation and integration (17%).

This shows a fascinating trend, in which labs are looking to make use of AI technology that is still new to the market to drive the industry forward, yet nearly 50% of those surveyed are only just beginning to adopt digital tools or are only partially digitized, with significant manual processes.

CAN WE TRUST AI WITH OUR DATA?

This is a highly debated question, not just in life sciences but in every industry right now. As we navigate a new normal where AI aims to take on operational tasks, we have to question what the longer-term implications of relying on AI are.

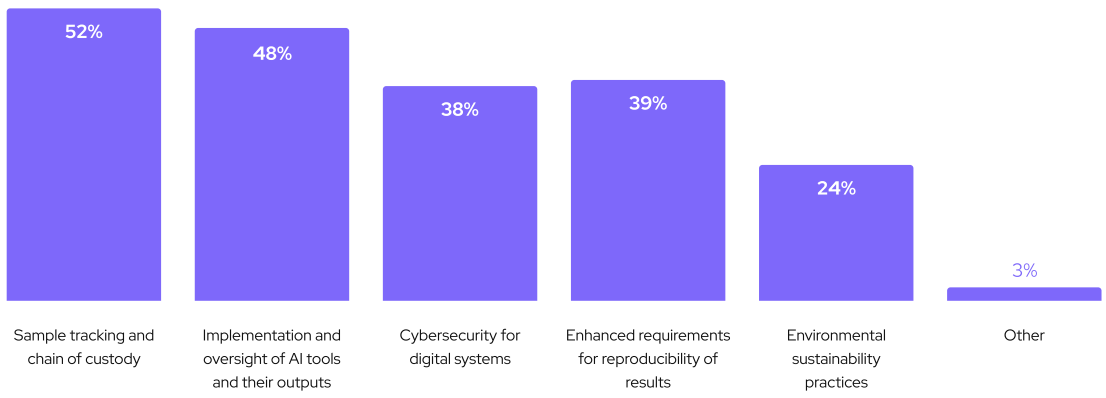
What happens when you ask Google's Gemini whether you can trust AI?

> ***"That's a really important and complex question! Whether we can "trust" AI isn't a simple yes or no, as it depends heavily on what aspect of AI we're talking about and the specific context."***

Despite AI's advanced automation capabilities and the enthusiasm to adopt it, you can see the hesitation to trust it in how people choose to implement it, the potential adoption timelines, and how people think it should be used in labs.

Labs also have to take regulatory compliance into account. As with any new technology coming into the lab, AI will need to be heavily scrutinized, and regulations around how and when it's used will be important. Over-reliance on AI could even lead to a loss of human oversight, which could be catastrophic for labs as we don't currently have all the evidence for how AI can perform long-term.

Which areas of lab operations are most likely to see enforced changes due to regulatory or market pressures? (Select all that apply)



CAN WE TRUST AI WITH OUR DATA?

Nearly half (48%) of respondents believe that the implementation and oversight of AI tools and their outputs will see enforced changes as a result of regulatory and market pressures. Also noticeable is that 39% said they think enhanced requirements for reproducibility of results will be enforced by regulatory and market pressures.

The overall view on how regulation and market changes will impact lab operations is skewed towards ensuring data integrity and security remains in place, possibly indicating fear of how AI could impact these areas.

To move forward confidently with AI in the lab and to trust it with lab data, organizations will need clearer guidance, ethical frameworks, and validation processes to ensure that AI complements the rigorous scientific standards. It's imperative that any new technologies coming into the lab don't alter the quality management and reproducibility of results.

FAIR data principles were created to support good data management and are increasingly becoming an industry standard. The adoption of the FAIR data principles of Findability, Accessibility, Interoperability, and Re-usability provide guidance to life sciences organizations on how to handle their data with the aim to promote data efficiency, quality and reproducibility.

It's possible that over time we might even see a "bring your own LLM" approach to AI, much in the same we have with data hosting in the past. This could alleviate some fears around how data is used by AI.

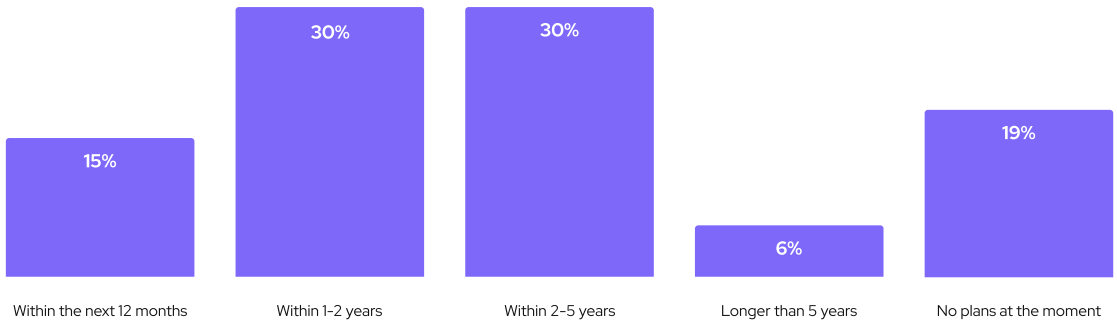
THE TIMELINE FOR AI

AI is coming to a lab near you, but possibly not as soon as you think.

