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The State of the Scientist

The **identity** of the modern scientist is, in every possible sense, a **work in progress**.

By Steven Shapin

Scientists, perhaps to a greater degree than any other sector of society, get to define what the world is like. They may not always be the most highly rewarded people in our communities, but they are among the most influential: When reality speaks, it speaks through them, and what we know about the world, we know because we have found grounds to recognize their competence and to trust them or the institutions they represent.

Our understanding of who these men and women are is central to the authority of modern science, and if, as seems to be the case, there are emerging problems with that authority, then a clarification of the scientist's identity is in order. It's not so easy, however, to know exactly *who* the scientist is. Public perception of the scientist probably owes much to the idea of mastering something known as the "scientific method" (even though there is no consensus on what exactly this consists of), but we also define scientists through some notion of integrity — an independent voice speaking truth to power. So any perceived problems concerning scientists' moral makeup are of great consequence: Scientists without credibility are culturally impotent, and science without credibility is a meaningless enterprise.

In recent times, and especially over the past quarter century, scientific integrity has become a live issue in public culture — think of the drumbeat of reports on commercially and politically induced bias and violations of research independence. Medical-journal editors despair of finding reviewers without financial ties to Big Pharma. The *New York Times* and the Associated Press now routinely inform readers not just about what scientists claim but also about their sources of commercial research funding and whether or not they act as consultants to, or accept speaking fees from, industry. It's become a truism — a point of pride for some, of anxiety for others — that academia and industry as scientific work environments have converged in all sorts of ways. At the same time, these ties and convergences have elicited diverse reactions from within the scientific community: Just as there are scientists wholly comfortable doing their work in industry or with industrial support, there are others who take the responsibility of defending scientific integrity and who seek to foreground commercial bias or government interference as public issues. Some scientists speak for reality from within the big oil companies; others claim that to do such a thing with integrity is impossible and speak up for the environment from an advertised position of institutional independence.

We are on the verge of a new administration, and major universities are holding public symposia on the likely fate of science in the next presidency — whether there will be more or fewer dollars for research and education, how the status of research independence will unfold; whether government will once again view science as an ally rather than an enemy. At the cusp of 2009, it's imperative that we now take stock of what we know, and what we think we know, about the remarkable, and remarkably influential, group of people called scientists. What's been changing about scientists' identity over recent history? How do they define their jobs and roles? What's always been the case and what's new?

Scientific research is a job, a decently remunerated living for significant numbers of people. According to the most recent statistics assembled by the National Science Foundation, there are 5.4 million Americans in science and engineering occupations, up from 3.3 million a decade ago, and from fewer than 200,000 in 1950. And a much larger number, 12.9 million, report that they need at least bachelor's-level science and engineering knowledge in their jobs. Figures for other developed countries vary, but the American trend is indicative — that's a lot of people with technical training, paid to deploy their scientific and engineering knowledge.

It was not always this way. Well into the 19th century, and even into the 20th, doing science was typically more of an avocation than a job. In the 17th century, the great chemist Robert Boyle not only financed his science out of his own deep pockets but also shared a common view that doing science as a "trade" was demeaning. Anyone who accepted money to pursue knowledge would compromise their integrity — who paid the piper called the tune. Isaac Newton, as professor of mathematics at Cambridge University, was not paid to do physical or mathematical research but to teach. The 19th century's most famous scientist, Charles Darwin, was never paid to do science. And Einstein's three great papers of 1905 were not part of his job specifications: He was then a patent clerk in Switzerland. True, over the course of history, many scientific researchers were in academic employment, but with few exceptions, before the 20th century, the job of a science professor was not to produce new knowledge but to transmit and safeguard existing knowledge. Until quite recent times, the number of people in the world paid to do original scientific research "for its own sake" was infinitesimally small.

