STEVEN WEINBERG

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Science and Its Cultural Adversaries

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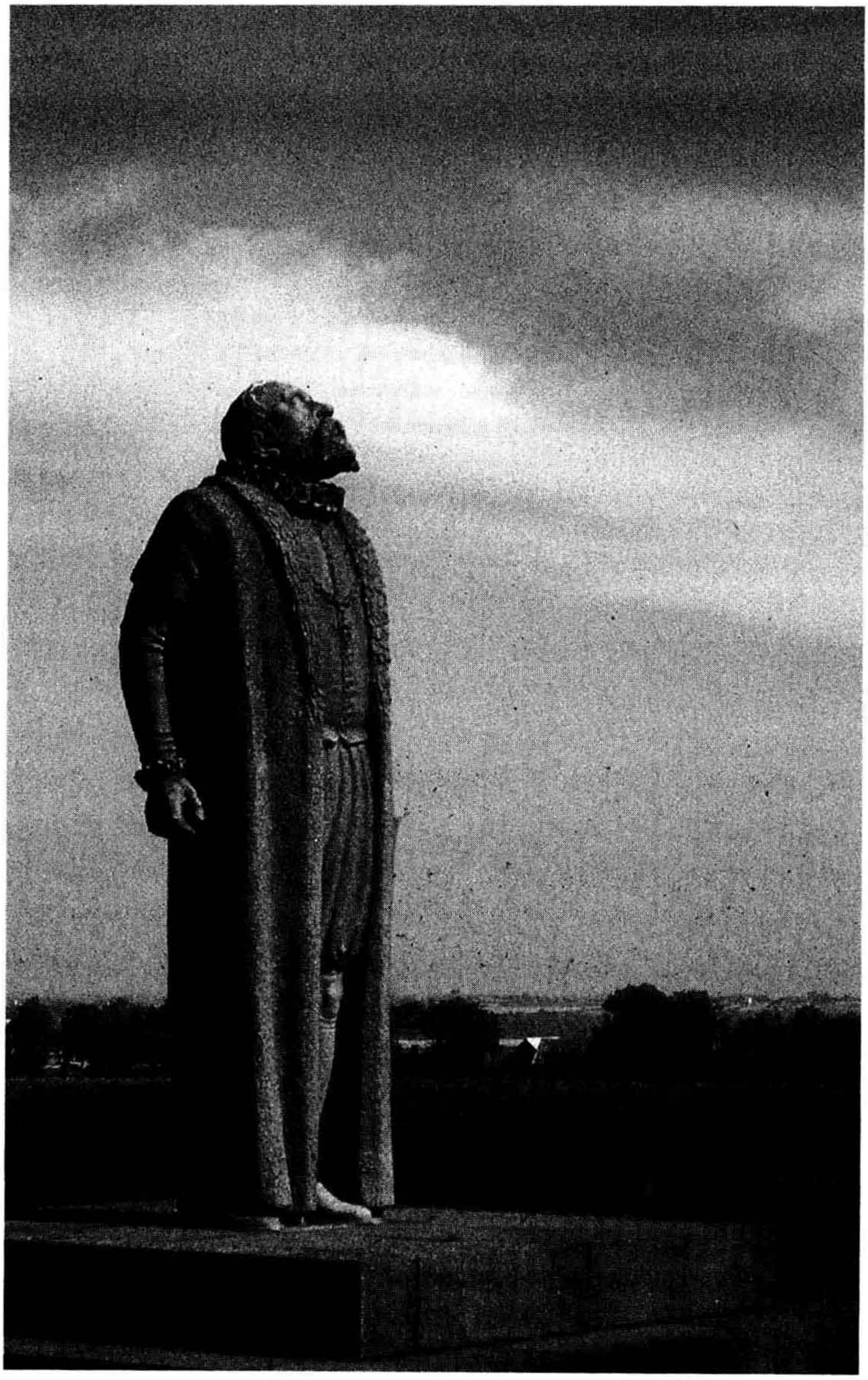

Statue of Tycho Brahe, at the site of his observatory
on the island of Hven

To Louise and Elizabeth

Preface

In the first year that we were married, my wife and I lived in an attic apartment on the coast road running along the Danish side of the strait between Denmark and Sweden. From our living room window we could see a little island in the strait, near the Swedish side. Our landlord told us that the island was named Hven. After returning to America we learned that Hven was the island where in the 1570s the Danish astronomer Tycho Brahe had built his observatory, Uraniborg. Without a telescope, but using giant naked-eye instruments anchored to massive foundations, Brahe made historic measurements of angles between stars and planets. It was partly the great precision of these measurements that allowed Tycho's successor Johannes Kepler to infer that the planets move on ellipses rather than circles, a result that later was of crucial importance to Isaac Newton in developing his theory of gravitation.

Years after, on a visit to Copenhagen one summer, my wife and I and our daughter finally had a chance to visit Hven. We took the ferry across the strait to the island, and drove out in a taxi to the site of Uraniborg. All around was farm land, with nothing left of the observatory but its impressive foundations. Above ground there was only a granite statue of Brahe, carved in 1936 by the Danish sculptor Ivar Johnsson. A photo of the statue appears facing the title page of this book. As can be seen, the statue shows Brahe in a posture appropriate for an astronomer, *facing up*.

