Wonder and Skepticism

CARL SAGAN

Science requires an almost complete openness to all ideas. On the other hand, it requires the most rigorous and uncompromising skepticism.

I was a child in a time of hope. I grew up when the expectations for science were very high: in the thirties and forties. I went to college in the early fifties, got my Ph.D. in 1960. There was a sense of optimism about science and the future. I dreamt of being able to do science. I grew up in Brooklyn, New York, and I was a street kid. I came from a nice nuclear family, but I spent a lot of time in the streets, as kids did then. I knew every bush and hedge, streetlight and stoop and theater wall for playing Chinese handball. But there was one aspect of that environment that, for some reason, struck me as different, and that was the stars.

Even with an early bedtime in winter you could see the stars. What were they? They weren't like hedges or even streetlights; they were different. So I asked my friends what they were. They said, "They're lights in the sky, kid." I could tell they were lights in the sky, but that

wasn't an explanation. I mean, what were they? Little electric bulbs on long black wires, so you couldn't see what they were held up by? What were they?

Not only could nobody tell me, but nobody even had the sense that it was an interesting question. They looked at me funny. I asked my parents; I asked my parents' friends; I asked other adults. None of them knew.

My mother said to me, "Look, we've just got you a library card. Take it, get on the streetcar, go to the New Utrecht branch of the New York Public Library, get out a book and find the answer."

That seemed to me a fantastically clever idea. I made the journey. I asked the librarian for a book on stars. (I was very small; I can still remember looking up at her, and she was sitting down.) She was gone a few minutes, brought one back, and gave it to me. Eagerly I sat down and opened the pages. But it was about Jean Harlow and Clark Gable, I think, a terrible disappointment. And so I went back to her, explained (it wasn't easy for me to do) that that wasn't what I had in mind at all, that what I wanted was a book about real stars. She thought this was funny, which embarrassed me further. But anyway, she went and got another book, the right kind of book. I took it and opened it and slowly turned the pages, until I came to the answer.

It was in there. It was stunning. The answer was that the Sun was a star, except very far away. The stars were suns; if you were close to them, they would look just like our sun. I tried to imagine how far away from the Sun you'd have to be for it to be as dim as a star. Of course I didn't know the inverse square law of light propagation; I hadn't a ghost of a chance of figuring it out. But it was clear to me that you'd have to be very far away. Farther away, probably, than New Jersey. The dazzling idea of a universe vast beyond imagining swept over me. It has stayed with me ever since.

I sensed awe. And later on (it took me several years to find this), I realized that we were on a planet—a little, non-self-luminous world going around our star. And so all those other stars might have planets going around them. If planets, then life, intelligence, other Brooklyns—who knew? The diversity of those possible worlds struck me. They didn't have to be exactly like ours, I was sure of it.

It seemed the most exciting thing to study. I didn't realize that you could be a professional scientist; I had the idea that I'd have to be, I don't know, a salesman (my father said that was better than the manufacturing end of things), and do science on weekends and evenings. It wasn't until my sophomore year in high school that my biology teacher revealed to me that there was such a thing as a professional scientist, who got paid to do it; so you could spend all your time learning about the universe. It was a glorious day.

Moon Catcher by Leonard Parkin

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It's been my enormous good luck—I was born at just the right time—to have had, to some extent, those childhood ambitions satisfied. I've been involved in the exploration of the solar system, in the most amazing parallel to the science fiction of my childhood. We actually send spacecraft to other worlds. We fly by them; we orbit them; we land on them. We design and control the robots: Tell it to dig, and it digs. Tell it to determine the chemistry of a soil sample, and it determines the chemistry. For me the continuum from childhood wonder and early science fiction to professional reality has been almost seamless. It's never been, "Oh, gee, this is nothing like what I had imagined." Just the opposite: It's exactly like what I imagined. And so I feel enormously fortunate.

Science is still one of my chief joys. The popularization of science that Isaac Asimov did so well—the communication not just of the findings but of the methods of science—seems to me as natural as breathing. After all, when you're in love, you want to tell the world. The idea that scientists shouldn't talk about their science to the public seems to me bizarre.

