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Review

Billions and Billions of Demons

By Richard C. Lewontin

The Demon-Haunted World: Science as a Candle in the Dark
by Carl Sagan
Random House, 457 pp., $25.95

> "But the Solar System!" I protested.
>
> "What the deuce is it to me?" he interrupted impatiently: "you say that we go round the sun. If we went round the moon it would not make a pennyworth of difference to me or my work."
>
> —Colloquy between Dr. Watson and Sherlock Holmes in *A Study in Scarlet*

Carl Sagan
(click for larger image)

I first met Carl Sagan in 1964, when he and I found ourselves in Arkansas on the platform of the Little Rock Auditorium, where we had been dispatched by command of the leading geneticist of the day, Herman Muller. Our task was to take the affirmative side in a debate: "*Resolved*, That the Theory of Evolution is proved as is the fact that the Earth goes around the Sun." One of our opponents in the debate was a professor of biology from a fundamentalist college in Texas (his father was the president of the college) who had quite deliberately chosen the notoriously evolutionist Department of Zoology of the University of Texas as the source of his Ph.D. He could then assure his students that he had unassailable expert knowledge with which to refute Darwinism.

I had serious misgivings about facing an immense audience of creationist fundamentalist Christians in a city made famous by an Arkansas governor who, having detected a resentment of his constituents against federal usurpation, defied the power of Big Government by interposing his own body between the door of the local high school and some black kids who wanted to matriculate.

Young scientists, however, do not easily withstand the urgings of Nobel Prize winners, so after several transparently devious attempts to avoid the job, I appeared. We were, in fact, well treated, but despite our absolutely compelling arguments, the audience unaccountably voted for the opposition. Carl and I then sneaked out the back door of the auditorium and beat it out of town, quite certain that at any moment hooded riders with ropes and flaming crosses would snatch up two atheistic New York Jews who had the chutzpah to engage in public blasphemy.

Sagan and I drew different conclusions from our experience. For me the confrontation between creationism and the science of evolution was an example of historical, regional, and class differences in culture that could only be understood in the context of American social history. For Carl it was a struggle between ignorance and knowledge, although it is not clear to me what he made of the unimpeachable scientific credentials of our opponent, except perhaps to see him as an example of the Devil quoting scripture. The struggle to bring scientific knowledge to the masses has been a preoccupation of Carl Sagan's ever since, and he has become the most widely known, widely read, and widely seen popularizer of science since the invention of the video tube. His only rival in the *haute vulgarisation* of science is Stephen Jay Gould, whose *vulgarisations* are often very *haute* indeed, and whose intellectual concerns are quite different.

While Gould has occasionally been enlisted in the fight to protect the teaching and dissemination of the knowledge of evolution against creationist political forces, he is primarily concerned with what the nature of organisms, living and dead, can reveal about the social construction of scientific knowledge. His repeated demonstrations that organisms can only be understood as historically contingent, underdetermined Rube Goldberg devices are meant to tell us more about the evolution of human knowledge than of human anatomy. From his early *Mismeasure of Man*,[1] which examined how the political and social prejudices of prominent scientists have molded what those scientists claimed to be the facts of human anatomy and intelligence, to his recent collection of essays, *Eight Little Piggies*,[2] which despite its subtitle, *Reflections on Natural History*, is a set of reflections on the intellectual history of Natural History, Gould's deep preoccupation is with how knowledge, rather than the organism, is constructed.

Carl Sagan's program is more elementary. It is to bring a knowledge of the facts of the physical world to the scientifically uneducated public, for he is convinced that only through a broadly disseminated knowledge of the objective truth about nature will we be able to cope with the difficulties of the world and increase the sum of human happiness. It is this program that inspired his famous book and television series, *Cosmos*, which dazzled us with billions and billions of stars. But Sagan realizes that the project of merely spreading knowledge of objective facts about the universe is insufficient. First, no one can know and understand everything. Even individual scientists are ignorant about most of the body of scientific knowledge, and it is not simply that biologists do not understand

quantum mechanics. If I were to ask my colleagues in the Museum of Comparative Zoology at Harvard to explain the evolutionary importance of RNA editing in trypanosomes, they would be just as mystified by the question as the typical well-educated reader of this review.

