Letters

The Core Curriculum

I am sympathetic to F. H. Westheimer's plea for more emphasis on science in the undergraduate curriculum ("Are our universities rotten at the 'core'?" Policy Forum, 5 June, p. 1165), but the issue of depth versus breadth afflicts many other curricular areas as well. I would submit that learning is no less cumulative and no less hierarchical when it comes to such "soft" fields as foreign languages, communication (writing, speaking, listening), and artistic technique (musical performance, dance, painting, and so on).

But a more fundamental consideration in trying to adjudicate competing claims on curricular time should be social and national need: What are the critical problems of our time, and which disciplines are in the best position to shed light on these problems? The natural sciences do not provide us with the means to cope with issues such as world peace, disarmament, international relations, human rights, poverty, debt, racism, and bigotry. These problems are much more relevant to the fields of psychology, history, economics, political science, anthropology, education, sociology, and area studies.

To a certain extent we have all been mesmerized by the spectacular successes of the natural sciences during the past half-century. Our understanding of the physical universe has increased exponentially, while our understanding of the behavior of human beings and of societies has lagged far behind. This imbalance is being exacerbated by national funding priorities, whereby the natural sciences and engineering enjoy lavish support while research in education and the social sciences gets virtually nothing, by comparison. As long as we continue to delude ourselves into thinking that the human dilemma is subject to a scientific or technological "fix" (the arms race—"Star Wars," in particular—is perhaps the most obvious example of this mind-set), this distortion of national priorities and values is bound to continue.

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A scientist writing to an audience of scientists in a scientific journal to say that science education is crucial to society is assured of a sympathetic audience. But that is, perhaps, not the ideal arena for testing hypotheses. As a professional humanist who reads *Science* regularly, I cannot let Westheimer's Policy Forum go unanswered. His complaints about our curricula are themselves a symptom of what is wrong with so much of our pedagogy.

Fallacy 1. Science is vertical whereas other fields are horizontal. To be sure, elementary science courses are sequential, but Westheimer misrepresents the structure of humanities disciplines. Ask humanities graduate students or advanced undergraduates whether their courses have not grown markedly more sophisticated and rigorous as they have proceeded up the ladder. Humanities courses are not sequential, but they are cumulative.

Study of the humanities is an exercise in making and using such conceptual distinctions. It is training, in other words, in thinking clearly. To be sure, humanists too have their *gradus ad Parnassum*. Westheimer concedes that elementary language courses, at least, are vertical. (I do not know how one could test whether they are "not generally as vertical as those in most of science.") The vertical and the elementary are naturally allied, for the same reason that one has to practice scales before one plays Bach, Beethoven, and Brahms or that one has to learn the multiplication tables step by step before one can do calculations freely. Westheimer's plea to teach science to all students at the highest level possible—with which I wholeheartedly concur—surely is based on an urge to get beyond the merely vertical and merely instrumental levels of education in all subjects.

Fallacy 2. One can "learn" Shakespeare more easily than molecular biology "without instruction in later life." One can indeed easily read Shakespeare (many scientists do), as one can read *Science* or *Scientific American* (many nonscientists do). Merely reading, however is neither studying nor learning. There is a reason why one cannot say, "I didn't learn Shakespeare in college, but that's all right; I learned him last year."

Fallacy 3. Students should learn science, not how scientists think. Westheimer wants us to learn "the advances in science that have occurred in the last half-century." Well and good. But (i) the exposure to salient developments in numerous fields that Westheimer urges is inconsistent with his main goal of exposing students to one or two fields at an advanced level. (ii) Those salient facts are precisely what the sequential, or rather the progressive, nature of science will gradually render obsolete. (iii) We can continue in later life to learn something about the new advances outside our own fields from the public media. We will learn those as we want to, provided that our education has enabled us to understand scientific discourse and scientific reasoning. Various levels of algebra and topology have helped me follow elementary presentations in *Science* of fractals and of other advances in mathematics. But far more important is that they trained a faculty of controlled, abstract reasoning. The contents were the means, not the end. In all other areas outside the field that we will continue practicing in later life, learning how to think should be the only goal, although it is necessary to climb the ladder of information in order to point toward that goal.

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. . . One is awash every day in science and technology; one cannot escape it. Better our future elite (and I dislike that word) should have 4 years of peace to delve into the pure world of thought to see what has happened in the past and to try to develop the moral and ethical insight to govern the staggering changes that science has thrust upon us. . . .

A core curriculum based on humanities is a totally reasonable course in our modern times. I think Westheimer should rethink his opposition to it. He also might consider what could be done to inculcate a sense of ethics into Ph.D. research scientists so that they do not feel that what is right is whatever they are doing.