There's another reason I think popularizing science is important, why I try to do it. It's a foreboding I have—maybe ill-placed—of an America in my children's generation, or my grandchildren's generation, when all the manufacturing industries have slipped away to other countries; when we're a service and information-processing economy; when awesome technological powers are in the hands of a very few, and no one representing the public interest even grasps the issues; when the people (by "the people" I mean the broad population in a democracy) have lost the ability to set their own agendas, or even to knowledgeably question those who do set the agendas; when there is no practice in questioning those in authority; when, clutching our crystals and religiously consulting our horoscopes, our critical faculties in steep decline, unable to distinguish between what's true and what feels good, we slide, almost without noticing, into superstition and darkness.

"To make sure that the powers of science and technology are used properly and prudently, we ourselves must understand science and technology."

CSICOP plays a sometimes lonely but still—and in this case the word may be right—heroic role in trying to counter some of those trends.

We have a civilization based on science and technology, and we've cleverly arranged things so that almost nobody understands science and technology. That is as clear a prescription for disaster as you can imagine. While we might get away with this combustible mixture of ignorance and power for a while, sooner or later it's going to blow up in our faces. The powers of modern technology are so formidable that it's insufficient just to say, "Well, those in charge, I'm sure, are doing a good job." This is a democracy, and for us to make sure that the powers of science and technology are used properly and prudently, we ourselves must understand science and technology. We must be involved in the decision-making process.

The predictive powers of some areas, at least, of science are phenomenal. They are the clearest counterargument I can imagine to those who say, "Oh, science is situational; science is just the current fashion; science is the promotion of the self-interests of those in power." Surely there is some of that. Surely if there's any powerful tool, those in power will try to use it, or even monopolize it. Surely scientists, being people, grow up in a society and reflect the prejudices of that society. How could it be otherwise? Some scientists have been nationalists; some have been racists; some have been sexists. But that doesn't undermine the validity of science. It's just a consequence of being human.

So, imagine—there are so many areas we could think of—imagine you want to know the sex of your unborn child. There are several approaches. You could, for example, do what the late film star who Annie and I admire greatly—Cary Grant—did before he was an actor: In a carnival or fair or consulting room, you suspend a watch or a plumb bob above the abdomen of the expectant mother; if it swings left-right it's a boy, and if it swings forward-back it's a girl. The method works one time in two. Of course he was out of there before the baby was born, so he never heard from customers who complained he got it wrong. Being right one chance in two—that's not so bad. It's better than, say, Kremlinologists used to do. But if you really want to know, then you go to amniocentesis, or to sonograms; and there your chance of being right is 99 out of 100. It's not perfect, but it's a whole lot better than one out of two. If you really want to know, you go to science.

Or suppose you wanted to know when the next eclipse of the sun is. Science does something really astonishing: It can tell you a century in advance where the eclipse is going to be on Earth and when, say, totality will be, to the second. Think of the predictive power this implies. Think of how much you must understand to be able to say when and where there's going to be an eclipse so far in the future.

Or (the same physics exactly) imagine launching a spacecraft from Earth, like the Voyager spacecraft in 1977; 12 years later Voyager 1 arrives at Neptune within 100 kilometers or something of where it was supposed to be—not having to use some of the mid-course corrections that were available; 12 years, 5 billion kilometers, on target!

So if you want to really be able to predict the future—not in everything, but in some areas—there's only one regime of human scholarship, of human claims to knowledge, that really delivers the goods, and that's science. Religions would give their eyeteeth to be able to predict anything like that

well. Think of how much mileage they would make if they ever could do predictions comparably unambiguous and *precise*.

Now how does it work? Why is it so successful?

Science has built-in error-correcting mechanisms—because science recognizes that scientists, like everybody else, are fallible, that we make mistakes, that we're driven by the same prejudices as everybody else. There are no forbidden questions. Arguments from authority are worthless. Claims must be demonstrated. Ad hominem arguments—arguments about the personality of somebody who disagrees with you—are irrelevant; they can be sleazeballs and be right, and you can be a pillar of the community and be wrong.