Second, to put a correct view of the universe into people's heads we must first get an incorrect view out. People believe a lot of nonsense about the world of phenomena, nonsense that is a consequence of a wrong way of thinking. The primary problem is not to provide the public with the knowledge of how far it is to the nearest star and what genes are made of, for that vast project is, in its entirety, hopeless. Rather, the problem is to get them to reject irrational and supernatural explanations of the world, the demons that exist only in their imaginations, and to accept a social and intellectual apparatus, Science, as the only begetter of truth. The reason that people do not have a correct view of nature is not that they are ignorant of this or that fact about the material world, but that they look to the wrong sources in their attempt to understand. It is not simply, as Sherlock Holmes thought, that the brain is like an empty attic with limited storage capacity, so that the accumulated clutter of false or useless bits of knowledge must be cleared out in a grand intellectual tag sale to make space for more useful objects. It is that most people's mental houses have been furnished according to an appallingly bad model of taste and they need to start consulting the home furnishing supplement of the Sunday *New York Times* in place of the stage set of *The Honeymooners*. The message of *The Demon-Haunted World* is in its subtitle, *Science as a Candle in the Dark.*

Sagan's argument is straightforward. We exist as material beings in a material world, all of whose phenomena are the consequences of physical relations among material entities. The vast majority of us do not have control of the intellectual apparatus needed to explain manifest reality in material terms, so in place of scientific (i.e., correct material) explanations, we substitute demons. As one bit of evidence for the bad state of public consciousness, Sagan cites opinion polls showing that the majority of Americans believe that extraterrestrials have landed from UFOs. The demonic, for Sagan, includes, in addition to UFOs and their crews of little green men who take unwilling passengers for a midnight spin and some wild sex, astrological influences, extrasensory perception, prayers, spoon-bending, repressed memories, spiritualism, and channeling, as well as demons *sensu strictu*, devils, fairies, witches, spirits, Satan and his devotees, and, after some discreet backing and filling, the supposed prime mover Himself. God gives Sagan a lot of trouble. It is easy enough for him to snort derisively at men from Mars, but when it comes to the Supreme Extraterrestrial he is rather circumspect, asking only that sermons "even-handedly examine the God hypothesis."

> The fact that so little of the findings of modern science is prefigured in Scripture to my mind casts further doubt on its divine inspiration.
>
> But of course, I might be wrong.

I doubt that an all-seeing God would fall for Pascal's Wager, but the sensibilities of modern believers may indeed be spared by this Clintonesque moderation.

Most of the chapters of *The Demon-Haunted World* are taken up with exhortations to the reader to cease whoring after false gods and to accept the scientific method as the unique pathway to a correct understanding of the natural world. To Sagan, as to all but a few other scientists, it is self-evident that the practices of science provide the surest method of putting us in contact with physical reality, and that, in contrast, the demon-haunted world rests on a set of beliefs and behaviors that fail every reasonable test. So why do so many people believe in demons? Sagan seems baffled, and nowhere does he offer a coherent explanation of the popularity at the supermarket checkout counter of the *Weekly World News*, with its faked photographs of Martians. Indeed, he believes that "a proclivity for science is embedded deeply within us in all times, places and cultures." The only explanation that he offers for the dogged resistance of the masses to the obvious virtues of the scientific way of knowing is that "through indifference, inattention, incompetence, or fear of skepticism, we discourage children from science." He does not tell us how he used the scientific method to discover the "embedded" human proclivity for science, or the cause of its frustration. Perhaps we ought to add to the menu of Saganic demonology, just after spoon-bending, ten-second seat-of-the-pants explanations of social realities.

