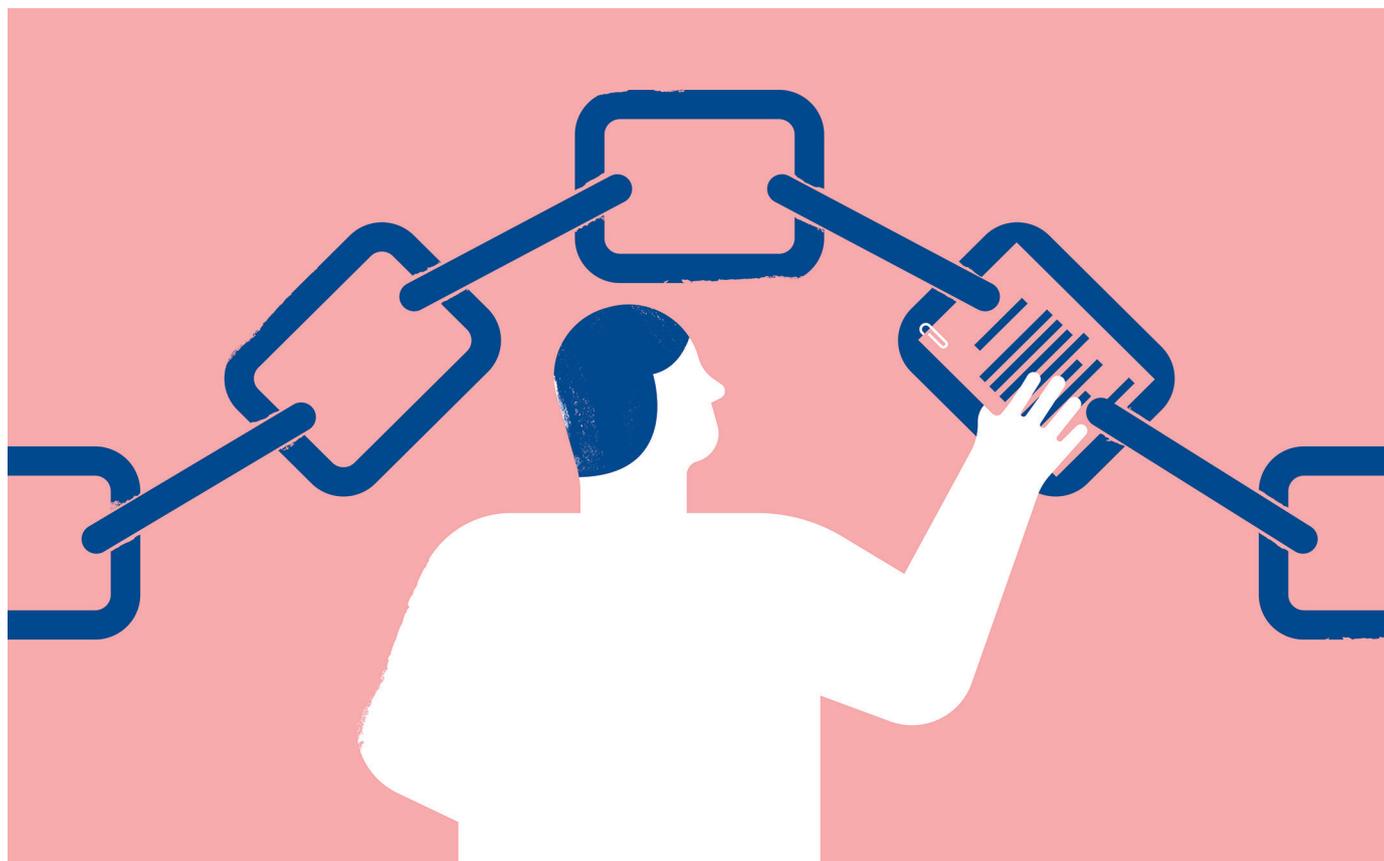# BITCOIN FOR THE BIOLOGICAL LITERATURE

Scientific publishing is increasingly adopting the technology underlying cryptocurrencies.