The transformation of science from a calling to a job happened largely during the course of the past century. Indeed, science is arguably the world's youngest profession: The routinization of the paid role is less than a hundred years old; the word "scientist," coined in 1840, was not in standard usage until the early 20th century. And though there are current concerns over commercial and military ties, practically no one now shares Boyle's worries that taking money to do science compromises its integrity or, indeed, that there is any conceivable alternative to government, industry, and, to a lesser extent, nonprofit foundations as sources of funding. Universities' own funds pay for only a small portion of scientific research, and while foundations have been a significant source of support for about a century, academic scientists without government funding are rare and usually handicapped in doing their work.

But this taken-for-granted state of affairs flowed from changing public perceptions of what scientific knowledge might be good for, indeed what science was. We should understand these changes and what brought them about, for they have enormous implications for the status, strength, and durability of present-day arrangements.

From a historical point of view, neither "science" nor "technology" is a self-evident category. In the 16th and 17th centuries, natural philosophers (we might now call them physicists) and mathematicians (whom we might now call engineers) were thought to have fundamentally different aims; incidentally, much more prestige was then attached to the philosopher seeking pure understanding than to the mathematician seeking to manipulate the world.

World War II fundamentally changed that state of affairs. At Los Alamos, physicist Robert Oppenheimer presided over the transformation of theoretical knowledge into practical application, of chalkboard equations into explosive reality. Hiroshima and Nagasaki profoundly altered public perceptions both of what scientific knowledge was and what scientists were capable of delivering, and in the immediate postwar period, Oppenheimer and his colleagues spoke about a new, widespread belief that apparently useless knowledge could unpredictably become extremely useful. Statesmen of science involved in the founding of the National Science Foundation urged that basic research deserved large-scale federal support for just that reason. Big German and American electrical, chemical, and photographical companies had accepted a limited version of that argument from very early in the 20th century, but it took the atomic bomb and its political fallout to extend the sensibility to almost all of science and to make it politically and culturally consequential. With the advent of the Bomb, almost all scientists — not just nuclear physicists — began to appear as sources of power, and the extent to which American science fed off that legacy during the Cold War decades cannot be overemphasized.

World War II did much to allay long-held American skepticism of scientific inquiry seemingly disengaged from material outcomes and a deep-rooted disapproval of government support for research not promising immediate contributions to national welfare or security. But it did so by enshrining what has been called the Linear Argument — pure science produces applied science, which produces technology and economic growth — at the heart of the new contract between science and the state. In the mid-1970s and '80s, the late Sen. William Proxmire used to give out monthly "Golden Fleece" awards to individuals and institutions wasting public money in the most "frivolous" and "egregious" ways. A famous award went to $2,000 toilet seats for Air Force planes, but also to projects funded by the National Science Foundation and National Institutes of Health for research whose point and payoff the good senator did not understand: research on the sex lives of quail and on alcoholism in rats, to name but two studies. And in the early 1980s, when a sample of the American public was asked whether they wanted their tax dollars spent in pursuit of pure research, only 9 percent said they did. The American public still tends to approve of science in proportion to the contribution they think it can make to a range of valued goals — better health, an improved environment, reduced crime, etc. In the first presidential debate, John McCain angled for applause by once again citing research on the DNA of bears: "I don't know if it was a criminal issue or a paternal issue," he quipped, "but the fact is that it was $3 million of our taxpayers' money. And it has got to be brought under control." Even Rita Colwell, who as director of the National Science Foundation was wholly committed to "curiosity-driven research," worked strenuously to convince the George W. Bush administration "how much of the wealth and health of the country…comes from our investment in science," thus paradoxically, but typically, defending intellectual curiosity on the grounds of material national interest. So the modern American scientist is held in some esteem, valued as a useful sort of person, but there is little understanding of what it might be to engage in scientific inquiry for its own sake and little evident approval of such a thing.

If early modern intellectual culture considered the "philosophers" to be the most prestigious sort of practitioner, the culture heroes of contemporary America are increasingly the "engineers" and the enterprising scientists whose discoveries can be turned to cures, power, and, of course, profit. Although only a fraction of present-day scientists and engineers fit this conspicuous mold, and an even smaller fraction become wealthy through entrepreneurial activities, the figure of the scientist-as-businessperson is fast becoming iconic. Our culture now admires commercializing entrepreneurs; it encourages and rewards them; and more and more it identifies the life of science with that of business and private enterprise.