Nearly every present-day scientist would agree with Carl Sagan that our explanations of material phenomena exclude any role for supernatural demons, witches, and spirits of every kind, including any of the various gods from Adonai to Zeus. (I say "nearly" every scientist because our creationist opponent in the Little Rock debate, and other supporters of "Creation Science," would insist on being recognized.) We also exclude from our explanations little green men from Mars riding in space ships, although they are supposed to be quite as corporeal as you and I, because the evidence is overwhelming that Mars hasn't got any. On the other hand, if one supposed that they came from the planet of a distant star, the negative evidence would not be so compelling, although the fact that it would have taken them such a long time to get here speaks against the likelihood that they exist. Even Sagan says that "it would be astonishing to me if there weren't extraterrestrial life," a position he can hardly avoid, given that his first published book was *Intelligent Life in the Universe* [3] and he has spent a great deal of the taxpayer's money over the ensuing thirty years listening for the signs.

Sagan believes that scientists reject sprites, fairies, and the influence of Sagittarius because we follow a set of procedures, the Scientific Method, which has consistently produced explanations that put us in contact with reality and in which mystic forces play no part. For Sagan, the method is the message, but I think he has opened the wrong envelope.

There is no attempt in *The Demon-Haunted World* to provide a systematic account of just what Science and the Scientific Method consist in, nor was that the author's intention. The book is not meant to be a discourse on method, but it is in large part a collection of articles taken from *Parade* magazine and other popular publications. Sagan's intent is not analytic, but hortatory. Nevertheless, if the exhortation is to succeed, then the argument for the superiority of science and its method must be convincing, and not merely convincing, but must accord with its own demands. The case for the scientific method should itself be "scientific" and not merely rhetorical. Unfortunately, the argument may not look as good to the unconvinced as it does to the believer.

First, we are told that science "delivers the goods." It certainly has, sometimes, but it has often failed when we need it most. Scientists and their professional institutions, partly intoxicated with examples of past successes, partly in order to assure public financial support, make grandiose promises that cannot be kept. Sagan writes with justified scorn that

> We're regularly bombarded with extravagant UFO claims vended in bite-sized packages, but only rarely do we hear of their comeuppance.

He cannot have forgotten the well-publicized War on Cancer, which is as yet without a victorious battle despite the successful taking of a salient or two. At first an immense amount of money and consciousness was devoted to the supposed oncogenic viruses which, being infectious bugs, could be exterminated or at least resisted. But these particular Unidentified Flying Objects turned out for the most part to be as elusive as the Martians, and so, without publicly calling attention to their "comeuppance," the General Staff turned from outside invaders to the enemy within, the genes. It is almost certain that cancers do, indeed, arise because genes concerned with the regulation of cell division are mutated, partly as a consequence of environmental insults, partly because of unavoidable molecular instability, and even sometimes as the consequence of a viral attack on the genome. Yet the realization of the role played by DNA has had absolutely no consequence for either therapy or prevention, although it has resulted in many optimistic press conferences and a considerable budget for the National Cancer Institute. Treatments for cancer remain today what they were before molecular biology was ever thought of: cut it out, burn it out, or poison it.

The concentration on the genes implicated in cancer is only a special case of a general genomania that surfaces in the form of weekly announcements in *The New York Times* of the location of yet another gene for another disease. The revealing rhetoric of this publicity is always the same; only the blanks need to be filled in: "It was announced today by scientists at [Harvard, Vanderbilt, Stanford] Medical School that a gene responsible for [some, many, a common form of] [schizophrenia, Alzheimer's, arterio-sclerosis, prostate cancer] has beenlocated and its DNA sequence determined. This

exciting research, say scientists, is the first step in what may eventually turn out to be a possible cure for this disease."

