dating back to the mid-19th century. It arose from the need to specialize, which has sharpened with the increasing complexity of civilization. But the gulf has widened and deepened in recent years. Ignorance of science is advertised today as the warrant of the self-styled humanist. The argument goes this way: "The aim of education is a decent, moral world made up of decent, moral people. Science must therefore be secondary, because science cannot help anyone to be a decent, moral person. Science is vacant where value is concerned. The humanities provide the value."

The humanities, by this line of argument, are staked out as the territory of the antirationalists. "Reason," they say, "must ever be the slave of passion." Science can show us how to achieve our ends. But for motivation and purpose we must seek guidance elsewhere, in tradition or faith, in the sensibilities, emotions, and yearnings that well up in the human spirit, beyond the understanding and control of reason.

To argue thus is to ignore how much of the outlook of all men in our time is conditioned by science. In politics, the choice of the aims of national policy is profoundly conditioned by what we know, from human biology and from cultural and physical anthropology, about mankind, its history, and its place in nature. Never again can a nation assume the mantle of a "master race" or take up a "white man's burden" or proclaim a "manifest destiny." Cultural relativism has even invaded the world behind the Iron Curtain, where the 19th-century naivetes of Marxism are undergoing revision. The politics of the world is modified, equally, by what we can do with what we know. The vision of the United Nations and its technical agencies is that of a world at peace because it has eliminated human destitution, misery, and disease. Contrast this vision with the view of the 17th-century moralist who held that human life is, of necessity and by definition, "nasty, brutish, and short."

In personal morality, the notion of the good life and of what men live for has been deeply modified by scientific understanding of the cosmos, of the origin of life, and of the structure of the human personality. Reason is the instructor of passion in other departments of our culture. Consider, for example, the bearing of science upon esthetics. Recent investigation of the giant molecules has shown us how nature achieves, in extraordinary perfection, the aim of art: in the molecule, function is the expression of structure; it is what it is because of the way it is made.

Such are the concerns that inspirit the scientist in his work. They are not different from those that move the painter or the composer, the historian or the poet. Utility alone could never have sufficed to bring science to its present wealth of understanding. The motivating drive could never have been less than passions which all men share and which inspire the best achievements of men in other fields of intellectual endeavor.

This is the aspect of science most neglected by science writing. It is, I submit, the facet that is most susceptible to popular appreciation and comprehension. The preoccupation with information should give way to popularization of the objectives, the method, and the spirit of science. If the public is to support the advance of science for motives other than utility, then people must be able to share not only the useful but the illuminating and the beautiful that come out of the work of science.

Abbreviations

Uptake of Laboratory Shorthand in *Science* (ULSS; $Q_{\mathrm{abbr.}}$)

Robert V. Ormes

In fitting articles and reports to the necessarily stringent space requirements of *Science,* authors frequently find it convenient to substitute capital-letter abbreviations for nouns and adjectives that they must use several times. The abbreviations are usually ready to hand, for they are used every day in the laboratory to save time and notebook space, and every science, and perhaps even every laboratory, has its own shorthand expressions and jargon. A few authors explain all their abbreviations in a footnote, some explain each abbreviation the first time it is used, some explain some of their abbreviations, and some do not explain any.

To what extent is the use of laboratory shorthand from many different sciences justified in a periodical that circulates among scientists of many different fields? Several points bearing on this question were discussed in a short article that was reprinted from *Nature* in last year's Book Issue of *Science* (*1*). We were impelled by this article to make a brief study of the capital-letter abbreviations that have been used in signed articles that have been published in *Science* during the past 2½ years. For material, we used a card file that we have accumulated for editorial purposes.

In making this investigation, we sought to determine particularly what abbreviations have had more than one meaning, especially in different fields, and what meanings have had more than one abbreviation. In addition, we considered the meanings that individual letters have had as elements of abbreviations and the number of abbreviations that have never been explained. We found that the overall result is a startling hodgepodge.

