

Is the staggeringly profitable business of scientific publishing bad for science?

It is an industry like no other, with profit margins to rival Google – and it was created by one of Britain’s most notorious tycoons: Robert Maxwell. By [Stephen Buranyi](#)

Tuesday 27 June 2017 06.00 BST Last modified on Monday 27 November 2017 21.10 GMT

In 2011, Claudio Aspesi, a senior investment analyst at Bernstein Research in London, made a bet that the dominant firm in one of the most lucrative industries in the world was headed for a crash. [Reed-Elsevier](#), a multinational publishing giant with annual revenues exceeding £6bn, was an investor’s darling. It was one of the few publishers that had successfully managed the transition to the internet, and a recent company report was predicting yet another year of growth. Aspesi, though, had reason to believe that that prediction – along with those of every other major financial analyst – was wrong.

The core of Elsevier’s operation is in scientific journals, the weekly or monthly publications in which scientists share their results. Despite the narrow audience, scientific publishing is a remarkably big business. With total global revenues of more than £19bn, it weighs in somewhere between the recording and the film industries in size, but it is far more profitable. In 2010, Elsevier’s scientific publishing arm reported profits of £724m on just over £2bn in revenue. It was a 36% margin – higher than Apple, Google, or Amazon posted that year.

But Elsevier’s business model seemed a truly puzzling thing. In order to make money, a traditional publisher – say, a magazine – first has to cover a multitude of costs: it pays writers for the articles; it employs editors to commission, shape and check the articles; and it pays to distribute the finished product to subscribers and retailers. All of this is expensive, and successful magazines typically make profits of around 12-15%.

The way to make money from a scientific article looks very similar, except that scientific publishers manage to duck most of the actual costs. Scientists create work under their own direction – funded largely by governments – and give it to publishers for free; the publisher pays scientific editors who judge whether the work is worth publishing and check its grammar, but the bulk of the editorial burden – checking the scientific validity and evaluating the experiments, a process known as [peer review](#) – is done by working scientists on a volunteer basis. The publishers then sell the product back to government-funded institutional and university libraries, to be read by scientists – who, in a collective sense, created the product in the first place.

It is as if the New Yorker or the Economist demanded that journalists write and edit each other’s work for free, and asked the government to foot the bill. Outside observers tend to fall into a sort of stunned disbelief when describing this setup. A 2004 parliamentary science and technology committee report on the industry drily observed that “in a traditional market suppliers are paid for the goods they provide”. A 2005 Deutsche Bank report referred to it as a “bizarre” “triple-pay” system, in which “the state funds most research, pays the salaries of

most of those checking the quality of research, and then buys most of the published product”.

Scientists are well aware that they seem to be getting a bad deal. The publishing business is “perverse and needless”, the Berkeley biologist Michael Eisen [wrote in a 2003 article for the Guardian](#), declaring that it “should be a public scandal”. Adrian Sutton, a physicist at Imperial College, told me that scientists “are all slaves to publishers. What other industry receives its raw materials from its customers, gets those same customers to carry out the quality control of those materials, and then sells the same materials back to the customers at a vastly inflated price?” (A representative of RELX Group, the official name of Elsevier since 2015, told me that it and other publishers “serve the research community by doing things that they need that they either cannot, or do not do on their own, and charge a fair price for that service”.)

Many scientists also believe that the publishing industry exerts too much influence over what scientists choose to study, which is ultimately bad for science itself. Journals prize new and spectacular results – after all, they are in the business of selling subscriptions – and scientists, knowing exactly what kind of work gets published, align their submissions accordingly. This produces a steady stream of papers, the importance of which is immediately apparent. But it also means that scientists do not have an accurate map of their field of inquiry. Researchers may end up inadvertently exploring dead ends that their fellow scientists have already run up against, solely because the information about previous failures has never been given space in the pages of the relevant scientific publications. A 2013 study, for example, reported that half of all clinical trials in the US [are never published](#) in a journal.