The entire public justification for the Human Genome Project is the promise that some day, in the admittedly distant future, diseases will be cured or prevented.[4] Skeptics who point out that we do not yet have a single case of a prevention or cure arising from a knowledge of DNA sequences are answered by the observations that "these things take time," or that "no one knows the value of a newborn baby." But such vague waves of the hand miss the central scientific issue. The prevention or cure of metabolic and developmental disorders depends on a detailed knowledge of the mechanisms operating in cells and tissues above the level of genes, and there is no relevant information about those mechanisms in DNA sequences. In fact, if I know the DNA sequence of a gene I have no hint about the function of a protein specified by that gene, or how it enters into an organism's biology.

What is involved here is the difference between explanation and intervention. Many disorders can be *explained* by the failure of the organism to make a normal protein, a failure that is the consequence of a gene mutation. But *intervention* requires that the normal protein be provided at the right place in the right cells, at the right time and in the right amount, or else that an alternative way be found to provide normal cellular function. What is worse, it might even be necessary to keep the abnormal protein away from the cells at critical moments. None of these objectives is served by knowing the DNA sequence of the defective gene. Explanations of phenomena can be given at many levels, some of which can lead to successful manipulation of the world and some not. Death certificates all state a cause of death, but even if there were no errors in these ascriptions, they are too general to be useful. An easy conflation of explanations in general with explanations at the correct causal level may serve a propagandistic purpose in the struggle for public support, but it is not the way to concrete progress.

Scientists apparently do not realize that the repeated promises of benefits yet to come, with no likelihood that those promises will be fulfilled, can only produce a widespread cynicism about the claims for the scientific method. Sagan, trying to explain the success of Carlos, a telepathic charlatan, muses on

> how little it takes to tamper with our beliefs, how readily we are led, how easy it is to fool the public when people are lonely and starved for something to believe in.

Not to mention when they are sick and dying.

Biologists are not the only scientists who, having made extravagant claims about their merchandise, deliver the goods in bite-sized packages. Nor are they the only

manufacturers of knowledge who cannot be bothered to pick up a return package when the product turns out to be faulty. Sagan's own branch of science is in the same business. Anxious to revive a failing public interest in spending large amounts on space research, NASA scientists, followed by the President of the United States, made an immense fuss about the discovery of some organic molecules on a Mars rock. There is (was) life (of some rudimentary kind) on Mars (maybe)! Can little green men in space machines be far behind? If it turns out, as already suggested by some scientists, that these molecules are earthly contaminants, or were produced in non-living chemical systems, this fact surely will not be announced at a White House press conference, or even above the fold in *The New York Times*.

Second, it is repeatedly said that science is intolerant of theories without data and assertions without adequate evidence. But no serious stu-dent of epistemology any longer takes the naive view of science as a process of Baconian induction from theoretically unorganized observations. There can be no observations without an immense apparatus of preexisting theory. Before sense experiences become "observations" we need a theoretical question, and what counts as a relevant observation depends upon a theoretical frame into which it is to be placed. Repeatable observations that do not fit into an existing frame have a way of disappearing from view, and the experiments that produced them are not revisited. In the 1930s well-established and respectable geneticists described "dauer-modifications," environmentally induced changes in organisms that were passed on to offspring and only slowly disappeared in succeeding generations. As the science of genetics hardened, with its definitive rejection of any possibility of the inheritance of acquired characteristics, observations of dauer-modifications were sent to the scrapheap where they still lie, jumbled together with other decommissioned facts.

The standard form of a scientific paper begins with a theoretical question, which is then followed by the description of an experimental technique designed to gather observations pertinent to the question. Only then are the observations themselves described. Finally there is a discussion section in which a great deal of energy is often expended rationalizing the failure of the observations to accord entirely with a theory we really like, and in which proposals are made for other experiments that might give more satisfactory results. Sagan's suggestion that only demonologists engage in "special pleading, often to rescue a proposition in deep rhetorical trouble," is certainly not one that accords with my reading of the scientific literature. Nor is this a problem unique to biology. The attempts of physicists to explain why their measurements of the effects of relativity did not agree with Einstein's quantitative prediction is a case no doubt well known to Sagan.