While 15% of respondents plan to implement next-generation technologies like AI within the next 12 months, the majority see it being a longer-term timeline, with 30% stating they plan to implement AI in 1-2 years, another 30% said 2-5 years.

The remaining 25% don't have any plans or think it will be longer than 5-years.

How soon do you plan to implement next-generation lab technologies like AI or advanced robotics?



Breaking down the implementation timelines by organization type, the majority of pharma and biotech companies, regardless of size, plan to implement next-generation lab technologies (including AI) in the next 5 years.

THE TIMELINE FOR AI

How soon do you plan to implement next-generation lab technologies like AI or advanced robotics (by organization type)?

	Academic institution	CRO	Large Pharma / Biotech	Mid-size Pharma / Biotech	Small Pharma / Biotech
Within the next 12 months	13%	29%	20%	0%	22%
Within 1-2 years	22%	14%	35%	22%	36%
Within 2-5 years	22%	14%	37%	56%	24%
Longer than 5 years	9%	0%	5%	11%	0%
No plans at the moment	34%	43%	3%	11%	18%

The acknowledgment of AI being a market changer shows that people understand the benefits of AI in life sciences, but they are unsure as to how much we can trust what it offers right now.

While AI has been shown to enhance productivity, streamline decision-making, and reduce operational friction, there is still risk of bias, lack of transparency, and over-reliance, especially where the data isn't strong enough for AI to reasonably make decisions.

What we're seeing is a clear preference for AI to augment and support operations, not replace human expertise. AI is viewed as a tool, and something that will work with human oversight and, until trust is built, the timelines for AI adoption may be extended.

INDUSTRY OUTLOOK

INDUSTRY OUTLOOK

The life sciences industry is on the cusp of a significant shift toward AI-powered digital lab operations.

> ***"Big pharma is already ahead of the curve, with robust AI initiatives in motion. That momentum will inevitably trickle down to the lab level – and that's where we're helping shape the future."***
>
> Jonathan Gross, Group Chief Product Officer, Titian and Labguru

While the recognition of AI's potential for enhancing efficiency, accelerating discovery, and improving data management is widespread, the current state of digital maturity varies considerably across organization types. Data silos and a cautious approach to trusting AI remain key challenges to overcome in the industry.

The future of digital lab operations will likely involve a strategic integration of AI as a powerful tool to augment human capabilities, rather than a complete replacement. Building trust in AI will necessitate addressing concerns around bias, transparency, and regulatory oversight.

Ultimately, organizations can't afford to ignore the impact AI will have on the industry – it will not be a strategic advantage in the future, but not using AI will be a strategic disadvantage.

> ***"In this landscape, AI isn't a 'nice to have.' It's survival. It's about doing more with less - fewer experiments, more insights; fewer wasted cycles, and more predictive modelling.***
>
> ***Smart lab operations powered by AI can shield companies from economic turbulence and position them to lead where others can only react.***
>
> ***The next frontier isn't just technological. It's strategic. Companies that use AI to optimize their resources, reduce costs, and accelerate time to value will be the ones that thrive, regardless of which way the political winds blow."***
>
> Jonathan Gross, Group Chief Product Officer, Titian and Labguru

SURVEY RESPONDENT PROFILE

SURVEY RESPONDENT PROFILE

This white paper is based on the findings of Titian Software and Labguru's Future of Digital Lab Operations survey, which 155 people in the life sciences industry completed.

Survey respondents:
Breakdown of organization type

Academic Institution	21%
CRO (Contract Research Organization)	4%
Large Pharma/Biotech (>5000 employees)	26%
Mid-size Pharma/Biotech (500-5000 employees)	12%
Small (startup) Pharma/Biotech (<500 employees)	29%
Other	8%

Other organization types specified included: research lab for manufacturing, research and consulting lab, chemical company, small startup, carbon capture tech development and government.

HOW WE CAN HELP

HOW WE CAN HELP

The survey results clearly highlight key drivers that we've seen in the industry for some time, based around data and inventory management, along with the desire for more automation.

These drivers also create new challenges as increasing amounts of data require different tools, and before organizations can adopt AI, they need to ensure their current processes are in order.

AI and automation will have a profound impact on digital lab operations, but with the right help and support, navigating this evolving landscape doesn't have to be a challenge.

Mosaic and Labguru provide solutions that make digital lab operations a success.
By combining three key pillars of automation, data management, and AI — all underpinned by quality and compliance — our solutions can help you with every aspect of your digital lab operations and help your lab be prepared for whatever the future holds.

About Mosaic and Labguru

Titian Software and Labguru are leading providers of lab data management solutions for life science research and industry. Following the recent acquisition of both companies by Battery Ventures, Labguru has joined forces with Titian Software. Together, the companies serve more than 45,000 scientists and manage vast repositories of over one billion samples across 900+ companies and universities, including eight of the top 10 biopharma companies.

Mosaic is a leading sample management platform with more than 150 device and system integrations. Mosaic enables lab automation integration and orchestration across multiple types of biopharma labs.

Labguru is an integrated data management research-to-production platform combining an ELN, LIMS, inventory management, and AI-based informatics tools.

Book a meeting with an expert today

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