According to critics, the journal system actually holds back scientific progress. In [a 2008 essay](#), Dr Neal Young of the National Institutes of Health (NIH), which funds and conducts medical research for the US government, argued that, given the importance of scientific innovation to society, “there is a moral imperative to reconsider how scientific data are judged and disseminated”.

Aspesi, after talking to a network of more than 25 prominent scientists and activists, had come to believe the tide was about to turn against the industry that Elsevier led. More and more research libraries, which purchase journals for universities, were claiming that their budgets were exhausted by decades of price increases, and were threatening to cancel their multi-million-pound subscription packages unless Elsevier dropped its prices. State organisations such as the American NIH and the German [Research](#) Foundation (DFG) had recently committed to making their research available through free online journals, and Aspesi believed that governments might step in and ensure that all publicly funded research would be available for free, to anyone. Elsevier and its competitors would be caught in a perfect storm, with their customers revolting from below, and government regulation looming above.

In March 2011, Aspesi published a report recommending that his clients sell Elsevier stock. A few months later, in a conference call between Elsevier management and investment firms, he pressed the CEO of Elsevier, Erik Engstrom, about the deteriorating relationship with the libraries. He asked what was wrong with the business if “your customers are so desperate”. Engstrom dodged the question. Over the next two weeks, Elsevier stock tumbled by more than 20%, losing £1bn in value. The problems Aspesi saw were deep and structural, and he believed they would play out over the next half-decade – but things already seemed to be moving in the direction he had predicted.

Over the next year, however, most libraries backed down and committed to Elsevier's contracts, and governments largely failed to push an alternative model for disseminating research. In 2012 and 2013, Elsevier posted profit margins of more than 40%. The following year, Aspesi reversed his recommendation to sell. "He listened to us too closely, and he got a bit burned," David Prosser, the head of Research Libraries UK, and a prominent voice for reforming the publishing industry, told me recently. Elsevier was here to stay.

Aspesi was not the first person to incorrectly predict the end of the scientific publishing boom, and he is unlikely to be the last. It is hard to believe that what is essentially a for-profit oligopoly functioning within an otherwise heavily regulated, government-funded enterprise can avoid extinction in the long run. But publishing has been deeply enmeshed in the science profession for decades. Today, every scientist knows that their career depends on being published, and professional success is especially determined by getting work into the most prestigious journals. The long, slow, nearly directionless work pursued by some of the most influential scientists of the 20th century is no longer a viable career option. Under today's system, the father of genetic sequencing, Fred Sanger, who published very little in the two decades between his 1958 and 1980 Nobel prizes, may well have found himself out of a job.

Even scientists who are fighting for reform are often not aware of the roots of the system: how, in the boom years after the second world war, entrepreneurs built fortunes by taking publishing out of the hands of scientists and expanding the business on a previously unimaginable scale. And no one was more transformative and ingenious than Robert Maxwell, who turned scientific journals into a spectacular money-making machine that bankrolled his rise in British society. Maxwell would go on to become an MP, a press baron who challenged Rupert Murdoch, and one of the most notorious figures in British life. But his true importance was far larger than most of us realise. Improbable as it might sound, few people in the last century have done more to shape the way science is conducted today than Maxwell.

In 1946, the 23-year-old Robert Maxwell was working in Berlin and already had a significant reputation. Although he had grown up in a poor Czech village, he had fought for the British army during the war as part of a contingent of European exiles, winning a Military Cross and British citizenship in the process. After the war, he served as an intelligence officer in Berlin, using his nine languages to interrogate prisoners. Maxwell was tall, brash, and not at all content with his already considerable success – an acquaintance at the time recalled him confessing his greatest desire: "to be a millionaire".

