then more power to it! But in fact, positivism, and in particular logical positivism, has had less influence than it deserves. This philosophical school advocates a logical analysis of scientific concepts and the avoidance of meaningless questions. It has helped to clear much metaphysical fog.

Finally, it is amazing to find you deprecating the use of mathematical methods in science. Without this, physics would be impossible, as has been known since the discovery of the laws of strings by Pythagoras. It is true that in some sciences at some periods qualitative methods may be sufficient, as in the case of Darwin. But Darwin was followed by Mendel, and who will deny the mathematical nature of modern genetics? And biophysics and biochemistry, insofar as physics is a component, must eventually be highly mathematical. In sum, science and technology are being used as a convenient scapegoat by those who refuse to see the real causes of the distress of our day.

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The editor comments: There was no intent in the December editorial to deprecate the value of mathematics. There is, of course, an immense advantage in being able to formulate the significant questions in a field of study in mathematical terms. But unfortunately there is too often an overreaction in the form of the attitude that unless a field of study is able to use mathematics it isn't really science. The result has been that frequently people in the "softer" sciences mistakenly try to employ mathematical approaches to problems for which the methods of Darwin would be more appropriate. See the late William Feller's views on this point (Scientific Research **4**, No. 3 24 (3 February 1969)).

How Neptune was discovered

For the sake of historical accuracy I would like to correct two minor points in the excellent article by John S. Rigden ("Reshaping the Image of Physics," October, page 48).

The English mathematician John Adams who calculated the location of Neptune prior to its discovery was not an undergraduate at the time he worked on this problem. Having already graduated at Cambridge as Senior Wrangler in 1843, he commenced work on the Uranus problem (part time!) arriving at his first results in 1845.

The often-referred-to "small discrepancy" that Bouvard noticed in Uranus's position was, in fact, substantial if measured against what was then detectable. In 1820 the error in Uranus's position was about 21 seconds of arc, which is approximately an order of magnitude larger than other effects that had been observed (such as stellar aberration and stellar parallax).

Indeed, the full story of the discovery of Neptune is one of the most dynamic and human stories in the entire history of physics. It is a shame that time has buried this tale so deeply. Congratulations to Rigden for giving it a moment's breath out in the open.

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What is modern physics?

Your March issue, devoted to physics for the nonscience major, carried a review (page 75) in which my recently published college text, *Introductory Physics, a Model Approach*, was compared with Leon Cooper's very excellent *An Introduction to the Meaning and Structure of Physics*. I should like to question reviewer Thomas Von Foerster's unspoken assumptions as revealed in his comments about my "slight" treatment of modern physics and his suggestion that my book was better suited to high-school courses.

▶ What is "modern physics"? Most authors and the reviewer appear to consider relativity, quantum theory, subnuclear particles, and symmetry principles to be essential ingredients of modern physics. While I agree that these are the important topics in current research, it is also a sad fact that their very abstract nature—the remoteness of their models from common experience—makes them exceedingly difficult for laymen to grasp. I have therefore looked beyond these specific areas and propose that operationalism, together with the awareness that models are not truth, characterizes 20th-century physics in a deeper way than relativity.

▶ What distinguishes "high-school" from "college" physics for nonscience students who avoided taking physics in high school because of disinterest, fear, or lack of time? The students are in college and have never had physics before. Should they ". . . stand, perhaps in awe, before the 'cathedral-like' structure of physics," as Von Foerster expects from Cooper's text? Or is it better that they ". . . feel at home in the structure of physics," as Von Foerster describes the aim of my book? Both of these objectives are undoubtedly worthwhile, but, "feeling at home" would seem to come before "standing in awe" if students are to understand rather than merely being impressed. This is especially true for the many students—50% in some of my classes—who hold an active hostility toward science because its technological applications can so easily be used for evil purposes. A