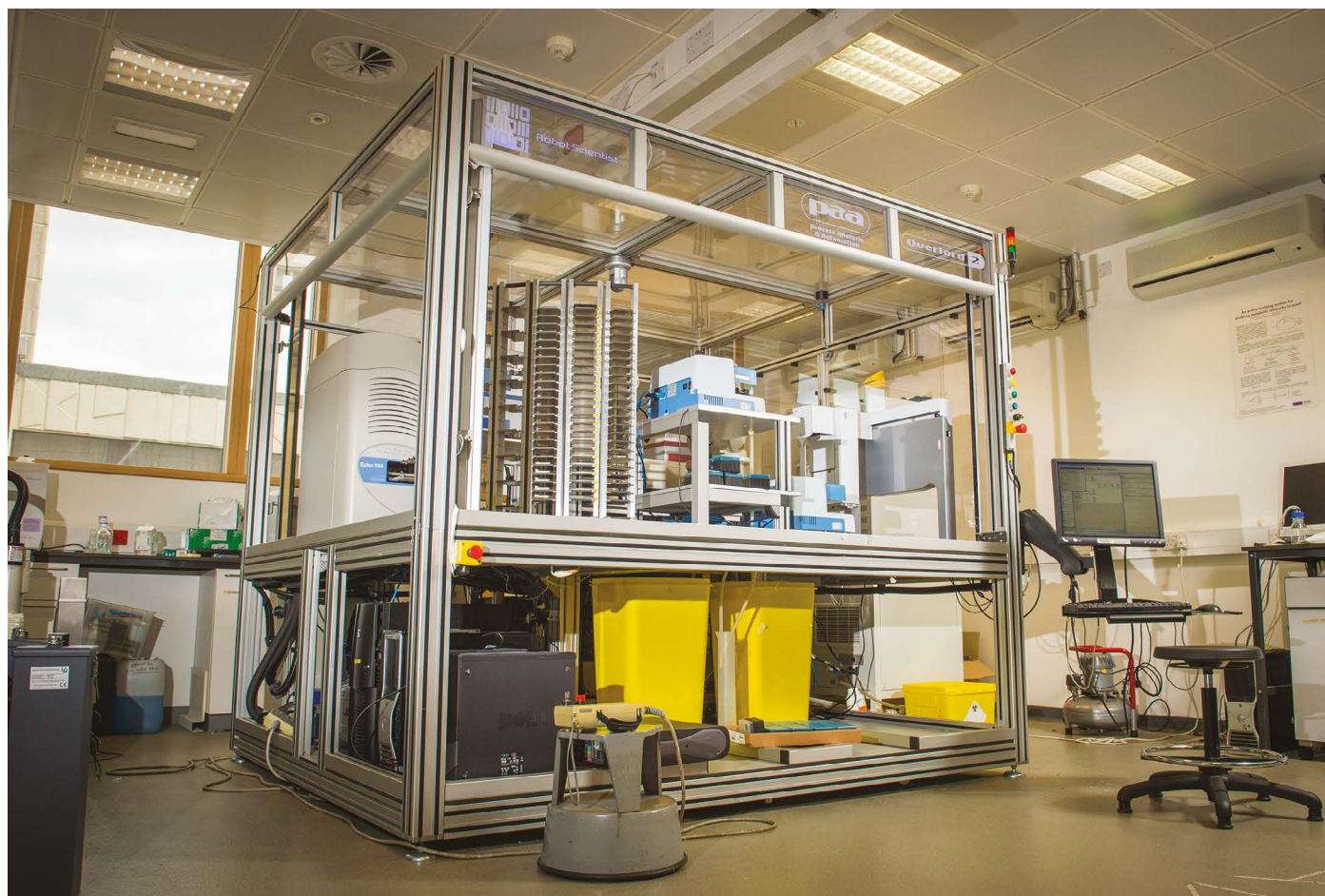




The robot scientist Eve was built at the University of Manchester, UK, before being moved to Sweden.

'SELF-DRIVING' LABS POWER UP

AI-powered robotic tools are muscling in on tasks typically done by humans. **By Rachel Brazil**

Measuring 5 metres square by 3 metres high, Eve takes up at least half of the floor space in the laboratory it now calls home.

The robotic platform at the Chalmers University of Technology in Gothenburg, Sweden, is the brainchild of autonomous-lab pioneer Ross King. It is powered by artificial intelligence, self-driving and "fairly quiet", King says. But it's also fast. Working at full speed, Eve's robotic arm can move a few metres per second, with a positional accuracy of a fraction of a millimetre. The team usually runs Eve slower than that – otherwise, King says, "it's too scary".

