Science and the Modern World

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Science Made the Modern World, and it's science that shapes modern culture. That's a sentiment that gained currency in the latter part of the nineteenth century and the early twentieth century—a sentiment that seemed almost too obvious to articulate then and whose obviousness has, if anything, become even more pronounced over time. Science continues to Make the Modern World. Whatever names we want to give to the leading edges of change—globalization, the networked society, the knowledge economy—it's science that's understood to be their motive force. It's science that drives the economy and, more pervasively, it's science that shapes our culture. We think in scientific terms. To think any other way is to think inadequately, illegitimately, nonsensically. In 1959, C. P. Snow's *Two Cultures and The Scientific Revolution* complained about the low standing of science in official culture, but he was presiding not at a funeral but at a christening. In just that very broad sense, the "science wars" have long been over and science is the winner.

In the 1870s, Andrew Dickson White, then president of Cornell, wrote about the great warfare between science and what he called "dogmatic theology" that was being inexorably won by science.[1] In 1918, Max Weber announced the "disenchantment of the world," conceding only that "certain big children" still harbored reservations about the triumph of amoral science (Weber, [1919]1991: 142). Some years earlier, writing from the University of Chicago, Thorstein Veblen described the essential mark of modern civilization as its "matter of fact" character, its "hard headed apprehension of facts." "This characteristic of western civilization comes to a head in modern science," and it's the possession of science that guarantees the triumph of the West over "barbarism." The scientist rules: "On any large question which is to be disposed of for good and all the final appeal is by common consent taken to the scientist. The solution offered by the scientist is decisive," unless it is superseded by new science. "Modern common sense holds that the scientist's answer is the only ultimately true one." It is matter-of-fact science that "gives tone" to modern culture (Veblen, 1906: 585–88). This is not an injunction about how modern people *ought* to think and speak but Veblen's description of how we *do* think and speak.

In 1925, Alfred North Whitehead's *Science and the Modern World* introduced the historical episode that "made modernity," which had not *yet* been baptized as "the

Scientific Revolution": it was "the most intimate change in outlook which the human race had yet encountered . . . Since a babe was born in a manger, it may be doubted whether so great a thing has happened with so little stir." What started as the possession of an embattled few had reconstituted our collective view of the world and the way to know it; the "growth of science has practically recoloured our mentality so that modes of thought which in former times were exceptional, are now broadly spread through the educated world." Science "has altered the metaphysical presuppositions and the imaginative contents of our minds . . ." Born in Europe in the sixteenth and seventeenth centuries, its home is now "the whole world." Science, that is to say, travels with unique efficiency: it is "transferable from country to country, and from race to race, wherever there is a rational society" (Whitehead, [1925]1946: 2).

The founder of the academic discipline called the history of science—Harvard's George Sarton—announced in 1936 that science was humankind's *only* "truly cumulative and progressive" activity, so if you wanted to understand progress towards modernity, the history of science was the only place to look (Sarton, 1936: 5). The great thing about scientific progress was—as was later said and often repeated—that "the average college freshman knows more physics than Galileo knew . . . and more too than Newton" (Gillispie, 1960: 9). Science, Sarton (1948: 55) wrote, "is the most precious patrimony of mankind. It is immortal. It is inalienable." When, toward the middle of the just-past century, the Scientific Revolution was given its proper name, it was, at the same time, pointed to as the moment modernity came to be. Listen to Herbert Butterfield in 1949, an English political historian, making his one foray into the history of science:

> [the scientific revolution] outshines everything [in history] since the rise of Christianity and reduces the Renaissance and Reformation to the rank of mere episodes, mere internal displacements, within the system of medieval Christendom. Since it changes the character of men's habitual mental operations even in the conduct of the non-material sciences, while transforming the whole diagram of the physical universe and the very texture of human life itself, it looms . . . large as the real origin of the modern world and of the modern mentality . . . (Butterfield, 1949: —viii)

Butterfield's formulation was soon echoed and endorsed, as in this example from the Oxford historian of science A. C. Crombie:

> The effects of the new science on life and thought have . . . been so great and special that the Scientific Revolution has been compared in the history of civilisation to the rise of ancient Greek philosophy in the 6th and 5th centuries B.C. and to the spread of Christianity throughout the Roman Empire . . . (Crombie, [1952]1959: vol. 1, p. 7)

And by 1960 it had become a commonplace—Princeton historian Charles Gillispie (1960: 8) concurring that modern science, originating in the seventeenth century, was "the most . . . influential creation of the western mind." As late as 1986, Richard Westfall—then the dean of America's historians of science—put science right at the heart of the modern order: "For good and for ill, science stands at the center of every dimen-

sion of modern life. It has shaped most of the categories in terms of which we think . . ." (Westfall, 1986).

