



**Opinion:**

# The Autonomous Digital Lab: Can Labs Truly Operate Without Humans?

By Dr. Sadiya Raja, Arcondis Global Head Lab Digitalisation Services

*The pace of digital transformation is accelerating, and scientific labs are no exception. Across the life sciences industry, labs are integrating automation, AI and robotics to improve efficiency, reduce errors, and accelerate discovery. The vision of an autonomous lab, where experiments run seamlessly with minimal human intervention, is becoming increasingly feasible.<sup>1,2</sup>*

**The question remains: Can labs truly operate without humans?** The short answer: not entirely. While automation will take over routine and repetitive tasks, human expertise will remain crucial for decision-making, troubleshooting, and innovation. Scientists are not being replaced but rather empowered by technology, shifting their roles from a focus on manual execution to strategic oversight and data-driven analysis.

## A NEW ERA OF COLLABORATION BETWEEN HUMANS AND MACHINES

Automation is reshaping labs, but not by eliminating the need for scientists. Instead, it is redefining their roles. Researchers will still be responsible for designing experiments, interpreting data, and making critical decisions, while automated systems handle repetitive, time-consuming tasks. In a high-throughput screening lab, for example, robots can plate samples, execute assays, and collect data. AI can analyse results, flag anomalies, and suggest optimisations.

Yet, human expertise remains crucial. Scientists must set research objectives, troubleshoot when things do not go as planned, and extract meaningful insights from complex data. The future lab will be a digitally integrated ecosystem where humans and machines work in tandem.

Researchers will use intuitive interfaces to orchestrate workflows instead of manually programming robots. AI-powered assistants will provide real-time insights, enabling scientists to focus on innovation rather than routine tasks.<sup>3</sup>

## THE EVOLVING ROLE OF HUMANS IN THE AUTONOMOUS LAB

The increasing adoption of automation does not diminish the need for human expertise, instead, it reshapes how scientists engage with the research process. Key areas where human involvement remains essential include:

1

### Research Strategy and Experiment Design

AI can generate hypotheses and suggest experimental designs based on existing data, but scientists will remain responsible for setting research goals and ensuring alignment with broader scientific and business objectives. Creativity, critical thinking, and domain expertise are essential in shaping meaningful experiments that drive innovation.

2

### Oversight and Quality Control

Although AI and automation systems are highly efficient, they are not infallible. Errors can occur due to data biases, unforeseen experimental conditions, or system failures. Scientists must oversee operations, validate data accuracy, and intervene when anomalies arise to ensure research integrity.

3

### Interpreting Complex Results

While AI can analyse large datasets and detect patterns, human intuition and expertise are required to contextualise findings, draw meaningful conclusions, and determine the next steps. Scientists must bridge the gap between computational insights and practical applications.

4

### Ethical Considerations and Compliance

Scientific research, particularly in industries such as pharma and biotechnology, must adhere to ethical standards and regulatory requirements. Humans will continue to play a vital role in ensuring that automation-driven research aligns with ethical guidelines, industry regulations, and societal expectations.

5

### Innovation and Breakthrough Discoveries

True scientific breakthroughs often result from unconventional thinking and unexpected discoveries, something AI struggles to replicate. Scientists bring intuition, creativity, and experience to the table, enabling them to make conceptual leaps that automation alone cannot achieve.



## EXAMPLE OF AN AUTONOMOUS LAB

One of the leading examples of an automated lab in action is Emerald Cloud Lab (ECL).<sup>4</sup> ECL is a fully automated, remote-controlled research facility that allows scientists to design and execute experiments from anywhere in the world. Unlike traditional labs, which require in-person operation of equipment, ECL leverages robotics and AI-driven automation to con-

duct experiments, collect data, and deliver results through a cloud-based platform.

While ECL demonstrates the potential of cloud-based autonomous labs, it also underscores the continued need for human oversight. Researchers are still responsible for defining experimental objectives, analysing results, and making critical decisions. The success of such labs depends on how effectively humans and automation collaborate to drive scientific progress.

## CHALLENGES OF THE AUTONOMOUS LAB<sup>5</sup>

While AI holds transformative potential, particularly in heavily regulated industries like healthcare, its adoption comes with significant challenges. The complexities and costs of compliance can temper the excitement of innovation. It is crucial to strike a balance between harnessing AI's power and ensuring its ethical and responsible use.

1

### Integration with Existing Infrastructure

Many labs rely on legacy systems and manual processes. Integrating new automation technologies requires significant investment in infrastructure, interoperability, and training.

2

### Data Security and Privacy Concerns

With an increasing reliance on cloud computing and AI-driven systems, protecting sensitive research data from cyber threats and ensuring compliance with data privacy regulations becomes a bigger area of concern. Cybersecurity has traditionally not been a priority, but organisations are beginning to proactively evaluate and address data security risks.

3

### Regulatory and Compliance Hurdles

Industries such as pharma and biotechnology operate under strict regulatory guidelines. Automated systems must adhere to compliance standards, and human oversight remains necessary to validate findings.

