LETTERS *(continued from page 15)*

Beneath these obvious technical changes, however, lie partially understood ideas that are beginning to shape the emerging new science. What is the role of modeling in physics? Is physics primarily conceptual or mathematical? Is truth unique? Some of our academic colleagues who are in the humanities and the history of science and have an interest in reconstructivism are beginning to press these questions.

The very suggestion that truth is not unique flies directly in the face of what most of us have been taught about the nature of physics, if not the nature of nature itself (or, more honestly, the limited ability of people to understand nature). If truth is not unique, then how do we determine what is true and what is the point of the natural sciences? This issue could be a Pandora's box: If we choose to look at the issue, we may be overwhelmed by the consequences that follow. The truth of physical law could become context dependent; the great pillars of scientific truth could be riddled with an openness of maybes.

The notion that truth is not unique neither invalidates nor weakens science. It does expand considerably the realm of possibility that scientists may wish to address. It does not diminish the concept of truth; it enlarges it. "Maybe" may be "may be."

Consider, for example, the common problem of throwing a small stone up into the air and trying to predict where it will land. We typically address this problem in physics using Newton's laws, which provide an exact way of predicting where the center of mass of the stone will go under the influence of the force of gravity. The position of this ideal point is described by a relatively simple mathematical equation that gives a unique answer.

But this answer is not always true. The assumptions we make in our modeling neglect the chaotic influence of the wind and the uncertain nature of the atoms in the stone itself. From this viewpoint the standard answer is not at all likely to be exactly true—although it is exact (that is, uniquely true).

The true answer is context sensitive. How large is the stone, how hard is the wind blowing? In principle, even the color of the stone could be significant if the absorption of light were to be considered.

New possibilities are opened by teaching and thinking about physics as being context sensitive, based on the use of flexible modeling (rather than rigid laws) and on the idea that physics may be more conceptual than mathematical. In this way, in principle, a broader, more realistic range of problems could be addressed. The notion of cause and effect may be measured by the degree of correlation between the cause and the effect. An exact description is the limit of perfect correlation of data with a given model. The absolute, but obviously absurd, determinism of Newton's laws may be sensibly softened.

Clearly there are dangers in softening science in this way. If science becomes unreliable, a great advantage is lost. Opening the question of the uniqueness of scientific truth is indeed risky. However, not all of the consequences of change are necessarily catastrophic. Intellectual fragmentation between the arts and the sciences has been of justifiably growing concern. By giving up a definition of truth that may be too narrow, we may open the door to some unification of a diverse spirit of the human intellect. We might also reach more people who do not understand science as we now teach it. We need them.

As Pascal noted three centuries ago, "There are two equally dangerous extremes—to shut reason out and to let nothing else in."

JIM MCGUIRE
Tulane University
New Orleans, Louisiana

Physics Teaching in Another Context

I feel compelled to comment on the "Reference Frame" article by Leon M. Lederman (April, page 11). I'm afraid that Dr. Lederman, with his impressive credentials and sweet smile, is living in an ivory-tower dream world.

Yes, physics is a disaster area in many, but certainly not all, American high schools. Yes, the sensible progression in science is physics first, then chemistry, followed by biology. Back in the mid-1970s, when I worked occasionally as a substitute teacher, I saw this sequence followed, apparently successfully, by the honors students at a high school.

There are two major reasons why physics education is what it is. One, correctly identified by Lederman, is that there are frightfully few teachers who are themselves comfortable enough with the subject matter to do an effective job of passing it along to students, with or without the mathematics.

More serious even than this, however, is the other reason: Too many high school students lack the mathematical skills to tackle even conceptual physics. Lederman presupposes a situ-

ation in which ninth-grade physics would be based on "a reasonable level of eighth-grade algebra."

Unfortunately, even this minimal level of skill is, in too many places, the exception rather than the rule. The reasons for this are complex and probably poorly understood, but if the remedy were as simple as to require "all students" to take algebra, the problem would have been solved long ago.

As Lederman's piece implies, the current educational fad is to require academic mathematics classes of all students. This sounds wonderful on paper, but the "all students" philosophy bandied about these days is too often interpreted to mean all students in the same class, doing the same things. Good math teachers have always known that there are prerequisite skills necessary to learn algebra, most crucially the ability to do and have a feel for simple arithmetic. Nowadays the idea is that everybody takes algebra, ready or not. Many are simply not ready, for any one of a number of reasons. And they can't all be allowed to fail for that would not be politically correct! The net result is that if everybody takes algebra, it has to be watered down so severely that there is nothing much left to it—except the title. When everybody takes algebra, nobody gets algebra—at least not algebra as we know it. It's the same with physics.

Many of the current educational reform movements sound wonderful and egalitarian on paper, but the net result is an almost inevitable dumbing down of the entire curriculum. Educational restructuring can and does create schools in which mediocre students are happy because they are getting easy credit for high-sounding classes, but in which any potential future reader of PHYSICS TODAY would be bored and miserable.

Many educational reform theories creating such havoc today have come from the research efforts of the faculty and students of university schools and departments of education. Please, scientists, before you buy into or advocate the implementation of these "proven" and "research driven" schemes, get a few of your colleagues' papers and theses. Read them, and evaluate them according to the same standards you would use to evaluate any research. It is possible to make an already bad situation a whole lot worse.

MARTHA SCHWARTZ
San Pedro, California

LEDERMAN REPLIES: I disagree with everything Martha Schwartz says, except her passing comment about my smile being "sweet" (and my credentials being "impressive").

Her letter illuminates the problem of what can happen when obviously intelligent and dedicated teachers oppose change they find uncomfortable. They seem to feel the old system sometimes works and change may make it worse; anyway, what do scientists know about the real world? But Schwartz should know that there do exist very successful, very real-world schools, such as Central Park East in Harlem and Whitney Young on the South Side of Chicago, not to mention comparable high schools in many other places. Students will respond to high standards if what they are doing makes sense. In fairness, however, one cannot overemphasize the need for continuous professional training of teachers.

LEON M. LEDERMAN
Illinois Institute of Technology
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Einstein a Red? The Response Was Verse

Edgar Villchur's comment (April, page 110) about Einstein's being suspected in the 1950s of having Communist sympathies brings to mind an amusing response to anti-Communist opposition to Einstein's being admitted into the US two decades earlier. A popular newspaper columnist, H. I. Phillips, was moved to address Einstein in verse, as follows (if memory serves faithfully):

Doctor with the bushy head
Tell us that you're not a Red.
Tell us that you do not eat
Capitalists in the street.
Say to us it isn't true
You devour their children too.
Speak, oh speak, and say you're notsky
Just a bent-space type of Trotsky.

NORMAN F. STANLEY
Rockland, Maine

Correction

October, page 41—In the photograph the person on the far right in the back row is Donald Kerst. ✻

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