# New ways to pay for research could boost scientific progress

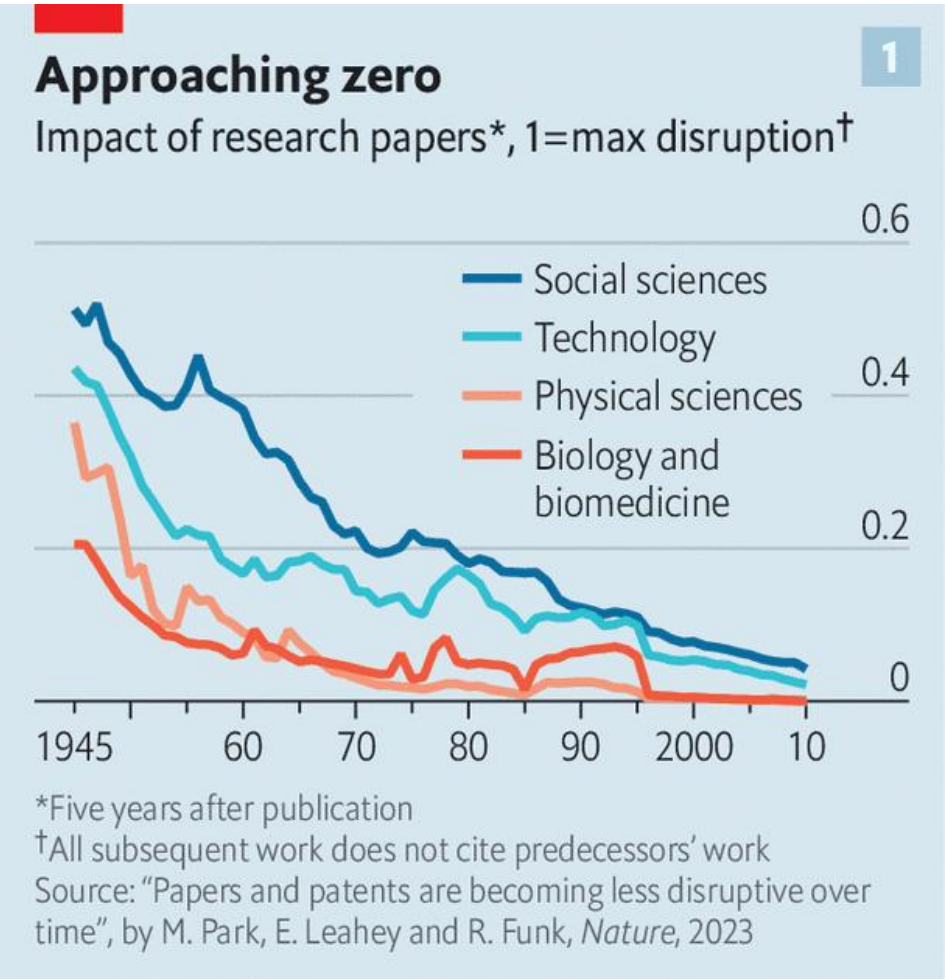
## A new field hopes to apply science's methods to science itself

[From *The Economist*, 18 November 2023]

How might science be done on an alien planet? Since the laws of nature are the same everywhere, the aliens would make the same discoveries as humans have—that matter is made of atoms, say, or that life develops via evolution. But while the results might be the same, aliens would be unlikely to have come up with the same methods for arriving at them. It would be remarkable if the little green men had invented universities, funding committees, a tenure system and all the other accoutrements of modern academic life.

This thought experiment, dreamed up by Michael Nielsen, a physicist, and Kanjun Qiu, an entrepreneur, was not merely a flight of fancy. It was part of an essay published last year pointing out that the way modern science is organised is not the only way it could be done, and perhaps not even the best way. Experimenting with different sorts of institutions, or novel

ways to hand out research money, might help fix what the authors say is a “discovery ecosystem in a state of near stasis”.

