Letters

Fashion and Competition in Science

Being a so-called applied mathematician, I do not intend to answer for so-called pure mathematics (these names make very little sense, anyhow) and high-energy physics. But the opinion of them expressed in G. C. McVittie's letter on "Fashion and competition in science" (16 Oct., p. 341) is not quite justified. [McVittie wrote: "Like some branches of pure mathematics, high-energy physics is becoming an isolated esoteric activity. . . ."]

The development of various fields of science cannot be regulated by dogmas. Group theory, function spaces, topology, and so forth, have already furnished many valuable results in physics, engineering, and elsewhere. If a field of science develops in such a way that it gives the impression of an "isolated esoteric activity with little bearing on any other aspect of physical science," it does not mean that in the future it may not have a great deal of bearing.

There is a difference between research in mathematics and high-energy physics on the earth and in the universe. We seek answers to two questions: "what" (phenomenon itself) and "why" (the fundamentals). It is possible to find both answers on the earth, but it may be impossible to find both answers in the universe. One cannot build a laboratory across the Milky Way. McVittie's statement that the dominance of gravitation "might lead us to ask whether nuclear or atomic physics should not somehow be derived from gravitation" is perfectly acceptable. We may go even further and claim that every physical phenomenon on the earth is influenced by everything that is in the universe. But again, a physics developed on such fundamentals would not lead us to anything, because of the impossibility of tests on a cosmological scale. Both physics and mathematics struggle very effectively to provide a proof for every statement they propose. These proofs are, of course, limited, owing to circumstances mentioned by McVittie. But on a cosmological scale we may be able to provide no proofs at all. The two approaches—terrestrial and cosmological—should complement each other.

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I am in complete agreement with McVittie's claims for the importance of cosmology. I am in strong disagreement with his evaluation of elementary-particle physics.

McVittie seems to argue that the observations of high-energy physics are the products only of the apparatus and its environment. "Clearly none of the phenomena observed in a betatron on earth," he writes, "would be observable at all on the surface of the sun, for the apparatus itself would there be turned into gas." It can equally well be argued that clearly none of the astronomer's observations of the universe would be observable from the surface of the sun, because there both he and his telescope would be vaporized. Protons, neutrons, electrons, positrons, μ-, π- and K-mesons Λ-, Σ- and Ξ-hyperons were all discovered outside of accelerators. The cosmologist's cosmic radiation has been the physicist's principal source of discovery. To study these fundamental objects in greater detail, larger fluxes were required. Particle accelerators provide these fluxes.

The astronomer does not confuse atmospheric variations with fluctuations of the object which he is observing. The elementary-particle physicist strives equally hard, and no less successfully, to achieve an appropriate level of generality in his work. The astronomer studies light signals that were emitted many thousands of years ago from sources that are more than 10^{15} miles away from earth and assumes that they were generated in physical processes similar to those with which we are familiar today. In almost every field of research, progress depends on the ability of scientists to make a valid set of simplifying assumptions. . . .

McVittie says physicists often claim that "gravitation is to be somehow derived from nuclear or atomic physics." I have never heard such a claim expressed, and I think it is as preposterous to claim that the nuclear force or electrical force dominates over gravitation as it is to claim that the gravitational force dominates over all others. Physicists now recognize the existence of at least four kinds of interactions: gravitational, electromagnetic, strong (nuclear), and weak (beta decay). Just as we know that the nuclear force, with its range of 10^{-12} centimeters, could not amount to much on a cosmological scale, we also know that the gravitational force cannot amount to much within the very small domain of the nucleus. Were there no nuclear force, there would certainly be no atoms more complicated than hydrogen, no universe as we know it, and no scientists to worry about it.