Eve automates the process of early-stage drug design. One of Eve's early achievements came in 2018, around three years after it was

created, when it identified that the common antimicrobial compound triclosan can target an enzyme that is crucial to the survival of *Plasmodium* malaria parasites during their dormant phase in the liver¹. To do this, Eve independently screened some 1,600 chemicals and modelled how their structure related to their activity to predict which ones were worth testing. King and his group armed the robot with background knowledge and a machine-learning framework for developing hypotheses. Eve then used those elements to design experiments to test these hypotheses and, crucially, performed them itself. The finding gave researchers a potential route to fighting treatment-resistant malaria. "It's trying to make the scientific method in a machine," says King.

In 2009, King used Eve's predecessor to

probe some of the 10–15% of yeast genes with unknown functions². He named the system Adam – a reference to both the biblical character and the eighteenth-century economist Adam Smith, who was a strong proponent of industrial mechanization. King sees parallels in the future of science.

"A lot of biology is done like craft work," King says: a lab with a principal investigator, postdocs and students operates much like an artisan works with their apprentices. Self-driving labs, by contrast, are more similar to a production line. As a result, "science will be done differently, like in a factory", he adds.

The technology is still in its infancy, and most of the advances so far have been incremental. But as the field encroaches on parts of the scientific process that are typically done by people – absorbing the literature, planning experiments, analysing data and deciding what hypothesis to test next – researchers will have to grapple with what the developments mean for the future of the lab.

The anatomy of a self-driving lab

Many sectors, from agriculture to surgery, are starting to embrace the promise of AI-powered robotics. Korean car manufacturer Hyundai, for example, announced in January that it will deploy tens of thousands of autonomous

humanoid robots in its manufacturing plants, and that they will be completing complex car-assembly work by 2030.

Industrial labs and centralized lab facilities have been using robots to speed up liquid handling and sample analysis since the mid-1980s. But self-driving labs can go much further. Blending AI, robotics and automated instrumentation, these platforms can design and perform experiments with minimal human input.

Adam is equipped with a freezer full of mutant yeast strains and the chemicals needed to measure cellular growth under various conditions. It also hosts three incubators, a centrifuge, two barcode readers, seven cameras and 20 environmental sensors. After being given an overarching goal by its human handlers, it independently develops hypotheses and then tests them, performing experiments much faster than a human could.

Hiring a student for the job would probably have been cheaper, King admits. But his newest robot, Genesis, will be able to do enough experiments to make the process economically feasible³. King estimates that Genesis will cost £1 million (US\$1.3 million) to build – the same price as Adam or Eve individually – but he estimates that it will eventually be at least an order of magnitude cheaper than human labour. King plans to use the system – which occupies one-fifth of floor space than Eve does – to model how genes, proteins and small molecules interact in cells. Part of that will involve taking around 10,000 mass-spectrometry measurements each day.

Chemist and computer scientist Alán Aspuru-Guzik at the University of Toronto in Canada supervises a fleet of 50 self-driving autonomous robots across several labs and universities. Known as the Acceleration Consortium, it is funded by a grant worth Can\$200 million (US\$146 million).

One of his former postdocs, chemist Gabe Gomes, went on to set up his own autonomous lab at Carnegie Mellon University (CMU) in Pittsburgh, Pennsylvania, which he calls Coscientist⁴. It is part of a new generation of systems that “allows users to give instructions or [make] requests in plain English”, says Gomes. Coscientist is driven by the large language model (LLM) GPT-4 and can interpret scientific problems, collect relevant information from web and document searches, plan experiments and interface with robotic lab hardware to perform them. This is done either on external automation platforms or by using the CMU Cloud Lab – a remote-controlled, fully automated research facility built by CMU and Emerald Cloud Lab, a biotechnology company in Austin, Texas.

Coscientist has designed and run palladium-catalysed organic reactions to find the best reagents and conditions⁴. But it has applications across a wide range of fields,

Gomes says. “It’s really field-agnostic. And as [AI] models get better, the problems that we can tackle are much greater.”

Global and cost-effective

One researcher hoping to leverage this technology is John Gregoire, chief autonomous-science officer at Lila Sciences, a start-up firm in Cambridge, Massachusetts.

With around 22,000 square metres of automated lab space at its AI Science Factory (AISF), the company plans to provide research and development services to pharmaceutical companies, materials-science firms and other research-intensive organizations. This year, it received about £500,000 from the UK government’s Advanced Research and Innovation Agency to test whether its self-driving robot – AI NanoScientist – can synthesize and improve the stability of colloidal nanoparticles, tiny particles suspended in a liquid medium.

