TWO OPEN LETTERS

Weisskopf ⟷ Weinberg

Dear Al:

Your article in *Physics Today* on "Scientific Choice"* touches some of the most important questions which we will face in the immediate future. You presented the situation in the clearest possible way and you pointed out the terrible difficulties which are inherent in any form of scientific planning. I agree with most of what you are saying and I like the way in which you said it. There is one important point, however, in which I cannot follow you. I accept your three "external criteria" for scientific choice: technological merit, scientific merit, and social merit. I would even go along with your sharper definition of scientific merit, when you propose that ". . . other things being equal, that field has the most scientific merit, which contributes most heavily to and illuminates most brightly its neighboring scientific disciplines". But I cannot follow your arguments when you apply your criteria to the field of high-energy physics.

You argue that, by the criteria which you have set forth, high-energy physics rates poorly. In particular, you argue that the world of subnuclear phenomena, which are discovered by this branch of physics, seems to be remote from the rest of the physical sciences. Here I cannot agree with you at all.

High-energy physics has shown that there is a structure in the proton and the neutron, that the nucleon is not as elementary as it seemed. This structure, and the internal dynamics of the nucleons, exhibit unexpected and completely novel features that show few parallels in the structure of previously known entities such as nuclei and atoms.

The nucleon is the basis of all matter and therefore of all science. Aren't you interpreting your own criteria in a rather superficial way if you consider subjects such as the structure of the nucleon as remote? Questions concerning the stability of nucleons, the reasons for the mass difference of neutron and proton on which the existence of matter is based, the question of the possibility of more basic units of which the nucleon is a compound system, the problem of why there is one and only one electric charge unit, are these and similar questions to be considered as unimportant and remote from the rest of science? It seems that they aim at the center of all scientific interest.

It is true that many scientific disciplines can be pursued without knowing the answers to these problems. For most of terrestrial physics and chemistry, the nucleus may be considered as a charged massive point. But should we therefore have discouraged science from penetrating the nuclear structure? It is also true that the theory of relativity is not very relevant for most scientific investigations outside high-energy physics. Still, you will agree that the deeper insight which relativity gave us into the structure of space and time would have justified even more efforts than we are now spending on high-energy physics. It is this kind of insight which high-energy physics is aiming at and I have no doubt that it will also lead to it, after more intensive study.

I am sure that you agree in some way with this point of view, which is deeply ingrained in the thinking of every physicist. You are a physicist like all of us, and a better one in many respects. Indeed, you pay respect in your article to this point of view when you admit that the discovery of the violation of parity conservation "bears strongly on the rest of science". In fact, this statement would not hold from the point of view which you adopt when you call high-energy physics remote from the rest of physics. The violation of parity has not much practical importance in any other discipline, except that it helps here and there in the determination of nuclear-level properties. It implies, however, a thorough change of our views on the role of symmetry in nature, and this is what determines its relevance for the rest of science. It is most likely that the study of the subnuclear world will lead to changes in our view of matter and space, compared to which parity violation will appear trivial.

But even on the somewhat superficial basis of direct connection with other sciences, the balance sheet of high-energy physics is not so negative as you have indicated. You mention in your article that "the strongest and most exciting motivation for measuring the neutron cross-section of the elements lies in the elucidation of the cosmic origin of the elements". I quote this statement because it puts emphasis on the understanding of a problem which has "philosophic" interest in itself. Now, let me draw your attention to the recent discoveries of violent events in the centers of galaxies. Here it seems that energy is produced in amounts and in rates that surpass by far everything that can be expected from ordinary nuclear or chemical processes. The order of magnitude alone of these energies makes it most likely that hyperons, mesons, and the whole subnuclear world play a role in these cataclysms. Here we have a clear connection with other sciences, such as radio astronomy and cosmology. The results of high-energy physics could be very relevant for questions regarding the creation of matter, the expansion of the universe, etc.; does this not represent an important contribution to the scientific merit of high-energy physics?

I agree with your negative estimation of the technological merit of high-energy physics, although we must be prudent not to dismiss completely the possibility of a technological application of subnuclear phenomena by future generations. After all, we are today creating in our reactors here on earth conditions prevalent in the centers of stars, and that must have appeared equally preposterous to scientists several decades ago.

