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ABSTRACT

Chemistry textbooks on the market during 1979-80 designated for non-majors were read and analyzed to determine references of value judgments made on social, political, or economic issues. Textbooks included those used in general education courses, first-year chemistry courses, and in terminal introductory courses such as those in allied health science programs. Rationale for and examples of texts grouped as (1) science and society textbooks and (2) skills and drills textbooks are provided. Truth and progress, issues, naturalistic, and theory/puzzle approaches used in science and society textbooks are discussed. The bibliography provided in this section includes comments for each entry on how the scientific method, science history, and technology are presented, as well as the specific value orientation. Topics discussed in the next section on skills and drills textbooks include the nature of such books, standardization and value dilemmas of standardization, technology (virtually a complete lack of applied chemistry), and the presentation of the image of science. Following a bibliography related to this section, one textbook for chemistry majors is evaluated. Various issues related to textbooks for allied health programs are discussed, followed by an annotated bibliography focusing on content and treatment of value judgments. Eight physics textbooks are also reviewed and evaluated. (Author/JN)

Value Presuppositions In Science Textbooks
A CRITICAL BIBLIOGRAPHY

by
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TABLE OF CONTENTS

INTRODUCTION: AN OVERVIEW

The title of this study calls attention to its central thesis - in scientific texts there are explicit and also tacit normative assertions which cover the full range of personal and public dilemnas confronting contemporary society. To some this will seem obvious and the only puzzles will be why authors and teachers do not see that their most important teaching vehicle includes evaluative opinion as well as descriptive fact. To others, it is not at all obvious that texts carry moral messages or normative prejudices. This study should resolve those doubts.

The term "value", as used in this study, must be taken in the broadest possible sense. It includes any principle, proposition, policy, fact, or idea which is the object of human interest. Values, as we understand them, include assertions about the nature of scientific method, e.g. that it is rational, its results objective, and its practitioners open-minded, honest and dedicated, etc. The term also includes assertions about the costs and benefits of a particular technology, characterizations or criticisms of environmental policies, or of particular products like DDT, thalidomide, and specific historical episodes such as the use of agent orange, or mustard gas. As a category, "values" must also include specific ethical principles or moral prescriptions such as the need to control world population, the belief that our standard of living is too high (or too low), that we are too exploitative of other cultures, too reckless, too fragile, too much a "mono-culture" and so on. All of these political and moral judgments can be found in one or more of the textbooks viewed in this study. We have included ethical prescriptions and moral judgements within our rubric of values knowing full well that many philosophers would argue that ethics, as a discipline, and values, as objects of empirical study, ought to be separated.[1] The primary reason that we have taken a very inclusive term is our conviction that many who doubt that science education reflects and conveys the multitudinous values of a pluralistic society will require an exhaustive documentation of the range of assertions in the first year course in science. Nothing should be left out if the case is to be made. Secondly, ethical and moral principles exist as a means of resolving conflict between individuals; consequently, they are subordinate to and supportive of social cooperation, cohesion, pluralism and freedom of expression.[2] All of those goals are "values"' consequently, as we are using these fugacious terms, "ethics" and "morals" are a part of values.

In introductory science courses, especially those designed for non-majors, textbooks are the primary and sometimes the only pedagogic vehicle. As such, they play a large role in shaping student opinion about science and technology, and they may be ultimately responsible for countless lasting impressions and prejudices about science itself. From the teacher's point of view a comparative survey of introductory texts will show which values, norms and goals are common to those members of the profession who use, endorse or write textbooks. Thus, given either a concern about what information students receive or a concern about the dominant communicated values of the profession, we believe this critical bibliography will inform teachers about the explicit value judgements and tacit pre-suppositions which are part of their professional pedagogic life.