At the same time, the British government was preparing an unlikely project that would allow him to do just that. Top British scientists – from Alexander Fleming, who discovered penicillin, to the physicist Charles Galton Darwin, grandson of Charles Darwin – were concerned that while British science was world-class, its publishing arm was dismal. Science publishers were mainly known for being inefficient and constantly broke. Journals, which often appeared on cheap, thin paper, were produced almost as an afterthought by scientific societies. The British Chemical Society had a months-long backlog of articles for publication, and relied on cash handouts from the Royal Society to run its printing operations.

The government's solution was to pair the venerable British publishing house Butterworths (now owned by Elsevier) with the renowned German publisher Springer, to draw on the latter's expertise. Butterworths would learn to turn a profit on journals, and British science would get its work out at a faster pace. Maxwell had already established his own business helping Springer ship scientific articles to Britain. The Butterworths directors, being ex-

British intelligence themselves, hired the young Maxwell to help manage the company, and another ex-spy, Paul Rosbaud, a metallurgist who spent the war passing Nazi nuclear secrets to the British through the French and Dutch resistance, as scientific editor.

They couldn't have begun at a better time. Science was about to enter a period of unprecedented growth, having gone from being a scattered, amateur pursuit of wealthy gentleman to a respected profession. In the postwar years, it would become a byword for progress. "Science has been in the wings. It should be brought to the centre of the stage – for in it lies much of our hope for the future," wrote the American engineer and Manhattan Project administrator Vannevar Bush, in a 1945 report to President Harry S Truman. After the war, government emerged for the first time as the major patron of scientific endeavour, not just in the military, but through newly created agencies such as the US National Science Foundation, and the rapidly expanding university system.

When Butterworths decided to abandon the fledgling project in 1951, Maxwell offered £13,000 (about £420,000 today) for both Butterworth's and Springer's shares, giving him control of the company. Rosbaud stayed on as scientific director, and named the new venture Pergamon Press, after a coin from the ancient Greek city of Pergamon, featuring Athena, goddess of wisdom, which they adapted for the company's logo – a simple line drawing appropriately representing both knowledge and money.

In an environment newly flush with cash and optimism, it was Rosbaud who pioneered the method that would drive Pergamon's success. As science expanded, he realised that it would need new journals to cover new areas of study. The scientific societies that had traditionally created journals were unwieldy institutions that tended to move slowly, hampered by internal debates between members about the boundaries of their field. Rosbaud had none of these constraints. All he needed to do was to convince a prominent academic that their particular field required a new journal to showcase it properly, and install that person at the helm of it. Pergamon would then begin selling subscriptions to university libraries, which suddenly had a lot of government money to spend.

Maxwell was a quick study. In 1955, he and Rosbaud attended the Geneva Conference on Peaceful Uses of Atomic Energy. Maxwell rented an office near the conference and wandered into seminars and official functions offering to publish any papers the scientists had come to present, and asking them to sign exclusive contracts to edit Pergamon journals. Other publishers were shocked by his brash style. Daan Frank, of North Holland [Publishing](#) (now owned by Elsevier) would later complain that Maxwell was "dishonest" for scooping up scientists without regard for specific content.

Rosbaud, too, was reportedly put off by Maxwell's hunger for profit. Unlike the humble former scientist, Maxwell favoured expensive suits and slicked-back hair. Having rounded his Czech accent into a formidably posh, newsreader basso, he looked and sounded precisely like the tycoon he wished to be. In 1955, Rosbaud told the Nobel prize-winning physicist Nevill Mott that the journals were his beloved little "ewe lambs", and Maxwell was the biblical King David, who would butcher and sell them for profit. In 1956, the pair had a falling out, and Rosbaud left the company.

By then, Maxwell had taken Rosbaud's business model and turned it into something all his own. Scientific conferences tended to be drab, low-ceilinged affairs, but when Maxwell returned to the Geneva conference that year, he rented a house in nearby Collonge-Bellerive, a picturesque town on the lakeshore, where he entertained guests at parties with booze, cigars

and sailboat trips. Scientists had never seen anything like him. “He always said we don’t compete on sales, we compete on authors,” Albert Henderson, a former deputy director at Pergamon, told me. “We would attend conferences specifically looking to recruit editors for new journals.” There are tales of parties on the roof of the Athens Hilton, of gifts of Concorde flights, of scientists being put on a chartered boat tour of the Greek islands to plan their new journal.

