further experimentation along that line would be pursued.

Whether the opinion is accepted or not, one may disagree with the antiexperimental hope that a relatively few laboratory animals will be spared a particular stress while countless animals and men suffering from it now and forevermore will be allowed no relief basically better than that currently available. Life presents a spectrum of stresses, the milder usually more common. I suggest that all deserve better understanding and management, and that animal experimentation is a rational means for gaining the necessary information quickly, with minimum confusion from variables of genetics, age, and environment, and without subjecting people to harmful procedures. Velay argued that sleep deprivation should not be studied experimentally with animals, because it involves no "situation crucial to mankind." He recognized no humane justification for discovering help for individual people deprived of sleep, whether by mere irritation or disaster. He recognized no survival value in learning to forestall resulting malfunction —most pointedly by emergency workers, soldiers, or negotiators deprived of sleep while protecting the rest of us from all manner of stresses, including situations "crucial to mankind." It is a tragic paradox that humane motivation, when constricted to animals and the immediate future, can turn against means for continued growth of man's capacity to be humane. It is a dangerous paradox that our society, precisely because of its humane ethic, could be misled into accepting the antiexperimental ideology and its impediments to the development of our ability to survive and prevail in contests with nature or nations less humanely motivated.

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. . . What is more normal than sleep deprivation for mothers of young children! Typically, the baby awakes early for a 2 a.m. feeding just after the eldest child, fortified by a long afternoon nap, has finally settled down to sleep. As the baby finishes feeding, the next eldest child awakes with a sniffle, cough, bad dream, or just an excess of good spirits and usually doesn't doze again until the morning hour comes when Dad leaves to go to work (or fishing or duck hunting). By then it is time for the eldest to get up to go to kindergarten or first grade. During the day the children either stagger their naps, one after the other, or, on rarer days, when they choose to nap simultaneously and provide their mother with a chance to lessen her own sleep deprivation, a salesman inevitably will come knocking. Is this cruel? Who suffers more—experimental animals or mothers?

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## Early Pragmatists

I have just now read this past summer's *Science* journals and wish to comment on one debate which might be entitled "the theoreticians or mathematicians versus the practical scientists." Apparently, this has been going on for some time since several quotations perhaps 50 to 100 years old come to mind.

Oliver Heaviside (1850–1925), when criticized for using operational calculus without rigid analytical proof, is reported to have said, "Should I refuse my dinner because I don't understand the digestive process?" Whether or not he was incapable of rigorously proving the operational calculus or just didn't care to bother seems unclear; apparently he found its justification in its "experimental" success and didn't need the analytical proof.

Another believer in the experimental approach was Claude Bernard, the famous French physiologist (1813–1878). He said, "A good technique sometimes renders more service to science than the elaboration of highly theoretical speculations," He, too, seems to have deplored at least some aspects of the theoretical approach.

James Clerk Maxwell of electromagnetics and "Maxwell's equations" fame (1831–1879) also seems to have been concerned with this debate when he said, "Mathematicians may flatter themselves that they possess new ideas which mere human language is as yet unable to express. Let them make the effort to express these ideas in appropriate words without the aid of symbols, and if they succeed they will not only lay us laymen under a lasting obligation, but, we venture to say, they will find themselves very much enlightened during the process, and will even be doubtful whether the ideas as expressed in symbols had ever quite found their way out of the equations into their minds." [*Nature*, **7**, 400 (1873)].

Perhaps he made a good point and perhaps too, the debate will last forever.

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## Father of Modern Geology

Implicit in the book *Lectures in Geology* (John Walker, edited by H. W. Scott, University of Chicago Press, 1966) and in the review of it by C. C. Albritton, Jr. (Book Reviews, 28 Oct., p. 497), is an important point in the history of geology that should be made explicit lest the casual reader be misled. When word first spread of Scott's remarkable find of the manuscripts of John Walker's early lectures given at the University of Edinburgh (1779–1803), it was only natural that many would jump to the conclusion that Walker had, in fact, anticipated most, if not all, of the important ideas generally attributed to James Hutton, a contemporary of Walker. But, upon reading Scott's valuable analysis of the manuscripts, it became clear that this was not the case, though it seems inescapable that the two were acquainted. Indeed, to me it seems probable that considerable professional jealousy existed between them, partly suggested by the fact that neither seems to have acknowledged in print the existence of the other—a not uncommon 18th century oversight. Walker's reluctance to stray from the facts even a short way into interpretation contrasts sharply with Hutton's passion to erect a unifying generalization that could give meaning and direction to the embryonic science of geology. Hutton also worked from factual observations, but the two men were so intellectually and temperamentally different that it seems inconceivable that Walker was the originator of Hutton's truly revolutionary theories of the earth. Walker's importance lies chiefly in his mineralogy and teaching, but in my opinion, until some new evidence to the contrary should appear, Hutton still stands as a remarkably original and creative thinker and, more than any other single man, the father of modern geology.

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