Of the abbreviations that have had more than one meaning, the following may be cited as examples. BP has been used for "before the present," "blood pressure," and "boiling point." BT for "bathythermograph" and "blue tetrazolium." DMF for "dimethyl formamide" and "decayed, missing, and filled teeth." DNP for "dinitrophenyl" and "dinitrophenol." EA for "experimenter associated with the agent" (used in parapsychology) and "enzyme activity." H for "sorbitol" and "histidine" as well as for a well-known element. IDP for "inosine diphosphate" and "integrated data processing." PNH for "reduced pyridine nucleotide" and "paroxysmal nocturnal hemoglobinuria."

On the other hand, several different abbreviations have been used for one

The author is a member of the editorial staff of *Science*.

meaning. Thus *p*-chloromercuribenzoate has been abbreviated CMB, PCMB, pCMB, and *p*ClHgBA; thyroxin, T, TX, and THY; hydrocortisone, F, compound F, and HC; and deoxyribonuclease, DNase and DNAse.

In addition, there are mixed forms—one meaning with several different abbreviations, one or more of these abbreviations having been used for still another meaning. α-Naphthaleneacetic acid has been abbreviated NA, NAA, N2A, and ANA; but NA has also been used for "nicotinamide."

Our file of capital-letter abbreviations contains 485 cards in all. The 485 abbreviations have had at least 542 different meanings—we say "at least" because 109 appeared without any explanation, and almost all of the other 376 appeared in at least one article without any explanation. Of the 485, 272 were used in only one article each.

One author, having 11 compounds to discuss, simply symbolized them A, B, C, D, E, F, G, H, I, J, and K. Most authors attempted to abbreviate rather than to symbolize, but the resulting form was occasionally a mixture: AMP was used in four articles for "adenosine monophosphate," in two for "adenylic acid" (which was abbreviated AA in two other articles), and was not explained in two articles. Chemical symbols for the elements were also used as parts of abbreviations, but without consistency. Aside from the example of *p*-chloromercuribenzoate that has already been cited, tetrapotassium pyrophosphate has been abbreviated TKPP and TPPP, and tetrasodium pyrophosphate TSPP. One author used TKPP and TSPP. TNaPP has not been used, but we may see it yet.

Among the 109 abbreviations that were not explained by any of the authors who used them were most of those in what we call the "dose" series: AD_{50}, ED_{50}, EI_{50}, ID_{50}, LD_{50}, LD-50, $LD_{42}{}^{30}$, $LD_{100/30}$, MLD, TC_{50}, TC 50, TCD, TCD_{50}, $TCID_{50}$, TD_{75}, and TI (therapeutic index, the ratio LD_{50}/AD_{50}) (TI has also been used to mean "total iodine"). Another series whose members usually appear without explanation, the "I-with-one-other-letter" series, is composed of ID (inside diameter and infective dose), IM (intramuscular and imidazole), IP (intraperitoneal and ipomeamarone), IQ (intelligence quotient), IR (infrared), IU (international unit), and IV (intravenous). In this particular series a further complication arises because many of the members are also abbreviated with lower-case letters, both with and without periods. A third series of seldom-explained abbreviations is the "EG" series: ECG (electrocardiogram and electrocorticogram), EEG, EKG, and ERG.

Table 1. Meanings of the letter *A* in abbreviations that have been used in *Science* during the past 2½ years.

Meanings in position 1	Meanings in position 2	Meanings in position 3	Meanings common to two or more positions
acridine	absorbed	absorption	acet-
acute	agent	alanine	acid
adenoidal	agglutinating	albumin	activating
adenylic	allantoic	allyl	adenine
adrenal	area	alternating	adenosine
alcohol	aspartic	amylose	amino-
alpha	avoidance		ammonium
androsterone	azo		anti-
anesthetic			antigen
animal			association
auto-			

Two abbreviations conflict with our own office jargon: SMO has been used for we know not what, but we use it to mean *The Scientific Monthly.* TP has been used for "titration-passage technique," "triphosphate," and "tryptophan peroxidase"; to us, it means "Report" (in the old format of *Science,* what are now called "Reports" were known as "Technical Papers," and we have not updated our shorthand).