Evidence of that contemporary influence and authority is all around us and is undeniable. In the academy, and most especially in the modern research university, it is the natural sciences that have pride of place and the humanities and social sciences that look on in envy and, sometimes, resentment. In academic culture generally, the authority of the natural sciences is made manifest in the long-established desire of many forms of inquiry to take their place among the "sciences": social science, management science, domestic science, nutrition science, sexual science. Just because the designation "science" is such a prize, more practices now represent themselves as scientific than ever before. The homage is paid from the weak to the strong: students in sociology, anthropology, and psychology commonly experience total immersion in "methods" courses, and while chemists learn how to use mass spectrometers and Bunsen burners, they are rarely exposed to courses in "scientific method." The strongest present-day redoubts of belief in the existence, coherence, and power of the scientific method are found in the departments of human, not of natural, science.

Moreover, though it may be vulgar to mention such things, one index of the authority of science in academic culture is the distribution of cash, a distribution that seems—crudely but effectively—to reflect public sensibilities about which forms of inquiry have real value and which do not. The National Science Foundation and the National Institutes of Health distribute vastly more money to natural scientific research than the National Endowment of the Humanities does to its constituents. Statistics firmly establish pay differentials between academic natural scientists and engineers and their colleagues in sociology and history departments, and the "summer salary" instituted by the National Science Foundation early in its career was one explicit means of ensuring this result in a Cold War era when the "scarcity" of physicists and chemists, but not of, say, art historians, was a matter of political concern. These days it is more likely the "opportunity cost" argument that justifies this outcome, even if it means that not just scientists and engineers but also academic lawyers, physicians, economists, and business school professors now command higher salaries.[2] Many scientists and engineers are now the apples of their administrators' eyes because their work brings in government and corporate funding, with the attendant overheads on which research universities now rely to pay their bills. Finally, the ability of university administrators to advertise to their political masters how their activities help "grow the local economy," spinning off entrepreneurial companies, transferring technology, and creating high-paid, high-tax jobs, all support the increasing influence of science and engineering in the contemporary research university. In the 1960s, social and cultural theorists—following Habermas—began to worry about what they called a "technocracy," in which decisions properly belonging in the public sphere, to be taken by democratically elected and democratically accountable politicians, were co-opted by a cadre of scientific and technical experts—as the saying is, "on top" rather than "on tap." Even though that worry seems to have been allayed by more recent concern with political interference in scientific judgments, a recent

New Yorker magazine piece complaining about the Bush Administration's attack on the autonomy of science blandly asserted the primacy of science as the leading force of modern historical change: "Science largely dictated the political realities of the twentieth century" (Specter, 2006: 61).

Sixty years after Hiroshima, and over a century after General Electric founded the first industrial research laboratory, it is almost too obvious to be pointed out that it is the natural sciences that are now so closely integrated into the structures of power and wealth, and not their poorer intellectual cousins. It is science that has the capacity to deliver the goods wanted by the military and by industry, and not sociology or history, though some obvious qualifications need to be made—not all the natural sciences do this—and there was a period, early in the post–World War II world, when there were visions of how the human sciences might make major contributions to problems of conflict, deviance, strategic war-gaming, the rational conduct of military operations and weapons development, and the global extension of benign American power. Few observers disagree when it is said that science has changed much about the way we live now and are likely to live in the future: how we communicate, how long we are likely to live and how well, whether any of the crucial global problems we now confront—from global warming to our ability to feed ourselves—are likely to be solved—indeed, what it will mean to be human.