If you take a look at science in its everyday function, of course you find that scientists run the gamut of human emotions and personalities and character and so on. But there's one thing that is really striking to the outsider, and that is the gauntlet of criticism that is considered acceptable or even desirable. The poor graduate student at his or her Ph.D. oral exam is subjected to a withering crossfire of questions that sometimes seem hostile or contemptuous; this from the professors who have the candidate's future in their grasp. The students naturally are nervous; who wouldn't be? True, they've prepared for it for years. But they understand that at that critical moment they really have to be able to answer questions. So in preparing to defend their theses, they must anticipate questions; they have to think, "*Where in my thesis is there a weakness* that someone else might find—because I sure better find it before they do, because if they find it and I'm not prepared, I'm in deep trouble."

You take a look at contentious scientific meetings. You find university colloquia in which the speaker has hardly gotten 30 seconds into presenting what she or he is saying, and suddenly there are interruptions, maybe withering questions, from the audience. You take a look at the publication conventions in which you submit a scientific paper to a journal, and it goes out to anonymous referees whose job it is to think, Did *you do anything stupid? If you didn't* do anything stupid, is there anything in here that is sufficiently interesting to be published? What are the deficiencies of this paper? Has it been done by anybody else? Is the argument adequate, or should you resubmit the paper after you've actually demonstrated what you're speculating on? And so on. And it's anonymous: You don't know who your critics are. You have to rely on the editor to send it out to real experts who are not overtly malicious. This is the everyday expectation in the scientific community. And those who don't expect it—even good scientists who just can't hold up under criticism—have difficult careers.

Why do we put up with it? Do we like to be criticized? No, no scientist likes to be criticized. Every scientist feels an affection for his or her ideas and scientific results. You feel protective of them. But you don't reply to critics: "Wait a minute, wait a minute; this is a really good idea. I'm very fond of it. It's done you no harm. Please don't attack it." That's not the way it goes. The hard but just rule is that if the ideas don't work, you must throw them away. Don't waste any neurons on what doesn't work. Devote those neurons to new ideas that better *explain the data. Valid criticism is* doing you a favor.

There is a reward structure in science that is very interesting: Our highest honors go to those who disprove the findings of the most revered among us. So Einstein is revered not just because he made so many fundamental contributions to science, but because he found an imperfection in the fundamental contribution of Isaac Newton. (Isaac Newton was surely the greatest physicist before Albert Einstein.)

Now think of what other areas of human society have such a reward structure, in which we revere those *who prove that the fundamental* doctrines that we have adopted are wrong. Think of it in politics, or in economics, or in religion; think of it in how we organize our society. Often, it's exactly the opposite: There we reward those who reassure us that what we've been told is right, that we need not concern ourselves about it. This difference, I believe, is at least a basic reason why we've made so much progress in science, and so little in some other areas.

We are fallible. We cannot expect to foist our wishes on the universe. So another key aspect of science is experiment. Scientists do not trust what is intuitively obvious, because intuitively obvious gets you nowhere. That the Earth is flat was once obvious. I mean, really obvious; obvious! Go out in a flat field and take a look: Is it round or flat? Don't listen to me; go prove it to yourself. That heavier bodies fall faster than light ones was once obvious. That blood-sucking leeches cure disease was once obvious. That some people are naturally and by divine right slaves was once obvious. That the Earth is at the center of the universe was once obvious. You're skeptical? Go out, take a look: Stars rise in the east, set in the west; here we are, stationary (do you feel the Earth whirling?); we see them *going around us. We are at the center;* they go around us.

"The least effective way for skeptics to get the attention of these bright, curious, interested people is to belittle, or condescend, or show arrogance toward their beliefs."

The truth may be puzzling. It may take some work to grapple with. It may be counterintuitive. It may contradict deeply held prejudices. It may not be consonant with what we desperately want to be true. But our preferences do not determine what's true. We have a method, and that method helps us to reach not absolute truth, only asymptotic approaches to the truth—never there, just closer and closer, always

finding vast new oceans of undiscovered possibilities. Cleverly designed experiments are the key.

