ing materials specifically prepared as aids in learning to read scientific literature are yet available.

3) There appear to be no technical Chinese-English dictionaries, such as exist for German, French, and Russian. The existing specialized dictionaries of technical terms, intended mainly for those who speak Chinese, are not easily used by the Western student.

4) Class instruction in Chinese for the scientist is not currently offered by universities in the United States (the Massachusetts Institute of Technology is planning a course in scientific Chinese for September 1960).

Learning Chinese is not as insuperable a problem for the Western scientist as many tend to believe. The grammar of the language is simple; words are not inflected as in Western languages, and number, tense, case, and person are all indicated by the context. Furthermore, an active interest in teaching Chinese to Western students in nonscientific fields already exists, and much of this experience would be of value in the teaching of scientific Chinese. An increase in interest and an organized effort on the part of individuals aware of the growing need for scientists with a reading knowledge of scientific Chinese could overcome most of the problems.

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References

1. J. T. Wilson, "Red China's hidden capital of science," *Saturday Review of Literature* (8 Nov. 1958); *One Chinese Moon* (Hill and Wang, New York, 1959); "Geophysical institutes of the U.S.S.R. and the People's Republic of China," *Trans. Am. Geophys. Union* **40**, 3 (1959).

The Scientist and Moral Values

The two letters concerning animal research [*Science* **131**, 263 (29 Jan. 1960)] by implication raise issues of fundamental importance to the role of science and to the respect it may claim in the world of tomorrow.

The first is a question one would like to see squarely answered: Are there any moral limits at all to animal experimentation? Or is it the responsible and considered opinion of today's biologists and psychologists that any experiment, no matter how cruel, is permissible as long as it is scientifically worth while?

The second is a scientific problem that has been surprisingly—and significantly—little investigated: that of the psychology of scientists. Who are the people who will choose lines of research leading them to ever more cruel and, to

an outsider, seemingly barbaric experiments? What are their motives and the conscious and subconscious satisfactions they derive from their work? What else would they be capable of doing if given the opportunity?

In the popular view of science, the scientist too often appears as a kind of impersonal superman, investigating with cold detachment, and with concern only for truth. But surely this is preposterous. The scientist as a human being is very much a part of the picture of science, and science cannot be adequately understood without an understanding of the scientist; this line of research has been surprisingly shunned by scientists themselves.

With respect to animal experiments, I venture the hypothesis that, as the intrinsic scientific value of experiments decreases and the cruelty to animals increases, a critical point is reached beyond which the driving force is no longer scientific curiosity but sadism pure and simple. "Research" becomes a legalized outlet for pathological drives. Placing no moral limitations whatsoever upon research is an open invitation for this.

If the scientific community were to condone this, it could only lead to justifiable distrust of scientists in the long run. Indeed, the great claims of science in the last analysis boil down to this: that science is a form of service to mankind. But the very idea of service to mankind is a moral ideal that is intimately linked with the whole of human morality, of which reverence for life is an essential part.

If, under the guise of science, that reverence for life were entirely discarded, the resulting moral debasement of scientists might well raise fears that, given the opportunity, they might turn against man himself in a sort of scientific folly. After all, it has already happened at least once: in Nazi Germany, where scientists performed "scientifically worth while" experiments on human beings they elected to consider "subhuman." In the modern world, scientists should not be the last to learn the lesson that, whenever the ends are thought to justify any means whatsoever, it is the means that will utterly corrupt the ends. Or, to put it in the words of a wise old Frenchman, Montaigne: *"Science sans conscience n'est que ruine de l'âme* (knowledge without conscience is nothing but the ruin of the soul)."

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A recent exchange of letters on animal research left me puzzled. Can the painful problem of what constitutes proper animal experimentation be solved by the magic of words?

R. B. Kelman objects on moral grounds to experiments published by V. H. Denenberg and G. G. Karas, in which animals were starved to death to measure their resistance to stress under certain conditions. Denenberg in his reply gives *relevancy*, *sensitivity*, and *precision* as his criteria in selecting a dependent variable. "Any variable which satisfies these demands is scientifically valid and may be used to study subhuman organisms." He points out that in starving animals to death survival time is a relevant dependent variable for measuring resistance to stress; that it is precise, because the same general findings can be obtained on different occasions; and that it is sensitive, since it uncovered statistically highly significant differences between different groups of animals. He concludes that survival time is a scientifically valid measure of resistance to stress; that it is specific, since "it is based upon the preservation of life"; and he adds that to him his data are most interesting.

