

What is science and why should we care?*

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I propose tonight to share with you a few reflections about the nature of scientific inquiry and its importance for public life. At a superficial level one could say that I will be addressing some aspects of the relation between science and society; but as I hope will become clear, my aim is to discuss the importance, not so much of *science*, but of what one might call the *scientific worldview*¹ — a concept that goes far beyond the specific disciplines that we usually think of as “science” — in humanity’s collective decision-making. I want to argue that clear thinking, combined with a respect for *evidence* — especially inconvenient and unwanted evidence, evidence that challenges our preconceptions — are of the utmost importance to the survival of the human race in the twenty-first century, and especially so in any polity that professes to be a democracy.

Of course, you might think that calling for clear thinking and a respect for evidence is a bit like advocating Motherhood and Apple Pie (if you’ll pardon me this Americanism) — and in a sense you’d be right. Hardly anyone will *openly* defend *muddled* thinking or *disrespect* for evidence. Rather, what people do is to surround these practices with a fog of verbiage designed to conceal from their listeners — and in most cases, I would imagine, from themselves as well — the true implications of their way of thinking. George Orwell got it right when he observed that the main advantage of speaking and writing clearly is that “when you make a stupid remark its stupidity will be obvious, even to yourself”.² So I hope that I will be as clear tonight as Orwell would have wished. And I intend to illustrate *disrespect* for evidence with a variety of examples — coming from the Left and the Right and the Center — starting from some fairly lightweight targets and proceeding to heavier ones. I aim to show that the implications of taking seriously an evidence-based worldview are rather more radical than many people realize.

So let me start, perhaps a bit pedantically, by drawing some important distinctions.

The word *science*, as commonly used, has at least four distinct meanings: it denotes an intellectual endeavor aimed at a rational understanding of the natural and social world; it denotes a corpus of currently accepted substantive knowledge; it denotes the community of scientists, with its mores and its social and economic structure; and, finally, it denotes applied science and technology. In this talk I will be concentrating on the first two aspects, with some secondary references to the sociology of the scientific community; I will not address technology at all. Thus, by *science* I mean, first of all, a worldview giving primacy to reason and observation and a methodology aimed at acquiring accurate knowledge of the natural and social world. This methodology is characterized, above all else, by the *critical spirit*: namely, the commitment to the incessant testing of assertions through observations and/or experiments — the more stringent the tests, the better — and to revising or discarding those theories that fail the test.³ One corollary of the critical spirit is *fallibilism*: namely, the understanding that all our empirical knowledge is tentative, incomplete and open to revision in the light of new evidence or cogent new arguments (though, of course, the most well-established aspects of scientific knowledge are unlikely to be discarded entirely).

It is important to note that well-tested theories in the mature sciences are supported in general by a powerful web of interlocking evidence coming from a variety of sources. Moreover, the progress of science tends to link these theories into a unified framework, so that (for instance) biology has to be compatible with chemistry, and chemistry with

physics. The philosopher Susan Haack has illuminatingly analogized science to the problem of completing a crossword puzzle, in which any modification of one word will entail changes in interlocking words; in most cases the required changes will be fairly local, but in some cases it may be necessary to rework large parts of the puzzle.⁴

I stress that my use of the term “science” is not limited to the *natural* sciences, but includes investigations aimed at acquiring accurate knowledge of factual matters relating to *any* aspect of the world by using rational empirical methods analogous to those employed in the natural sciences. (Please note the limitation to questions of fact. I intentionally exclude from my purview questions of ethics, aesthetics, ultimate purpose, and so forth.) Thus, “science” (as I use the term⁵) is routinely practiced not only by physicists, chemists and biologists, but also by historians, detectives, plumbers and indeed all human beings in (some aspects of) our daily lives.⁶ (Of course, the fact that we all practice science from time to time does not mean that we all practice it equally well, or that we practice it equally well in all areas of our lives.)

The extraordinary successes of the natural sciences over the last 400 years in learning about the world, from quarks to quasars and everything in-between, are well known to every modern citizen: science is a fallible yet enormously successful method for obtaining objective (albeit approximate and incomplete) knowledge of the natural (and to a lesser extent, the social) world.

But, surprisingly, not everyone accepts this; and here I come to my first — and most lightweight — example of adversaries of the scientific worldview, namely academic postmodernists and extreme social constructivists. Such people insist that so-called scientific knowledge does *not* in fact constitute objective knowledge of a reality external to ourselves, but is a mere social construction, on a par with myths and religions, which therefore have an equal claim to validity. If such a view seems so implausible that you wonder whether I am somehow exaggerating, consider the following assertions by prominent sociologists:

[T]he validity of theoretical propositions in the sciences is in no way affected by factual evidence. (Kenneth Gergen)⁷

The natural world has a small or non-existent role in the construction of scientific knowledge. (Harry Collins)⁸

For the relativist [such as ourselves] there is no sense attached to the idea that some standards or beliefs are really rational as distinct from merely locally accepted as such. (Barry Barnes and David Bloor)⁹

Since the settlement of a controversy is the *cause* of Nature’s representation, not the consequence, we can never use the outcome — Nature — to explain how and why a controversy has been settled. (Bruno Latour)¹⁰

Science legitimates itself by linking its discoveries with power, a connection which *determines* (not merely influences) what counts as reliable knowledge . . . (Stanley Aronowitz)¹¹

Statements as clear-cut as these are, however, rare in the academic postmodernist literature. More often one finds assertions that are ambiguous but can nevertheless be

interpreted (and quite often *are* interpreted) as implying what the foregoing quotations make explicit: that science as I have defined it is an illusion, and that the purported objective knowledge provided by science is largely or entirely a social construction. For example, Katherine Hayles, professor of literature at Duke University and former president of the Society for Literature and Science, writes the following as part of her feminist analysis of fluid mechanics:

Despite their names, conservation laws are not inevitable facts of nature but constructions that foreground some experiences and marginalize others. . . . Almost without exception, conservation laws were formulated, developed, and experimentally tested by men. If conservation laws represent particular emphases and not inevitable facts, then people living in different kinds of bodies and identifying with different gender constructions might well have arrived at different models for [fluid] flow.¹²

(What an interesting idea: perhaps “people living in different kinds of bodies” will learn to see beyond those masculinist laws of conservation of energy and momentum.) And Andrew Pickering, a prominent sociologist of science, asserts the following in his otherwise-excellent history of modern elementary-particle physics:

[G]iven their extensive training in sophisticated mathematical techniques, the preponderance of mathematics in particle physicists’ accounts of reality is no more hard to explain than the fondness of ethnic groups for their native language. On the view advocated in this chapter, there is no obligation upon anyone framing a view of the world to take account of what twentieth-century science has to say.¹³

But let me not spend time beating a dead horse, as the arguments against postmodernist relativism are by now fairly well known: rather than plugging my own writings, let me suggest the superb book by the Canadian philosopher of science James Robert Brown, *Who Rules in Science?: An Opinionated Guide to the Wars*.¹⁴ Suffice it to say that postmodernist writings systematically confuse truth with *claims* of truth, fact with *assertions* of fact, and knowledge with *pretensions* to knowledge — and then sometimes go so far as to deny that these distinctions have any meaning.