Some time about the middle of the just-past century, sociologists noted an exponential increase in the size of the scientific enterprise. By any measure, almost everything to do with science was burgeoning: in the early 1960s, it was said that 90 percent of all the scientists who had ever lived were then alive and that a similar proportion of all the scientific literature ever published had been published in the past decade. Expenditures on scientific research were going up and up, and, if these trends continued—which in the nature of things they could not—every man, woman, child, and dog in the United States would be a scientist and every dollar of the Gross Domestic Product would be spent on the support of science (Price, [1963]1968: 19). By these and many other measures, it makes excellent sense to observe that science *is* constitutive of the Modern World. And so it's hard to say that claims that Science either Made the Modern World or that Science is constitutive of Modern Culture are either nonsense or that they need massive qualification. Nevertheless, unless we take a much closer look at such claims, we will almost certainly fail to give any worthwhile account of the Way We Live Now.

Do we live in a scientific world? Assuming that we could agree on what such a statement might mean, there is quite a lot of evidence that we do not now and never have. In 2003, a Harris poll revealed that 90 percent of American adults believe in God, a belief that, of course, is not now, and never was, in any necessary conflict with whatever might be meant by a scientific mentality. But 82 percent believe in a physical Heaven—a belief that is—perhaps predictably, just because Heaven is so much more pleasant than The Other Place—13 percent more popular than a belief in Hell; 84 percent believe in the survival of an immaterial soul after death, and 51 percent in the reality of ghosts. The triumph of science over religion trumpeted in the late nine-

teenth century crucially centered on the question of whether or not supernatural spiritual agencies could intervene in the course of nature, that is to say, whether such things as miracles existed. By that criterion, 84 percent of American adults are unmarked by the triumph of science over religion that supposedly happened over a century ago. These responses are not quite the same thing as the "public ignorance of science" (or "public misunderstanding of science") so frequently bemoaned by leaders of the scientific community. For that, you'll want statistics on public beliefs about things like species change or the Copernican system. Such figures are available: 57 percent of Americans say they believe in psychic phenomena, such as ESP and telepathy, that cannot be explained by "normal means."[3] Americans are often said to be more credulous than Europeans, but comparative statistics point to a more patchy state of affairs. Forty percent of Americans said astrology is "very" or "sort of" scientific, while 53 percent of Europeans that it was "rather scientific." Americans did somewhat better than Europeans in grasping that the Earth revolves around the Sun and not the other way: 24 percent of Americans got that wrong compared with 32 percent of Europeans, and only 48 percent of Americans believed that antibiotics killed viruses compared with 59 percent of Europeans. Unsurprisingly, the "Darwin question" is flunked by more Americans than Europeans: 69 percent of Europeans, but only 52 percent of Americans, agreed that "Human beings developed from earlier species of animals" (National Science Foundation, 2001; European Commission, 2001). A still more recent transnational survey published in *Science* shows that, when asked the same question, Americans yielded the second-lowest rate of acceptance (now 40 percent) of all 34 countries polled—above only Turkey (Miller et al., 2006). If you believe the Gallup pollsters, then in 2005 the percentage of Americans who agreed with the more specific and loaded statement that "Man has developed over millions of years from less advanced forms of life [and] no God participated in this process" was 12 percent, encouragingly up from 9 percent in 1999.[4]

Whitehead's *Science and the Modern World* was based on the Lowell Lectures given at Harvard by a newly minted professor of philosophy, and perhaps that context is relevant to his assertion that scientific modes of thought "are now broadly spread through the educated world." Perhaps we can conclude that there is now, just as there always has been, a big gulf between "the educated world" and the unwashed and unlettered. But Whitehead was quite aware that the Galilean-Newtonian "revolution" was the possession of only a very small number of people and that their beliefs bore slight relationship to those of the peasantry in Sussex, much less in Serbia or Siam. Although a number of twentieth-century scholars loosely referred (and refer) to science-induced tectonic and decisive shifts in "our" ways of thinking, or to those of "the West," Whitehead, addressing his Harvard audience, confined himself to "the educated world." So it must, then, be relevant that the 84 percent of contemporary Americans who profess belief in miracles does indeed drop when the responses of only those with *postgraduate degrees* are considered, that is to say, not just who are college educated but have master's or doctoral degrees. The percentage of *these* elites who say they believe in miracles is *only* 72 percent and the percentage of college graduates who agree with the

Gallup poll's version of Darwinian evolution is 16.5 percent. The possibility remains that we can still make some distinction of the general sort that Whitehead intended: suppose that "science" is what's believed at Harvard and Haverford that's not believed at, say, Oral Roberts. Maybe that's right, but that's not *quite* what Whitehead said.