In view of my present position at CERN, you will not be surprised if

*A. M. Weinberg, *Physics Today*, March 1964, p. 42

V. F. Weisskopf

A. M. Weinberg

Victor F. Weisskopf, director-general of CERN, in Geneva, Switzerland, has held that post since the summer of 1961 while on leave of absence as professor of physics at the Massachusetts Institute of Technology. Alvin M. Weinberg is director of the Oak Ridge National Laboratory in Oak Ridge, Tennessee.

I wholeheartedly support your assertion of the great social merit of high-energy physics as a field of international collaboration. Here the possibility and the efficiency of common efforts among different nations was impressively demonstrated. Let me point out, however, that this value stems mainly from the fact that this field is basic and relevant for all sciences and therefore touches questions which all thinking human beings are deeply interested in. This, and of course the high cost of that research, are the reasons why it is a most proper object to be tackled by a collaboration of all nations. If we are not convinced of the intrinsic value of this research, if we consider its scientific merits marginal, if we consider national efforts as wasted when devoted to it, it will never serve as it should, as a worthy object for a common effort of all humanity.

Sincerely yours,
Victor F. Weisskopf

Dear Viki:

I am grateful to you for your generous and thoughtful letter. That we agree on as much as we do, I find satisfying even though we disagree on some aspects of the assessment of high-energy physics.

To some extent, our disagreement hangs around the word "remote". My belief is simple: that high-energy physics is remote in the same sense that cosmology is remote—not that it is lacking in the highest order of intellectual excitement and stimulation. What we are trying to decide, basically, is *how fast* high-energy physics should be pushed relative to competing branches of science. I submit that most discoveries in high-energy physics, intrinsically exciting and interesting as they may be, will probably not make very much difference as far as *what is done* to elucidate the rest of the physical universe. So to speak, there are few parts of science (aside possibly from cosmology itself) that are waiting breathlessly for insights from high-energy physics and without which they cannot progress.

You draw the analogy with relativity. Here I have two points: first, that relativity was a cheap discovery (and I have no argument at all about cheap discoveries); and second, that even relativity bears widely on our understanding of things around us, like atomic fine structure.

But I think the force of my argument would have been clearer had you compared high-energy physics with quantum mechanics. Before quantum mechanics the world around us, the feelable and touchable world of solids and chemicals, was mysterious; quantum mechanics illuminated the vast stretches of science dealing with these things in a way that I cannot visualize high-energy physics doing.

Quantum mechanics not only deepened our conceptual insights into the world about us; it enabled scientists concerned with many diverse fields to progress at a rate impossible without quantum mechanics. Lack of a theory of the atom, in 1926, was holding up progress in all of physical science, particularly the parts dealing with the tangible and accessible world around us. I would therefore, admittedly in retrospect, see great urgency in getting on with the exploitation of Schroedinger's and Heisenberg's insights. Though I am impressed with the possibility, even probability, that high-energy physics may yield the key to understanding gravity and cosmology, I just cannot visualize high energy as having the all-pervading influence on physical science that quantum mechanics has had. I believe in this sense I am justified in characterizing high-energy physics as "rather remote" from the rest of science and in disagreeing with your implied assumption as to the urgency with which it is to be pursued.

As a physicist, I am enchanted and astonished by the wonderful new symmetry principles, and their violations, and I am convinced that a clearer understanding of where the elementary charge comes from, or the reason the nuclear force saturates, would be intellectual gems that we who are even a little trained in physics could gain enormous satisfaction from. But there are other gems that I personally also would find at least as satisfying: the elucidation of just what protein in the brain is the memory element; or what mechanism governs cellular differentiation; or why the universe expands.

If we could afford to support everything at a rate sufficient to satisfy everyone, there would be no problem. As a scientist, I hope that our society will devote an ever-increasing share of its resources to science. As a citizen, I hope that basic science is recognized and appreciated for what it is—a manifestation of man's highest intellectual aspiration—and that it is supported at a level determined in competition with other worthy and intellectually satisfying activities of the society. All of us, scientists and citizens, hope that our society will become much more enlightened and affluent than it now is, and that what this better society decides to spend on science matches what scientists can reasonably use for science.

Sincerely yours,
Alvin M. Weinberg