Now, it’s worth noting that the postmodernist writings I have just quoted all come from the 1980s and early 1990s. In fact, over the past decade, academic postmodernists and social constructivists seem to have backed off the most extreme views that they previously espoused. Perhaps I and like-minded critics of postmodernism can take some small credit for this, by initiating a public debate that shed a harsh light of criticism on these views and forced some strategic retreats. But most of the credit, I think, has to be awarded to George W. Bush and his friends, who showed just where science-bashing can lead in the real world. Nowadays, even sociologist of science Bruno Latour, who spent several decades stressing the so-called “social construction of scientific facts”¹⁵, laments the ammunition he fears he and his colleagues have given to the Republican right-wing, helping them to deny or obscure the scientific consensus on global climate change, biological evolution and a host of other issues.¹⁶ He writes:

While we spent years trying to detect the real prejudices hidden behind the appearance of objective statements, do we now have to reveal the real objective and

incontrovertible facts hidden behind the *illusion* of prejudices? And yet entire Ph.D. programs are still running to make sure that good American kids are learning the hard way that facts are made up, that there is no such thing as natural, unmediated, unbiased access to truth, that we are always prisoners of language, that we always speak from a particular standpoint, and so on, while dangerous extremists are using the very same argument of social construction to destroy hard-won evidence that could save our lives.¹⁷

That, of course, is exactly the point I was trying to make back in 1996 about social-construction talk taken to subjectivist extremes. I hate to say I told you so, but I did — as did, several years before me, Noam Chomsky, who recalled that in a not-so-distant past,

Left intellectuals took an active part in the lively working class culture. Some sought to compensate for the class character of the cultural institutions through programs of workers' education, or by writing best-selling books on mathematics, science, and other topics for the general public. Remarkably, their left counterparts today often seek to deprive working people of these tools of emancipation, informing us that the “project of the Enlightenment” is dead, that we must abandon the “illusions” of science and rationality — a message that will gladden the hearts of the powerful, delighted to monopolize these instruments for their own use.¹⁸

Let me now pass to a second set of adversaries of the scientific worldview, namely the advocates of pseudoscience.¹⁹ This is of course an enormous area, so let me focus on one socially important aspect of it, namely so-called “complementary and alternative therapies” in health and medicine. And within this, I'd like to look in a bit of detail at one of the most widely used “alternative” therapies, namely homeopathy — which is an interesting case because its advocates sometimes claim that there *is* evidence from meta-analyses of clinical trials that homeopathy works.

Now, one basic principle in all of science is GIGO: garbage in, garbage out. This principle is particularly important in statistical meta-analysis: because if you have a bunch of methodologically poor studies, each with small sample size, and then subject them to meta-analysis, what can happen is that the systematic biases in each study — if they mostly point in the same direction — can reach statistical significance when the studies are pooled. And this possibility is particularly relevant here, because meta-analyses of homeopathy invariably find an inverse correlation between the methodological quality of the study and the observed effectiveness of homeopathy: that is, the sloppiest studies find the strongest evidence in favor of homeopathy.²⁰ When one restricts attention only to methodologically sound studies — those that include adequate randomization and double-blinding, predefined outcome measures, and clear accounting for drop-outs — the meta-analyses find no statistically significant effect (whether positive or negative) of homeopathy compared to placebo.²¹

But the lack of convincing statistical evidence for the efficacy of homeopathy is *not*, in fact, the main reason why I and other scientists are skeptical (to put it mildly) about

homeopathy; and it's worth taking a few moments to explain this main reason, because it provides some important insights into the nature of science.

Most people — perhaps even most users of homeopathic remedies — do not clearly understand what homeopathy is. They probably think of it as a species of herbal medicine. Of course plants contain a wide variety of substances, some of which can be biologically active (with either beneficial or harmful consequences, as Socrates learned). But homeopathic remedies, by contrast, are pure water and starch: the alleged “active ingredient” is so highly diluted that in most cases *not a single molecule* remains in the final product.

And so, the fundamental reason for rejecting homeopathy is that there is no plausible mechanism by which homeopathy could possibly work, unless one rejects everything that we have learned over the last 200 years about physics and chemistry: namely, that matter is made of atoms, and that the properties of matter — including its chemical and biological effects — depend on its atomic structure. There is simply no way that an *absent* “ingredient” could have a therapeutic effect. High-quality clinical trials find no difference between homeopathy and placebo because homeopathic remedies *are* placebos.²²

Now, advocates of homeopathy sometimes respond to this argument by asserting that the curative effect of homeopathic remedies arises from a “memory” of the vanished active ingredient that is somehow retained by the water in which it was dissolved (and then by the starch when the water is evaporated!). But the difficulty, once again, is not simply the lack of any reliable experimental evidence for such a “memory of water”. Rather, the problem is that the existence of such a phenomenon would contradict well-tested science, in this case the statistical mechanics of fluids. The molecules of any liquid are constantly being bumped by other molecules — what physicists call thermal fluctuations — so that they quickly lose any “memory” of their past configuration. (Here when I say “quickly”, I’m talking picoseconds, not months.)

In short, all the millions of experiments confirming modern physics and chemistry also constitute powerful evidence *against* homeopathy. For this reason, the flaw in the justification of homeopathy is not merely the lack of statistical evidence showing the efficacy of homeopathic remedies over placebo at the 95% or 99% confidence level. Even a clinical trial at the 99.99% confidence level would not begin to compete with all the evidence in favor of modern physics and chemistry. Extraordinary claims require extraordinary evidence. (And in the unlikely event that such convincing evidence is ever forthcoming, the person who provides it will assuredly win a triple Nobel Prize in physics, chemistry and biology — beating out Marie Curie, who won only two.)