That is only part of the reason for my choice of *Facing Up* for the title of this collection of essays. (Brahe is not one of my special heroes; he rejected the idea of Copernicus that the earth goes around the sun, and he was a rotten landlord.) The researches of

Brahe, Kepler, Newton, and their successors have presented us with a cold view of the world. As far as we have been able to discover the laws of nature, they are impersonal, with no hint of a divine plan or any special status for human beings. In one way or another, each of the essays in this collection struggles with the necessity of facing up to these discoveries. They express a viewpoint that is rationalist, reductionist, realist, and devoutly secular. Facing up is, after all, the posture opposite to that of prayer.

Most of my working life has been devoted to research in physics and astronomy. My papers were published in *The Physical Review* and other scientific journals, and I did not expect to do much writing outside the technical literature of physics and astronomy. Then in the 1980s I started to speak and write in defense of spending on research in science, and in particular on the Superconducting Super Collider, a large and controversial facility for research in elementary particle physics. I found that I had a taste for controversy, and I began to accept invitations to write and speak on wider issues—on the follies that I found in the attitudes toward science of many sociologists, philosophers, and cultural critics, and on the ancient tension between science and religion. Even so, only a few of these essays were initiated by me. Something like a chain reaction took place—articles when published led to invitations to write other articles or to give talks that I then wrote up as articles. But I would not have written these essays if I had not enjoyed it so much.

The essays in this collection are presented here in chronological order, and pretty much as they were first published over the past fifteen years, with just a little editing to clarify some points and mitigate repetitions. I have added new introductions to all the articles to explain how the articles came to be written and bring them up to date where necessary.

I am grateful to Michael Fisher of Harvard University Press for suggesting the publication of a collection of my articles, and for his good advice. Thanks are due to Owen Gingerich for providing the photo of the statue of Brahe, and to Nancy Clemente

for her sensitive and intelligent editing. I thank Terry Riley for finding countless books and articles, and Jan Duffy for many helps. For suggestions that I think greatly improved these articles I also owe thanks to many friends and to the editors of the periodicals in which the articles originally appeared, especially Robert Silvers of *The New York Review of Books*.

Austin, Texas
January 2001

FACING UP

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Science as a Liberal Art

I like college commencements. The ceremonies are held in attractive settings, usually at the nicest time of the year, and, best of all, you are thrown together with interesting people whom you would not otherwise have met. The 1985 commencement at Washington College was no exception; Washington is a lovely old liberal arts college on the Eastern Shore of Maryland, and my wife and I had the pleasure, at a small dinner party the night before the commencement ceremony, of listening to Isaac Stern talking about the emotional impact of music.

The down side was that I had to give the commencement address. This is hard enough if you are an Isaac Stern, but I couldn't imagine anything in which undergraduates on the day of their graduation would be less interested than a talk by a theoretical physicist of whom they had never heard. I decided not to worry about it, and just talk about some things that were on my mind at the time. One of them was a subject to which I frequently return in the pages of this book, the effect of progress in science on the human spirit.

I also touched on another topic that was in the news then and is again now: the proposal that the United States should build a ballistic missile defense system. I was one of many scientists who had fought this proposal from the 1960s on, not only because of its technical problems but also because I thought that building an antimissile defense would lead the Soviet Union to increase its missile forces. Since 1985 the Soviet Union has collapsed, and some admirers of Ronald Reagan have claimed that it was the failed effort of the Soviets to keep up with American antimissile technology that led to the economic breakdown that ended Soviet communism. Nevertheless, I still think that I and my colleagues had

been right to oppose deploying an antimissile system. For one thing, whatever alarm Soviet leaders felt when the Strategic Defense Initiative was first proposed, it is hard to believe that the prospect of an American antimissile program remained terribly frightening to the Soviets, when we manifestly were not building such a system, or even deploying the sort of antimissile system allowed by the 1972 arms control treaty. Public statements by the Reagan administration kept reassuring the Soviets that our Strategic Defense Initiative was not intended to threaten their strategic deterrent.

But suppose that Reagan and his advisers knew that the Soviets would feel threatened anyway, and would be led thereby to disastrous overspending on military programs, as some now claim. If this were true, then whatever its success, we were playing an incredibly dangerous game. Instead of overspending, the Soviets might have inexpensively preserved their deterrent by putting their forces on a hair-trigger "launch on warning" status, in which a radar or computer malfunction could start World War III. Not only is this a risk that we should never have taken—it is a risk that the American people were told that they were not taking. Reagan's admirers can't have it both ways; they can't deny that the Strategic Defense Initiative threatened the Soviet nuclear deterrent, and at the same time give it credit for wrecking the Soviet economy. I think that in fact our government was neither so diabolically clever nor so reckless, and that want of good judgment provides an adequate explanation for both the Soviet economic collapse and the Strategic Defense Initiative.