By 1959, Pergamon was publishing 40 journals; six years later it would publish 150. This put Maxwell well ahead of the competition. (In 1959, Pergamon’s rival, Elsevier, had just 10 English-language journals, and it would take the company another decade to reach 50.) By 1960, Maxwell had taken to being driven in a chauffeured Rolls-Royce, and moved his home and the Pergamon operation from London to the palatial Headington Hill Hall estate in Oxford, which was also home to the British book publishing house Blackwell’s.

Scientific societies, such as the British Society of Rheology, seeing the writing on the wall, even began letting Pergamon take over their journals for a small regular fee. Leslie Iversen, former editor at the *Journal of Neurochemistry*, recalls being wooed with lavish dinners at Maxwell’s estate. “He was very impressive, this big entrepreneur,” said Iversen. “We would get dinner and fine wine, and at the end he would present us a cheque – a few thousand pounds for the society. It was more money than us poor scientists had ever seen.”

Maxwell insisted on grand titles – “International Journal of” was a favourite prefix. Peter Ashby, a former vice president at Pergamon, described this to me as a “PR trick”, but it also reflected a deep understanding of how science, and society’s attitude to science, had changed. Collaborating and getting your work seen on the international stage was becoming a new form of prestige for researchers, and in many cases Maxwell had the market cornered before anyone else realised it existed. When the Soviet Union launched Sputnik, the first man-made satellite, in 1957, western scientists scrambled to catch up on Russian space research, and were surprised to learn that Maxwell had already negotiated an exclusive English-language deal to publish the Russian Academy of Sciences’ journals earlier in the decade.

“He had interests in all of these places. I went to Japan, he had an American man running an office there by himself. I went to India, there was someone there,” said Ashby. And the international markets could be extremely lucrative. Ronald Suleski, who ran Pergamon’s Japanese office in the 1970s, told me that the Japanese scientific societies, desperate to get their work published in English, gave Maxwell the rights to their members’ results for free.

In a letter celebrating Pergamon’s 40th anniversary, Eiichi Kobayashi, director of Maruzen, Pergamon’s longtime Japanese distributor, recalled of Maxwell that “each time I have the pleasure of meeting him, I am reminded of F Scott Fitzgerald’s words that a millionaire is no ordinary man”.

The scientific article has essentially become the only way science is systematically represented in the world. (As Robert Kiley, head of digital services at the library of the Wellcome Trust, the world’s second-biggest private funder of biomedical research, puts it: “We spend a billion pounds a year, and we get back articles.”) It is the primary resource of our most respected realm of expertise. “Publishing is the expression of our work. A good idea, a conversation or correspondence, even from the most brilliant person in the world ... doesn’t count for anything unless you have it published,” says Neal Young of the NIH. If you control access to the scientific literature, it is, to all intents and purposes, like controlling

science.

Maxwell's success was built on an insight into the nature of scientific journals that would take others years to understand and replicate. While his competitors groused about him diluting the market, Maxwell knew that there was, in fact, no limit to the market. Creating *The Journal of Nuclear Energy* didn't take business away from rival publisher North Holland's journal *Nuclear Physics*. Scientific articles are about unique discoveries: one article cannot substitute for another. If a serious new journal appeared, scientists would simply request that their university library subscribe to that one as well. If Maxwell was creating three times as many journals as his competition, he would make three times more money.

The only potential limit was a slow-down in government funding, but there was little sign of that happening. In the 1960s, Kennedy bankrolled the space programme, and at the outset of the 1970s Nixon declared a "war on cancer", while at the same time the British government developed its own nuclear programme with American aid. No matter the political climate, science was buoyed by great swells of government money.