We have read and studied nearly all the chemistry texts on the market during the 1979-80 academic year which might be designated for "non-majors". We have included books which would be used in courses satisfying a general education requirement, a first-time chemistry course, or a terminal introductory course serving such vocational aims as those in allied health science programs. Although difficult to define in terms other than "a science course for non-majors", the profession probably has a very good working understanding of what these books are, the level of difficulty and the audience which they address. It is perhaps a less well known, but none the less remarkable fact, that a small number of introductory textbooks apparently dominate the market. This is clearly the case in major level texts. The Journal of Chemical Education records 18 general chemistry textbooks for science majors. (Vide "Book Buyers Guide" Journal of Chemical Education, Vol. 55, No. 9, Sept. 1978). Of these texts another study of course adoption in 86 U.S. institutions shows that three texts account for 42 percent of the market (Vide Hung, Carl C. "Survey of Evaluation and Grading in Undergraduate General Chemistry" Journal of Chemical Education, Vol. 53, No. 9, Sept. 1976). More remarkable still is the fact reported in the same study that one textbook, Masterson and Slowinski's Chemical Principles is the choice of 21 of the 86 schools. Although we were unable to determine which books dominate the non-major market, there are probably a few which hold the commanding lead.

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[1] These opinions have been canvassed in Arthur Kaplan's article, "Ethics and Values in Education: Are the Concepts Distinct and Does It Make a Difference?" Educational Theory (Summer 1979) Vol. 29 No. 3, p. 245-253.

[2] Here as Peter Caws has said, "Some form of moral rule, therefore, becomes a value in common for people required to live in a common world. It is to be noted that (ethical) rules are not wanted for their own sake, but for the sake of further values, which are not held in common or at any rate need not be. And the nature of these further values is left completely open, save for the condition....that they be compatible with observance of the moral rules". Peter Caws, "Teaching Ethics in a Pluralistic Society, Hastings Center Report 8, 5 (October 1978): 35.

The methodology of this study was arduous, sometimes tedious, but not elaborate. We read each book and took notes on any mention of value judgements on social, political, or economic issues. When a large amount of space was devoted to an issue such as drugs, pollution, or nuclear energy, we counted the number of paragraphs describing that issue. It is important to note that these paragraph counts often called for borderline judgements about content because authors often mix many issues; consequently, we exhort the reader to look upon the charts at the end of this bibliography as something of a thumb-nail sketch which reveals differing directions and areas of emphasis. No one should assume that an author who spends only 20 paragraphs on nuclear energy while another devotes 70 paragraphs to the same topic, has produced an inferior treatment. The rough quantitative method of paragraph counting says nothing about quality. In a general way it shows something about which issues are thought to be important or significant for undergraduate students. What is interesting is that texts can be grouped according to the similarity of value presuppositions and these show great uniformity in the topics covered.

Since this study was the collaborative effort of a physical chemist and a philosopher of science, and since each book was read and discussed by both, the scope of our reflections extended to some general observations about the nature of science education itself. We have called our study a critical bibliography because while there are descriptive bibliographic entries for each textbook, we have also included an explanation of the general patterns and trends which this study reveals. It is important to note that we have not rated or ranked any book. There is no separation of wheat from chaff here. We did not think of our task as that of a book reviewer making recommendations for text selection, but rather as that of concerned teachers initiating dialogue about certain patterns of pedagogy.

The investigators share a common appreciation of the work of Thomas Kuhn, The Structure of Scientific Revolutions[3], and Jerome Ravetz's Scientific Knowledge and Its Social Problems[4]. The former is probably better known, but the latter is more rewarding for insights and descriptions of science as a social process. Both are seminal books in the continuing development of the "new common sense of science". This new understanding shows the positivist's concern with a rational reconstruction of science according to strict criteria of verifiability is only part of the reality of science. It does not ask how a given piece of perfected scientific knowledge arrived at truth, but rather what are the processes and activities by which that knowledge passed from the personal and ambiguous dimensions of a problem situation to the public world of shared knowledge. Of course, one terminus of that public world is the classroom and the textbook, consequently, the "new common sense of science", gives some guidelines for grasping, as a whole, both the research and the pedagogic roles of science.