Perhaps, then, we should find some statistics about what *scientists* believe. A survey conducted in 1916 found that 40 percent of randomly selected American scientists professed belief in a personal God. This was a surprise to the author of the report, and he expressed his confidence that the figure would surely drop as education spread (Leuba, 1916). But it has not. In a survey published in *Nature* in 1997, an identical 40 percent of American scientists counted themselves as believers in God, with only 45 percent willing to say they did not believe (Radford, 2003; Larson & Witham, 1997). Those wanting to get the figure of scientists believing in a personal God or human immortality under 10 percent will have to accept a 1998 survey confined to members of the National Academy of Sciences, while the mathematicians among this elite were the most likely to believe, at about 15 percent (Larson & Witham, 1998). Scientists, of course, are leading the charge in the recent American defense of Darwinism in the classroom, but according to the Gallup poll, only a bare majority of *them*—55 percent—actually assent to the poll's version of Darwinian evolution.[5]

There is no reason to fetishize a Harris, Gallup, or any other systematic attitude survey. We do not know with any great specificity what people might *mean* when they say they believe in miracles (or, indeed, astrology), and the inadequacy of any simple-minded juxtaposition of "scientific" versus "fundamentalist" beliefs is indicated by the soaring popularity of stem cell research, even among evangelical Christians who are widely supposed to be against tampering with God-given human life. Religiosity seems to bear on embryo destruction in abortion in a way it does not in stem cell research.[6] And, if it were thought that religiosity translates into a "don't mess with God's Nature" attitude, then Americans again are much more favorably disposed towards genetically modified foods than are Western Europeans or Japanese.[7] The legal scholar Ronald Dworkin has recently pointed out——without evidence, but plausibly enough—that not a lot should be inferred about overall attitudes to scientific expertise from evangelicals' doubts about Darwinism:

> Almost all religious conservatives accept that the methods of empirical science are in general well designed for the discovery of truth . . . They would not countenance requiring or permitting teachers to teach, even as an alternate theory, what science has established as unquestionably and beyond challenge false: that the sun orbits the earth or that radioactivity is harmless, for example"[8] (Dworkin, 2006: 24).

But it still seems safe to say that the great majority of the people professing belief in things like miracles have been presented with multiple articulations of what it might mean to "think scientifically" and that thinking that miracles happen is understood not to be part of the scientific game.[9] Quite a lot of the people saying they believe in miracles, like quite a lot of the people saying that human beings were specially created

by a divine agency, must be well aware that they are, in so saying, poking one in the eye of scientific authority. And so one thing we cannot sensibly mean when we say that we live in a Scientific Age or that Science Made the Modern World is that scientific beliefs have got much grip on the modern mind writ large. That just isn't true. Maybe, if we mean anything legitimate at all by saying such things, we mean that the *Idea of Science* is widely held in respect. That seems plausible enough. Consider the litany of complaints from high scientific places about "public ignorance of science"—complaints that often are inspired by such statistics as those just cited. Such complaints can actually help establish the esteem in which science is held in our culture. It's been some time since I heard anyone gain a public platform for complaining about "public ignorance of sociological theory" or "public ignorance of the novels of Mrs. Gaskell." Nor do official worries about the proliferation of pseudo-science or junk science necessarily bear on the authority of science. Consider present-day concerns over "Intelligent Design" and "Creation Science," but note that these represent themselves as forms of science, not as nonscience or as antiscience. Advocates of Intelligent Design want it taught in *science* classrooms. From a pertinent perspective, the problem today is not antiscience but a contest for the proper winner of the designation "science." That's a sign that the label "science" is a prize very much worth having. A writer in *The New York Times* (Holt, 2005), referring to the apparent upsurge in evangelical Christianity, recently announced that "Americans on the whole do not seem to care greatly for science," but such conclusions are not well grounded. American faith in the power of science—or, more accurately, of science and technology—has been, and continues to be, enormous. In the late 1950s, surveys showed that a remarkable 83 percent of the U.S. public reckoned that the world was "better off" because of science and only a negligible 2 percent thought it was "worse off" (Whithey, 1959).[10] Amid anxieties about "increasing public skepticism toward science," various surveys conducted in the 1970s—phrasing their questions somewhat differently—purported to find a decline in approval (to between 71 and 75 percent, with a negative assessment rising to between 5 and 7 percent)—though few other modern American institutions could hope to come close to that level of public favor (Pion & Lipsey, 1981: 304, table 1).[11] In the most recent survey, Americans expressed a "great deal" of confidence (42 percent) in the scientific community and significantly less in the banking system (29 percent), the presidency (22 percent), and, tellingly, organized religion (24 percent).[12] The Pew Research Center's Global Attitudes Project discovered that 19 percent of Americans surveyed recently accounted "Science/Technology" to be the "greatest achievement" of the U.S. government during the course of the twentieth century—more than twice as many as those who pointed to civil rights and more than three times as many as those giving the prize to the social security system. In the public mind, science and technology are endowed with colossal power: about 80 percent of Americans think that within the next fifty years science will ("probably/definitely") deliver cures for cancer and AIDS and will "improve [the] environment," compared with just 44 percent who believe that Jesus Christ will reappear on Earth during that period (Kohut & Stokes, 2006: 60, 86).