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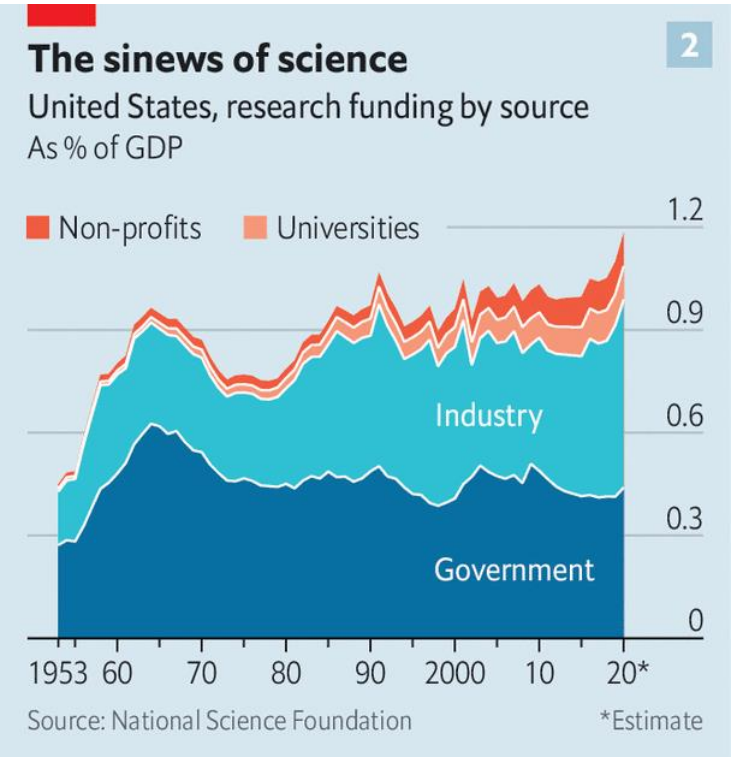
Dr Nielsen and Ms Qiu are among a band of researchers concerned that progress is slowing. A paper published in 2020 by economists from the Massachusetts Institute of Technology (mit) and Stanford University concluded that American research productivity was falling, with more effort required to produce smaller gains in knowledge. A second paper, published in January this year, argued that the “disruptiveness” of both scientific papers and patents, as measured by citation patterns, fell by over 90% for papers, and more than 80% for patents, between 1945 and 2010 (see chart 1).

“The main thing I’d like to see is far more diversity in how we fund and organise research,” says Dr Nielsen. There are plenty of ideas around. Some researchers advocate giving out research grants via lotteries, or expanding the system of competitive scientific or technological prizes. Others prefer to found entirely new types of institutions, displacing the universities that dominate scientific research today. And many see a chance to run a grand

scientific experiment, turning science's methods inwards to work out how science itself might be improved.

## Following the Benjamin Franklins

The modern system of science funding—at least in America, the world's leading scientific power—is relatively recent. The Royal Society in Britain, the world's oldest national scientific academy, was founded in 1660 but limited its funding to an elite group of fellows. Before the second world war a good deal of American science was paid for by rich industrialists and corporate laboratories. The modern system in America owes much to the Rockefeller Foundation, a charity, in particular. It disbursed its money as grants for specific, well-defined projects, such as investigating the cause of yellow fever. As government funding rose after the second world war (see chart 2), America's government adopted a similar system.




These days, over half the funding given to universities by the National Institutes of Health (nih)—which, with its budget of nearly $50bn, is the world's biggest funder of medical science—is given out as fixed-term grants. Around 70% of the $8.6bn distributed in 2022 by the National Science Foundation (nsf) was structured the same way. A scientist applying for this money must write a grant proposal, perhaps 15 pages long, and ideally including some early results to prove her project's worthiness. The proposal is given a score by other researchers; this, in turn, helps a committee decide whether to fund it. Some 80% of NIH funding, and 90% of NSF grants, go through such peer review.

Silvana Konermann, a biochemist at Stanford University, notes that, with its mix of short timelines and small grants, the system leaves researchers "constantly thinking" about where their next cheque is coming from. But skill at raising money is not necessarily correlated with the usefulness of one's research. In October Katalin Karikó won a Nobel prize for discoveries

that led to mrna vaccines. She had been demoted early in her career by the University of Pennsylvania because of her failure to bring in sufficient money.

And grants are becoming harder to win. Between 2003 and 2015 the likelihood that a researcher would be funded by the NIH at least once over a five-year window fell from 43% to 31%. One study estimated that researchers applying for grants from the National Health and Medical Research Council in Australia cumulatively spent 614 years writing them in 2014. One prominent biologist quips that if success rates keep falling, more money will be lost in wasted researcher time than the value of the grants themselves.

There are plenty of ideas for how to do things better. One criticism of having committees decide where money goes is that the need for consensus will suppress unorthodox ideas. Sethuraman Panchanathan, the director of the nsf, is keen to try a proposal called the "golden ticket". Reviewers would be able to back a few risky ideas despite disagreement from their colleagues.

A more radical solution is to abandon committees altogether and hand out money by lottery. Some organisations are already experimenting along such lines. In 2013 the Health Research Council of New Zealand began giving out around 2% of its annual funding at random—though proposals had to first clear a minimum quality bar. The Novo Nordisk foundation, in Denmark, is testing a hybrid system that rejects projects assessed as being of poor quality, gives money to good ones, and randomly hands cash to some of those judged middling. The Volkswagen Foundation in Germany, the British Academy and the National Science Foundation in Switzerland are all running similar trials.

Rather than reforming existing institutions, another idea is to create new ones. In his essay Dr Nielsen suggested an "Institute for Travelling Scientists". Inspired by Craig Venter, a biologist and entrepreneur who has done much good science from the deck of his yacht, the institute would be based on a boat that would travel around the world, picking up and dropping off scientists with the aim of offering a relaxing atmosphere in which to master a new discipline or meet unusual collaborators.