In the 1920s, there was a dinner at which the physicist Robert W. Wood was asked to respond to a toast. This was a time when people stood up, made a toast, and then selected someone to respond. Nobody knew what toast they'd be asked to reply to, so it was a challenge for the quick-witted. In this case the toast was: "To physics and metaphysics." Now by metaphysics was meant something like philosophy—truths that you could get to just by thinking about them. Wood took a second, glanced about him, and answered along these lines: The physicist has an idea, he said. The more he thinks it through, the more sense it makes to him. He goes to the scientific literature, and the more he reads, the more promising the idea seems. Thus prepared, he devises an experiment to test the idea. The experiment is painstaking. Many possibilities are eliminated or taken into account; the accuracy of the measurement is refined. At the end of all this work, the experiment is completed and . . . the idea is shown to be worthless. The physicist then discards the idea, frees his mind (as I was saying a moment ago) from the clutter of error, and moves on to something else.

The difference between physics and metaphysics, Wood concluded, is that the metaphysicist has no laboratory.

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Why is it so important to have widely distributed understanding of science and technology? For one thing, it's the golden road out of poverty for developing nations. And developing nations understand that, because you have only to look at modern American graduate schools—in mathematics, in engineering, in physics—to find, in case after case, that more than half the students are from other countries. This is something America is doing for the world. But it conveys a clear sense that the developing nations understand what is essential for their future. What worries me is that Americans may not be equally clear on the subject.

Let me touch on the dangers of technology. Almost every astronaut who has visited Earth orbit has made this point: I was up there, they say, and I looked toward the horizon, and there was this thin, blue band that's the Earth's atmosphere. I had been told we live in an ocean of air. But there it was, so fragile, such a delicate blue: I was worried for it.

In fact, the thickness of the Earth's atmosphere, compared with the size of the Earth, is in about the same ratio as the thickness of a coat of shellac on a schoolroom globe is to the diameter of the globe. That's the air that nurtures us and almost all other life on Earth, that protects us from deadly ultraviolet light from the sun, that through the greenhouse effect brings the surface temperature above the freezing point. (Without the greenhouse effect, the entire Earth would plunge below the freezing point of water and we'd all be dead.) Now that atmosphere, so thin and fragile, is under assault by our technology. We are pumping all kinds of stuff into it. You know about the concern that chlorofluorocarbons are depleting the ozone layer; and that carbon dioxide and methane and other greenhouse gases are producing global warming, a steady trend amidst fluctuations produced by volcanic eruptions and other sources. Who knows what other challenges we are posing to this vulnerable layer of air that we haven't been wise enough to foresee?

The inadvertent side effects of technology can challenge the environment on which our very lives depend. That means that we must understand science and technology; we must anticipate longterm consequences in a very clever way—not just the bottom line on the profit-and-loss column for the corporation for this year, but the consequences for the nation and the species 10, 20, 50, 100 years in the future. If we absolutely stop all chlorofluorocarbon and allied chemical production right now (as we're in fact doing), the ozonosphere will heal itself in about a hundred years. Therefore our children, our grandchildren, our great-grandchildren must suffer through the mistakes that we've made. That's a second reason for science education: the dangers of technology. We must understand them better.

A third reason: origins. Every human culture has devoted some of its intellectual, moral, and material resources to trying to understand where everything comes from—our nation, our species, our planet, our star, our galaxy, our universe. Stop someone on the street and ask about it. You will not find many people who never thought about it, who are incurious about their ultimate origins.

I hold there's a kind of Gresham's Law that applies in the confrontation of science and pseudoscience: In the popular imagination, at least, the bad science drives out the good. What I mean is this: If you are awash in lost continents and channeling and UFOs and all the long litany of claims so well exposed in the SKEPTICAL INQUIRER, you may not have intellectual room for the findings of science. You're sated with wonder. Our culture in one way produces the fantastic findings of science, and then in another way cuts them off before they reach the average person. So people who are curious, intelligent, dedicated to understanding the world, may nevertheless be (in our view) enmired in superstition and pseudoscience. You could say, Well, they ought to know better, they ought to be more critical, and so on; but that's too harsh. It's not very much their fault, I say. It's the fault of a society that preferentially propagates the baloney and holds back the ambrosia.

The least effective way for skeptics to get the attention of these bright, curious, interested people is to belittle, or condescend, or show arrogance toward their beliefs. They may be credulous, but they're not stupid. If we bear in mind human frailty and fallibility, we will understand their plight.