Suppose we concede that scientific *beliefs*—or at least beliefs of the sort approved of at Harvard—are not very widely distributed in modern culture. This means that the authority of science—the sense that we live in a scientific age—has to reside in something other than the widespread *understanding* of particular scientific facts or theories, no matter how important, foundational, or elementary they may be. This would be quite a concession in itself, and we should reflect a lot more on what it means. But can't we nevertheless say that the authority and influence of science reside in something other than shared beliefs, something that nevertheless "belongs to" science? Consider, again, the notion of the Idea of Science. I've given some reasons to think that the Idea of Science confers authority, even if a range of specific scientific beliefs do not. What might be meant by the Idea of Science? There are difficulties in saying much about such an Idea. If we want to talk about the Idea of Science apart from specific beliefs, then we probably are pointing at some notion of scientific method. Scientists—and, more importantly, philosophers of science—have been identifying, celebrating, and propagating the scientific method for a long time—arguably at least as far back as the time of Descartes, Newton, and Boyle. It's that universal, rational, and effective method which has been said to account for the power of science and to mark it out from other modes of inquiry lacking such a method. As the recent *New Yorker* piece announced, "The scientific method has come to shape our notion of progress and of modern life" (Specter, 2006: 61).

The problem is that there is not now, and never has been, a consensus about what such a method is.[13] The first two entries for "scientific method" that Google gave me opted for observation before the formulation of an explanatory hypothesis, followed by experimental tests of the hypothesis, though that account excludes all those sciences which are not experimental, for example, geology, meteorology, and many forms of evolutionary biology.[14] The current Wikipedia entry makes reference to the views of Thomas Kuhn, who, like Karl Popper, Imre Lakatos, and Paul Feyerabend, famously doubted whether theory-free observation ever occurred. *Science* magazine has usefully addressed the question by annotating a number of scientific papers to show the scientific method at work.[15] A "pragmatical scheme" of that seven-step method is provided, starting with "define the question," going through "analyze the data," and concluding with "publish results," but it's hard to look at this list without concluding that—"perform experiment" apart—its directions can be found in any kind of systematic inquiry pretending to rigor, and not just in science.[16] Other entries early in the Google list give deductive, rather than inductive, inference pride of place and omit references to experiment.[17] Some make reference to "proof" or "confirmation" of a hypothesis; others point out—following Popper—that one can never prove but only disprove the validity of a hypothesis. Few bother to cite T. H. Huxley's ([1854]1900: 45) view that science is "nothing but trained and organised common sense" or that of the Nobel Prize–winning immunologist Peter Medawar (1967: 132) that "The scientific method does not exist."

In fact, if the authority of science—the way in which it is supposed to mark modernity—resides in some idea of scientific method, that would be as much as saying not

just that academic *philosophy of science* rules the roost, but that some specific *version* of philosophy of science was the most authoritative form of modern culture. Somehow that doesn't seem right. The authority of philosophers in our culture doesn't come close to the authority of scientists. Much the same sort of argument, I think, applies to any Idea of Science that flows from identifying shared *conceptual* content. The Unity of Science movement of the early and middle part of the twentieth century arose out of a worry that, while science *must*, of course, be conceptually unified, no one had yet definitively shown what the basis of that unity was. That situation has not changed, and although scientists these days seem not to be much worried about "unity," leading-edge philosophers of science are now increasingly writing books and papers taking the "*disunity*" of science as their subject (e.g., Dupré, 1993; Rosenberg, 1994; Cartwright, 1999; Galison & Stump, 1996).