When we considered the meanings that various letters have had as individual elements within the abbreviations, we found that confusion was compounded. In the three positions of three-element abbreviations, the letter *A* alone had numerous meanings, as follows: in first position, 19 meanings with three others that were not explained; in second position, 16 meanings with one other not explained; in third position, 12 meanings with two others not explained. The various meanings of *A* in these positions are summarized in Table 1, where meanings that appeared in more than one position are listed in a separate column.

Several of the abbreviations that have been used, such as TNT, DDT, ACTH, TV, and IQ, have become a part of the language and are perhaps better known than their parent expressions. Certain others, such as ADP and ATP (adenosine di- and triphosphate), DPN and TPN (di- and triphosphopyridine nucleotide), and DNA and RNA (deoxyribonucleic acid and ribonucleic acid), are well known, at least in biochemistry and related fields. But even such a well-known abbreviation as ADP has had different meanings: "adenosine diphosphate," "automatic data processing," and "ammonium dihydrogen phosphate."

Moreover, we have found the ambiguities listed here by considering only the abbreviations that have been used in signed articles. We do not doubt that we could find more conflicts by including abbreviations for government agencies, societies, strains of mice and viruses, universities, models of instruments, and nuclear reactors in the list. The multiple meanings of MIT (Massachusetts Institute of Technology and monoiodotyrosine) (*1*) and AA (adenylic acid and Alcoholics Anonymous) come to mind immediately.

A few abbreviations that did not appear often suggest ways in which the list of ambiguities could be extended still further. For example, CHR (*Cercarienhüllen Reaktion*) suggests that we consider German-language terms. RP (serum *lacking* in properdin) suggests almost frightening possibilities: How many of the 109 unexplained abbreviations denote *absence of* something rather than *presence of* something? N2A (one of several abbreviations used for α-naphthaleneacetic acid) suggests that abbreviations could be abbreviated by using number coefficients: AAAS (American Association for the Advancement of Science) would become 3AS, as, indeed, it already has in the spoken language.

Most of the abbreviations are not sufficiently redundant to carry their meaning despite a typographic error. Thus, despite proof-reading in the editorial office and by the authors, RNA (ribonucleic acid) once became PNA in the published version (PNA has been used to mean *any* nucleic acid); DPO (diphenyloxazole) became PPO, which was one of two abbreviations used for "pleuropneumonialike organisms"; and UV (ultraviolet) became IV (intravenous). A simple transposition would change UDPGla (uridine diphosphoglucosamine) into UDPGal (uridine diphosphogalactose), but fortunately this has not yet happened.

The meaning of nearly every one of the 109 unexplained abbreviations could be ascertained by a general reader, but sometimes only by study of the context.

Presumably readers from the same field of science would recognize the intended meaning instantly, but the main point is that those in other fields might have to study.

We feel that we should make more effort to eliminate abbreviations from the texts of "Articles" and "Reports," particularly abbreviations that appear only occasionally. Of course, it is necessary to use them in equations and reaction schemes, and perhaps in the texts of articles when a long chemical name is used again and again.

However, as has been suggested before (*1*), judicious use of pronouns, and care on the part of authors, might reduce the number of different abbreviations used in any one article, as well as the total number of all abbreviations. The saving of space obtained by use of abbreviations is hardly worth the restriction of understanding, and only a few of these abbreviations can become any more than what they are, laboratory and notebook shorthand.

Reference

1. "Use and abuse of English in science," *Science* 123, 720 (1956). This article was an excerpt from the leading article in *Nature* for 5 Nov. 1955.