Denenberg's criteria for scientific validity are explicit and sufficient. They help one think up other vaild experiments to measure resistance to stress, such as immersion into chemically inert hot liquids. Unlike starvation, an all-or-none affair, thermal stress can be varied in degree. Survival time in total body thermal stress (TBTS) probably depends upon the degree of stress and the surface area of the animal, or, perhaps, a surface-volume relationship; one might get a family of curves for animals of different size when plotting survival time as a function of temperature. Simple refinements of these experiments might include a one-lead electrocardiogram, to show the combined effect of nonspecific stress and rising temperature on myocardial conductivity. Or the electrical activity of the brain could be recorded during these conveniently shortened (as compared to starvation) tests for resistance to stress; a simultaneous temperature curve of the cerebrospinal fluid obtained through a needle thermocouple in one of the cerebral ventricles would provide convenient arbitrary landmarks in the gradual transition from being into nonbeing. The brief survival time would lead to a greater number of experiments, improving their reliability and increasing efficiency in utilizing scientific manpower.

Such experiments would fully satisfy the stated requirements for scientific validity, yet one would not wish to maintain that boiling them alive in mineral oil is a proper way of testing resistance to stress in mice, rats, or other "subhuman" mammals. Our criteria let us down, for at least two reasons: they have no circumscribed meaning and they are not pertinent to the issue, which is a moral one. *Relevancy* of survival time in indicating resistance to stress is assured by definition; no matter what we do to shorten the life of our animals, survival time will remain relevant in measuring resistance to what we are doing to them. The same is true of *specificity*. *Sensitivity* and *precision*, as used in this context, can be interpreted rather broadly to fit almost any experiment in biology worth reporting; they do not describe the experiments as much as the frame of mind of the person talking about them. In general, applying such terms to one's own results amounts to little more than saying, "I like what I am doing," in different words. Admitting this in public is proper and may even have didactic value, but it is a pity to conceal an essentially noble message behind inappropriate words.

The problem of what constitutes humane experimentation on animals is painful and difficult, and most of us are reluctant to think it through. Like other moral problems, it probably cannot be solved by rules that are simple, consistent, and always uniquely applicable. Even if rules were set up they

would have to be interpreted in doubtful cases; ultimately it must be the scientist concerned who decides whether work he is about to undertake is sound intellectually and morally, and we had better select our scientists so that we can entrust them with such decisions. On occasion, a scientist may feel the need to show the rest of us his work as a source of excitement, delight, or inspiration, but the justification of what he is doing—its agreement with a given set of standards, scientific and moral—rests in itself; the record is all that is needed, and nothing else will do. Calling one's results relevant, sensitive, specific, precise, significant, and scientifically valid adds nothing to them.

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More about Nomenclature

I have just read K. E. Boulding's letter in [*Science* **131**, 874 (1960)]. I don't think that it will be necessary to waste any space on the proposed astronomical classification since, like his "Bimbambim" it probably won't be used by anybody.

But I do wish to protest three statements: (i) that names like selenium, tellurium, or, for that matter, Rhynchocephalia are "unscientific"; the history of science happens to be a science too; (ii) that it is "fortunate" that most scientists are not acquainted with the "dead" languages from which nomenclature is drawn. I, for one, consider this most unfortunate, provided it were true; (iii) that the letter *x* cannot be used to begin a syllable. Boulding may have heard of St. Xavier at one time. To be more personal about it, my younger daughter is named Xenia, and even in grade school her classmates had no trouble learning the proper pronunciation, Ksay-niya.

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As an old S-F fan I am flattered by Willy Ley's attention to my excursion into the grain-of-truth-among-chaff business. But the history of science is not science but History, an appalling mishmash of unrepeatable accidents, quite unfit company for the respectable readers of this journal. Selenium has nothing to do with the Greeks, the moon, or the metal, just as (to cover his second point) irony has nothing to do with Fe. And in a world in which so much information has to be carried in such little sculls, there is a real problem of Economy in language.

But I am sorry about *x*. It has always