Theory and Hypothesis

If you had chosen to reprint (7 May, p. 754) the 1897 *Journal of Geology* revision of T. C. Chamberlin's paper, "The method of multiple working hypotheses," you would have included the following desirable footnote:

I use the term theory here instead of hypothesis because the latter is associated with a better controlled and more circumspect habit of mind. This restrained habit leads to the use of the less assertive term hypothesis, while the mind in the habit here sketched more often believes itself to have reached the higher ground of a theory and more often employs the term theory. Historically also I believe the word theory was the term commonly used at the time this method ["the habit of precipitate explanation"] was predominant.

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Subnuclear Particles: A Question of Social Priorities

I wish to explore two interrelated, disturbing attitudes which were exhibited by most of the authors quoted in the collective appeal, "Purposes of high energy physics" (26 Mar., p. 1548). These authors, all leading theoretical physicists, reveal a narrow view of the relation of the intellectual and practical contributions of modern physics to the foundations of other parts of science, to our society, and to our culture in general, and it could be intellectually (and ultimately technologically and socially) debilitating were such attitudes inculcated in future generations of physicists or nonphysicists. And in their "remarkably unanimous plea for support for high energy physics and for the construction of much more powerful particle accelerators" they completely fail to give attention to the kinds of evaluation that policy makers should have available when they must weigh the physicists' values against the values of other segments of our society. They therefore innocently encourage the kinds of political decision-making that have led to disproportionate support of such "scientific" undertakings as the Apollo project.

"The world view of the physicist sets the style of the technology and the culture of the society and gives direction to future progress," says Schwinger. "But I believe that particle physics deserves the greatest support among all branches of our science because it gives the most fundamental insights. . . . [T]his is indeed the most basic field of knowledge in the physical world," says Bethe. "If we cut back on [high energy physics] for reasons of budgetary limitations or political squabbling, I think we will have seriously damaged the best single element we have contributed to human culture," says Feinberg. "A great society is ultimately known for the monuments it leaves for later generations. . . . . [S]uch a machine will without question be a source of inspiration for new science and a monument to our days," says Pais. It seems fantastic that these physicists should ask the scientific community and the American people to underwrite a billion-dollar project with such flimsy metaphysical arguments as these.

Weisskopf properly argues the importance of "intensive" research (research associated with those fundamentals of ordering and classification that can lead to the discovery of fundamental laws of nature) as the necessary base for "extensive" research ("the explanation of phenomena in terms of known fundamental laws"). In his judgment, "High-energy physics and a good part of nuclear physics are intensive"; biology is "perhaps" extensive. "It is granted that further progress, say in biology or in solid state physics, is possible without any further research into the subnuclear field. But let there be no doubt that the style of the scientific community would change its character if *the* frontier of intensive research were hampered . . ." (italics mine). Such exuberance may be understood in terms of the impact of our recent feast of "elementary" particles and quasars. This has brought an end to that relative famine of observational stimuli to further "intensive" research in physics which followed the successes of quantum mechanics and electrodynamics (1926–1950). That the famine was not science-wide has, however, been apparent to at least one renowned theoretical physicist (*1*). It needs also to be said that, although in principle quantum mechanics and electrodynamics permit the solution of most microscopic and macroscopic problems of chemistry and biology, there are formidable computational barriers to a solution in even so simple a system as the three-body problem (*2*). This points up the fact that most fundamental progress in biology has been and must continue to be of the same "intensive" kind as at present enchants the high-energy specialists in this latest renaissance in the physics of the elementary particles. Darwinian evolutionary theory and evolutionary taxonomy, Mendelian inheritance, the rules of chromosomal inheritance, the Watson-Crick model of DNA, the genetic code, and nonchromosomal genetics (*3*) are all of the same genre as SU-3 symmetry, which Bethe so feelingly describes. And I choose these particular examples of biological concepts—which have set, are setting, and will set "the style of the scientific community" and of "the culture of the society" at least as strikingly as any contributions of high-energy physics—because they developed virtually independently of any contributions from the fundamental "intensive" researches into the physics of matter or cosmology. In fact, it could be argued that the shoe is sometimes on the other foot. For example, it appears that Darwin's "most wonderful mechanical theory" explaining natural processes (those of evolution) in statistical terms provided an important stimulus for Boltzmann's development of the statistical formulation of the second law of thermodynamics, which led to the birth of statistical mechanics (*4*).

It seems to me highly undesirable, at this juncture in history, to foster attitudes in and of science which would give any significant primacy to the study of matter over the study of life (or conversely, perhaps, of life over matter). But in a dollar-conscious culture, the investment in a 10^{12}-electron-volt alternating-gradient synchrotron, like the investment in the Apollo project, will necessarily encourage attitudes among our youth which must have exactly this effect.

Congressional largess is not unlimited, and without any doubt expenditures on high-energy physics and space will necessarily limit expenditures elsewhere in science—as well as outside science. The decision to spend or not to spend requires an evaluation of the "purposes of high-energy physics" relative to other possible expenditures. "By ignoring this question, we have been trying to escape to science as an endless frontier, and to turn our backs on the more difficult problems that it has produced" (*5*). Some standard or standards of value (and taste) must and will be used, and just which those will be should be of considerable con-