In one sense, the enfolding of science in structures that produce wealth and project power is just a sign of its practitioners' immense success over the course of the past century. Even in the early 1900s, it was common for the public to think of scientists as useless, funny, and rather eccentric. Now, while the caricature is still, if just barely, recognizable, and while *Beauty and the Geek* trades on the supposed social ineptness of the technically knowledgeable, governments and industry around the world compete for their services. The global "knowledge economy" calls out for universities to supply more of them and, since the proportion of science and engineering degrees awarded by US universities to US citizens is declining precipitously, for government to supply many more H-1B visas for the large numbers that must be imported.

Science is now widely understood as an engine of economic growth, so it is remarkable that there are still many who associate the scientific life with institutions of higher education conceived on the model of the Ivory Tower. This was not the case in the early part of the previous century, nor is it the case now. Today almost two-thirds of all American science and engineering degree-holders are working either in the forprofit sector or are self-employed; only 9 percent work for colleges or universities. Even pure science has long had a significant presence outside academia. At the origins of corporate research in the early 20th century, big companies such as General Electric, AT&T, Eastman Kodak, and DuPont were the dominant sponsors of industrial science, and although the great majority of their money went to applied research and development, government and academia then supplied so little funding for basic research that most of that too was done in industry. It is now widely said that the research laboratories of big industrial firms are on their way out: The decline and fall of Bell Labs and the so-called “crisis in innovation” in global Big Pharma have both made recent headlines. Yet, if anything, the place of science in the for-profit sector has become more secure due to the past four decades of growth by small, entrepreneurial high-tech and biotech firms, where the boundary between making things and making knowledge is increasingly unclear and even irrelevant, and by the burgeoning commitment to all sorts of scientific research by such companies as Microsoft, Intel, and, most visibly, Google. The commercial sector now does about 70 percent of all American R&D in dollar terms. And while the overwhelming majority of corporate R&D remains biased toward development and applied research, about a fifth of US basic research is still done in industry.

The dissolution of boundaries between academia and industry has given enormous strength to modern American science: resources to do what scientists want to do, time (substantially freed from academic teaching and administration) to do it, and the reputation that comes from aligning science with the concrete goods — better communications, better health, more energy-efficient products, and enhanced national security — so evidently valued by citizens who may have little or no concern for the pursuit of knowledge “for its own sake.” And if the scientists inhabiting such institutions can now make a good living, or even on occasion fabulous wealth, then that too augments the value that our sort of society grants science, perhaps acting as effectively as any other inducement to attract young people to careers in science and engineering.

But two problems seem to flow from this success story. The first is a traditional one faced by scientists who work in democratic societies. The evidently useful will be valued, and supported, at the expense of the evidently useless, and no overall credibility associated with the Linear Argument will do much good for the evidently useless: research on the evolution of Central American birds, brachiopod paleontology, the chemical composition of Pluto, and, indeed, the sex life of quails. The version of the Linear Argument our society seems to find credible is the one that says, “There’s no certainty that the evidently useless will actually turn out to be useless,” but still, that’s not quite the same thing as the version that says, “All knowledge will ultimately turn out to be useful.”

The second problem concerns the integrity associated with the scientific life and the authority of scientists. The increasing alignment of science with commercial institutions carries a risk: the loss in the public mind of the idea of an independent scientific voice — not truth speaking to power but power shaping what counts as truth. Thus, we have the Bush administration’s attempt to muzzle one of its leading climate scientists, reports of routine political interference in the scientific work of the Environmental Protection Agency, and Big Pharma ghostwriting papers supporting the efficacy of new drugs. Yet the enfolding of science into institutions of wealth generation and power projection makes independence that much harder to recognize and to acknowledge. And when scientific knowledge becomes patentable property, a state secret, or a plaything of political ideology, then science loses its independence from civic institutions. We’re still a long way from the general “corruption” of science — witness the moral outrage attending stories about commercial or political incursions into science. But if it came to pass that these associations count as normal, then the scientific voice would no longer sound independent. The material utility of science that is a substantial basis for its success would then undermine itself. To be a modern scientist is to be an employee, but the job must have a degree of autonomy or scientists will be of no use — to the institutions that engage their services or to the public.

