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Nanomaterials research in the age of AI-generated images

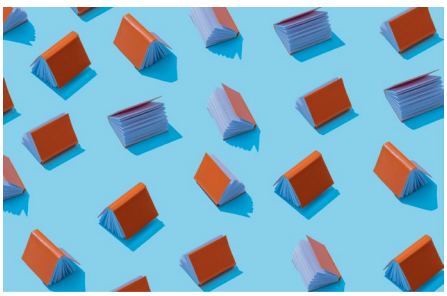
With simple prompts it is possible to generate fake microscopy images of nanomaterials that are virtually indistinguishable from real images. Should we worry?

In a sobering Comment article published in this issue, several academics raise concerns about the misuse of generative artificial intelligence (AI), specifically in nanomaterials synthesis papers. Using simple prompts and just a few hours of training, the authors show that an AI tool can produce atomic force microscopy and electron microscopy images of nanomaterials that are indistinguishable from the real ones. They also show AI-generated images of 'fantasy nanomaterials' (for example, 'nanocheetos'). Readers are encouraged to test whether they can distinguish between the real and the fake images.

Whilst unsurprising, this Comment serves as a stark reminder of the ease with which fake microscopy images can nowadays be produced. Whether researchers will use AI to generate fake images in papers is the cogent issue for the scientific community. What can be done against this unethical use of generative AI?

The best place to start is education. The learning curve of any professional scientist starts during PhD training, but bachelor's and master's degree students already acquire behaviours from their surroundings. A healthy lab culture that emphasizes scientific rigor, attention to detail and good practice, such as data handling and curation, goes a long way towards forging generations of scientists who understand what is acceptable and what is not in science. Research integrity courses should be mandatory in all PhD programmes worldwide. Whether there are enough qualified instructors to deliver them is another matter.

As a global endeavour that feeds on exchanging ideas among international collaborators, scientific research has developed a shared set of ethical behaviours[1,2]. Misconduct is centred around three main practices: plagiarism, falsification and fabrication.



AI-generated microscopy images, like those shown in the Comment, would constitute image fabrication.

Whilst it is concerning that not even a highly trained human can recognize fake AI-generated images, we should also note that AI tools can be used to identify them. Indeed, AI tools are used to detect image fabrication, falsification and plagiarism by many publishers, including Springer Nature[3]. In *Nature* and the Nature Portfolio journals, life-science papers are routinely screened using a commercial AI tool (Proofig) prior to acceptance. If potential image manipulation is detected, authors will be guided to resolve any identified problem. A similar process is in place in the *Science* journal family[4].

Importantly, peer review, in which peer researchers evaluate research for validity, ethical design and merit, was never designed to catch fraudsters. We do not ask our reviewers to examine data for possible manipulation or to repeat experiments, because science is based on trust. And it should remain that way. Retaining trust in science is a collective responsibility and requires contributions from researchers, publishers, universities, research-based businesses, government and non-government bodies alike. A stronger collaboration between AI-tools developers and science integrity experts needs to be fostered.

Publishers are being called on to check that what is published is reproducible, trustworthy science. In Nature Portfolio journals, reporting summaries, checklists for specific topics (for example, lasers or solar cells), enabling or mandating data reposition, quality checks and careful editing to moderate conclusions occur in the submission-to-publication journey of a manuscript with no or minimal reviewer involvement. For post-publication concerns, Springer Nature has a dedicated research integrity team that oversees policies and procedures in accordance with the guidelines of COPE (Committee on Publication Ethics) and investigates these cases.

The sophistication of images produced using AI tools means that copying and pasting noise traces or cropping out unwanted parts of an image is now obsolete. But in the age of AI too, the words of Richard Feynman loom large[5]: "We've learned from experience that the truth will come out. Other experimenters will repeat your experiment and find out whether you were wrong or right. Nature's phenomena will agree or they'll disagree with your theory. And, although you may gain some temporary fame and excitement, you will not gain a good reputation as a scientist if you haven't tried to be very careful in this kind of work."

AI arrives at a fertile time in the history of science, when high-throughput experiments generate big datasets that the human brain struggles to process, and science-driven policies are needed to address pressing and complex societal issues. The potential of AI tools is still to be fully appreciated by researchers, but every field will be profoundly transformed by their use[6]. Researchers should become adept at using AI tools to increase their creativity and productivity, rather than generate fake results.

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