For example: I've lately been thinking about alien abductions, and false claims of childhood sexual abuse, and stories of satanic ritual abuse in the context of recovered memories. There

are interesting similarities among those classes of cases. I think if we are to understand any of them, we must understand all of them. But there's a maddening tendency of the skeptics, when addressing invented stories of childhood sexual abuse, to forget that real and appalling abuse happens. It is not true that all these claims of childhood sexual abuse are silly and pumped up by unethical therapists. Yesterday's paper reported that a survey of 13 states found that one-sixth of all the rape victims reported to police are under the age of 12. And this is a category of rape that is preferentially under-reported to police, for obvious reasons. Of these girls, one-fifth were raped by their fathers. That's a lot of people, and a lot of betrayal. We must bear that in mind when we consider patients who, say, because they have an eating disorder, have suppressed childhood sexual abuse diagnosed by their psychiatrists.

People are not stupid. They believe *things for reasons. Let us not dismiss* pseudoscience or even superstition with contempt.

In the nineteenth century it was mediums: You'd go to the séance, and you'd be put in touch with dead relatives. These days it's a little different; it's called channeling. What both are basically about is the human fear of dying. I don't know about you; I find the idea of dying unpleasant. If I had a choice, at least for a while, I would just as soon not die. Twice in my life I came very close to doing so. (I did not have a near-death experience, I'm sorry to say.) I can understand anxiety about dying.

About 14 years ago both my parents died. We had a very good relationship. I was very close to them. I still miss them terribly. I wouldn't ask much: I would like five minutes a year with them; to tell them how their kids and their grandchildren are doing, and how *Annie and I are doing. I know it* sounds stupid, but I'd like to ask them, "Is everything all right with you?" Just a little contact. So I don't guffaw at women who go to their husbands' tombstones and chat them up every now and then. That's not hard to understand. And if we have difficulties *on the ontological status of who it is* they're talking to, that's all right. That's not what this is about. This is humans being human.

In the alien-abduction context, I've been trying to understand the fact that humans hallucinate—that it's a human commonplace—yes, under conditions of sensory deprivation or drugs or deprival of REM sleep, but also just in the ordinary course of existence. I have, maybe a dozen times since my parents died, heard one of them say my name: just the single word, "Carl." I miss them; they called me by my first name so much during the time they were alive; I was in the practice of responding instantly when I was called; it has deep psychic roots. So my brain plays it back every now and then. This doesn't surprise me at all; I sort of like it. But it's a hallucination. If I were a little less skeptical, though, I could see *how easy it would be to say, "They're* around somewhere. I can hear them."

Raymond Moody, who is an M.D., I think, an author who writes innumerable books on life after death, actually quoted me in the first chapter of his latest book, saying that I heard my parents calling me Carl, and so, look, *even he believes in life after death. This* badly misses my point. If this is one of the arguments from Chapter 1 of the latest book of a principal exponent of life after death, I suspect that despite our most fervent wishes, the case is weak.

But still, suppose I wasn't steeped in the virtues of scientific skepticism and felt as I do about my parents, and along comes someone who says, "I can put you in touch with them." Suppose he's clever, and found out something about my parents in the past, and is good at faking voices, and so on—a darkened room and incense and all of that. I could see being swept away emotionally.

Would you think less of me if I fell for it? Imagine I was never educated about skepticism, had no idea that it's a virtue, but instead believed that it was grumpy and negative and rejecting *of everything that's humane. Couldn't* you understand my openness to being conned by a medium or a channeler?

The chief deficiency I see in the skeptical movement is its polarization: Us vs. Them—the sense that we have a monopoly on the truth; that those other people who believe in all these

On Sober Reflection . . .