As to assertions without adequate evidence, the literature of science is filled with them, especially the literature of popular science writing. Carl Sagan's list of the "best contemporary science-popularizers" includes E.O. Wilson, Lewis Thomas, and Richard Dawkins, each of whom has put unsubstantiated assertions or counterfactual claims at the very center of the stories they have retailed in the market. Wilson's *Sociobiology* and *On Human Nature*[5] rest on the surface of a quaking marsh of unsupported claims about the

genetic determination of everything from altruism to xenophobia. Dawkins's vulgarizations of Darwinism speak of nothing in evolution but an inexorable ascendancy of genes that are selectively superior, while the entire body of technical advance in experimental and theoretical evolutionary genetics of the last fifty years has moved in the direction of emphasizing non-selective forces in evolution. Thomas, in various essays, propagandized for the success of modern scientific medicine in eliminating death from disease, while the unchallenged statistical compilations on mortality show that in Europe and North America infectious diseases, including tuberculosis and diphtheria, had ceased to be major causes of mortality by the first decades of the twentieth century, and that at age seventy the expected further lifetime for a white male has gone up only two years since 1950. Even *The Demon-Haunted World* itself sometimes takes suspect claims as true when they serve a rhetorical purpose as, for example, statistics on child abuse, or a story about the evolution of a child's fear of the dark.

Third, it is said that there is no place for an argument from authority in science. The community of science is constantly self-critical, as evidenced by the experience of university colloquia "in which the speaker has hardly gotten 30 seconds into the talk before there are devastating questions and comments from the audience." If Sagan really wants to hear serious disputation about the nature of the universe, he should leave the academic precincts in Ithaca and spend a few minutes in an Orthodox study house in Brooklyn. It is certainly true that within each narrowly defined scientific field there is a constant challenge to new technical claims and to old wisdom. In what my wife calls the Gunfight at the O.K. Corral Syndrome, young scientists on the make will challenge a graybeard, and this adversarial atmosphere for the most part serves the truth. But when scientists transgress the bounds of their own specialty they have no choice but to accept the claims of authority, even though they do not know how solid the grounds of those claims may be. Who am I to believe about quantum physics if not Steven Weinberg, or about the solar system if not Carl Sagan? What worries me is that they may believe what Dawkins and Wilson tell them about evolution.

With great perception, Sagan sees that there is an impediment to the popular credibility of scientific claims about the world, an impediment that is almost invisible to most scientists. Many of the most fundamental claims of science are against common sense and seem absurd on their face. Do physicists really expect me to accept without serious qualms that the pungent cheese that I had for lunch is really made up of tiny, tasteless, odorless, colorless packets of energy with nothing but empty space between them? Astronomers tell us without apparent embarrassment that they can see stellar events that occurred millions of years ago, whereas we all know that we see things as they happen. When, at the time of the moon landing, a woman in rural Texas was interviewed about the event, she very sensibly refused to believe that the television pictures she had seen had come all the way from the moon, on the grounds that with her antenna she couldn't even get Dallas. What seems absurd depends on one's prejudice. Carl Sagan accepts, as I

do, the duality of light, which is at the same time wave and particle, but he thinks that the consubstantiality of Father, Son, and Holy Ghost puts the mystery of the Holy Trinity "in deep trouble." Two's company, but three's a crowd.