A similar venture, Periodic Labs, was launched in 2025 in San Francisco, California. It was co-founded by San Francisco-based Liam Fedus, a creator of ChatGPT at US tech firm OpenAI, and Ekin Dogus Cubuk, who previously led materials and chemistry research at Google DeepMind. Periodic Labs has developed an automated materials-synthesis lab that can mix powders, heat them in a furnace and characterize the products. The company aims to perform 1,000 experiments each day, but Cubuk says that success will depend not on throughput, but on how well the LLM can ana-

“You can’t put a robot arm into a cage and catch a mouse in a corner.”

lyse results to progress to further experiments. Similar ventures are popping up around the world, including LabGenius in London. Its discovery platform, called EVA, combines AI and robotic automation to develop complex therapeutic antibodies. Novartis, a pharmaceutical company in Basel, Switzerland, has developed a platform called MicroCycle, which can autonomously synthesize, purify and test compounds, analyse the data and choose new compounds to synthesize⁵. And an AI-powered robotic chemist called ChemAgents, developed by researchers at the University of Science and Technology of China in Hefei, helped its creators to discover functional materials and optimize light-activated organic reactions⁶.

Evidence is mounting that autonomous labs can be more cost-effective than conventional approaches are. For example, scientists at OpenAI and Ginkgo Bioworks, a biotech company in Cambridge, Massachusetts, tested more than 30,000 experimental conditions over six months. They demonstrated that

blending Ginkgo’s Reconfigurable Automation Cart cloud lab with the GPT-5 LLM reduces the cost-per-gram of protein production in a test tube by 40% relative to state-of-the-art methods⁷. The experiment improved protein yield by 27%.

Humans welcome

That’s not to say robots can do everything humans can. “You can’t put a robot arm into a cage and catch a mouse in a corner, for instance. Human dexterity is amazing compared to current robots,” says King. Gregoire echoes the point, noting that some processes are simply too expensive to automate for now.

But AI-powered robots are starting to perform more-complex experiments than standard automated systems can handle, which generally involve single-stage syntheses. One robot in Aspuru-Guzik’s Acceleration Consortium, for instance, is working on multi-step methods that would otherwise be difficult to automate because the desired compounds must be purified at each step – a complex, delicate task that requires nuanced judgement. Solve that problem and “the world is yours”, Aspuru-Guzik says, “because then you can, in principle, automate any chemical reaction”. Using the consortium’s SDL7 ‘scale-up’ automated lab at the University of British Columbia in Vancouver, Canada, his team is working with the pharmaceutical giant Bristol Myers Squibb in Princeton, New Jersey, on a platform that can separate mixtures of liquids. It can operate autonomously to prepare samples, measure pH and analyse the different liquid layers.

Some of these systems even have ‘eyes’. In December 2025, Aspuru-Guzik’s group published a guide on how to use a simple webcam to empower self-driving labs to watch as experiments progress and respond to what happens – in this case, the high-throughput synthesis of highly tunable, porous lattice structures known as metal–organic frameworks⁸. “With the computer eyes, [the robot] was able to actually see what happens in the reaction, and then actually act upon it,” he explains. It could identify plates on which products had crystallized and select only those for characterization, increasing efficiency.

Incremental improvements

For now, researchers at Lila Sciences are moving towards fully autonomous operation of the AISF for developing messenger RNA therapeutics and catalysts, but the system still relies on human input to validate AI predictions. Fedus and Cubuk say that Periodic Labs is likewise easing into the process by automating pieces of it to ensure that the AI’s proposed syntheses make sense. “It’s a very iterative process,” says Fedus.

Indeed, the types of hypothesis that self-driving labs can test for now are “relatively constrained”, says King, and focus mainly on incremental improvements. “They optimize

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compounds in a drug assay, or they optimize some material for a battery or solar panel.” Typically, this is accomplished using Bayesian optimization, a method that uses probabilistic modelling to select the experiments and conditions most likely to improve current results. “Bayesian optimization is awesome and powerful,” says Gomes. But Coscientist’s LLM-guided optimization technique could make things even better. The system is pretrained with chemical knowledge, giving it an edge over the conventional Bayesian approach, Gomes says.

In a preprint posted on the arXiv server last August, Gomes and his colleagues demonstrated that Coscientist could optimize a synthesis in about 20 iterative experimental cycles⁹. “Even if you’re a very skilled medicinal chemist or process chemist, that would be quite remarkable.”

Gregoire says the AISF is developing quickly, too. “A year ago, it was a fair amount of hand holding, of asking it to do little steps and [having] a human checking.” Now, he needs to check in much less frequently.

