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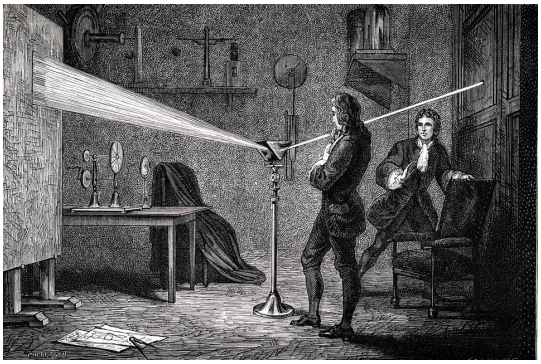
The Myth of Basic Science

Does scientific research drive innovation? Not very often, argues Matt Ridley: Technological evolution has a momentum of its own, and it has little to do with the abstractions of the lab



Isaac Newton (1642-1727) uses a prism to separate white light into the colors of the spectrum, watched by his Cambridge University roommate John Wickins, right, as rendered in an 1874 print. *PHOTO: ANN RONAN PICTURES/PRINT COLLECTOR/GETTY IMAGES*

By **MATT RIDLEY**

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Innovation is a mysteriously difficult thing to dictate. Technology seems to change by a sort of inexorable, evolutionary progress, which we probably cannot stop—or speed up much either. And it's not much the product of science. Most technological breakthroughs come from technologists tinkering, not from researchers chasing hypotheses. Heretical as it may sound, "basic science" isn't nearly as productive of new inventions as we tend to think.

Suppose Thomas Edison had died of an electric shock before thinking up the light bulb. Would history have been radically different? Of course not. No fewer than 23 people deserve the credit for inventing some version of the incandescent bulb before Edison, according to a history of the invention written by Robert Friedel, Paul Israel and Bernard Finn.

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The same is true of other inventions. Elisha Gray and Alexander Graham Bell filed for a patent on the telephone on the very same day. By the time Google came along in 1996, there were already scores

of search engines. As Kevin Kelly documents in his book "What Technology Wants," we know of six different inventors of the thermometer, three of the hypodermic needle, four of vaccination, five of the electric telegraph, four of photography, five of the steamboat, six of the electric railroad. The history of inventions, writes the historian Alfred Kroeber, is "one endless chain of parallel instances."

It is just as true in science as in technology. Boyle's law in English-speaking countries is the same thing as Mariotte's Law in French-speaking countries. Isaac Newton vented paroxysms of fury at Gottfried Leibniz for claiming, correctly, to have invented the calculus independently. Charles Darwin was prodded into publishing his theory at last by Alfred Russel Wallace, who had precisely the same idea after reading precisely the same book, Malthus's "Essay on Population."

Increasingly, technology is developing the kind of autonomy that hitherto characterized biological entities. The Stanford economist Brian Arthur argues that technology is self-organizing and can, in effect, reproduce and adapt to its environment. It thus qualifies as a living organism, at least in the sense that a coral reef is a living thing. Sure, it could not exist without animals (that is, people) to build and maintain it, but then that is true of a coral reef, too.

And who knows when this will no longer be true of technology, and it will build and maintain itself? To the science writer Kevin Kelly, the "technium"—his name for the evolving organism that our collective machinery comprises—is already "a very complex organism that often follows its own urges." It "wants what every living system wants: to perpetuate itself."

By 2010, the Internet had roughly as many hyperlinks as the brain has synapses. Today, a significant proportion of the whispering in the cybersphere originates in programs—for monitoring, algorithmic financial trading and other purposes—rather than in people. It is already virtually impossible to turn the Internet off.

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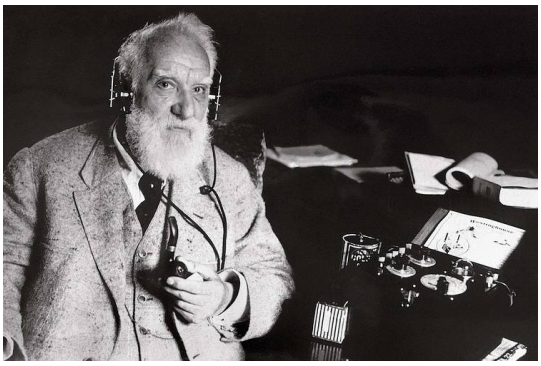
The implications of this new way of seeing technology—as an autonomous, evolving entity that continues to progress whoever is in charge—are startling. People are pawns in a process. We ride rather than drive the innovation wave. Technology will find its inventors, rather than vice versa. Short of bumping off half the population, there is little that we can do to stop it from happening, and even that might not work.