The view that I have most frequently heard enunciated by physicists in general, and by elementary-particle physicists in particular, is that there are two somewhat similar frontiers in fundamental physics research today. One of these is the frontier at which we are exploring things on a smaller and smaller scale; the other is the frontier at which we are exploring phenomena on a larger and larger scale. The first is elementary-particle physics; the second is cosmology. In both these fields, entirely new principles may be established by experimentation and observation in a new range of the distance variable. Within the last 25 years, as a matter of fact, there has been rather strong interplay between these two fields. An understanding of nuclear interactions has provided an explanation of the source of stellar energy. It is ironic, in view of McVittie's criticism, that even within the past few months some elementary-particle theorists have envisioned a completely new kind of interaction in which the very particles that are familiar to us may be formed from the binding of much more massive fundamental entities. Inherent in this new process is an enormous energy release which might well be the explanation of the quasars. This possibility can be fully explored only through further experimentation in elementary-particle physics.

McVittie deplores "fashion and competition" in science. One of the reasons a branch of science becomes fashionable and therefore competitive is that it ad-

dresses itself to a challenging and fascinating problem. The problem is frequently a timely one in that techniques have become available which offer a new leverage with which to pry answers from nature. These factors apply to the "fashionableness" of elementary-particle physics today. This field has very little trouble in attracting bright, imaginative, and creative people. The limitation at present lies not in the technology and not in the availability of interested scientists, but only in the availability of support for an expanding program. The planning of a reasonable level at which such support should be provided requires much careful thought and review. In indulging in this planning scientists must be careful not to cut off capriciously and completely any other promising field of study.

McVittie appears to resent the participation of scientists in the mass communication media of radio, TV, and the press. In view of the fact that large amounts of public funds are being spent for research programs in cosmology as well as in elementary-particle physics, it is not unreasonable or even undesirable that scientists should be eager to have their results quoted in the New York *Times* or to lecture on the BBC. If the public is not involved at some level in these programs, why should public funds be used for them? Scientists should be much more aware than they have been in the past of their responsibilities to the public. Scientific research in all fields is becoming more and more costly, and the motivation for carrying on this research must be very carefully examined and interpreted to the public if a stable program is to be achieved.

In one paragraph McVittie expounds the dangers to branches of science "where quick results are expected." In another he asks whether the total flux of energy from an extended source of radiation can be determined "satisfactorily and relatively quickly from the earth's surface" or whether it may "require an orbiting astronomical observatory." Why should anyone be motivated to get this information relatively quickly? I can answer for McVittie that all of us would like to see the questions that perplex us answered within our lifetimes. I can also answer that creative people will be attracted to a field of research only so long as there is some hope for their creativity to bear fruit within a time that will provide for them a satisfying professional career. As the scale of apparatus that is required in various fields of research becomes ever larger, the time scale for accomplishing anything grows commensurately. It would be my guess that for the health of our science and probably for the health of our entire culture it is important that cosmologists should get their orbiting astronomical observatory, if it is feasible to launch and profitable to use, and that elementary-particle physicists should get their accelerators if these are feasible to construct and useful to have.

No one could take exception to McVittie's plea for careful planning. The costs for all these programs are large. Competition is not the end toward which we strive, but the human being is a competitive animal and as long as there are interesting things to do, more than one man of talent will be engaged in the doing. All would like the satisfaction of success. In a large sense, each scientist gets satisfaction from the success of another, but we all get special satisfaction, as well as recognition, from our own successes. We cannot abolish competition, but we should certainly not support hasty and slipshod work. Elementary-particle physicists are investing enormous time and effort in trying to establish a responsibly scaled program in their field. They need help from other scientists.

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Aid for the University of Skopje

In the months since the first appeal appeared in *Science* (Letters, 19 June 1964, p. 1409) for aid in replacing scientific equipment destroyed by an earthquake in Skopje, Yugoslavia, negotiations between UNESCO and the government of Yugoslavia have cleared the way for immediate shipment of gifts in kind to the University of Skopje. Scientists around the world are reminded that there is still great need for equipment for teaching and research. Lists of items required by the various departments will be provided at once, along with instructions for shipping. Please write to UNESCO Gift Coupon Office, Place de Fontenoy, Paris 7°, France.

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