BY DOUGLAS HEAVEN

When Sarah Bajan finished a study on the argonaute-2 protein last year, she found herself in a position all too common in scientific research: she had an interesting finding, but not enough for a full publication. "I had data from a project that was mostly observational, with no more resources to continue," says Bajan, a geneticist at the University of Technology Sydney, Australia. But she was happy with the results, which revealed a previously unidentified form of the protein, and it would have been a shame to stuff them in a drawer.

Fortunately, she didn't have to. A colleague told Bajan about ScienceMatters, an open-access publishing platform that posts peer-reviewed short papers and single-observation studies — research that most journals would dismiss. Bajan submitted her work last October and it was accepted two weeks later.

That speed, as well as the subject matter, is unusual. But ScienceMatters is different in another way, too: it's developing a peer-review process based on the Bitcoin blockchain technology — a public, but tamper-proof database of transactions shared across thousands of computers around the world.

Blockchain technology seems to be everywhere, from the financial industry and energy grids to manufacturing. Over the past year or so, a number of blockchain-based tools and services for scientists have popped up, offering simple ways to manage collaborations, establish precedence and publish early results. But all of them are preliminary, and it remains to be seen whether they can become the game changers that their adherents think they are.

"Some blockchain applications are productive and sensible, while others are foolish and introduce complexity with little benefit," says Daniel Himmelstein, a bioinformatician at the University of Pennsylvania in Philadelphia, who has developed blockchain-based software.

A blockchain is simply a database shared across a network of computers that is computationally difficult to update. These features make the database relatively tamper resistant, creating trust in its records without the need for an outside adjudicator, such as a bank. The ▶

▶ technology is what allows one user to know that the same Bitcoin, a form of cryptocurrency, wasn't also transferred to another recipient, a trick known as a double-spend, which previous digital currencies could not easily prevent.

ESTABLISHING PRECEDENCE

Such tamper-proof records have obvious uses in science. Himmelstein is the author of Manubot, a piece of open-source software that automates the process of collating, formatting and publishing a scientific paper. Each time an author creates a version of the manuscript, the software logs that event on the Bitcoin blockchain.

This, Himmelstein says, allows researchers to establish definitive claims of precedence. "Imagine an authorship dispute where two authors claim to have both written the same thing," he says. An indelible record of who wrote what, and when makes such disagreements moot.

Himmelstein admits that such disputes might be uncommon, and with only around 100 projects logged by the software there has been no need to fall back on Manubot's time stamps so far. But the principle is a good one, Himmelstein argues. "Time stamping should be adopted by all preprint servers and journals."

To log activity, Manubot uses OpenTimestamp, a free-to-use, open-source service that records time stamps in batches in Bitcoin transactions. Himmelstein wrote code to 'hook' into the OpenTimestamp software and add automatic time stamping to his software directly. But OpenTimestamp targets a highly technical audience, he warns; an easier alternative is to record blockchain time stamps yourself on the OpenTimestamp website.

PROMOTING TRANSPARENCY

For ScienceMatters, plans are under way to use blockchain to promote scientific transparency. Using a peer-review platform called Eureka, ScienceMatters will this year begin offering its triple-blind peer-review process through a publishing platform that uses the Ethereum blockchain, another popular choice. Authors and reviewers will be unknown to one another (with reviewers crowdsourced from Eureka users), but their activities and reviews will be logged for all to see.

"Eureka's crowdsourced scoring will provide researchers as well as publishers with a new metric that can be used to evaluate the work swiftly, thus speeding up the publication process," says ScienceMatter's editorial director Tamara Zaytouni, who is based in Zurich.

Reviewers will be compensated for their time with Eureka tokens — a cryptocurrency tied to the Eureka network that can be exchanged for other currencies, as Bitcoin can be. Because all data around a submission are open, immutable and time stamped, Eureka will provide a public and trusted research management service, says Lawrence Rajendran, a neuroscientist at King's College London, who founded ScienceMatters and Eureka.

ScienceMatters does not yet use Eureka, but from the users' point of view, little should change, Rajendran says. "I found the peer-review process to be very thorough and fair, and the process was quick compared to other journals," Bajan says. She also likes that authors are invited to follow up on initial studies and link future results to the first paper — a process of incremental data publication that Rosa Paolicelli, a molecular biologist at the University of Lausanne in Switzerland and an advocate of ScienceMatters, has described in an online video (see go.nature.com/2hhhopx) as "Lego science". "You can have continuity on a project in one place," Bajan says.