In discussing with President Cater[1] by phone what sort of commencement talk might be appropriate here today, the idea occurred to both of us that, since Washington College is setting out on a major renovation of its science facilities, and since I am a sci-

1. The late Douglas Cater, then president of Washington College. [Added note.]

entist, I might speak on the place of science education in small liberal arts colleges. But as soon as I hung up the phone, my heart sank. Many of you today are saying your goodbyes to college. I am afraid that for you to have to listen to me talk about education is much like passengers on a ship just coming into port after a long voyage having to listen to a sailor lecture on the principles of navigation.

But then I warmed to the task. Most of my life has been spent in studying or working in a different sort of educational institute, the large research university. The research university is a peculiar sort of institution that began in Germany in the nineteenth century, and was first transplanted to the United States not far from here, at Johns Hopkins, about a century ago. Our universities are marvelous places for faculty members and graduate students to do research, and as such they have been tremendously important to our country. I am convinced that without great research universities we in the United States would have to support ourselves by growing soybeans and showing the Grand Canyon to tourists from Germany and Japan.

But research universities are generally not institutions that focus on the role of science education. I don't say that no one in these universities cares about education, but it is research and not education that drives our most important decisions. After over twenty years of faculty meetings, I can say that I've never seen any physicist hired because he or she was a good teacher rather than a good researcher. But thank heaven for the variety in America! At small liberal arts colleges like Washington there is an intensity of concern about education that is rare at research universities.

Let me put aside right away the topic of science education for future scientists. In doing so, I don't for a minute mean to imply that small liberal arts colleges have no role here. In fact, they seem to do about as well in preparing future scientists for graduate school as do the large research universities. I just don't think that the undergraduate training of future scientists raises any deep questions—most of these students seem to get the important part

of their education from self-propelled reading rather than from courses anyway. I want to talk here about the role of science in the education of undergraduates who have no interest in becoming scientists themselves.

The most frequently heard rationale for science in a liberal arts curriculum is that it is needed to help us understand the technological background of modern society. Maybe so, but in my view this is the least important aspect of science education. Take a current issue that has a lot to do with applied science, the administration's Strategic Defense Initiative, or "star wars defense." Now I happen to believe that, although it is worthwhile to do some quiet research in this area, as we've in fact been doing for decades (I've done some myself), the scale and publicity of the current program are terribly foolish. This isn't at all because I have some special knowledge about scientific matters like x-ray lasers; in fact, I think that it probably would be possible, at great expense, to build a satellite-based x-ray laser that would, under favorable circumstances, knock out a few missiles as they rose above the atmosphere. My worry about star wars arises from a general sense of skepticism about the motives of the policymakers who claim that this sort of system can work effectively in an unfavorable environment and, even more, from a sense of the likely reactions of both our adversaries (and our allies) when they see their deterrent threatened. I am much less worried that our leaders are not the sort of people who understand how lasers work than I am about the fact that they do not seem to be the sort of people who read history.

Much more important than the effect of science on our capabilities, it seems to me, is its effect on *ourselves*. Nothing in the last five hundred years has had so great an effect on the human spirit as the discoveries of modern science. Just think of the effect of the discoveries of Copernicus, Galileo, and Hubble in astronomy, and Darwin, Wallace, and Mendel in biology. We find that the earth on which we live is a speck of matter revolving around a commonplace star, one of billions in a galaxy of stars, which itself is only one of trillions of galaxies. Even more chilling, we ourselves are

the end result of a vast sequence of breedings and eatings, the same process that has also produced the clam and the cactus.

I can't tell anyone what sort of spiritual conclusions they should draw from all this. Giordano Bruno wrote that when he learned that the earth was just a small part of the universe, he felt that he could breathe more freely. On the other hand, some of the old magic has gone out of our view of the role of humanity in the universe, its place being taken by what Matthew Arnold called the "note of sadness."

You know, our fundamentalist friends dislike the teaching of evolution in schools because of the effect they feel it has on our view of our own special importance, while liberals insist that scientific and spiritual matters can be kept in separate compartments. On this point, I tend to agree with the fundamentalists, though I come to opposite conclusions about teaching evolution because I am convinced it's true. The human race has had to grow up a good deal in the last five hundred years to confront the fact that we just don't count for much in the grand scheme of things, and the teaching of science as a liberal art helps each of us to grow up as an individual.

Even more important than the specific discoveries of science in astronomy and biology has been the discovery of science itself. Although we ourselves don't play a large role in it, there is a grand order: the tides and planets and stars move according to the same physical laws, and the laws that govern lightning are the same as those that control "the force that through the green fuse drives the flower." It's an old idea that the laws that rule us here on earth are the same as those obeyed by what we see in the sky. In George Meredith's poem *Lucifer by Starlight,* the archfiend rebels, and flies about doing all sorts of nastinesses, until

> He reach'd a middle height, and at the stars,
> Which are the brain of heaven, he look'd, and sank.
> Around the ancient track march'd, rank on rank.
> The army of unalterable law.