Steven Weinberg

Physics and History

I AM ONE OF THE FEW CONTRIBUTORS to this issue of *Dædalus* who is not in any sense a historian. I work and live in the country of physics, but history is the place that I love to visit

[redacted]

physicist, the uses that history has for physics, and the dangers both pose to each other.

I should begin by observing that one of the best uses of the

under the influence of various forces, about energy and momentum, and about electric and magnetic fields. Thus, in order to understand the stories, they need to learn some of the physics we think they should know. It was Gerald Holton's 1952 book *Introduction to Concepts and Theories of Physical Science* that first utilized precisely this method of teaching physics; Holton told the story of the development of modern physics, all the while using it as a vehicle for teaching physics. Unfortunately, despite his efforts and those of many who came after him, the problem of teaching physics to nonphysicists remains unsolved. It is still one of the great problems facing education—how to communicate "hard sciences" to an unwilling public. In many colleges throughout the country the effort has been given up completely. Visiting small liberal-arts colleges, one often finds that the only course offered in physics at all is the usual course for pre-medical students. Many undergraduates will thus never get the chance to encounter a book like Holton's.

History plays a special role for elementary particle physicists like myself. In a sense, our perception of history resembles that of Western religions, Christianity and Judaism, as compared to the historical view of other branches of science, which are more like that of Eastern religious traditions. Christianity and Judaism teach that history is moving toward a climax—the day of

Einstein in 1915, general relativity appears almost logically inevitable. There was a fundamental principle, Einstein's principle of the equivalence of gravitation and inertia, which says that there is no difference between gravity and the effects of inertia (like centrifugal force). The principle of equivalence can be reformulated as the principle that gravity is just an effect of the curvature of space and time—a beautiful principle from which Einstein's theory of gravitation follows almost uniquely. But there is an "almost" here. To arrive at the equations of general relativity, Einstein in 1915 had to make an additional assumption; he assumed that the equations of general relativity would

her transactions are carried through, but also to reach as far as possible the utopian and seemingly arrogant aim of knowing why nature is thus and not otherwise. . . ." He certainly was not achieving that goal when he arbitrarily assumed that the equations for general relativity were second-order differential equations. He could have made them fourth-order differential equa-

Our perspective on this today, which has been developing gradually over the last fifteen or twenty years, is different from that of Einstein. Many of us now regard general relativity as

tronomy, but distances much smaller than the size of an atomic nucleus.

From the point of view of modern effective field theory, there are

no infinities in the quantum theory of gravity. The infinities are

cancelled in exactly the same way that they are in all our other theories, by just being absorbed into a redefinition of parameters in the field equations; but this works only if we include terms involv-

ing rates of fourth order and all higher orders. (John Donaghue of the University of Massachusetts at Amherst has done more than

has to look at things as they really were in their own time. This also applies, of course, to political history. Consider the term "Whig interpretation of history," which was invented by Herbert Butterfield in a lecture in 1931. As Butterfield explained it, "The Whig historian seems to believe that there is an unfolding logic in history." He went on to attack the person he regarded as the archetypal Whig historian, Lord Acton, who wished to use history as a way to pass moral judgments on the past. Acton wanted history to serve as the "arbiter of controversy, the up-

holder of that moral standard which the powers of earth and religion itself tend constantly to depress. . . . It is the office of historical science to maintain morality as the sole impartial criterion of men and things." Butterfield went on to say:

> "If history can do anything it is to remind of us of those compli-

merely staggers from one fashion, conversion, revolution, or incommensurable exemplar to the next in a kind of perpetual, senseless Brownian motion, without discernible direction or goal."[3] I made a similar observation in an address to the American

Academy of Arts and Sciences about a year and a half ago, noting in passing that there are people who see scientific theories as nothing but social constructions. The talk was circulated by the Academy, as is their practice, and a copy of it fell into the hands of someone who over twenty years ago had been closely associated with a development known as the Sociology of Scientific Knowledge (SSK). He wrote me a long and unhappy letter; among other things, he complained about my remark that the Strong Program initiated at the University of Edinburgh embod

Kepler's work in terms of what we now know about planetary motion.

Even so, the attitude of methodological antirealism bothered me, though for a while I could not point to what I found wrong with it. In preparing this essay I have tried to think this through,

it is unlike any other sort of consensus in that it is culture-free and permanent.

This is just what many sociologists of science deny. David Bloor stated in a talk at Berkeley a year ago that "the important thing is that reality underdetermines the scientists' understanding." I gather he means that although he recognizes that reality has some effect on what scientists do—so that scientific theories are also not what they are simply because that is the way nature

physicists has changed, in particular, as the number of women and Asians in physics has increased, the nature of our under-

The history of science is further distinguished from political or artistic history (in such a way as to reinforce my remarks about

reached, will be a permanent part of our knowledge of the world. Then our work as elementary particle physicists will be done, and will become nothing but history.

ENDNOTES

[1]Steven Weinberg, *The Discovery of Subatomic Particles* (San Francisco: Scien-