AI and modern experimental biology: A historical perspective

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Ute Deichmann, Director of the Jacques Loeb Centre for the History and Philosophy of the Life Sciences at Ben-Gurion University of the Negev, discusses the adoption and limitations of Artificial Intelligence within modern experimental biology

‘How generative AI could disrupt scientific publishing.’ ‘ChatGPT use shows that the grant-application system is broken.’ ‘Companies say the technology will lead to faster drug development. Independent verification and clinical trials will determine whether the claim holds up.’ ‘AlphaFold touted as next big thing for drug discovery — but is it?’

Understanding the scope and limitations of AI

These recent headlines from the journal Nature not only indicate the enormous impact of artificial intelligence (AI), the intelligence of machines or software, on research across various scientific disciplines but also point to challenges regarding AI reliability. What does intelligence here mean? The Cambridge Dictionary defines intelligence as ‘the ability to learn, understand, and make judgments or have opinions based on reason.’

But can AI be intelligent according to this definition? Understanding implies an understanding of the reasons for statements or decisions, something that AI so far cannot provide, and AI also does not have opinions because it is not a personality. According to Evgeny Morosov (2023), a severe critic of the cultural implications of AI, the concept of intelligence underlying AI concentrates on the mostly individual solving of problems with AI, that is, with perception and prediction—the two tasks that deep learning knows how to carry out with the help of huge data.

These capacities are, of course, a great help for science, but science is more than that. The question is, can AI be really intelligent one day? We do not know the answer, but for now, it is just a tool.

ChatGPT confirms this assessment. When asked about the impact of AI on biological research, it answered that ‘AI helps in understanding complex biological systems, predicting protein structures, analyzing DNA sequences, and modeling genetic interactions. This aids in advancing fields like personalized medicine and genetic engineering.’ This means it only assists or helps. All in all, AI alone does not seem to be able to lead to revolutionary discoveries or inventions.

AI can write conventional review articles but not research articles based on new experimental or theoretical data. As physicist A. Ghosh (2023) commented, ‘some key challenges’ have to be ‘overcome for AI to be more widely adopted in science, such as causal inference and the treatment of uncertainties.’ We can assume that this assessment also holds true for AI applications in industry, the military, and other sectors of society.

Safety issues

Against this background, we may ask, why is it that some of AI’s pioneers and early protagonists have begun to warn against potential dangers caused by AI? Among them is Geoffrey Hinton, who contributed to the development of the artificial neural networks behind chatbots and left Google with a warning that his invention could cause severe damage and that the programs might destroy humanity.

There are also Elon Musk and Steve Wozniak, who in March 2023 called on all AI labs to immediately stop training AI (though at the same time, Musk developed TruthGPT, an AI startup that wants to compete with Open AI).

These warnings are reminiscent of warnings, media hypes, and apocalyptic visions launched against new scientific developments and applications in the history of science, for example, atomic fission.

In experimental biology, a well-known example is the Asilomar conference on DNA recombination in 1975, following the successful insertion by Paul Berg of bacterial DNA into the DNA of a virus, SV 40, and its subsequent cloning.

Berg was one of the conference organizers, where scientists discussed their concerns, called for a voluntary moratorium on certain DNA recombination, and agreed on many safety practices in research on recombinant DNA that have been valid till today. Genetic recombination has since become a widely used tool in basic and applied research.

The Asilomar conference served as a model for the Future of Life Institute to convene a similar conference in 2017 on AI and propose 23 ‘Asilomar AI principles’ for future research on ‘beneficial AI’, one of the earliest and most influential sets of AI governance principles. Among them were: ‘1) Research Goal: The goal of AI research should be to create not undirected intelligence but beneficial intelligence. 2) Research Funding: Investments in AI should be accompanied by funding for research on ensuring its beneficial use …’

Some scientists are sceptical of such warnings, emphasizing that it is not the technology that causes dangers but human beings. Thus, Ralf Otte, professor of industrial automatization and AI in Ulm, holds that ‘it does not make sense to forbid ChatGPT or impose a moratorium. We don’t have to protect ourselves against AI but against human beings who want to uninformedly use or abuse this technology. The machines don’t have a will.’ (Otte 2023; translation U. Deichmann).

AI and experimental biology research

There is a significant difference between the scientific innovation brought about by AI and previous major innovations in biomedical research, such as recombinant DNA technology. While the latter has not resulted in questioning the philosophical or epistemological foundations of biomedical research, this is not the case for research based solely on AI and big data technology.

The traditional epistemologies used to establish the reliability and fruitfulness of research, combine inductive reasoning—the accumulation, guided by thought, of experimental and theoretical data—with hypothesis creation and critical theory testing. Knowledge and subjective judgements are required to correct too blind a belief in experimental or other data, as was explained for organic chemistry by Nobel Laureate E.J. Corey (1967), 'the synthetic chemist is more than a logician and strategist; he is an explorer strongly influenced to speculate, to imagine, and even to create. These added elements provide the touch of artistry which can hardly be included in a cataloguing of the basic principles of Synthesis, but they are very real and extremely important.'

Though Corey wrote this in the 1960s when computers were not yet used in chemical research, current research in organic synthesis (and many other fields), too, does not rely solely on AI predictions based on big data. Experiments, intuition, and knowledge have remained important in current computer-aided synthesis research (e.g., Ishida et al., 2022).

It is a fact that AI, along with big data technology, is having a huge impact on many sciences, even if we only consider its tremendous capacities for prediction and pattern recognition. But as Judea Pearl and Dana Mackenzie in Book of Why made clear, these technologies cannot – at least not yet – answer causal questions or provide molecular or other underlying explanations for statistically determinable phenomena beyond establishing correlations.

In the biomedical sciences, it is important to know where AI can be used and trusted and where the limits are. Otherwise, AI predictions, for example, in structural biology, may be misleading. The question arises: Do all the scientists using AI technologies know how to use and interpret AI properly in their work?

In conclusion, knowledge, causal analyses, and subjective judgements, which have been cornerstones of research in many fields of experimental biology and other sciences until now, remain indispensable in the era of AI and big data technology.

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