Scientific Approach to Ethics

Anatol Rapoport

Opinions on the relation of science to ethics are usually strong ones and are often arrived at not so much by investigation of such relations as through conviction about what these relations ought to be. These opinions tend to divide those concerned with such matters into two camps. In one, the feeling runs high that science is ethically neutral, that it is concerned with what is and not with what ought to be. This view is usually stated categorically and enjoys a high degree of agreement among its adherents. No such unanimity prevails in the other camp, where it is felt that connections do exist between science and ethics. This is not surprising. Those who deny that such connections exist can readily agree, for once something is declared to be nonexistent there is nothing further to be said about it. But if something is said to exist, we wish to say more about it, and the more one says, the more controversial one's opinions are likely to be.

To preserve the lines of communication in such a discussion, it may help to agree, first of all, on what is meant by an ethics or an ethical system. It seems to me that in every ethics there is involved a set of choices and a set of rules governing the making of the choices, with a proviso, however, that these rules are not entirely instrumental in the pursuit of an explicit, unambiguously defined goal. This last restriction serves to differentiate an ethics from a strategy. For in a strategy, too, one has a set of choices and a set of rules for making choices, but the goal is explicit and unambiguous. Thus, the principles governing the choices of plays in a game of bridge are principles of strategy. But there is also an ethics which excludes acts defined as cheating. The "ethics" of bridge can also be said to have a goal—for example, the assurance that the players will continue to respect one another and will continue to play—but this goal is certainly not nearly so explicit and unambiguous as the goal of winning.

In this sense, we may speak of various professional ethics as distinguished from the "strategy" or the technique of the profession. There is an ethics in the legal and the medical professions. There is an ethics in the business community, in the military, and in the underworld.

Often strategy and ethics are not easily distinguishable. For example, the saying "honesty is the best policy" indicates that one of the ethical principles of business is seen to be also a strategic principle. On the other hand, ethics and strategy may conflict. This is dramatically shown in the frequent violations of the so-called "rules of warfare."

We note, next, that scientific practice also has an ethics, and, characteristically, that the ethical principles of scientific practice are intimately intertwined with strategic principles. The scientist is guided by certain rules of evidence in his definition of what is true. Furthermore, the scientist binds himself to hold and profess views (at least in regard to matters subject to scientific investigation) which he must acknowledge to be true according to those rules of evidence. Since these rules are remarkably consistent and remarkably easy to apply (compared with other rules that govern ethical decisions), the ideal of universal agreement on matters within the jurisdiction of science seems attainable in practice. Therefore, the scientist (if he is consistent) is bound to strive for universal agreement among scientists on these matters. Moreover, the agreement is to be attained neither by coercion nor by force of personal appeal but by examination of evidence alone. In other words, if "conversion" of an opponent to one's point of view is a desideratum (such desiderata are really not included in the ethics of scientific practice but are nevertheless carried over into scientific practice from other areas), the satisfaction of such a conversion in scientific matters is complete only if the change of view comes independently of any pressure other than the weight of evidence.

Thus, even our characteristically human tendency of wishing that others thought and acted as we do becomes modified in scientific practice, because coercive measures toward those ends are pointless. Unless the conversion is made by force of evidence, it is an empty victory to achieve it.

These, then, are the ethical principles inherent in scientific practice: the conviction that there exists objective truth; that there exist rules of evidence for discovering it; that, on the basis of this objective truth, unanimity is possible and desirable; and that unanimity must be achieved by independent arrivals at convictions—that is, by examination of evidence, not through coercion, personal argument, or appeal to authority.

I submit that here is a respectable chunk of an ethical system. The question before us is whether this is, characteristically, a "professional" ethical system on a par with other such systems, like those that govern the medical, legal, military, and criminal professions, or whether there is something unique about the ethics of scientific practice which makes it a particularly suitable basis for a more general system.

Dr. Rapoport is a member of the Mental Health Research Institute of the University of Michigan. This article is based on a paper presented on 27 Dec. 1956 at the annual meeting of the AAAS, in New York.