A more hard-headed, if less relaxing, source of inspiration is the Defence Advanced Research Agency (darpa), an American military funding agency originally founded in 1958 that has had a hand in developing everything from the internet to gps and voice interfaces for computers. darpa's $4bn budget sits outside the rest of America's military-research bureaucracy. Around 100 programme managers—described by Adam Russell, formerly one of their number, as "aliens" on account of their often unconventional backgrounds—can fund ambitious research problems however they see fit. At its best, it acts as a "force multiplier" on entirely new fields of research, says Dr Russell.

In America, the idea has given birth to organisations such as iarpa, which applies the same model to America's spy agencies rather than its armies, and arpa e, which pays for research into novel energy technologies. *The Economist* calculates that the total amount of cash handed out by such entities rose from about $4bn in 2021 to nearly $6bn in 2022. The most recent addition to the family, founded in 2022, is arpa-h, which covers health care. Britain, Germany and Japan have all tried to copy the model outside America in recent years, setting up aria, sprin-d and Moonshot r&d, respectively.

But how well the arpa model can be replicated is unclear. One former employee notes that darpa "no longer attracts the same talent as it used to" and says there is "little interest" in studying cases of failure to figure out how to improve. The model may be less successful outside military research, suggests a book chapter written by Pierre Azoulay and Danielle Li, a pair of economists at mit, published in 2022. America's armed forces are the end-users of the technologies darpa develops, and have a good understanding of what they need. End-users in other fields, such as energy or health care, are less single-minded.

Prizes, which offer a jackpot to anyone who can meet a scientific or engineering goal, can also push research in new directions. The Clay Mathematics Institute's $1m Millennium Prize Problems exist to focus attention on unsolved problems in mathematics. So-called XPrizes have boosted research into everything from rainforest preservation to space flight. The biggest, for removing carbon dioxide from the atmosphere, has a total pot of $100m, paid for by Elon Musk, an entrepreneur. A study in 2021 found that research topics that were associated with prizes gained 40% more papers and 37% more new scientists than fields that were not.

Prizes also have the advantage of being tightly focused. Adam Marblestone and Sam Rodriques, a physicist and a biologist respectively, have been thinking along similar lines. They have proposed setting up a series of "focused-research organisations" (fros). Each fro would have well-specified goals and limited lifetimes, a bit like the Human Genome Project, which began in 1990 and then shut down in 2003 after the first draft of a human genome had been published. The hope is that this would prevent them from sliding into bureaucratic complacency over time. Money could come from governments or philanthropists, for whom the prospect of bold, time-limited funding may prove attractive.

Mr Marblestone's organisation, Convergent Research, has helped launch six fros. One is trying to map neural circuits in mammalian brains. On November 1st Mr Rodriques launched a fro-like non-profit called Future House that aims to create a semi-autonomous "ai scientist" within ten years. It is backed by Eric Schmidt, a former boss of Google. Mr Rodriques expects it to spend $20m next year. In March Rishi Sunak, Britain's prime minister, announced his intention to set up several such organisations—though exactly what they will study remains unclear.

And then there is the idea of funding people rather than projects. In theory, that would give researchers freedom to follow their noses, pursue ideas that may not have an obvious pay-off, and change course when something doesn't work. The idea is not new: the most famous example is the Howard Hughes Medical Institute (hhmi), founded in 1953 in Maryland. Researchers are generously funded for seven or more years, compared with four for the typical nih grant. Between them they have won over 30 Nobel prizes, as many as Russia and the Soviet Union combined.

There is other evidence to suggest the approach works well. Dr Azoulay has compared the hhmi with the nih's standard funding programme. Hhmi researchers produced nearly twice as much highly cited work, as well as a third more flops, suggesting a willingness to take more risks. Inspired, in 2021 Dr Konermann of Stanford (an hhmi fellow herself) started the Arc Institute, which is run on similar lines.

**The science of science**

No one knows how fruitful any of these ideas will prove. Dr Russell argues it is vital to try many things, "collect data" and build "feedback loops" to improve the system. Kyle Myers, an economist at Harvard Business School, thinks funders should appoint chief economists to keep track of how each approach is working.

This turning of science's methods back on itself has been dubbed "meta-science". It is a growing field of study, says Ilan Gur, aria's boss. Dr Myers calculates that since 2015 there have been an average of nearly 60 randomised experiments studying the scientific process. Two decades ago that number would have been in the single digits. More are coming: on September 28th the nsf announced a partnership with the Institute for Progress, a science-and-technology think-tank, to conduct metascientific experiments.

Using science to decide how best to do science is an idea with a pleasing symmetry. Yet Dr Nielsen cautions that finding out which funding method gives the best bang for each buck may take a long time. In the meantime, says James Wilsdon, who runs the Research on Research Institute at University College London, a diverse ecosystem of funders would bring its own benefits. "If you can't get funded one way, you have another," he says. That might help prevent others falling through the cracks in the way Dr Karikó did.

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