I doubt that searching for some stable and plausible Idea of Science is going to get us very far in trying to describe the authority of science in the modern world, or in showing that science *does* have such authority. But, if I'm right, we're beginning to see the shape of a real problem: science, we say, marks modernity—it enjoys unique authority—but that authority does not seem to consist either in lay possession of any specific set of scientific beliefs—no matter how elementary or fundamental—nor in any stable sense of the method scientists supposedly used to guarantee the power of their knowledge. Should we just agree that science has very little to do with Modern Culture—bizarre as that might sound—*or* that the authority of science resides in something besides knowledge of its beliefs or methods?

It seems that if we want to talk about the authority of science in the Modern World, we can't sensibly talk about our culture's knowledge of scientific beliefs or our grasp of some notion of Method. What seems to be essential is not knowing *science* but knowing where to look for it, knowing who are the relevant authorities, knowing that we can and should assent to what they said, *that* we can and should trust them in their proper domains. Pragmatically, there's a lot to recommend this state of affairs: it's unfortunate that the ideas of both Darwinian evolution and the heliocentric system have not taken better root in our culture, but, in general, *no one* can know very much of science, and so knowing who the relevant experts are is sufficient in the great majority of cases. This applies to scientists as well as the laity: even plant physiologists are likely to have a deficient knowledge of astrophysics, and a cardiologist is going to go to a neurologist if she has persistent headaches. Expertise isn't considered to be fungible: it comes in various special flavors. And so knowing where to look for the relevant experts has to involve some notion of relevant expertise, of relevant authority.

When we say that our task is recognizing the experts in their proper domains, what *are* those domains? Putting the question that way identifies a sense in which scientific authority is now not greater but clearly much *less* than it once was. Consider what philosophers—following G. E. Moore in the first years of the twentieth century—call "the Naturalistic Fallacy." That fallacy is believing something that is impossible, moving logically from an "is-statement"—a description of how things are in the

world—to an "ought-statement"—a prescription of how things should be. Put another way, science is one thing, morality another; and you should not think of deducing what's good from what is. But the Naturalistic Fallacy is not just about a philosopher's boundary; during the course of the twentieth century, very many scientists publicly insisted that they possessed no special moral authority and that questions of what ought to be done—for example, about the consequences of their own work—were not their preserve. As Edward Teller (1950) put it, it was the scientist's job to discover the laws of nature, not to pronounce on whether the laws permitting nuclear fusion ought to be mobilized for the construction of a hydrogen bomb. You would think that Oppenheimer would have disagreed with such a sentiment, but on this point he was at one with Teller (see, for example, Oppenheimer, 1965: 272).

Scientists—it was widely insisted by modern scientists themselves—possessed no particular moral authority. It was once assumed they did; now it was not. If moral authority is what you want, you should go to some other sort of person, and that's why the late Stephen Jay Gould (1997) referred to science and religion as "non-overlapping magisteria." That division of labor between natural experts and ethical experts is now institutionalized, accepted almost as a matter of course. Yet it leads to a pervasive awkwardness in contemporary culture. Just as so many social and political decisions increasingly come to draw on massive amounts of specialized expertise—even to understand what they're *about*—so it is accepted that those who know most should accept radical restrictions on having consequential opinions about *what ought to be done*. Here, the up-curve of the reach of science in our social and political life meets the down-curve of scientists' acknowledged moral authority. Who are they, such that we can trust them—not just to know more about their specialized bits of the world but to do the right thing?