Seeing modern scientists in an uneasy position between the polarized force fields of truth and commerce, or of truth and politics, is one way of understanding the current condition. It is a story that has deep roots in history, that is readily recognized in our culture, and that powerfully mobilizes the passions. The story is not wrong, but it is incomplete. It fails to grasp some radical changes in the institutional condition of the scientist and in the nature of scientific work that are even now taking place at the leading edges of technoscientific change. Consider an emerging field like synthetic biology, which aims to build biological systems at the molecular level that do not exist in nature. The circumstances in which synthetic biologists live and work are certainly not typical of the modern scientific life, but they are arguably emblematic of the direction of major 21st century changes.

Many researchers doing this sort of work couldn't care less whether their activities are called science or technology. Their chief concern is the opportunity to do interesting research. And a growing number are leveraging their expertise against some of the world's most intractable problems: They say that what moves them is the possibility to develop new malaria drugs or to design microbes to solve the energy crisis. Some synthetic biologists work in universities, others in industry, and still others in new public-private ventures that defy those categories altogether. The National Science Foundation, for example, recently committed tens of millions of dollars to SynBERC, a multi-site academic synthetic biology consortium, on the condition that it not only have significant industrial ties, but also that the research itself becomes self-financing within 10 years, while the Gates Foundation has poured $42 million into SynBERC's malaria work. Drew Endy, a leading academic synthetic biologist affiliated with the consortium, freely acknowledges that industry is the innovation leader in the field. At the same time, he has established an open source framework for the free sharing of standard molecular components, modeled historically on 19th century patterns of American mechanical engineering and on the contemporary open source software movement. Endy says he wants to make everything publicly available and that we can't afford to go the way of a biological Microsoft: It makes him "physically angry" to patent entities that already exist in nature, yet he and his associates have founded a company to patent and license inventions that has attracted over $40 million from some of the most high-powered venture capital firms in the country.

In a recent roundtable discussion published in the journal *Biosocieties*, synthetic biologists countered concerns about bioterrorism by invoking well-established arguments that this is the state's concern, that government support for this work enhances preparedness, and that the global practice of traditional scientific openness will be a bulwark against the militarization of engineered microbes. The likelihood of intense ethical and moral concerns about research like synthetic biology has propelled scientists beyond occasional internecine conversations about the "ethical, social, and legal implications" of their work and into new collaborations with humanists and social scientists about the very nature of the work and the institutional environments in which it is taking place. Increasingly, social scientists want to be players, not mere outside commentators, in a major technoscientific enterprise, and they've received a government mandate to play that role. SynBERC's funding from the NSF, for instance, has been at least partly contingent on its inclusion of a "human practices" component, led by an anthropologist and a political scientist. Synthetic biologists reluctantly admit that this sort of collaboration is not something that comes naturally to them but that it's a necessary condition of forging ahead in a culture where the walls of science have become partly transparent. No one knows how any of this is going to play out, but one possibility is a redrawing of the map of the sciences, with an adjustment of the boundaries between the natural and social sciences.

As we enter the 21st century, new institutional configurations for doing science emerge, together with new scientific agendas and new conceptions of what it is to be a scientist. Some participants and observers of the scene celebrate these changes; others are seriously worried about them. We can be sure of only one thing: The identity of the modern scientist is, in every possible sense, a work in progress.

Steven Shapin is a historian and sociologist of science at Harvard University. His latest book, Never Pure, examines the shifting modern roles and definitions of scientists.