Lila has seen exciting progress in finding alternatives to expensive precious-metal catalysts, Gregoire says. Given the freedom to design its own experiments, the AISF increasingly ventures beyond what Gregoire would do towards “completely foreign” solutions involving new combinations of materials. It has already improved the performance of some non-precious-metal catalysts to rival that of existing, precious-metal counterparts, he says. “It’s been beautiful to see the departure from human-like design of experiments from a year ago to, I believe, superhuman at this point.”

Indeed, Gregoire envisions self-driving labs as a generation of “super scientists” that embody the knowledge of several human researchers on everything from synthesis to simulation. “We can now take the kind of week-by-week group meetings and collaborative sessions of humans and collapse that down from many hours to seconds,” he says.

But the threat that experiments run by an autonomous lab might get out of control and cause an accident is a significant concern. Cubuk says that Periodic Labs is using data on hazardous materials and reactions already available in the literature and general good-practice rules to train its LLM to understand safety issues. And Aspuru-Guzik is collaborating with computational chemist Varinia Bernales, co-director of the Matter Lab at the University of Toronto, to strengthen the controls on the Acceleration Consortium’s self-driving labs. “There are a lot of pieces missing, especially in terms of safety,” Bernales says.

Aspuru-Guzik and Bernales’s solution is a bespoke AI agent that can produce safety guidelines for any experiment. At its heart is an autonomous agent that uses quantum chemical modelling to predict safety issues for experiments in which reagent reactivity is unknown.



CODY O'LOUGHLIN/NEW YORK TIMES/REDUX/EYEVINE

Researchers at Lila Sciences hope to provide services to research-intensive organizations.

“Now, we can model anything,” says Bernales. The next step, she says, is to plug this into the team’s current self-driving labs. The Matter Lab is also taking advantage of computer vision so that its self-driving robots can detect problems in real time and adjust to them.

Whither the lab worker?

As practical work becomes increasingly automated, will self-driving labs fundamentally change how scientific groups are set up? Is this the end of the PhD student? “I just do not know,” Gomes admits.

Fedus acknowledges that automation could cause the structure of scientific teams to change, but that doesn’t necessarily mean

“There’s a lot of biologists who want things to stay the same as they have been.”

fewer staff members, he says. Instead, he sees it as an opportunity to elevate what people do. “[It] frees up the scientists to think about the chemistry and new synthesis techniques, rather than just measuring these things,” he says.

Aspuru-Guzik is also confident that robotic labs will not replace humans, but will instead become more like assistants that can accelerate the pace of science. “It’s all about adaptation,” he says. One of his self-driving labs is a scientific assistant called ORGANA, which can plan and perform an experimental campaign after a discussion with a scientist. In one YouTube video, the robot helps a researcher to measure the electrochemical characteristics of a chemical solution. The user describes what reagents and equipment they have available, the goal of the experiment and the method, and the system returns with results in just over

two hours, after less than five minutes of user interaction.

King anticipates a paradigm shift such that day-to-day experiments will be done in big, automated factories, with AI doing the thinking and humans directing the AI’s focus.

Current self-driving labs “don’t understand the big picture,” says King. And, even if these labs can do thousands of well-designed experiments, he can’t imagine the AI powering a lab such as Genesis making a truly conceptual advance – at least not yet. “No machine is anywhere near wondering about deep questions like that,” he says.

Still, many researchers regard self-driving labs with scepticism, hostility and understandable concern for their jobs. “It’s been a problem in my lab,” says King, who has experienced pushback in his department. “There’s a lot of biologists who want things to stay the same as they have been.”

Gomes also sees resistance. In his own field of organic chemistry, he says, there is an idea that “my lab is my kingdom and you shall not trespass. Having to flip the whole culture and mindset would be very challenging.”

Rachel Brazil is a freelance journalist in London.

1. Billsland, E. *et al. Sci. Rep.* **8**, 1038 (2018).
2. King, R. D. *et al. Science* **324**, 85–89 (2009).
3. Tiukova, I. A. *et al. Preprint at arXiv* <https://doi.org/10.48550/arXiv.2408.10689> (2024).
4. Boiko, D. A., MacKnight, R., Kline, B. & Gomes, G. *Nature* **624**, 570–578 (2023).
5. Brocklehurst, C. E. *et al. J. Med. Chem.* **67**, 2118–2128 (2024).
6. Song, T. *et al. J. Am. Chem. Soc.* **147**, 12534–12545 (2025).
7. Smith, A. A. *et al. Preprint at bioRxiv* <https://doi.org/10.64898/2026.02.05.703998> (2026).
8. Gaidimas, M. A. *et al. Digit. Discov.* **5**, 510–522 (2026).
9. MacKnight, R., Regio, J. E., Ethier, J. G., Baldwin, L. A. & Gomes, G. *Preprint at arXiv* <https://doi.org/10.48550/arXiv.2509.00103> (2025).