In its early days, Pergamon had been at the centre of fierce debates about the ethics of allowing commercial interests into the supposedly disinterested and profit-shunning world of science. In a 1988 letter commemorating the 40th anniversary of Pergamon, John Coales of Cambridge University noted that initially many of his friends "considered [Maxwell] the greatest villain yet unhung".

But by the end of the 1960s, commercial publishing was considered the status quo, and publishers were seen as a necessary partner in the advancement of science. Pergamon helped turbocharge the field's great expansion by speeding up the publication process and presenting it in a more stylish package. Scientists' concerns about signing away their copyright were overwhelmed by the convenience of dealing with Pergamon, the shine it gave their work, and the force of Maxwell's personality. Scientists, it seemed, were largely happy with the wolf they had let in the door.

"He was a bully, but I quite liked him," says Denis Noble, a physiologist at Oxford University and the editor of the journal *Progress in Biophysics & Molecular Biology*. Occasionally, Maxwell would call Noble to his house for a meeting. "Often there would be a party going on, a nice musical ensemble, there was no barrier between his work and personal life," Noble says. Maxwell would then proceed to alternately browbeat and charm him into splitting the biannual journal into a monthly or bimonthly publication, which would lead to an attendant increase in subscription payments.

In the end, though, Maxwell would nearly always defer to the scientists' wishes, and scientists came to appreciate his patronly persona. "I have to confess that, quickly realising his predatory and entrepreneurial ambitions, I nevertheless took a great liking to him," Arthur Barrett, then editor of the journal *Vacuum*, wrote in a 1988 piece about the publication's early years. And the feeling was mutual. Maxwell doted on his relationships with famous scientists, who were treated with uncharacteristic deference. "He realised early on that the scientists were vitally important. He would do whatever they wanted. It drove the rest of the staff crazy," Richard Coleman, who worked in journal production at Pergamon in the late 1960s, told me. When Pergamon was the target of a hostile takeover attempt, a 1973 *Guardian* article reported that journal editors threatened "to desert" rather than work for another chairman.

Maxwell had transformed the business of publishing, but the day-to-day work of science remained unchanged. Scientists still largely took their work to whichever journal was the best fit for their research area – and Maxwell was happy to publish any and all research that his editors deemed sufficiently rigorous. In the mid-1970s, though, publishers began to meddle with the practice of science itself, starting down a path that would lock scientists' careers into the publishing system, and impose the business's own standards on the direction of research. One journal became the symbol of this transformation.

“At the start of my career, nobody took much notice of where you published, and then everything changed in 1974 with *Cell*,” Randy Schekman, the Berkeley molecular biologist and Nobel prize winner, told me. *Cell* (now owned by Elsevier) was a journal started by [Massachusetts Institute of Technology \(MIT\)](#) to showcase the newly ascendant field of molecular biology. It was edited by a young biologist named Ben Lewin, who approached his work with an intense, almost literary bent. Lewin prized long, rigorous papers that answered big questions – often representing years of research that would have yielded multiple papers in other venues – and, breaking with the idea that journals were passive instruments to communicate science, he rejected far more papers than he published.

What he created was a venue for scientific blockbusters, and scientists began shaping their work on his terms. “Lewin was clever. He realised scientists are very vain, and wanted to be part of this selective members club; *Cell* was ‘it’, and you had to get your paper in there,” Schekman said. “I was subject to this kind of pressure, too.” He ended up publishing some of his Nobel-cited work in *Cell*.

Suddenly, *where* you published became immensely important. Other editors took a similarly activist approach in the hopes of replicating *Cell*'s success. Publishers also adopted a metric called “impact factor,” invented in the 1960s by Eugene Garfield, a librarian and linguist, as a rough calculation of how often papers in a given journal are cited in other papers. For publishers, it became a way to rank and advertise the scientific reach of their products. The new-look journals, with their emphasis on big results, shot to the top of these new rankings, and scientists who published in “high-impact” journals were rewarded with jobs and funding. Almost overnight, a new currency of prestige had been created in the scientific world. (Garfield later referred to his creation as “like nuclear energy ... a mixed blessing”.)

