Letters

On the Two Cultures

I was especially interested in the comments of C. P. Snow, printed as an editorial in *Science* [**130**, 419 (21 Aug. 1959)]. Those of us in the science teaching field are reminded of the existence of the two cultures both by our association with colleagues who represent each of them and by student comments and attitudes.

Some years ago William James wrote an essay entitled "On a certain blindness in human beings." While having been very much aware of this blindness for a long time, I am still disturbed after more than 35 years of college teaching to see how little impact scientific ideas have had on some segments of the college community. I was forcibly reminded of this on two occasions last year when students who were being subjected to the requirement of some course work in science while majoring in a humanities area protested inclusion of factual material in examinations. One of these students commented that as an English-journalism major he was taught to "think in ideas rather than in facts." The same student objected to scientific writing being couched in technical terms.

There is also the attitude on the part of humanities and even of some social-science specialists that scientists are a rather uneducated group, that real education consists of knowledge of literature and philosophy, acquaintance with which is mandatory, whereas ignorance of science somehow enhances one's intellectual respectability. A short time ago I heard a philosopher speaking over a television network. While admitting that science was one way of looking at the world, he seemed to think of it as a rather distorted one, and of philosophy as the true way.

We scientists are not guiltless. I find some of my scientific colleagues using *liberal arts* as a term of opprobrium, designating those who have the one culture, to which "science" is much superior. We have also placed some rather formidable hurdles before the aspirant to scientific knowledge and have sometimes assumed that unless he is capable of understanding in the critical sense the mathematical jargon in which some scientists must express their findings, he is incapable of understanding what the scientist is about. We have often looked upon the man who attempts to translate scientific information into the less rigid terminology of the layman as almost guilty of desecration.

The gap needs bridging. The vocabularies of both groups need to be expanded to include reading knowledge of the other culture's literature. This is a very real challenge to both groups and especially to those who try to teach at the undergraduate level. Wordsworth might write that he would rather be "a pagan, suckled in a creed outworn," but he could not be, any more than Thoreau could live in complete independence at Walden Pond.

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Your quotation from Sir Charles P. Snow properly points out the serious shortcomings of science education. But I feel that it is incorrect in one important respect.

Sir Charles assumes that there is a substantial proportion of intelligent people who are incapable of grasping mathematical concepts. A similar view is held by many concerning the existence of people who are ineducable in science. Although a certain amount of such ineducability is probably inevitable, I think that the extent of it is grossly overestimated.

There was a time only three centuries ago when a majority of the population was considered incapable of mastering the 3 R's. Long division was at that time a college subject.

Science and mathematics education are at a similar early stage of development. Almost no real science is taught until age 12. Thereafter, science education (and to a lesser degree mathematics education) is hit-and-run, improperly presented, and generally inadequate. It is largely taught as a mass of facts. Experimentation, observation, and critical thinking are almost totally absent. In many schools mastery of terminology is sufficient to pass an objective test, a poor substitute for real science.

Techniques and materials have been developed to arouse curiosity and interest and challenge children's abilities at an early age. But these techniques and materials are not yet in widespread use.

For example, for many young people experiments with magnets and simple circuits at age 6 will do more to develop scientific attitudes than hours of book study at age 16. Cutting and pasting cardboard tetrahedrons and prisms instead of paper dolls, and making interesting designs with ruler and compass can prepare a child for a smooth transition to formal geometry. Simple puzzles and interesting experiments will help to lay the basis for satisfying successful experiences and serve to prevent future mental blocks and failures.

Until proper techniques of science and mathematics education are actually in widespread use at school and at home, it is too early to think in terms

of large numbers of otherwise intelligent people being unable to grasp fundamental ideas in mathematics and science.

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Publications and Basic Research

In his article "Basic research in industry" J. C. Fisher [*Science* **123**, 1653 (1959)] attempted to gauge the extent of basic research in U.S. industry by a count of scientific publications. I suggest that Fisher's basic assumption may contain a much larger error than he recognized.

Fisher assumes that a count of publications gives a "relatively good picture of the quantity and distribution of basic research effort." He also states, "Publications were counted indirectly, by counting abstracts . . . in the 1955 volume of *Chemical Abstracts*. . . . It is only approximately true that *Chemical Abstracts* finds and abstracts all publications concerned with basic research and rejects all publications concerned with applied work. However, the proportion of abstracts dealing with applied work appears to be *reasonably small and invariant*" (italics mine). It is this latter premise which my associates and I question.

Through the courtesy of Fisher, we obtained a list of the titles of those articles which he counted in the 1955 volume of *Chemical Abstracts* for Esso Research and Engineering Company, Humble Oil and Refining Company (which carries out research and development under contract to Esso Research), and two other leading petroleum research organizations. We have analyzed the articles so listed and find that the bulk of these articles would, in our opinion, be classed as other than basic research. Furthermore, the proportion of papers which we would class as basic research varies greatly, from about 10 to 48 percent of the total listed in *Chemical Abstracts*.

Fisher's tabulation of papers for Esso Research and Engineering Company also was incorrectly low, due to his assignment of ten Esso Research papers to Standard Oil Company (Indiana). A paper originating from Standard Oil Company of Ohio was also attributed to Standard Oil Company (Indiana). These errors perhaps arose because various companies use the Standard Oil name. The papers appearing in 1955 *Chemical Abstracts* were published from the Standard Oil Development Company, the predecessor to Esso Research and Engineering Company.

A final comment—there has been a marked increase since 1953-54 in the amount of basic research being done by private industry. I am sure Fisher would be the first to suggest that this subject warrants an up-to-date and quantitative analysis.

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I wish to thank W. T. Knox for finding the error in Table 1 of my article, wherein ten papers belonging to Esso Research and Engineering Company were mistakenly attributed to Standard Oil Company (Indiana). The wrong figures were

Rank	*Company*	*No. of publications*
13	Standard Oil (Indiana)	48
48	Esso Research and Engineering	13

The correct figures are

Rank	*Company*	*No. of publications*
15	Standard Oil (Indiana)	38
28	Esso Research and Engineering	23

The change affects the position of Standard Oil (Indiana) relatively little, moving it from 13th to 15th position. Esso Research and Engineering is more significantly affected, moving from 48th to 28th position. The error came about because Esso Research and Engineering changed its name from Standard Oil Development during the period covered by the study, and the earlier name did not appear in my check list of companies and affiliates (*Poor's Register of Directors and Executives, 1956*). I extend my apologies to Esso Research and Engineering for the error.

The Standard Oil of Ohio paper mistakenly attributed to Standard Oil (Indiana) seems to be an example of the random errors that arose because of company names that were missing, wrong, or incompletely given in *Chemical Abstracts*.

The assumption that a reasonably small and invariant proportion of abstracts dealt with applied work is not as good as I had thought, and I must agree with Knox's criticism of this point. My associate, J. B. Newkirk, has made an independent study of this matter and feels that only about half of the chemistry research and two-thirds of the physics research was properly classifiable as basic. Although the proportion of basic work abstracted by *Chemical Abstracts* is smaller than I had thought, I believe that the general conclusions of the study remain valid. Certainly a more up-to-date study is in order to show the considerable growth of basic research in industry since 1954.

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