Letters

Basic Science in Underdeveloped Countries

A foreign aid program to support basic science in India cannot be compared (Editorial, 25 March, p. 1485) with the obstacles that face a similar effort in smaller underdeveloped countries. India, the world's second largest country, has a population of nearly one-half billion, whereas the majority of underdeveloped countries have near to or less than 10 million. The 10 million figure is in fact equalled by the sum of the populations of Calcutta and Bombay. If only 5 percent of India's population were professionals, that would provide a cadre of 25 million, a group roughly equal to the population of some underdeveloped countries such as Turkey or South Korea.

We must not forget the educational traditions brought to India by the British two centuries ago. Today there are more than two thousand colleges in India and a tradition of scholarly activity. This educational legacy has a strong bias towards classical erudition. In addition, Hindu philosophy is extremely abstract and other-worldly. It is not simply the caprice of recent foreign meddlers which today results in India's having a strong atomic research program, but no " . . . capacity to design and build new steel plants." India was ripe for modern physics research in terms of numbers of scholars and inclination.

This is not to say that underdeveloped countries should abjure scientific research. It is certainly valuable in fields relating to indigenous agricultural, industrial, and health problems. Active research programs provide a firm basis for the scholarly character of fledgling educational institutions. What is unreasonable is to expect science to be the basis of a modern technological society in developing countries with limited financial and manpower resources.

Here in Afghanistan, a healthy vigorous people are making rapid strides toward development, but they can only hope to have a few thousand high school graduates per year in the near future, from a population of over 12 million. Here, as in other underdeveloped countries, the entire output of the nation's educational system is needed to fill positions in the government organization, the expanding school system, the replacement of expensive foreign technicians, programs for health and rural development, and the expansion of an industrial base.

Even with generous outside help, most underdeveloped countries cannot afford the manpower for a science program which could put them in competition with the developed countries. However, we have many precedents for cooperative efforts in science. American universities have pooled their talent in the national laboratories; the European nations have banded together in the Euratom program. On a larger scale, we have witnessed the success of the International Geophysical Year. The U.S. might profitably consider supporting regional scientific centers. A good model is the SEATO graduate school of engineering in Bangkok which conducts excellent research in civil engineering for the benefit of Southeast Asia. The U.S. could sponsor something like an Alliance for Progress University or research center in Puerto Rico, where Latin American scientists could join forces. The American University of Beirut already provides the basis for a much larger American contribution to science development in the Middle East.

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LSD: Requiescat in Pace!

While I agree with Lowinger's reference (Letters, 8 July) to the existence of a "state of hysteria" in regard to the so-called psychedelic drugs, his identification of Sandoz with the "Cowardly Lion of Oz" hardly fits the facts. For more than 20 years Sandoz has supplied LSD-25 to bona fide investigators in psychiatry and the life sciences without charge or profit. It has supplemented this with extensive and up-to-date bibliographies (there are in excess of 3000 references), laboratory data, and other services. In other words, Sandoz has for years assumed alone the role of "Dorothy" with not inconsiderable sacrifice in time and money with a uniformly acknowledged sense of responsibility because it recognized that this drug represented a worthwhile instrument of research rather than a pharmaco-therapeutic agent of agreed merit. However, with the entry into the ring of fringe operators, black marketeers, and misguided idealists assisted by an irresponsible sector of the press, the problems of preserving its reputation, policing of supplies, servicing law enforcement agencies, and keeping track of legitimate projects became too heavy a burden to carry. The drug was therefore withdrawn and a stand-in for the role of "Dorothy" was sought. The transfer of supplies and responsibility to the NIMH seemed the best compromise short of completely removing access to the compound. Lowinger can be assured that cancellation and recall of supplies was decided upon with regret in recognition of the legitimate place which LSD-25 has earned in psychobiological research.

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Mathematical Illusions

The scatter-shot attack made on a number of mathematical and computer disciplines by I. D. J. Bross (Letters, 3 June) seems to be somewhat unjustified. Because one area of study has not yielded tangible achievement, should all related areas (some of which have been demonstrably productive) also be condemned? It would seem more rational, instead of casting aspersions on "a whole series of mathematically oriented new 'sciences'," to look at them individually, with at least as careful a treatment as E. N. Gilbert has given to information theory (15 April, p. 320).

Even more disturbing is that Bross has grouped in "the rest of the new math" fields which are as different as night and day. Game theory and information theory are just what the name implies: highly theoretical and abstract constructs. Computer simulation, on the other hand, is a pragmatic technique, used in experimental fashion as a last resort when the system under study cannot be satisfactorily analyzed by more rigorous mathematical approaches. Evidence of the difference between mathematical theory and computer simulation is found in titles of publications dealing with simulation; for example, *The Art of Simulation* (K. D. Tocher, English Universities Press, Ltd., London, 1963) and "Some tactical problems in digital simulation" (R. W. Conway, *Management Science* **10**, October 1963). Simulation is about as much kin to information theory as is rat-maze experimentation to neural network theory.

It is certainly true that "there is no magic in mathematical languages." It is not clear just how the failure of information theory as a productive field verifies this conclusion, nor how it bears on other areas such as computer simulation.