4

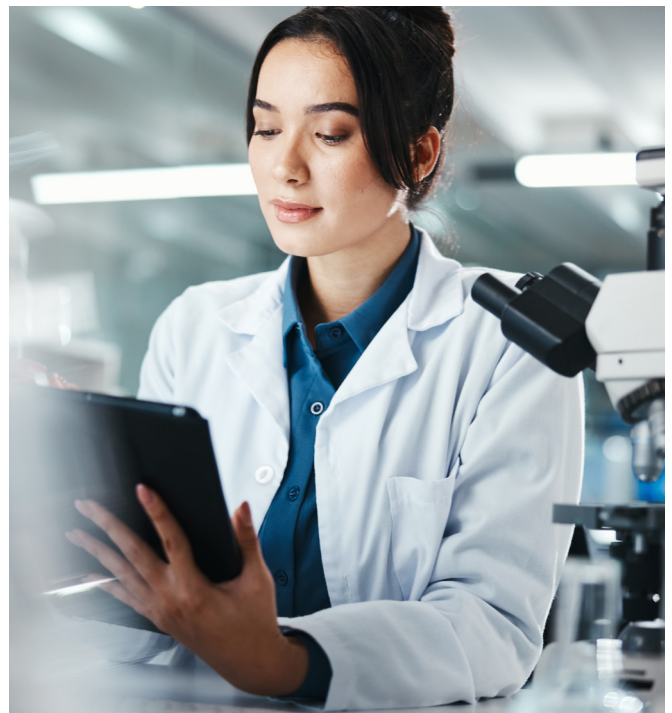
### High Initial Investment

Implementing an autonomous lab requires significant capital investment in robotics, AI-driven analytics, and secure digital infrastructure. Organisations must weigh these costs against long-term efficiency gains. On the one hand, not all labs should be automated. On the other hand, the long-term benefits of an autonomous lab may far outweigh the significant short-term investments.

5

### Trust and Adoption Among Scientists

Scientists must be willing to embrace automation and AI-driven insights. Resistance to change and scepticism about AI's reliability can slow adoption. Organisations must build trust through training and demonstrating tangible benefits.



## WHAT ORGANISATIONS MUST DO TO PREPARE?

To bring the vision of an autonomous lab to life, organisations must establish the right systems and strategies. A successful autonomous lab is not just about implementing cutting-edge technologies but creating an environment where humans and machines work synergistically.

1

### Seamless and Scalable Digital Infrastructure

A truly autonomous lab relies on uninterrupted data flow. This requires integrating lab information management systems, electronic lab notebooks, and AI-driven analytics platforms. These systems must be fully connected, ensuring researchers have immediate access to the data they need. A robust cloud infrastructure, coupled with secure data-sharing protocols, ensures scalability and accessibility across global teams.

2

### Upskilling

Digital transformation is not just about technology, it is about people. Scientists must learn to work with AI and automation, develop skills to interpret AI-generated insights, and trust system recommendations while applying their own expertise. Training programs should focus on digital fluency, data literacy, and adaptive problem-solving.

***“Scientists are not being replaced but rather empowered by technology, shifting their roles from a focus on manual execution to strategic oversight and data-driven analysis.”***

3

### Change Management

Change management strategies must address resistance and develop a culture of innovation. Leadership teams should actively communicate the benefits of automation, ensuring scientists see it as an enabler rather than a disruptor.

4

### AI-Augmented, Flexible Workflows

Labs should implement AI-powered workflow orchestration tools that optimise resource allocation and adapt to evolving experimental demands. AI can anticipate bottlenecks, propose alternative setups, and automate routine decisions, freeing scientists to focus on high-impact research.

## THE FUTURE OF AUTONOMOUS LABS: A HYBRID APPROACH

While complete autonomy remains a distant goal, the hybrid model, where AI and automation handle routine tasks while humans provide strategic oversight, will define the future of labs. Companies that invest in AI-driven research environments are already pioneering this shift, demonstrating that the future of scientific discovery will be faster, more efficient, and deeply data-driven.

Moreover, as technology advances, autonomous labs will become increasingly sophisticated, capable of conducting more complex experiments with minimal intervention. The integration of AI-driven predictive modelling and real-time adaptive experimentation will allow for dynamic research processes, accelerating discoveries beyond traditional methods. The labs of the future will be hubs of continuous innovation, where human intellect and AI work hand in hand to push the boundaries of what is scientifically possible.

## CONCLUSION

The real question is not whether labs can operate without humans but how humans and technology can work together to push the boundaries of innovation. The evolution of labs into highly automated AI-driven environments presents both challenges and opportunities. While automation will continue to streamline workflows, reduce human error, and accelerate research, human scientists remain irreplaceable in their ability to think critically, solve complex problems, and drive innovation forward.

**Ultimately, the goal is not to replace human scientists but to empower them.** By leveraging automation and AI, researchers can direct their efforts toward the most intellectually demanding aspects of science, pushing the frontiers of discovery in ways that benefit society. The autonomous lab of the future is not a lab without humans, it is a lab where humans and machines collaborate smoothly to achieve outstanding scientific advancements.

Arcondis helps life sciences organisations seamlessly integrate automation and AI into their labs, ensuring that human expertise and advanced technologies work together to drive innovation and scientific breakthroughs. Contact me for more information.

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### About the author



**Dr. Sadiya Raja**  
Arcondis Global Head Lab Digitalisation

[Sadiya.Raja@arcondis.com](mailto:Sadiya.Raja@arcondis.com)  
+41 61 717 82 00

Dr. Sadiya Raja is the Global Head of Lab Digitalisation Services at Arcondis, where she leads a team focused on strategic initiatives to optimise lab operations through digital transformation. With a PhD in Chemistry and extensive experience in R&D, she has a deep understanding of customers' unique challenges and supports them in implementing impactful digital solutions to enhance lab efficiency.

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