No one, we believe will dispute the notion that society carries different images of what science is. It has been at various times characterized as, "the champion of reason", as "dirty and threatening", as "mankind's great hope", and as his "destroyer". Which of these images or value orientations will be found in introductory chemistry books? The key to answering that question is to look carefully at passages describing technology and its products. Our bibliographic entries pay close attention to technology whenever it is mentioned. To anticipate what the reader will find, we note that the predominant value transmitted at the introductory level is what might be called the "scientific (or technological science related) fix". In brief, it is the belief that there is no problem or social issue which cannot be satisfactorily resolved given sufficient investment of research funds and time. The "technologic fix" is part and parcel of a more general belief that science always progresses towards greater understanding and truth, and that these new truths produce concomitant technological developments which continue to better the lot of mankind. There are one or two books which offer a more pessimistic outlook, but by far the large majority of books underscore and reaffirm the dominant motif of the union of scientific truth with material progress.

Many authors include episodes from the history of science in their textbooks and they write about these episodes in a way which conveys an appraisal of scientists and their work. In summarizing each book we gave close attention to their remarks. We found that texts which pride themselves on incorporating the history of chemistry into the factual content of the textbook, often in the name of "humanizing" science, perpetuate the illusion that the history of science is the story of progress and enlightenment in conflict with forces of ignorance and superstition. It is the story of heroes and villians. A particular achievement such as the work of Dalton, Lavoisier, or Mendeleev prefigures or merely illustrates contemporary knowledge. The actual religious or philosophic convictions as well as the social context which conditioned these achievements are completely ignored. Using episodes from the history of science in this way reinforces the notion that history is merely facts and dates, some of which are vindicated by present knowledge. One does not get the countervailing impression that there could not have been current chemical knowledge

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[3] Kuhn, Thomas, The Structure of Scientific Revolutions, 2nd edition, University of Chicago Press, Chicago, 1970.

[4] Ravetz, Jerome R., Scientific Knowledge and Its Social Problems, Oxford University Press, New York, 1971.

without those achievements and the men who made them.

The scientific method is a frequent topic in the first year text. Like the history of science, it sometimes suffers from a caricature. In this case it is the tired old saw that science arises solely from observation and proceeds by induction to law and theory. The story goes something like this: science begins with observations, then by induction the investigator arrives at a hypothesis which is subject to experimental testing. When the hypothesis has been confirmed and linked with related hypothesis on the same subject, scientists formulate laws of nature. When laws of nature are collected and combined, scientific theories are produced. Philosophers of science call this the "narrow inductivist" model. Its origin goes back to J. S. Mill's System of Logic (1843). Although the inductivist model receives lip service and endorsement, no author seriously uses it in organizing the material. In fact, it is seldom mentioned once the introductory chapters are out of the way. Why is the scientific method characterized by cliches and ideas from a model which no scientist or philosopher takes seriously? What apparently has happened is this. Because there is widespread agreement about what sort of standardized facts and skills ought to be covered in an introductory text, perhaps some authors cannot resist the temptation to transfer this impressive agreement and consensus to statements about the scientific method. Afterall, if there is common consent about what the basic facts are, musn't there be similar agreement about the method by which those facts were discovered and received? The need to present the scientific method as a piece of perfected uniform procedure equal to and responsible for the pyramid of facts certainly inhibits an awareness to the actual processes and activities of scientific research. It is refreshing to find that some authors have abandoned all mention of inductivism and treat the scientific method as a combination of imagination and experimentation.

There is a remarkable uniformity in the factual content of introductory chemistry textbooks. This sort of general agreement about basic content allowed us to separate the books into three categories which are distinguished by pedagogic design. The first division, "science and society" texts, use a phrase which seems to be gaining some currency as the best rubric to describe those books which emphasize personal and societal issues arising from the application of chemistry and technology. The range of issues is broad, and as our analysis indicates we have divided this group into subcategories which reflect different perspectives and treatment of the issues.