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Westheimer cuts right to the core. Humanists learn too little science (two semesters at most colleges); and the sciences focus on vertical learning ("depth"), while the humanities focus on horizontal learning ("breadth"). We have recently addressed these issues at Loyola University of Chicago, and as of September 1988 have increased the core requirements for all students to three semesters of science (plus one semester of math) with the proviso that students must choose a sequence of courses providing both breadth and depth. We hope that other schools will follow suit; we can only underscore Westheimer's observation that two courses in science do not prepare our students for life in this and the next century.

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Response: The essential thesis of my Policy Forum ("Are our universities rotten at the 'core'?") is that learning in science is very

much more vertical than that in the humanities. If this point is granted, the need for a reconsideration of college curricula will necessarily follow. I am naturally delighted that Marshall Brown, "a professional humanist," reads *Science*, and I agree that it is not the appropriate journal in which to engage humanists in the important debate on curricula; I shall certainly try to go further. Brown states as "Fallacy 1" my thesis that "Science is vertical whereas other fields are horizontal." He then goes on to state that "Humanities courses are not sequential, but they are cumulative." I couldn't find a better way to explain just what I mean by the distinction between vertical and horizontal learning. This is the heart of the matter.

Later in my article I wrote, "Which will be easier to learn without instruction in later life, *more* Shakespeare or molecular biology?" (emphasis added). The word, "more," carries the firm implication that students will at least be exposed to some. Brown somewhat misquotes me as saying that "One can 'learn' Shakespeare more easily than molecular biology 'without instruction in later life.' " There is no danger that a humanist will not be exposed to enthusiastic teaching of Shakespeare (and other literature, for which "Shakespeare" serves as proxy), but perhaps he or she could sacrifice some part of it for a course in calculus or general biology or elementary chemistry. Finally, Brown criticizes me for claiming that "Students should learn science, not how scientists think." Can anyone really be educated in this modern world without a reasonable knowledge of some of the major generalizations of science? And I deny that one can learn how scientists think without having a good portion of the meat of science to chew on.

In his letter, Alexander Astin agrees that we need more science in undergraduate curricula, but contends that "learning is no less cumulative and no less hierarchical when it comes to such 'soft' fields as foreign languages, communication . . . and artistic technique . . . ." I am enthusiastic about teaching foreign languages, and learning in foreign languages is certainly vertical as compared with that in history or literature, although probably still less vertical than that in physics or molecular biology. But fortunately much of the cultural value of foreign literature, at least for nonspecialists, can be obtained from translations. Even George Steiner used translations in preparing his highly regarded treatise *Tolstoy or Dostoevsky* (Knopf, New York, 1959). Mathematics may be the language of science, but regrettably no one has yet found a way to translate it. The distinction between vertical education in science and horizontal education in the humanities is not absolute, but on balance the distinction stands.

Astin writes, "A more fundamental consideration in trying to adjudicate competing claims on curricular time should be social and national need: what are the critical problems of our time, and which disciplines are in the best position to shed light on these problems?" My Policy Forum contained a list of some of the intellectual and practical problems of our day that depend on science; isn't it fascinating to find a humanist arguing for the practical application of knowledge and a scientist arguing for better understanding? No one is asking that our students give up history and psychology and economics. Certainly scientists want a base in these areas for future learning. My suggestion is that humanists should spend 80% of their time in college, rather than 94% of it, with these subjects and increase their effort (or at least their time) in science from 6% to 20%. This may, of course, be what Astin had in mind anyway when he agreed to more science in our curricula.

C. Tyler Burt asks that "our future elite . . . should have 4 years of peace to delve into the pure world of thought. . . ." Peace? Avoiding instruction in science is "peace"? Science and mathematics have no place in "the pure world of thought"? Burt's letter illustrates why we need curricular reform.

Finally, and thankfully, Jeffry Mallow has written that Loyola University will ask their students to learn more mathematics and science. Yale has also expanded its science requirements. May they lead us out of the wilderness. Science isn't easy, but there is still no royal road to learning.

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Erratum: The first sentence of the second paragraph of Richard A. Kerr's Research News article "Halocarbons linked to ozone hole" (5 June, p. 1182) should have read, "Using a technique borrowed from galactic astronomy, the Stony Brook researchers believe that they have detected roughly 0.5 to 1.5 parts per billion of chlorine monoxide within the deepening hole. . . ." The article incorrectly referred to "0.5 to 1.5 parts per million."

Erratum: In the article "Space station price climbs higher" by Eliot Marshall (News & Comment, 17 July, p. 242), Herbert Friedman, a member of the National Research Council panel studying the space station, was incorrectly identified as a former presidential economic adviser. He is emeritus scientist, Naval Research Laboratory and Martin Marietta Fellow of the National Air and Space Museum.