Despite the utter scientific implausibility of homeopathy, homeopathic products can be marketed in the United States *without* having to meet the safety and efficacy requirements that are demanded of all other drugs (because they got a special dispensation in the Food, Drug, and Cosmetic Act of 1938). Indeed, U.S. government regulations *require* each homeopathic remedy that is marketed over-the-counter (OTC) to state, on the label, at least one medical condition that the product is intended to treat — but without requiring any evidence that the product is actually *efficacious* in treating that condition!²³ The laws in other Western countries are equally scandalous, if not more

Fortunately, it seems that this particular pseudoscience has thus far made only modest inroads in the United States — by contrast with its wide penetration in France and Germany, where homeopathic products are packaged like real medicines and sold side-by-side with them in virtually every pharmacy. But other and more dangerous pseudosciences are endemic in the United States: prominent among these is the denial of biological evolution.

It is essential to begin our analysis by distinguishing clearly between three very different issues: namely, the *fact* of the evolution of biological species; the *general mechanisms* of that evolution; and the *precise details* of those mechanisms. Of course, one of the favorite tactics of deniers of evolution is to confuse these three aspects.

Among biologists, and indeed among the general educated public, the *fact* that biological species have evolved is established beyond any reasonable doubt. Most species that existed at various times in the past no longer exist; and conversely, most species that exist today did not exist for most of the Earth's past. In particular, modern *Homo sapiens* did not exist 1,000,000 years ago; and conversely, other species of hominids, such as *Homo erectus*, existed then and are now extinct. The fossil record is unequivocal on this point, and this has been well understood since at least the late 19th century.

A more subtle issue concerns the mechanisms of biological evolution; and here our modern scientific understanding took a longer time to develop. Though the basic idea — descent with modification, combined with natural selection — was set forth with eminent clarity by Darwin already in his 1859 book, the precise mechanisms underlying Darwinian evolution did not become fully elucidated until the development of genetics and molecular biology in the first half of the twentieth century. Nowadays we have a good understanding of the overall process: errors in copying DNA during reproduction cause mutations; some of these mutations either increase or decrease the organism's success at survival and reproduction; natural selection acts to increase the frequency in the gene pool of those mutations that increase the organism's reproductive success; as a result, over time, species develop adaptations to ecological niches; old species die out and new species arise. This general picture is nowadays established beyond any reasonable doubt, not only by paleontology but also by laboratory experiments.

Of course, when it comes to the precise details of evolutionary theory, there is still lively debate among specialists (just as there is in any active scientific field): for instance, concerning the quantitative importance of group selection or of genetic drift. But these debates in no way cast doubt on either the fact of evolution or on its general mechanisms. Indeed, as the celebrated geneticist Theodosius Dobzhansky pointed out in a 1973 essay, “nothing in biology makes sense except in the light of evolution”.²⁵

Everything that I have just said is of course common knowledge to anyone who has taken a half-decent course in high-school biology. The trouble is, fewer and fewer people — at least in the United States — nowadays have the good fortune to be exposed to a half-decent course in high-school biology. And the cause of that scientific illiteracy is (need I say it?) politics: more precisely, politics combined with religion. Some people

reject evolution because they find it incompatible with their religious beliefs. And in countries where such people are numerous or politically powerful or both, politicians kowtow to them and suppress the teaching of evolution in the public schools — with the result that the younger generation is denied the opportunity to evaluate the scientific evidence for themselves, and the scientific ignorance of the populace is faithfully²⁶ reproduced in future generations.

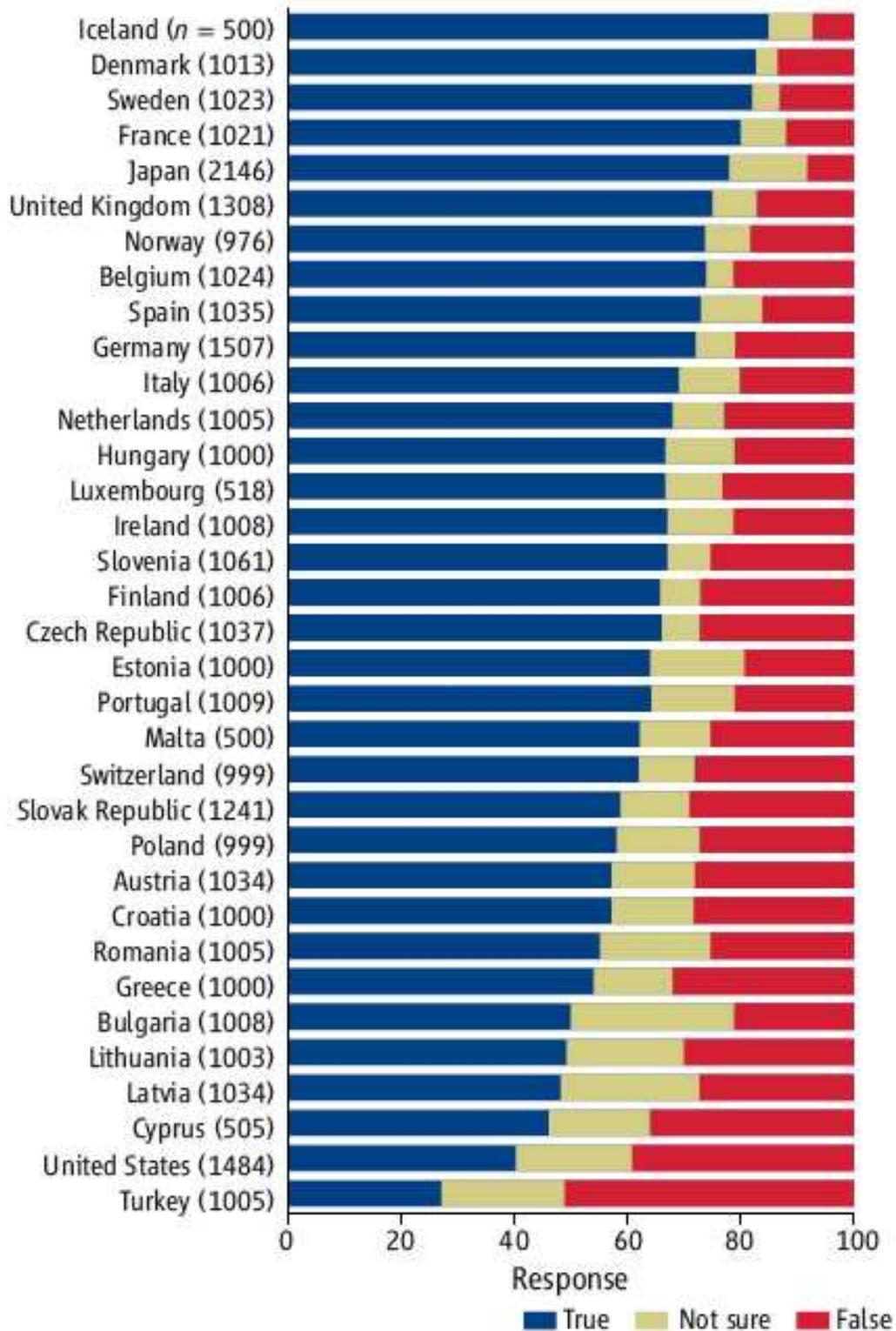
Figure 1 shows the results of a fascinating cross-cultural survey, carried out in 2005 in 32 European countries along with the United States and Japan.²⁷ Respondents were read the statement, “Human beings, as we know them, developed from earlier species of animals”, and were asked whether they considered it to be true, false, or were not sure. Of all 34 countries, the United States holds 33rd place for belief in evolution (with roughly equal numbers responding “true” and “false”). Only Turkey — where the secular heritage is under increasing assault from the elected Islamist government and its supporters — shows less belief in evolution than the United States. (Please note that this question concerns merely the *fact* of evolution, not its mechanisms.)