Our willingness to accept scientific claims that are against common sense is the key to an understanding of the real struggle between science and the supernatural. We take the side of science *in spite* of the patent absurdity of some of its constructs, *in spite* of its failure to fulfill many of its extravagant promises of health and life, *in spite* of the tolerance of the scientific community for unsubstantiated just-so stories, because we have a prior commitment, a commitment to materialism. It is not that the methods and institutions of science somehow compel us to accept a material explanation of the phenomenal world, but, on the contrary, that we are forced by our *a priori* adherence to material causes to create an apparatus of investigation and a set of concepts that produce material explanations, no matter how counter-intuitive, no matter how mystifying to the uninitiated. Moreover, that materialism is absolute, for we cannot allow a Divine Foot in the door. The eminent Kant scholar Lewis Beck used to say that anyone who could believe in God could believe in anything. To appeal to an omnipotent deity is to allow that at any moment the regularities of nature may be ruptured, that miracles may happen.

The mutual exclusion of the material and the demonic has not been true of all cultures and all times. In the great Chinese epic *Journey to the West*, demons are an alternative form of life, responsible to certain deities, devoted to making trouble for ordinary people, but severely limited. They can be captured, imprisoned, and even killed by someone with superior magic.[6] In our own intellectual history, the definitive displacement of divine powers by purely material causes has been a relatively recent changeover, and that icon of modern science, Newton, was at the cusp. It is a clich? of intellectual history that Newton attempted to accommodate God by postulating Him as the Prime Mover Who, having established the mechanical laws and set the whole universe in motion, withdrew from further intervention, leaving it to people like Newton to reveal His plan. But what we might call "Newton's Ploy" did not really get him off the hook. He understood that a defect of his system of mechanics was the lack of any equilibrating force that would return the solar system to its regular set of orbits if there were any slight perturbation. He was therefore forced, although reluctantly, to assume that God intervened from time to time to set things right again. It remained for Laplace, a century later, to produce a mechanics that predicted the stability of the planetary orbits, allowing him the hauteur of his famous reply to Napoleon. When the Emperor observed that there was, in the whole of the *M?canique C?leste*, no mention of the author of the universe, he replied, "Sire, I have no need of that hypothesis." One can almost hear a stress on the "I."

The struggle for possession of public consciousness between material and mystical

explanations of the world is one aspect of the history of the confrontation between elite culture and popular culture. Without that history we cannot understand what was going on in the Little Rock Auditorium in 1964. The debate in Arkansas between a teacher from a Texas fundamentalist college and a Harvard astronomer and University of Chi-cago biologist was a stage play recapitulating the history of American rural populism. In the first decades of this century there was an im-mensely active populism among poor southwestern dirt farmers and miners.[7] The most widely circulated American socialist journal of the time (*The Appeal to Reason*!) was published not in New York, but in Girard, Kansas, and in the presidential election of 1912 Eugene Debs got more votes in the poorest rural counties of Texas and Oklahoma than he did in the industrial wards of northern cities. Sentiment was extremely strong against the banks and corporations that held the mortgages and sweated the labor of the rural poor, who felt their lives to be in the power of a distant eastern elite. The only spheres of control that seemed to remain to them were family life, a fundamentalist religion, and local education.

This sense of an embattled culture was carried from the southwest to California by the migrations of the Okies and Arkies dispossessed from their ruined farms in the 1930s. There was no serious public threat to their religious and family values until well after the Second World War. Evolution, for example, was not part of the regular biology curriculum when I was a student in 1946 in the New York City high schools, nor was it discussed in school textbooks. In consequence there was no organized creationist movement. Then, in the late 1950s, a national project was begun to bring school science curricula up to date. A group of biologists from elite universities together with science teachers from urban schools produced a new uniform set of biology textbooks, whose publication and dissemination were underwritten by the National Science Foundation. An extensive and successful public relations campaign was undertaken to have these books adopted, and suddenly Darwinian evolution was being taught to children everywhere. The elite culture was now extending its domination by attacking the control that families had maintained over the ideological formation of their children.

The result was a fundamentalist revolt, the invention of "Creation Science," and successful popular pressure on local school boards and state textbook purchasing agencies to revise subversive curricula and boycott blasphemous textbooks. In their parochial hubris, intellectuals call the struggle between cultural relativists and traditionalists in the universities and small circulation journals "The Culture Wars." The real war is between the traditional culture of those who think of themselves as powerless and the rationalizing materialism of the modern Leviathan. There are indeed Two Cultures at Cambridge. One is in the Senior Common Room, and the other is in the Porter's Lodge.