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Bross is distressed over the failure of information theory to show practical results in an 18-year period. Perhaps, as he suggests, many modern mathematicians cannot resist the temptation to flights of fancy, particularly since there may be no practicalities to restrain them. On the other hand, mathematics is a most extraordinary aspect of the physical world. How can it be otherwise, when such useful manipulations as addition, subtraction, multiplication, and division have no counterparts in the physical world? Addition and multiplication might be represented in the physical world by moving objects, atoms, or particles, closer together; subtraction and division might be represented by moving these same objects further apart. Yet even without a basis in reality, who can deny that these four basic manipulations of mathematics have extraordinary practical value?

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Since 1945 countless graduate students in mathematics have wasted time on simulation, game theory, war games, and information theory. The appeal was subtlety of the notation. The possibility that some computer application would pull out a rabbit caused many to string along beyond the point where it should have been said: enough. Bross was right in inferring that not a single scientific discovery or achievement can be traced to these pseudosciences. If someone can point to a scientific discovery attributable to game theory or information theory, perhaps this journal is the place where it should be cited.

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. . . The allegation of Bross that information theory has been "almost entirely sterile and useless" demands that the product of science shall be immediately used in major technological advances. This is certainly based on a misconception of the roles of science and technology as well as the history of their interaction. By these rules, Darwin's evolution and Einstein's general relativity must be abandoned. Electromagnetic theory, nuclear physics, and quantum theory are certainly suspect since many years of development of their concepts were required before they became the basis of a practical technology. It is the function of science to supply the knowledge which illuminates and defines an area of human interest. Technology combines knowledge with the available means of implementation to accomplish useful ends when needed.

Even by the rules of technological usefulness, information theory has had a sturdy youth. It is now possible to determine the capacity of information systems, to predict the rate of error that will be created under specific transmission conditions, to compare theoretically the effectiveness for given applications of systems using different methods or coding. Methods of detecting and correcting many kinds of errors are well known although not yet widely practiced. The methods of trading off bandwidth and power are known and extensively practiced. Perhaps most importantly, the knowledge of the ultimate limits of channel capacity has prevented much work on impossible communication concepts. In all these ways, information theory is an invaluable tool for the communication system engineer.

Bross's statement that Gilbert was "unable to cite a single tangible, scientific achievement that has resulted from information theory" is both irrelevant and incorrect. The statement is irrelevant because Gilbert's conclusion "portrayed that aspect of modern information theory which relates to explicit coding systems intended to signal at high rates." It did not deal with the general applications of the theory. Although that very difficult problem has not been solved in a broad and general sense, nevertheless Bross's statement is incorrect because Gilbert's paper cites many significant steps toward the solution of the problem.

These steps include many excellent special solutions which have not found wide technological use because of economic limitations. These are tangible achievements. The economic limitation in technology is being reduced rapidly by the decreasing cost of devices for coding and decoding. Would Bross suggest that we abandon thermodynamics because most heat engines do not reach ideal efficiency?

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Excluding information theory, I have always had the impression that simulation and fields mentioned by Bross under the name of "mathematically oriented new sciences," are not "sciences" at all, in the full meaning of this word. These may be new tools in technological sciences, perhaps mathematical physics and the sociological sciences, constructed primarily for engineers, applied mathematicians, and theoretical sociologists (if the name is proper) to enable them to cope with more complicated problems.

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Experimentation on Humans

Your debate on the ethics of human experimentation (Letters, 13 May) reminded me of my undergraduate experience in 1927 when I served as a human guinea pig for a Nobel laureate, Professor A. V. Hill. Hill was always eager to explain his theories concerning oxygen consumption by the human being while working under stress. At the time he was testing the candidates for crew, he even apologized for not using his oxygen measuring device on himself under the stress of rowing. He found it impracticable, he said, since he had great difficulty handling both the stick and the sliding seat of a rowing machine.

Because I broke his record for the consumption of oxygen per unit of time while under stress of severe exercise, Hill paid me a great deal of attention. Later, when a track man surpassed my record, Hill was very eager for me to run with his device in an attempt to regain the "world's record for oxygen consumption," as he called it. Since running is a faster motion than rowing, he hoped that I would show greater oxygen intake. My coach was reluctant to give his permission as the rowing season was upon us and he feared running would make me lame. Although "jolly well disappointed," Hill would not consider testing me while the exercise stress was running. Throughout, Hill considered the convenience and welfare of his guinea pigs; the convenience of the experimenter came second.

Owing to my experience with Hill, I am strongly in favor of human experimentation, especially when the subject is also the experimenter. As a research scientist in biology, I have not hesitated to experiment on myself. Two years ago, when I developed symptoms of coronary disease I tested an essential trace element combined with a vitamin that had "no established minimum daily dosage." The results exceeded my fondest hopes, and numerous symptoms, including one that had been conspicuous for 40 years, disappeared.

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A Protest of Innocence

In his article, "Speaking of space" (13 May, p. 875), David McNeill gives credit (or blame) where it is not due when he imputes certain contributions to "space speak" to newsmen. ". . . some of the most popular specimens . . . [were] invented by newsmen . . . among these are *A-OK*, *blast off*, and *spin off*," McNeill says.

To my personal knowledge, "A-OK" was invented not by newsmen but by an imaginative public relations man named John A. Powers, who as "Voice of Mercury" of the flight of Alan B. Shepard in May 1961 attributed the phrase to the astronaut. Later it developed that Shepard had not said "A-OK," but by that time the phrase was a part of the English language, having been *adopted*, not *invented*, by newsmen.