I'm pleased to have been associated for a long time with the Committee for the Scientific Investigation of Claims of the Paranormal (CSICOP). When the SKEPTICAL INQUIRER arrives, I always take it home from the office and pore through its pages, wondering what new misunderstandings will be revealed. I'm always amazed that there's still another subject that I never thought of. Crop circles! Aliens have come and made mathematical messages—in wheat! Who would have thought it? So unlikely an artistic medium. Or they've come and eviscerated cows—on a large scale, systematically. Farmers are furious. I'm often impressed by the depths of inventiveness that the new stories that are debunked in SKEPTICAL INQUIRER reveal. But then, on more sober reflection, it always strikes me how unimaginative most of these stories are; how, compared with the unexpected findings of science, they have a kind of dreariness about them, stale ideas, chauvinisms, hopes and fears dressed up as facts, a reflection of people who imagine that what pops into their heads can be more stunning than what Nature provides us with every day. In almost every case, I have this second thought: That's all they can imagine the extraterrestrials doing—making circles in hay? —C.S.

stupid doctrines are morons; that if you're sensible, you'll listen to us; and if not, to hell with you. This is nonconstructive. It does not get our message across. It condemns us to permanent minority status. Whereas, an approach that from the beginning acknowledges the human roots of pseudoscience and superstition, that recognizes that the society has arranged things so that skepticism is not well taught, might be much more widely accepted.*

If we understand this, then of course we have compassion for the abductees and those who come upon crop circles and believe they're supernatural, or at least of extraterrestrial manufacture. This is key to making science and the scientific method more attractive, especially to the young, because it's a battle for the future.

Science involves a seemingly self-contradictory mix of attitudes: On the one hand, it requires an almost complete openness to all ideas, no matter how bizarre and weird they sound, a propensity to wonder. As I walk along, my time slows down; I shrink in the direction of motion, and I get more massive. That's crazy! On the scale of the very small, the molecule can be in this position, in that position, but it is prohibited from being in any intermediate position. That's wild! But the first is a statement of special relativity, and the second is a consequence of quantum mechanics. Like it or not, that's the way the world is. If you insist that it's ridiculous, you will be forever closed to the major findings of science. But at the same time, science requires the most vigorous and uncompromising skepticism, because the vast majority of ideas are simply wrong, and the only way you can distinguish the right from the wrong, the wheat from the chaff, is by critical experiment and analysis.

Too much openness and you accept every notion, idea, and hypothesis—which is tantamount to knowing nothing. Too much skepticism—especially rejection of new ideas before they are adequately tested—and you're not only unpleasantly grumpy, but also closed to the advance of science. A judicious mix is what we need.

It's no fun, as I said at the beginning, to be on the receiving end of skeptical questioning. But it's the affordable price we pay for having the benefits of so powerful a tool as science.

*If skeptical habits of thought are widely distributed and prized, then who is the skepticism going to be mainly applied to? To those in power. Those in power, therefore, do not have a vested interest in everybody being able to ask searching questions.

7th European Skeptics Conference: in Rossdorf, Germany

The central theme at the 7th European Skeptics Conference will be the influence of fringe-science on society, politics, and culture. A number of other controversial themes will be addressed, including fringe medicine (homeopathy), faith healing, problems of perception and memory, pseudoscience and the philosophy of science, and current paranormal claims.

Date: May 4-7, 1995
Location: Rossdorf (near Darmstadt, Germany) about an hour by bus from Frankfurt Airport.
Languages: English and German

Speakers include John Maddox (Chief Editor, *Nature*), Professor Gerhard Vollmer (philosopher), Dr. Barbara Burkhardt (medical insurance issues), Paul Kurtz (CSICOP Chairman), and James Randi.

Registration
Registrations before February 28:
DM 95, Students DM 45
Late registration surcharge: DM 20
Proceedings: DM 20 special rate for participants only
(current rates: 1US$ = DM 1.55)

Proceedings
Conference papers will be published as proceedings

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Or call Barry Karr, CSICOP Exeuctuve Director at 716-636-1425

Conference Schedule (in English language unless noted otherwise)

Thursday, May 4
ECSO meeting, reception, welcome address, and keynote speech.

Friday, May 5
The two morning sessions will discuss pseudoscience (in German) and for non-German-speaking participants, an excursion is planned to the Messel pit, a trip 50 million years into the past. Following lunch will be two sessions on fringe science in Europe. The evening entertainment will consist of magic, music, and sketches.

Saturday, May 6
The morning session will focus on the problems of perception and memory and will be followed by a discussion of fraud and self-deception in science. Workshops will follow lunch and a panel session discussing the formation of a lobby against fringe science. A banquet will be held in the evening.

Sunday, May 7
The morning session will discuss the promotion of science as a protection against pseudoscience. A GWUP members meeting will be held following the close of the conference.