Of course, not all religious people reject evolution. Fundamentalist Christians do reject evolution, as do many Muslims and orthodox Jews; but Catholics and liberal Protestants have come (over time and perhaps grudgingly) to accept evolution, as have some Muslims and most Jews.²⁸ Therefore, from a purely tactical point of view, non-fundamentalist religious people are the allies of scientists in their struggle to defend the honest teaching of science.

And so, if I were tactically minded, I would stress — as most scientists do — that science and religion need not come into conflict. I might even go on to argue, following Stephen Jay Gould, that science and religion should be understood as “nonoverlapping magisteria”: science dealing with questions of fact, religion dealing with questions of ethics and meaning.²⁹ But I can’t in good conscience proceed in this way, for the simple reason that I don’t think the arguments stand up to careful logical examination. Why do I say that? For the details, I have to refer you to a 75-page chapter in my book³⁰; but let me at least try to sketch now the main reasons why I think that science and religion are fundamentally incompatible ways of looking at the world.³¹

When analyzing religion, a few distinctions are perhaps in order. For starters, religious doctrines typically have two components: a factual part, consisting of a set of claims about the universe and its history; and an ethical part, consisting of a set of prescriptions about how to live. In addition, all religions make, at least implicitly, epistemological claims concerning the methods by which humans can obtain reasonably reliable knowledge of factual or ethical matters. These three aspects of each religion obviously need to be evaluated separately.

Furthermore, when discussing any set of ideas, it is important to distinguish between the intrinsic merit of those ideas, the objective role they play in the world, and the subjective reasons for which various people defend or attack them.



Public acceptance of evolution in 34 countries, 2005.

Figure 1: From Miller, Scott and Okamoto (2006).

(Alas, much discussion of religion fails to make these elementary distinctions: for instance, confusing the intrinsic merit of an idea with the good or bad effects that it may have in the world.)

Here I want to address only the most fundamental issue, namely, the intrinsic merit of the various religions' factual doctrines. And within that, I want to focus on the epistemological question — or to put it in less fancy language, the relationship between belief and evidence. After all, those who believe in their religion's factual doctrines presumably do so for what they consider to be good reasons. So it's sensible to ask: What are these alleged good reasons?

Each religion makes scores of purportedly factual assertions about everything from the creation of the universe to the afterlife. But on what grounds can believers presume to know that these assertions are *true*? The reasons they give are various, but the ultimate justification for most religious people's beliefs is a simple one: we believe what we believe *because our holy scriptures say so*. But how, then, do we know that our holy scriptures are factually accurate? *Because the scriptures themselves say so.*³² Theologians specialize in weaving elaborate webs of verbiage to avoid saying anything quite so bluntly, but this gem of circular reasoning really is the epistemological bottom line on which all "faith" is grounded. In the words of Pope John Paul II: "By the authority of his absolute transcendence, God who makes himself known is also the source of the credibility of what he reveals."³³ It goes without saying that this begs the question of whether the texts at issue really were authored or inspired by God, and on what grounds one knows this. "Faith" is not in fact a rejection of reason, but simply a lazy acceptance of bad reasons. "Faith" is the pseudo-justification that some people trot out when they want to make claims without the necessary evidence.

But of course we never apply these lax standards of evidence to the claims made in *the other fellow's* holy scriptures: when it comes to religions other than one's own, religious people are as rational as everyone else. Only our own religion, whatever it may be, seems to merit some special dispensation from the general standards of evidence.

And here, it seems to me, is the crux of the conflict between religion and science. Not the religious rejection of specific scientific theories (be it heliocentrism in the 17th century or evolutionary biology today); over time most religions do find some way to make peace with well-established science. Rather, the scientific worldview and the religious worldview come into conflict over a far more fundamental question: namely, what constitutes *evidence*.

Science relies on publicly reproducible sense experience (that is, experiments and observations) combined with rational reflection on those empirical observations. Religious people acknowledge the validity of that method, but then claim to be in the possession of *additional* methods for obtaining reliable knowledge of factual matters — methods that go beyond the mere assessment of empirical evidence — such as intuition, revelation, or the reliance on sacred texts. But the trouble is this: What good reason do we have to believe that such methods *work*, in the sense of steering us systematically (even if not invariably) towards true beliefs rather than towards false ones?³⁴ At least in the domains where we have been able to test these methods — astronomy, geology and history, for instance — they have not proven terribly reliable. Why should we expect

them to work any better when we apply them to problems that are even more difficult, such as the fundamental nature of the universe?