> *"Some blockchain applications are productive and sensible, while others are foolish."*

The downside, Bajan says, is that ScienceMatters requires authors to pay a US$595 fee for manuscript processing upfront, rather than on acceptance; the fee is only partially refunded if the journal declines the submission. "There is the chance that you will be rejected for publication even though you have paid," she says. ScienceMatters has adopted this policy to cover the costs of paying reviewers, says Zaytouni. "Unlike other journals, we compensate our reviewers for the work they put in to evaluate manuscripts."

Jason Snyder, a psychologist at the University of British Columbia in Vancouver, was drawn to ScienceMatters for similar reasons to Bajan. His lab was looking for a forum to publish the results of an undergraduate summer project investigating the effect of stress on memory and emotion. "That particular line of experiments never really took off," he says. "But there was nothing wrong with the data, and we felt they were worth publishing and adding to the scientific record." Snyder's report has since been cited in the journal *Neural Plasticity*.

SHARING RESEARCH OUTPUT

Another firm is hoping to use blockchain technology to simplify the publication and citation of research products other than manuscripts.

According to Dave Kochalko, co-founder of the collaboration and citation platform Artifacts in Cambridge, Massachusetts, research produces a wealth of interesting material — such as data sets, single observations and hypotheses — in the long run-up to publication that doesn't get cited until the final peer-reviewed article appears, if it does at all. At that point, credit comes only if other researchers cite that work, when their own research is published.

Artifacts provides a forum in which researchers can upload almost anything that they deem worth sharing, with each file logged to a blockchain. Users can set permissions so that their uploads are private, public or available to collaborators. (Services such as Figshare and Zenodo also provide such forums, but without the blockchain.)

Launched in March last year, Artifacts is still in development, but users can sign up to try it out. A dashboard lists what you have shared, the attributions you have received, and those you've given to others. To make citation as easy as possible, Artifacts plans to integrate its platform with several widely used bibliography packages, including the open-source reference manager Zotero.

Jim Tate, president of EMR Advocate, a health-care technology consultancy based in Asheville, North Carolina, has been using Artifacts for six months as a member of a working group called Blockchain in Healthcare Today. "We have been using Artifacts as a tool to organize the information we are gathering, cite references, employ version control and document the status of articles being authored," Tate says. "The underlying blockchain technology of Artifacts has directly increased the speed and efficiency of our entire project."

Ultimately, Artifacts plans to join forces with universities, publishers and funding bodies, each of which will run the Artifacts blockchain, Kochalko says. In return, participating institutions will get to see what is being shared on the Artifacts network, providing real-time insight into what scientists are doing.

DELAYED REWARDS

ScienceMatters and Artifacts are two early champions of blockchain technology for scientific publishing. And that's just one possible application. Nebula Genomics, for instance, a start-up co-founded by geneticist George Church at Harvard Medical School in Boston, Massachusetts, plans to use blockchain for sharing genetic data.

But whatever the application, it is likely to be some time before scientists reap the rewards, says Joris van Rossum, who authored the report *Blockchain for Research* (see go.nature.com/2wqqvrg) for Digital Science, a London-based technology firm (operated by the Holtzbrinck Publishing Group, which also has a majority share in *Nature*'s publisher).

That's mainly because the technology is still immature, but the usefulness of these services also depends largely on their adoption. A network of collaborating peer reviewers and authors will fail if nobody is participating. Convincing users to test drive an unproven service is the biggest challenge that platforms such as Eureka and Artifacts face.

"Remember that a blockchain is just an inefficient database that is very difficult to update," says Himmelstein. In many cases, he notes, a plain old database might be all you need.

Even advocates, such as Rajendran, who are sold on blockchain technology, admit that there might be false starts and dead ends. "I am still sceptical," he says. "Not about the technology, but about how well this will be adopted by society." The research community in particular often takes a while to move away from existing practices, he says. "It is going to be a challenge." ∎

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