Indeed, the history of technological prohibitions is revealing. The Ming Chinese prohibited large ships; the Shogun Japanese, firearms; the medieval Italians, silk-spinning; Americans in the 1920s, alcohol. Such prohibitions can last a long time—three centuries in the case of the Chinese and Japanese examples—but eventually they come to an end, so long as there is competition. Meanwhile, elsewhere in the world, these technologies continued to grow.

Today it is impossible to imagine software development coming to a halt. Somewhere in the world, a nation will harbor programmers, however strongly, say, the U.N. tries to enforce a ban on software development. The idea is absurd, which makes my point.

It is easier to prohibit technological development in larger-scale technologies that require big investments and national regulations. So, for example, Europe has fairly successfully maintained a de facto ban on genetic modification of crops for two decades in the name of the "precautionary principle"—the idea that any possibility of harm, however remote, should scuttle new technology—and it looks as if it may do the same for shale gas. But even here, there is no hope of stopping these technologies globally.



Elisha Gray and Alexander Graham Bell, pictured, filed for a patent on the telephone on the very same day. *PHOTO: AISA/EVERETT COLLECTION*

And if there is no stopping technology, perhaps there is no steering it either. In Mr. Kelly's words, "the technium wants what evolution began." Technological change is a far more spontaneous phenomenon than we realize. Out with the heroic, revolutionary story of the inventor, in with the inexorable, incremental, inevitable creep of innovation.

Simultaneous discovery and invention mean that both patents and Nobel Prizes are fundamentally unfair things. And indeed, it is rare for a Nobel Prize not to leave in its wake a train of bitterly disappointed individuals with very good cause to be bitterly disappointed.

Patents and copyright laws grant too much credit and reward to individuals and imply that technology evolves by jerks. Recall that the original rationale for granting patents was not to reward inventors with monopoly profits but to encourage them to share their inventions. A certain amount of intellectual property law is plainly necessary to achieve this. But it has gone too far. Most patents are now as much about defending monopoly and deterring rivals as about sharing ideas. And that discourages innovation.

Even the most explicit paper or patent application fails to reveal nearly enough to help another to retrace the steps through the maze of possible experiments. One study of lasers found that blueprints and written reports were quite inadequate to help others copy a laser design: You had to go and talk to the people who had done it. So a patent often does not achieve the openness that it is supposed to but instead hinders progress.

The economist Edwin Mansfield of the University of Pennsylvania studied the development of 48 chemical, pharmaceutical, electronic and machine goods in New England in the 1970s. He found that, on average, it cost 65% as much money and 70% as much time to copy products as to invent them. And this was among specialists with technical expertise. So even with full freedom to copy, firms would still want to break new ground. Commercial companies do basic research because they know it enables them to acquire the tacit knowledge that assists further innovation.

Politicians believe that innovation can be turned on and off like a tap: You start with pure scientific insights, which then get translated into applied science, which in turn become useful technology. So what you must do, as a patriotic legislator, is to ensure that there is a ready supply of money to scientists on the top floor of their ivory towers, and lo and behold, technology will come clanking out of the pipe at the bottom of the

tower.

This linear model of how science drives innovation and prosperity goes right back to Francis Bacon, the early 17th-century philosopher and statesman who urged England to catch up with the Portuguese in their use of science to drive discovery and commercial gain. Supposedly Prince Henry the Navigator in the 15th century had invested heavily in mapmaking, nautical skills and navigation, which resulted in the exploration of Africa and great gains from trade. That is what Bacon wanted to copy.

Yet recent scholarship has exposed this tale as a myth, or rather a piece of Prince Henry's propaganda. Like most innovation, Portugal's navigational advances came about by trial and error among sailors, not by speculation among astronomers and cartographers. If anything, the scientists were driven by the needs of the explorers rather than the other way around.

Terence Kealey, a biochemist turned economist, tells this story to illustrate how the linear dogma so prevalent in the world of science and politics—that science drives innovation, which drives commerce—is mostly wrong. It misunderstands where innovation comes from. Indeed, it generally gets it backward.