"The scientist is not a priest." That's another way of identifying the limited authority of the modern scientist, and the nonpriestly status of the scientist was much insisted on throughout the twentieth century by scientists themselves. At the same time, and perhaps responding to what was seen as the *increasing* cultural authority of science during the course of the century, the scientific community was accused of becoming "the new priesthood" and scientists as "the new brahmins" (e.g., Lapp, 1965; Klaw, 1968). An essay in the *Bulletin of the Atomic Scientists* about immediate postwar Congressional engagements with science noted that, after Hiroshima,

> [S]cientists became charismatic figures of a new era, if not a new world, in which science was the new religion and scientists the new prophets . . . Scientists appeared to [politicians] as superior beings who had gone far ahead of the rest of the human race in knowledge and power . . . Congressmen perceived scientists as being in touch with a supernatural world of mysterious and awesome forces whose terrible power they alone could control. Their exclusive knowledge set scientists apart and made them tower far above other men (quoted in Hall, [1956]1962: 270–72).

It's a tension that remains unresolved: science is our most powerful form of knowledge; it's scientists—or at least those pretending to be scientists—that are turned to when we want an account of how matters stand in the natural world. But, however

esoteric their knowledge is, it is not scientists who decide what ought to be done. For those decisions—and there are an increasing number of them that are potentially world-changing—it's politics as usual.

Knowing where to look for the relevant experts also involves some notion of what it is they know. In the early modern period, a common cultural distinction was made between mathematics and natural philosophy. Philosophy was understood as the search for Truth, for the realities behind appearances, for the real causal structure of the world. Mathematics, by contrast, was taken as the quest for regular patterns of natural relationships, such that you could use the resulting knowledge to predict and control, without necessarily taking a bet on what the world was really like. Copernicus was acting as a mathematician when he stipulated that the heliocentric system was to be regarded as a predictive tool, and Galileo was blurring the boundaries between mathematics and philosophy when he defied the Vatican in asserting the physical reality of Copernicanism.[18] I mention this old chestnut, just because it may have significance for our current problem of identifying who the relevant experts are.

At least from the early twentieth century, very many scientists—physicists, of course, but not just physicists—publicly asserted that they were not, so to speak, in the Truth Business.[19] Their task, it was insisted, was not metaphysics; it was not discovering ultimate realities. It was, rather, finding out what "works": what picture of nature was maximally coherent, with existing theories and evidence, and what picture of nature would allow scientists most powerfully to predict and control. Pragmatism was one version of such a sensibility, but so were those positions called operationalism, conventionalism, and phenomenalism. In 1899, the Johns Hopkins physicist Henry Rowland (1899: 13), making no allusions to pragmatism or to any other formal philosophy of science, explicitly contrasted the scientific with the "vulgar" or "ordinary crude" mind: the scientist alone properly appreciated that "There is no such thing as absolute truth and absolute falsehood."[20] By the 1920s, Albert Einstein ([1929]1954) was reminding the general reader that "It is difficult even to attach a precise meaning to the term 'scientific truth,'" its semantics varying radically according to context of use.[20] And C. P. Snow (1961: 257) surely spoke for most scientists when he bumptiously stipulated that "By *truth*, I don't intend anything complicated . . . I am using the word as a scientist uses it. We all know that the philosophical examination of the concept of empirical truth gets us into some curious complexities, but most scientists really don't care." The scientist was properly to be understood not on the model of the philosopher but on the model of the engineer and technician. Our culture used to insist on massive differences between science and technology and between the role of the scientist and that of the engineer. It's a distinction that now makes less and less sense: we're all engineers now, and the authority of science is increasingly based not on what scientists know but on what they can help make happen. It's a distinction that increasingly resonates in the public culture: an NSF survey in 1976 revealed that government funding of science was overwhelmingly popular but that only 9 percent of the respondents wanted any of their tax dollars used to support basic research (Pion & Lipsey, 1981: 308 [table IV] and 309).

What difference does it make to the public authority of science if scientific knowledge is just what works and if the scientist is understood as an aid to the technologist? First, at one time it was believed that a world saturated with technology would not only be a modernized world but a secularized world. That turned out to be spectacularly untrue. The mere presence of advanced technology in a society seems to have little or nothing to do with how people think and what they value: some of the world's Web wizards are *jihadis*, and there seems to be no conflict between computer skill and religious fundamentalism. We should be clear about another thing: engineers seem to include as many morally admirable people as any other group of professionals; some are more admirable than some scientists I know. But it's the institutions we're talking about here, and what virtues and authority are associated with the institutions. The technologist supplies what society wants; the scientist used to give society what it didn't know it wanted. That's a simplification, but, I think, a useful one: corporations, governments, and the military enlist experts in the natural world overwhelmingly on the condition that they can assist them in achieving useful goals—wealth, health, and power. During the course of the twentieth century, the enterprise called science was effectively enfolded in the institutions dedicated to the production of wealth and the projection of power. That's where we started, and that's one way of describing the success of science in modernity. But one of the conditions of that success is, at the same time, a problem for the authority of science in the modern world.