Last but not least, these non-empirical methods suffer from an insuperable logical problem: What should we do when different people's intuitions or revelations conflict? How can we know *which* of the many purportedly sacred texts — whose assertions frequently contradict one another — are *in fact* sacred?

In all these examples I have been at pains to distinguish clearly between *factual* matters and *ethical* or *aesthetic* matters, because the epistemological issues they raise are so different. And I have restricted my discussion almost entirely to factual matters, simply because of the limitations of my own competence.

But if I am preoccupied by the relation between belief and evidence, it is not solely for intellectual reasons — not solely because I'm a "grumpy old fart who aspire[s] to the sullen joy of having it known that [I] don't suffer fools gladly"³⁵ (to borrow the words of my friend and fellow gadfly Norm Levitt, who died suddenly four years ago at the young age of 66). Rather, my concern that public debate be grounded in the best available evidence is, above all else, *ethical*.

To illustrate the connection I have in mind between epistemology and ethics, let me start with a fanciful example: Suppose that the leader of a militarily powerful country believes, sincerely but erroneously, on the basis of flawed "intelligence", that a smaller country possesses threatening weapons of mass destruction; and suppose further that he launches a preemptive war on that basis, killing tens of thousands of innocent civilians as "collateral damage". Aren't he and his supporters *ethically* culpable for their epistemic sloppiness?

I stress that this example is fanciful. The overwhelming preponderance of currently available evidence suggests that the Bush and Blair administrations *first* decided to overthrow Saddam Hussein, and *then* sought a publicly presentable pretext, using dubious or even forged "intelligence" to "justify" that pretext and to mislead Congress, Parliament and the public into supporting that war.³⁶

Which brings me to the last, and in my opinion most dangerous, set of adversaries of the evidence-based worldview in the contemporary world: namely, propagandists, public-relations flacks and spin doctors, along with the politicians and corporations who employ them — in short, all those whose goal is not to analyze honestly the evidence for and against a particular policy, but is simply to manipulate the public into reaching a predetermined conclusion by whatever technique will work, however dishonest or fraudulent.

So the issue here is no longer mere muddled thinking or sloppy reasoning; it is fraud.

The Oxford English Dictionary defines "fraud" as "the using of false representations to obtain an unjust advantage or to injure the rights or interests of another".³⁷ In the Anglo-American common law, a "false representation" can take many forms, including³⁸:

- A false statement of fact, known to be false at the time it was made;
- A statement of fact with no reasonable basis to make that statement³⁹;

- A promise of future performance made with an intent, at the time the promise was made, not to perform as promised⁴⁰;
- An expression of opinion that is false, made by one claiming or implying to have special knowledge of the subject matter of the opinion — where “special knowledge” means knowledge or information superior to that possessed by the other party, and to which the other party did not have equal access.^{41,42}

Anything here sound familiar? These are the standards that we would use if George Bush and Tony Blair had sold us a used car. In fact, they sold us a war that has thus far cost the lives of 179 British soldiers, 4486 American soldiers, and somewhere between 112,000 and 600,000 Iraqis⁴³ — a human toll, that is, of somewhere between 35 and 200 September 11ths; that has thus far cost the American taxpayers a staggering \$810 billion (with ultimate estimates ranging from \$1–3 trillion)⁴⁴; and that has strengthened both al-Qaeda and Iran — in short, a war that may well turn out to be the greatest foreign-policy blunder of American history. (Of course the British have a longer history, and hence a longer history of blunders to compete with.)

Now, in the common law there are in fact two distinct torts of misrepresentation: *negligent misrepresentation* and *fraudulent misrepresentation*. Fraudulent misrepresentation is of course difficult to prove because it involves the state of mind of the person making the misrepresentation, i.e. what he actually knew or believed at the time of the false statement.⁴⁵ Which means that the question becomes (as it was in the case of an earlier American president who stood accused of far lesser crimes and misdemeanors): What did George Bush and Tony Blair know and when did they know it? Unfortunately, the documents that could elucidate this question are top secret, so we may not know the answer for 50 years, if ever. But enough documents have been leaked so far to support, I think, a verdict of fraudulent misrepresentation.⁴⁶

Now, all this is very likely old hat to most of the people in this room. We know perfectly well that our politicians (or at least some of them) lie to us; we take it for granted; we are inured to it. And that may be precisely the problem. Perhaps we have become so inured to political lies — so hard-headedly cynical — that we have lost our ability to become appropriately outraged. We have lost our ability to call a spade a spade, a lie a lie, a fraud a fraud. Instead we call it “spin”.⁴⁷

We have now travelled a long way from “science”, understood narrowly as physics, chemistry, biology and the like. But the whole point is that any such narrow definition of science is misguided. We live in a single real world; the administrative divisions used for convenience in our universities do not in fact correspond to any natural philosophical boundaries. It makes no sense to use one set of standards of evidence in physics, chemistry and biology, and then suddenly relax your standards when it comes to medicine, religion or politics. Lest this sound to you like a scientist’s imperialism, I want to stress that it is exactly the contrary. As the philosopher Susan Haack lucidly observes,

Our standards of what constitutes good, honest, thorough inquiry and what constitutes good, strong, supportive evidence are not internal to science. In judging where science has succeeded and where it has failed, in what areas and at what times it has done better and in what worse, we are appealing to the standards by which we judge the solidity of empirical beliefs, or the rigor and thoroughness of empirical inquiry, generally.⁴⁸

The bottom line is that science is not merely a bag of clever tricks that turn out to be useful in investigating some arcane questions about the inanimate and biological worlds. Rather, the natural sciences are nothing more or less than one particular application — albeit an unusually successful one — of a more general rationalist worldview, centered on the modest insistence that empirical claims must be substantiated by empirical evidence.

Conversely, the philosophical lessons learned from four centuries of work in the natural sciences can be of real value — if properly understood — in other domains of human life. Of course, I am not suggesting that historians or policy-makers should use exactly the same methods as physicists — that would be absurd. But neither do biologists use precisely the same methods as physicists; nor, for that matter, do biochemists use the same methods as ecologists, or solid-state physicists as elementary-particle physicists. The detailed methods of inquiry must of course be adapted to the subject matter at hand. What remains unchanged in all areas of life, however, is the underlying philosophy: namely, to constrain our theories as strongly as possible by empirical evidence, and to modify or reject those theories that fail to conform to the evidence. That is what I mean by the scientific worldview.