It is difficult to overstate how much power a journal editor now had to shape a scientist's career and the direction of science itself. “Young people tell me all the time, ‘If I don't publish in CNS [a common acronym for *Cell/Nature/Science*, the most prestigious journals in biology], I won't get a job,” says Schekman. He compared the pursuit of high-impact publications to an incentive system as rotten as banking bonuses. “They have a very big influence on where science goes,” he said.

And so science became a strange co-production between scientists and journal editors, with the former increasingly pursuing discoveries that would impress the latter. These days, given a choice of projects, a scientist will almost always reject both the prosaic work of confirming or disproving past studies, and the decades-long pursuit of a risky “moonshot”, in favour of a middle ground: a topic that is popular with editors and likely to yield regular publications. “Academics are incentivised to produce research that caters to these demands,” said the biologist and Nobel laureate Sydney Brenner in a [2014 interview](#), calling the system “corrupt.”

Maxwell understood the way journals were now the kingmakers of science. But his main

concern was still expansion, and he still had a keen vision of where science was heading, and which new fields of study he could colonise. Richard Charkin, the former CEO of the British publisher Macmillan, who was an editor at Pergamon in 1974, recalls Maxwell waving [Watson and Crick's one-page report](#) on the structure of DNA at an editorial meeting and declaring that the future was in life science and its multitude of tiny questions, each of which could have its own publication. "I think we launched a hundred journals that year," Charkin said. "I mean, Jesus wept."

Pergamon also branched into social sciences and psychology. A series of journals prefixed "Computers and" suggest that Maxwell spotted the growing importance of digital technology. "It was endless," Peter Ashby told me. "Oxford Polytechnic [now Oxford Brookes University] started a department of hospitality with a chef. We had to go find out who the head of the department was, make him start a journal. And boom – International Journal of Hospitality Management."

By the late 1970s, Maxwell was also dealing with a more crowded market. "I was at Oxford University Press at that time," Charkin told me. "We sat up and said, 'Hell, these journals make a lot of money!'" Meanwhile, in the Netherlands, Elsevier had begun expanding its English-language journals, absorbing the domestic competition in a series of acquisitions and growing at a rate of 35 titles a year.

As Maxwell had predicted, competition didn't drive down prices. Between 1975 and 1985, the average price of a journal doubled. The New York Times reported that in 1984 it cost \$2,500 to subscribe to the journal *Brain Research*; in 1988, it cost more than \$5,000. That same year, Harvard Library overran its research journal budget by half a million dollars.

Scientists occasionally questioned the fairness of this hugely profitable business to which they supplied their work for free, but it was university librarians who first realised the trap in the market Maxwell had created. The librarians used university funds to buy journals on behalf of scientists. Maxwell was well aware of this. "Scientists are not as price-conscious as other professionals, mainly because they are not spending their own money," he told his publication *Global Business* in a 1988 interview. And since there was no way to swap one journal for another, cheaper one, the result was, Maxwell continued, "a perpetual financing machine". Librarians were locked into a series of thousands of tiny monopolies. There were now more than a million scientific articles being published a year, and they had to buy all of them at whatever price the publishers wanted.

From a business perspective, it was a total victory for Maxwell. Libraries were a captive market, and journals had improbably installed themselves as the gatekeepers of scientific prestige – meaning that scientists couldn't simply abandon them if a new method of sharing results came along. "Were we not so naive, we would long ago have recognised our true position: that we are sitting on top of fat piles of money which clever people on all sides are trying to transfer on to their piles," wrote the University of Michigan librarian Robert Houbeck in a trade journal in 1988. Three years earlier, despite scientific funding suffering its first multi-year dip in decades, Pergamon had reported a 47% profit margin.