Carl Sagan, like his Canadian counterpart David Suzuki, has devoted extraordinary energy to bringing science to a mass public. In doing so, he is faced with a contradiction

for which there is no clear resolution. On the one hand science is urged on us as a model of rational deduction from publicly verifiable facts, freed from the tyranny of unreasoning authority. On the other hand, given the immense extent, inherent complexity, and counterintuitive nature of scientific knowledge, it is impossible for anyone, including non-specialist scientists, to retrace the intellectual paths that lead to scientific conclusions about nature. In the end we must trust the experts and they, in turn, exploit their authority as experts and their rhetorical skills to secure our attention and our belief in things that we do not really understand. Anyone who has ever served as an expert witness in a judicial proceeding knows that the court may spend an inordinate time "qualifying" the expert, who, once qualified, gives testimony that is not meant to be a persuasive argument, but an assertion unchallengeable by anyone except another expert. And, indeed, what else are the courts to do? If the judge, attorneys, and jury could reason out the technical issues from fundamentals, there would be no need of experts.

What is at stake here is a deep problem in democratic self-governance. In Plato's most modern of Dialogues, the *Gorgias*, there is a struggle between Socrates, with whom we are meant to sympathize, and his opponents, Gorgias and Callicles, over the relative virtues of rhetoric and technical expertise. What Socrates and Gorgias agree on is that the mass of citizens are incompetent to make reasoned decisions on justice and public policy, but that they must be swayed by rhetorical argument or guided by the authority of experts.[8]

> Gorgias: "I mean [by the art of rhetoric] the ability to convince by means of speech a jury in a court of justice, members of the Council in their Chamber, voters at a meeting of the Assembly, and any other gathering of citizens, whatever it may be."
>
> Socrates: "When the citizens hold a meeting to appoint medical officers or shipbuilders or any other professional class of person, surely it won't be the orator who advises them then. Obviously in every such election the choice ought to fall on the most expert."[9]

Conscientious and wholly admirable popularizers of science like Carl Sagan use both rhetoric and expertise to form the mind of masses because they believe, like the Evangelist John, that the truth shall make you free. But they are wrong. It is not the truth that makes you free. It is your possession of the power to discover the truth. Our dilemma is that we do not know how to provide that power.

Notes

[1] *The Mismeasure of Man* (Norton, 1978). See my review in *The New York Review*, October 22, 1981.

[2] *Eight Little Piggies: Reflections on Natural History* (Norton, 1993).

[3] I.S. Shklovskii and C. Sagan's *Intelligent Life in the Universe* (Holden Day, 1966) began as a translation of a Russian work by the senior astronomer, Shklovskii, but soon grew into a joint work.

[4] See my "The Dream of the Human Genome" in *The New York Review*, May 28, 1992.

[5] *Sociobiology: The New Synthesis* (Harvard University Press, 1975); *On Human Nature* (Harvard University Press, 1978).

[6] There is, in fact, an array of life forms with both mortal and magical characteristics. The hero of *Journey to the West* is Monkey, possessed of considerable powers, but potentially vulnerable to men and demons alike.

[7] For an illuminating history of this period, see James R. Green, *Grass-Roots Socialism: Radical Movements in the Southwest 1895-1943* (Louisiana State University Press, 1978).

[8] I am indebted for my appreciation of this basic agreement between the contending parties to Bruno Latour, who allowed me to read an as yet unpublished essay of his on the dialogue.

[9] Plato, *Gorgias*, translated by Walter Hamilton (Penguin, 1960), pp. 28, 32.

Letters

March 6, 1997: Wayne C. Booth, Science & 'The Demon-Haunted World': An Exchange

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