It is because of this general philosophical lesson, far more than any specific discoveries, that the natural sciences have had such a profound effect on human culture since the time of Galileo and Francis Bacon. The affirmative side of science, consisting of its well-verified claims about the physical and biological world, may be what first springs to mind when people think about “science”; but it is the critical and skeptical side of science that is the most profound, and the most intellectually subversive. The scientific worldview inevitably comes into conflict with all non-scientific modes of thought that make purportedly factual claims about the world. And how could it be otherwise? After all, scientists are constantly subjecting their colleagues’ theories to severe conceptual and empirical scrutiny. On what grounds could one reject phlogistic chemistry, the fixity of species, or Newton’s particle theory of light — not to mention thousands of other plausible but wrong scientific theories — and yet accept astrology, homeopathy or the virgin birth?

The critical thrust of science even extends beyond the factual realm, to ethics and politics. Of course, as a logical matter one cannot derive an “ought” from an “is”.⁴⁹ But historically — starting in the 17th and 18th centuries in Europe and then spreading gradually to more or less the entire world — scientific skepticism has played the role of an intellectual acid, slowly dissolving the irrational beliefs that legitimated the established social order and its supposed authorities, be they the priesthood, the monarchy, the aristocracy, or allegedly superior races and social classes.⁵⁰ Four hundred years later, it seems sadly evident that this revolutionary transition from a dogmatic to an evidence-based worldview is very far from being complete.

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Notes

1. It is crucial, in order to avoid misunderstandings, that the word “scientific” here be understood in the broad sense to be explained below, namely as “investigations aimed at acquiring accurate knowledge of factual matters relating to *any* aspect of the world by using rational empirical methods analogous to those employed in the natural sciences”. Alternatively, one could use the phrase *evidence-based worldview*.
2. Orwell (1953 [1946], p. 171).
3. See Bricmont (2005) for an illuminating discussion of the critical/skeptical aspect of science.
4. Haack (1993, 1998, 2003).
5. If you, by contrast, prefer to restrict the term “science” to the natural sciences only, then it suffices to replace the word “science” everywhere in my text by the phrase “investigations aimed at acquiring accurate knowledge of factual matters relating to any aspect of the world by using rational empirical methods analogous to those employed in the natural sciences”.
6. The allusion to historians and detectives was employed previously by Haack (1993, p. 137): “there is no reason to think that [science] is in possession of a special method of inquiry unavailable to historians, detectives, and the rest of us”. See also Haack (1998, pp. 96–97; 2003, pp. 18, 24, 95, 102 and *passim*).
7. Gergen (1988, p. 37).
8. Collins (1981, p. 3). Two qualifications need to be made: First, this statement is offered as part of Collins’ introduction to a set of studies (edited by him) employing the relativist approach, and constitutes his summary of that approach; he does not *explicitly* endorse this view, though an endorsement seems implied by the context. Second, while Collins appears to intend this assertion as an empirical claim about the history of science, it is possible that he intends it neither as an empirical claim nor as a normative principle of epistemology, but rather as a methodological injunction to sociologists of science: namely, to act *as if* “the natural world ha[d] a small or non-existent role in the construction of scientific knowledge”, or in other words to *ignore* (“bracket”) whatever role the natural world may in fact play in the construction of scientific knowledge. I have argued elsewhere (Bricmont and Sokal 2001, 2004) that this approach is seriously deficient *as methodology* for sociologists of science.
9. Barnes and Bloor (1981, p. 27), clarification added by me.
10. Latour (1987, pp. 99, 258), emphasis in the original. See Sokal and Bricmont (1998, chapter 4) for a detailed analysis of this claim and its various possible meanings.

11. Aronowitz (1988, p. 204), emphasis in the original.
12. Hayles (1992, pp. 31–32).
13. Pickering (1984, p. 413). Can Pickering, who was initially trained as a physicist, really be unaware of four centuries’ work demonstrating the extraordinary power of mathematics as a tool for formulating and solving problems in the physical (and, to a lesser extent, the biological) sciences? See Wigner (1960) for a prominent physicist’s reflections on the “unreasonable effectiveness” of mathematics in the natural sciences.
14. Brown (2001).
15. This is the subtitle of Latour and Woolgar (1979).
16. See Mooney (2005) for an extensively documented account of the assault on science being carried out by Republican politicians on behalf of an unholy (and uneasy) alliance of big corporations seeking to escape environmental and safety regulations and religious fundamentalists seeking to impose their dogmas on education and health policy.
17. Latour (2004, p. 227), italics in the original.
18. Chomsky (1993, p. 286). See also Albert (1992), Chomsky (1992) and Ehrenreich (1992) for related commentary.
19. See also Sokal (2006) for a tentative exploration of the curious nexus between pseudo-science and postmodernism.
20. Kleijnen *et al.* (1991), Linde *et al.* (1997, 1999), Linde and Melchart (1998), Cucherat *et al.* (2000), Shang *et al.* (2005). See also Ernst (2002) for a useful review of meta-analyses of homeopathy. In fairness, it should be pointed out that the inverse correlation between methodological quality and observed treatment efficacy holds also in conventional medicine: see e.g. Schulz *et al.* (1995), Khan *et al.* (1996), Moher *et al.* (1998), Shang *et al.* (2005), and Poolman *et al.* (2007). The difference is that, in at least some cases of conventional medicine, analyses restricted to high-quality studies can show an indisputably significant treatment effect. For a lucid explanation of the importance of allocation concealment and double-blinding — and the distinction between the two — see Schulz (2000).
21. There was one apparent exception: a 1997 meta-analysis of homeopathy published in the *Lancet* (Linde *et al.* 1997), which is frequently cited by advocates of homeopathy because it found positive effects that were statistically significant at the 95% confidence level even when restricting attention to the 26 studies (out of 119) that met the authors’ criteria for “high quality”. However, a subsequent reanalysis of the same data by the same group (Linde *et al.* 1999), paying greater attention to the effects of study quality, found “clear evidence that in the study set investigated more rigorous trials tended to yield smaller effects” (p. 634), with the five highest-quality studies showing an effect that is no longer statistically significant at the 95% confidence level (Table 2: odds ratio 1.55 for homeopathy over placebo, with the 95% confidence interval running from 0.77 to 3.10). The authors conclude that

The most plausible explanation of this finding is bias. . . . The evidence of bias weakens the findings of our original meta-analysis. . . . It seems, therefore, likely that our meta-analysis at least overestimated the effects of homeopathic treatments. (pp. 634–635)

Furthermore, in response to a letter-writer who suggested “an analysis restricted to good-quality studies . . . with a clear predefined main endpoint” (Seed 1998), the authors admitted that “there are insufficient studies to conduct a useful analysis of only high-quality investigations with predefined outcome measures” (Linde and Jonas 1998, p. 367) — which suggests that the small residual effect in the “highest-quality” studies might itself be a result of bias. See also Ernst (2002).