When you examine the history of innovation, you find, again and again, that scientific breakthroughs are the effect, not the cause, of technological change. It is no accident that astronomy blossomed in the wake of the age of exploration. The steam engine owed almost nothing to the science of thermodynamics, but the science of thermodynamics owed almost everything to the steam engine. The discovery of the structure of DNA depended heavily on X-ray crystallography of biological molecules, a technique developed in the wool industry to try to improve textiles.

Technological advances are driven by practical men who tinkered until they had better machines; abstract scientific rumination is the last thing they do. As Adam Smith, looking around the factories of 18th-century Scotland, reported in "The Wealth of Nations": "A great part of the machines made use in manufactures...were originally the inventions of common workmen," and many improvements had been made "by the ingenuity of the makers of the machines."

It follows that there is less need for government to fund science: Industry will do this itself. Having made innovations, it will then pay for research into the principles behind them. Having invented the steam engine, it will pay for thermodynamics. This conclusion of Mr. Kealey's is so heretical as to be incomprehensible to most economists, to say nothing of scientists themselves.

For more than a half century, it has been an article of faith that science would not get funded if government did not do it, and economic growth would not happen if science did not get funded by the taxpayer. It was the economist Robert Solow who demonstrated in 1957 that innovation in technology was the source of most economic growth—at least in societies that were not expanding their territory or growing their populations. It was his colleagues Richard Nelson and Kenneth Arrow who explained in 1959 and 1962, respectively, that government funding of science was necessary, because it is cheaper to copy others than to do original research.

"The problem with the papers of Nelson and Arrow," writes Mr. Kealey, "was that they were theoretical, and one or two troublesome souls, on peering out of their economists' aeries, noted that in the real world, there did seem to be some privately funded research happening." He argues that there is still no empirical demonstration of the need for public funding of research and that the historical record suggests the opposite.

After all, in the late 19th and early 20th centuries, the U.S. and Britain made huge contributions to science with negligible public funding, while Germany and France, with hefty public funding, achieved no greater results either in science or in economics.

After World War II, the U.S. and Britain began to fund science heavily from the public purse. With the success of war science and of Soviet state funding that led to Sputnik, it seemed obvious that state funding must make a difference.

The true lesson—that Sputnik relied heavily on Robert Goddard's work, which had been funded by the Guggenheims—could have gone the other way. Yet there was no growth dividend for Britain and America from this science-funding rush. Their economies grew no faster than they had before.

In 2003, the Organization for Economic Cooperation and Development published a paper on the "sources of economic growth in OECD countries" between 1971 and 1998 and found, to its surprise, that whereas privately funded research and development stimulated economic growth, publicly funded research had no economic impact whatsoever. None. This earthshaking result has never been challenged or debunked. It is so inconvenient to the argument that science needs public funding that it is ignored.

In 2007, the economist Leo Sveikauskas of the U.S. Bureau of Labor Statistics concluded that returns from many forms of publicly financed R&D are near zero and that "many elements of university and government research have very low returns, overwhelmingly contribute to economic growth only indirectly, if at all."

As the economist Walter Park of American University in Washington, D.C., concluded, the explanation for this discrepancy is that public funding of research almost certainly crowds out private funding. That is to say, if the government spends money on the wrong kind of science, it tends to stop researchers from working on the right kind of science.

To most people, the argument for public funding of science rests on a list of the discoveries made with public funds, from the Internet (defense science in the U.S.) to the Higgs boson (particle physics at CERN in Switzerland). But that is highly misleading. Given that government has funded science munificently from its huge tax take, it would be odd if it had not found out something. This tells us nothing about what would have been discovered by alternative funding arrangements.

And we can never know what discoveries were not made because government funding crowded out philanthropic and commercial funding, which might have had different priorities. In such an alternative world, it is highly unlikely that the great questions about life, the universe and the mind would have been neglected in favor of, say, how to clone rich people's pets.

The perpetual-innovation machine that feeds economic growth and generates prosperity is not the result of deliberate policy at all, except in a negative sense. Governments cannot dictate either discovery or invention; they can only make sure that they don't hinder it. Innovation emerges unbidden from the way that human beings freely interact if allowed. Deep scientific insights are the fruits that fall from the tree of technological change.

Mr. Ridley is the author of "The Evolution of Everything: How New Ideas Emerge," to be published next week by Harper (which, like The Wall Street Journal, is owned by News Corp). He is a member of the British House of Lords.