Modern scientists are not priests. Their expertises are not fungible—either one form of technical expertise into another or technical expertise into moral authority. What the modern scientist *may* have left as a basis of authority is a kind of independence and a resulting notion of integrity. Yet the enfolding of science into the institutions of wealth-making and power-projecting makes that independence harder to recognize and acknowledge. And when scientific knowledge becomes patentable property, then the independence of science from civic institutions becomes finally invisible. We've gone some way in these directions—but not yet all the way, so it's not a bad moment to reflect on where we've come from and where we might be going.

I started by recalling how easy it once was to talk about science as an independent cause of modernity, as modernity's characteristic form of culture and as its distinct master authority. It's not so easy now. And one reason it's not so easy is that our ability to recognize relevant experts, and to recognize their independent authority, is harder and harder to do. The success of science has created its successor problem. That problem—the problem of the independent authority of science in our modern world—may be a problem *for* science, but, more importantly, it's a problem *in* our modern order of things. The place of science in the modern world is just the problem of *describing* the way we live now: what to believe, whom to trust, what to do.

Notes

1. White (1876), and then developed as White (1896). White was following in the tradition of John William Draper, whose *History of the Conflict Between Religion and Science* (1874) similarly announced the inevitable triumph of science over religion.

2. See, for example, Hollinger (2000).

3. Available at: http://www.cbsnews.com/stories/2002/04/29/opinion/polls/main507515.shtml.

4. Available at: http://www.pollingreport.com/science.htm *and* http://www.unl.edu/rhames/courses/current/creation/evol-poll.htm.

5. Available at: http://www.religioustolerance.org/ev_publi.htm. (These figures are from a poll conducted in November 1991.)

6. According to Kohut & Stokes (2006: 61), "In 2004, by a 52 percent to 34 percent margin, Americans said it was more important to conduct such research, which might result in new cures for human diseases, than to avoid destroying the potential life of embryos. Two years earlier, only a plurality of Americans supported stem-cell research (43 percent in favor to 38 percent against)."

7. Available at: http://pewglobal.org/commentary/display.php?AnalysisID=66.

8. We can set aside without comment, as an instance of a lawyer's scientific naivete, the fact that much radioactivity is indeed "harmless."

9. See, e.g., Turner (1974).

10. Etzioni and Nunn (1974) argue convincingly that the public mind makes little, if any, distinction between science and technology.

11. The National Opinion Research Center (NORC) has compiled time-series data on public confidence in various institutions. The data show a decline in confidence in science from the early 1960s to the late 1970s, but this follows a drop in confidence for *all* major public institutions, and the decline for science was notably *less* than it was for others (Pion & Lipsey, 1981: 307).

12. Figures quoted in Holt (2005: 25), from an NORC survey conducted between August 2004 and January 2005.

13. See, for example, Shapin (2001).

14. Available at: http://teacher.pas.rochester.edu/phy_labs/AppendixE/AppendixE.html *and* http://physics.ucr.edu/~wudka/Physics7/Notes_www/node5.html.

15. For example, available at: http://www.sciencemag.org/feature/data/scope/keystone1/.

16. "1. Define the question; 2. Gather information and resources; 3. Form hypothesis; 4. Perform experiment and collect data; 5. Analyze data; 6. Interpret data and draw conclusions that serve as a starting point for new hypotheses; 7. Publish results." Available at: http://en.wikipedia.org/wiki/Scientific_method.

17. Available at: http://www2.selu.edu/Academics/Education/EDF600/Mod3/sld001.htm.

18. See, for example, Dear (1995); Westman (1980).

19. The material in this and the next several paragraphs is included in Shapin (forthcoming: chapters 2–3).

20. For a pertinent Hopkins context to Rowland's remarks, see Feldman and Desrochers (2004: 117–18).

21. For Einstein's early operationalism, influenced by Mach, see Holton (1972).

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