22. Moreover, “different” homeopathic remedies — for instance, *nux vomica* and *excrementum caninum* — are the *same* placebo. This was inadvertently admitted by Kate Chatfield of the (British) Society of Homeopaths in testimony before the House of Lords Select Committee on Science and Technology (21 February 2007):

Q538 Lord Broers: I have a simple, technical question about homeopathy and drugs. Is it possible to distinguish between homeopathic drugs after they have been diluted? Is there any means of distinguishing one from the other?

Ms Chatfield: Only by the label.

(U.K. House of Lords 2007)

Indeed, an amusing situation of this type arose in France in 2007, when it was discovered that one of the major producers of homeopathic products, Laboratoires Boiron, had accidentally interchanged the labels in bottles of *Ginkgo biloba* and *Equisetum arvense*. Apparently no one noticed any unusual effects during the 5 months of this inadvertent double-blind trial.

23. See U.S. Food and Drug Administration (2010).
24. In the European Union, the situation is similar to that in the U.S.: Directive 2001/83/EC of 6 November 2001 relating to medicinal products for human use contains special provisions applicable to homeopathic products only (Title III, Chapter 2), which state *inter alia* (Article 14, paragraphs 2 and 3):

The criteria and rules of procedure provided for in Article 4(4), Article 17(1) and Articles 22 to 26, 112, 116 and 125 shall apply by analogy to the special, simplified registration procedure for homeopathic medicinal products, *with the exception of the proof of therapeutic efficacy*.

The proof of therapeutic efficacy shall not be required for homeopathic medicinal products registered in accordance with paragraph 1 of this Article, or, where appropriate, admitted in accordance with Article 13(2). [italics mine]

In the United Kingdom, by contrast, homeopathic products do not receive any overt exemption from the requirement of efficacy; rather (and even more scandalously in my opinion), the word “efficacy” is given — for homeopathic products only — a special *redefinition* that allows those products to be declared “efficacious” even if they completely lack efficacy in the ordinary sense of the word. If you don’t believe me, go read

U.K. Secretary of State for Health (2006) and U.K. Medicines and Healthcare Products Regulatory Agency (2006) and see for yourself.

25. Dobzhansky (1973).
26. Pardon the pun.
27. Miller, Scott and Okamoto (2006).
28. Catholics have accepted evolution, albeit with many caveats, since the 1950 encyclical *Humani Generis* of Pope Pius XII (see its paragraphs 36 and 37). One of the caveats is an insistence that there is an individual Adam from which all humans are descended (see paragraph 37). Concerning Muslim attitudes towards evolution, see Hassan (2007, p. 466) and Hameed (2008).
29. Gould (1999).
30. Sokal (2008, Chapter 9).
31. See also Bricmont (1999) for an illuminating discussion.
32. This important point was made by Harris (2004, p. 35).
33. John Paul II (1998, paragraph 13).
34. Of course, the same question can and should be posed about scientific methods, but in this case there is a strong answer: the fact that we are able to make accurate predictions of the results of experiments that have *never yet been performed* — sometimes to extraordinary accuracy — strongly suggests that our scientific theories must be correctly capturing *at least something* about the world. [See Sokal (2008, Chapter 7) for further details of this argument.] If “direct experience” of “spiritual reality” has some equally compelling argument in favor of its reliability, I would very much like to hear it.
35. Levitt (1996).
36. See e.g. Prados (2004), Miller (2006, chapter I) or Rich (2006) for extensive documentation. As the 23 July 2002 Downing Street Memo candidly put it (for private consumption within the Prime Minister’s inner circle), “the intelligence and facts were being fixed around the policy” (Smith 2005).

See also U.S. House of Representatives (2004) and the associated website, which contains “a searchable collection of 237 specific misleading statements made by Bush Administration officials about the threat posed by Iraq. It contains statements that were misleading based on what was known to the Administration at the time the statements were made. It does not include statements that appear mistaken only in hindsight. If a statement was an accurate reflection of U.S. intelligence at the time it was made, it was excluded even if it now appears erroneous.”
37. Black’s Law Dictionary defines “fraud” rather more ornately as

all the multifarious means which human ingenuity can devise, which are resorted to by one individual, to get an advantage over another by false suggestions or suppression of the truth. . . . [I]t includes all surprise, trick, cunning, dissembling, and any unfair way by which another is cheated. [Black (1979), citing *Barr v. Baker*, 9 Mo. 850 (1846), at 854.]

Black goes on to say that “the only boundaries defining [fraud] are those which limit human knavery.” In subsequent editions of Black’s Law Dictionary, the definitions have become less eloquent, though the meaning is unchanged.

Elsewhere, Black (1916, p. 43) observes that “to defraud another is not only to deprive or withhold from him that which belongs to or is due to him, but also to deprive him of any right . . . by any artifice or wrong practised upon him. And it is not essential that fraud should be accomplished by means of spoken or written falsehoods. If the intended result is accomplished, it is immaterial whether the means employed are affirmative or negative, that is, whether they consist of false pretenses or representations, deceptive acts or conduct, or the fraudulent suppression of material facts.”