Maxwell wouldn't be around to tend his victorious empire. The acquisitive nature that drove Pergamon's success also led him to make a surfeit of flashy but questionable investments, including the football teams Oxford United and Derby County FC, television stations around the world, and, in 1984, the UK's *Mirror* newspaper group, where he began to spend more and more of his time. In 1991, to finance his impending purchase of the *New York Daily News*, Maxwell sold Pergamon to its quiet Dutch competitor Elsevier for £440m (£919m

today).

Many former Pergamon employees separately told me that they knew it was all over for Maxwell when he made the Elsevier deal, because Pergamon was the company he truly loved. Later that year, he became mired in a series of scandals over his mounting debts, shady accounting practices, and an explosive accusation by the American journalist Seymour Hersh that he was an Israeli spy with links to arms traders. On 5 November 1991, Maxwell was found drowned off his yacht in the Canary Islands. The world was stunned, and by the next day the Mirror's tabloid rival Sun was posing the question on everyone's mind: "DID HE FALL ... DID HE JUMP?", its headline blared. (A third explanation, that he was pushed, would also come up.)

The story dominated the British press for months, with suspicion growing that Maxwell had committed suicide, after an investigation revealed that [he had stolen more than £400m](#) from the Mirror pension fund to service his debts. (In December 1991, a Spanish coroner's report ruled the death accidental.) The speculation was endless: in 2003, the journalists Gordon Thomas and Martin Dillon published a book alleging that Maxwell was assassinated by Mossad to hide his spying activities. By that time, Maxwell was long gone, but the business he had started continued to thrive in new hands, reaching new levels of profit and global power over the coming decades.

If Maxwell's genius was in expansion, Elsevier's was in consolidation. With the purchase of Pergamon's 400-strong catalogue, Elsevier now controlled more than 1,000 scientific journals, making it by far the largest scientific publisher in the world.

At the time of the merger, Charkin, the former Macmillan CEO, recalls advising Pierre Vinken, the CEO of Elsevier, that Pergamon was a mature business, and that Elsevier had overpaid for it. But Vinken had no doubts, Charkin recalled: "He said, 'You have no idea how profitable these journals are once you stop doing anything. When you're building a journal, you spend time getting good editorial boards, you treat them well, you give them dinners. Then you market the thing and your salespeople go out there to sell subscriptions, which is slow and tough, and you try to make the journal as good as possible. That's what happened at Pergamon. And then we buy it and we stop doing all that stuff and then the cash just pours out and you wouldn't believe how wonderful it is.' He was right and I was wrong."

By 1994, three years after acquiring Pergamon, Elsevier had raised its prices by 50%. Universities complained that their budgets were stretched to breaking point – the US-based Publishers Weekly reported librarians referring to a "doomsday machine" in their industry – and, for the first time, they began cancelling subscriptions to less popular journals.

At the time, Elsevier's behaviour seemed suicidal. It was angering its customers just as the internet was arriving to offer them a free alternative. A 1995 Forbes article described scientists sharing results over early web servers, and asked if Elsevier was to be "The Internet's First Victim". But, as always, the publishers understood the market better than the academics.

In 1998, Elsevier rolled out its plan for the internet age, which would come to be called "The Big Deal". It offered electronic access to bundles of hundreds of journals at a time: a university would pay a set fee each year – according to a report based on freedom of information requests, Cornell University's 2009 tab was just short of \$2m – and any student or professor could download any journal they wanted through Elsevier's website. Universities

signed up en masse.

Those predicting Elsevier's downfall had assumed scientists experimenting with sharing their work for free online could slowly outcompete Elsevier's titles by replacing them one at a time. In response, Elsevier created a switch that fused Maxwell's thousands of tiny monopolies into one so large that, like a basic resource – say water, or power – it was impossible for universities to do without. Pay, and the scientific lights stayed on, but refuse, and up to a quarter of the scientific literature would go dark at any one institution. It concentrated immense power in the hands of the largest publishers, and Elsevier's profits began another steep rise that would lead them into the billions by the 2010s. In 2015, a Financial Times article anointed Elsevier “the business the internet could not kill”.