In English law, the definition of fraud is essentially identical to that given by Black:

Fraud . . . may be said to include properly all acts, omissions, and concealments which involve a breach of legal or equitable duty, trust or confidence, justly reposed, and are injurious to another, or by which an undue or unconscientious advantage is taken of another. All surprise, trick, cunning, dissembling and other unfair way that is used to cheat any one is considered as fraud. (McDonnell and Monroe 1952, p. 1)

[F]raud is proved when it is shewn that a false representation has been made (1) knowingly, or (2) without belief in its truth, or (3) recklessly, careless whether it be true or false. To prevent a false statement being fraudulent, there must, I think, always be an honest belief in its truth. . . . [I]f fraud be proved, the motive of the person guilty of it is immaterial. [*Derry v Peek* (1889) 14 App Cas 337 at 374, per Lord Herschell]

Furthermore,

if I thought that a person making a false statement had shut his eyes to the facts, or purposely abstained from enquiring into them, I should hold that honest belief was absent, and that he was just as fraudulent as if he had knowingly stated that which was false. [*ibid.*, at 376]

38. See Spencer Bower and Handley (2000, chapters 2–5) for a detailed discussion. See also <http://en.wikipedia.org/wiki/Fraud> and <http://en.wikipedia.org/wiki/Misrepresentation> for a brief summary.
39. “Although an absence of reasonable grounds for believing a statement to be true is not itself a ground for liability [as fraud], it is important evidence that no such belief really exists and therefore that the defendant is guilty not of negligence but of fraud.” (Heuston and Buckley 1996, p. 372)

40. “[For there to be fraud] there must be a misstatement of an existing fact: but the state of a man’s mind is as much a fact as the state of his digestion. It is true that it is very difficult to prove what the state of a man’s mind at a particular time is, but if it can be ascertained it is as much a fact as anything else. A misrepresentation as to the state of a man’s mind is, therefore, a misstatement of fact.” [*Edgington v Fitzmaurice* (1885) 29 Ch.D. 459 at 483, CA, per Bowen LJ]
41. “[I]f the facts are not equally known to both sides, then a statement of opinion by the one who knows the facts best involves very often a statement of a material fact, for he impliedly states that he knows facts which justify his opinion.” [*Smith v Land and House Property Corporation* (1885) 28 Ch.D. 7 at 15, per Bowen LJ]
42. It is worth noting the analogy, in this last case, with scientific fraud. A scientist frequently has privileged access to information concerning his own research: raw experimental data, unpublished details of calculations, etc. For this reason, every scientist is ethically obliged to bend over backwards to disclose all potentially relevant information (and to make further data available to other scientists upon request), especially if it might cast doubt on his or her own theory.
- It is also worth stressing that, in law as well as in science, misrepresentation is not limited to asserting as true a proposition that one knows for a fact to be false; it also — and far more importantly — includes misrepresenting the *strength* of the evidence that one possesses for or against a particular proposition. [See American Law Institute (1977, §526b,c) and Prosser (1971, p. 701), cited in footnote 45 below.] This is crucial, both in science and in public policy, because one rarely possesses, in the case of any controversial scientific or policy question, “proof beyond a reasonable doubt”.
43. The 112,000 figure is a *lower bound*, based on reports of civilian deaths between March 2003 and March 2013 — due to coalition and insurgent military action, sectarian violence and increased criminal violence — that have been published in English-language media (including Arabic media translated into English). See <http://www.iraqbodycount.org/>
- Other estimates of deaths due to violence, based on professional polling and published in peer-reviewed journals, range from 151,000 through June 2006 (Iraq Family Health Survey Study Group 2008) to 601,000 through July 2006 (Burnham *et al.* 2006).
- For an extremely detailed account of the radically divergent estimates of excess Iraqi deaths by violence since 2003, along with methodological criticisms and rebuttals, see http://en.wikipedia.org/wiki/Casualties_of_the_Iraq_War and the pages to which it links.
44. The \$810 billion estimate (as of 24 May 2013) is due to the National Priorities Project (<http://costofwar.com>). It includes military and non-military (e.g. reconstruction) spending in Iraq (incremental costs only, e.g. combat pay but not soldiers’ regular pay). It does not include future medical care for wounded soldiers, interest payments on Iraq-related debt, or any indirect economic costs (e.g. increased oil prices). Broadly similar figures are found by the Congressional Research Service (Belasco 2007) and the Congressional Budget Office (Orszag 2007).
- Economists’ estimates of the ultimate total cost of the Iraq war (to the U.S. alone) range from approximately \$1 trillion (Wallsten and Kosec 2005) to \$3 trillion (Bilmes

and Stiglitz 2008). See Leonhardt (2007) for an illuminating perspective on “what \$1.2 trillion can buy”.

45. In English law, see *Derry v Peek*, quoted in footnote 37 above; and see Spencer Bower and Handley (2000, chapters 2–5) for more details.

The definition in American law is as follows (American Law Institute 1977):

§526. Conditions Under Which Misrepresentation Is Fraudulent (Scienter) A misrepresentation is fraudulent if the maker (a) knows or believes that the matter is not as he represents it to be, (b) does not have the confidence in the accuracy of his representation that he states or implies, or (c) knows that he does not have the basis for his representation that he states or implies.

The following addendum is also relevant to the cases of Bush and Blair:

§527. Ambiguous Representation A representation that the maker knows to be capable of two interpretations, one of which he knows to be false and the other true is fraudulent if it is made: (a) with the intention that it be understood in the sense in which it is false, or (b) without any belief or expectation as to how it will be understood, or (c) with reckless indifference as to how it will be understood.

The subsequent commentary adds that

Even though the maker of the statement did not realize the ambiguity of the statement when he made it, if he subsequently becomes aware that as a result of its ambiguity the statement is understood by the recipient in a sense that would make it false, he is under a duty to use reasonable care to disclose to the recipient information to prevent him from being misled by the statement.

Furthermore,

§529. Representation Misleading Because Incomplete A representation stating the truth so far as it goes but which the maker knows or believes to be materially misleading because of his failure to state additional or qualifying matter is a fraudulent misrepresentation.

Note, finally, that “a defendant who asserts a fact as of his own knowledge, or so positively as to imply that he has knowledge, under circumstances where he is aware that he will be so understood when he knows that he does not in fact know whether what he says is true, is found to have the intent to deceive, not so much as to the fact itself, but rather as to the extent of his information.” (Prosser 1971, p. 701)

46. See note 36 above.
47. One of the additional corrupting effects of cynicism is that it undermines our ability to properly appreciate those politicians who *do* have the courage to tell us the truth — even when it is unsettling, even when it contradicts our (and their own) preconceptions.
48. Haack (1998, p. 94).

49. Many postmodernists reject the fact-value distinction, but I strongly uphold it.
50. The argument (as well as some of the phraseology) in the preceding two paragraphs is shamelessly plagiarized from Bricmont (2005, pp. 21–23 and 32–33).

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