Publishers are now wound so tightly around the various organs of the scientific body that no single effort has been able to dislodge them. In a 2015 report, an information scientist from the University of Montreal, Vincent Larivière, showed that Elsevier owned 24% of the scientific journal market, while Maxwell's old partners Springer, and his crosstown rivals Wiley-Blackwell, controlled about another 12% each. These three companies accounted for half the market. (An Elsevier representative familiar with the report told me that by their own estimate they publish only 16% of the scientific literature.)

“Despite my giving sermons all over the world on this topic, it seems journals hold sway even more prominently than before,” Randy Schekman told me. It is that influence, more than the profits that drove the system's expansion, that most frustrates scientists today.

Elsevier says its primary goal is to facilitate the work of scientists and other researchers. An Elsevier rep noted that the company received 1.5m article submissions last year, and published 420,000; 14 million scientists entrust Elsevier to publish their results, and 800,000 scientists donate their time to help them with editing and peer-review. “We help researchers be more productive and efficient,” Alicia Wise, senior vice president of global strategic networks, told me. “And that's a win for research institutions, and for research funders like governments.”

On the question of why so many scientists are so critical of journal publishers, Tom Reller, vice president of corporate relations at Elsevier, said: “It's not for us to talk about other people's motivations. We look at the numbers [of scientists who trust their results to Elsevier] and that suggests we are doing a good job.” Asked about criticisms of Elsevier's business model, Reller said in an email that these criticisms overlooked “all the things that publishers do to add value – above and beyond the contributions that public-sector funding brings”. That, he said, is what they were charging for.

In a sense, it is not any one publisher's fault that the scientific world seems to bend to the industry's gravitational pull. When governments including those of China and Mexico offer financial bonuses for publishing in high-impact journals, they are not responding to a demand by any specific publisher, but following the rewards of an enormously complex system that has to accommodate the utopian ideals of science with the commercial goals of the publishers that dominate it. (“We scientists have not given a lot of thought to the water we're swimming in,” Neal Young told me.)

Since the early 2000s, scientists have championed an alternative to subscription publishing called “open access”. This solves the difficulty of balancing scientific and commercial imperatives by simply removing the commercial element. In practice, this usually takes the

form of online journals, to which scientists pay an upfront fee to cover editing costs, which then ensure the work is available free to access for anyone in perpetuity. But despite the backing of some of the biggest funding agencies in the world, including the Gates Foundation and the Wellcome Trust, only about a quarter of scientific papers are made freely available at the time of their publication.

The idea that scientific research should be freely available for anyone to use is a sharp departure, even a threat, to the current system – which relies on publishers' ability to restrict access to the scientific literature in order to maintain its immense profitability. In recent years, the most radical opposition to the status quo has coalesced around a controversial website called Sci-Hub – a sort of Napster for science that allows anyone to download scientific papers for free. Its creator, Alexandra Elbakyan, a Kazhakstani, is in hiding, facing charges of hacking and copyright infringement in the US. Elsevier recently obtained [a \\$15m injunction](#) (the maximum allowable amount) against her.

Elbakyan is an unabashed utopian. “Science should belong to scientists and not the publishers,” she told me in an email. In a letter to the court, she cited Article 27 of the UN's Universal Declaration of Human Rights, asserting the right “to share in scientific advancement and its benefits”.

Whatever the fate of Sci-Hub, it seems that frustration with the current system is growing. But history shows that betting against science publishers is a risky move. After all, back in 1988, Maxwell predicted that in the future there would only be a handful of immensely powerful publishing companies left, and that they would ply their trade in an electronic age with no printing costs, leading to almost “pure profit”. That sounds a lot like the world we live in now.

Note

This article was amended on 28 June and 5 July 2017. Elsevier published 420,000 papers last year, after receiving 1.5m submissions; a previous version incorrectly stated that it publishes 1.5m papers a year. This article was further amended to correct the date that the Soviet Union launched Sputnik. That was in 1957, not 1959.