The second division, called "skills and drills" or "fact-acquiring", includes those books which virtually eliminate personal and social issues and concentrate entirely on the transmission and acquisition of chemical facts or of problem solving skills. This class resembles more the introductory text for majors than it does the science and society texts. The uniformity of factual content, examples and even of diagrams and pictures is so striking and so consistent throughout the group we decided to provide an analysis for the class as a whole while providing only short bibliographic comments on each particular book. In the lucrative market of textbook publication, one would expect a vast diversity comparable to an oriental bazaar, but surprisingly, this is not the case. It appears that there is a large scale concensus among science teachers about what should be taught in the first course. Fixity of content, whether enforced by the publishers or by the profession, certainly exists, but this does not explain why there is such a great uniformity of style, examples, drills, and even pictures. If one looks back several decades, chemistry textbooks were once weighty tomes with little in the way of pictures and illustrations and much in the way of written descriptions. By contrast the textbooks of today are not nearly so long as their ancestors, and possibly not as well written, but they all include far more pictures, cartoons, diagrams, charts, and all manner of graphics. The skills and drills textbooks have gone even further in this direction. The growing conformity in content, styles, examples, and of drill, illustrates the process of standardization of facts. We believe that the forces at work in the process of standardization are little understood by either the research scientist or the dedicated undergraduate teacher despite the fact that they both play key roles in shaping that process. To call attention to this process and open it to examination by the profession as a whole, we have included a separate section on the "standardization of facts". Reading this section will explain why the skills and drills texts are grouped together, but it also raises pivotal questions about the directions of science education today.

The third category lumps together texts to which we might apply the label "applied relevance". The basic aim of these books is to provide chemical facts to students who, the authors claim, will need the knowledge in their chosen vocations. Not surprisingly, most of these texts emphasize the application of chemistry to the allied health professions. These books, with their claim of useful application, present their own unique set of value presuppositions.

Our study is not itself value free, nor does it pretend to be, for like the myth of total objectivity, the notion of value free inquiry is a story gone stale. The general presuppositions guiding our investigations appear in the recommendations which are included in each section. If the mastery of standardized facts is the paramount educational goal, we recommend that authors and teachers explain the process of standardization itself. One way to do this is to trace the growth, development, and theoretical underpinnings of a particular scientific achievement such as the Lewis octet rule (see p. 22). Certainly not every achievement could be given this sort of detailed attention, but at least one thorough case study of the growth and development of a standardized fact will reveal how actual scientific practice shapes the acquired knowledge which emerges from seminal research. A thorough immersion in one case study will do more to teach a student the richness of the scientific method than all the textbook platitudes about inductivism combined. Moreover, it will give a truer and more recondite sense of the history of science than the misleading name and date versions. If science is indeed part of the search for truth and if truth seeking is its paramount internal value (as many writers say it is), then is there not an obligation to give a more truthful account of the nature of science itself? A major step towards an honesty about science and its methods will be taken when teachers and writers do something to demonstrate to students that the textbook version of science, with its accompanying laboratory exercises, is quite distinct from the history of science and from the actual scientific practice which ultimately produces a textbook's standardized facts.

SCIENCE AND SOCIETY TEXTBOOKS

The term "science and society textbook" is widely understood as a designation for an approach which stresses the relevance of basic science for understanding social issues, such as pollution and nuclear energy, and personal issues, such as alcohol and drug abuse. In higher education "relevance" is and has been a buzz word. Whatever it connotes, it most assuredly remains vague in the extreme until one knows what (and how) an author treats his topics. Many issues have received public attention, but very few remain long in the public eye. It would, therefore, be a mistake to define "relevance" of a textbook solely in terms of which issues it covers. The chart on page 47 gives some indication of the range of issues in the survey books, but this is not the whole story and possibly it is the least informative section. In our opinion the question of how authors make chemistry relevant can be answered in two ways. First, there is one group of writers, who despite differences in style and content, organize their material in a remarkably similar way. They introduce social issues as examples of what chemistry helps us to understand. These books resemble a text for majors in their emphasis on the mastery of basic facts, but their examples, some of which are quite extensive, are almost exclusively discussions of social issues. The general supposition is that a given issue will make more sense to the reader (and possibly more easily resolved) if the reader understands the basics of chemistry. This approach tends to emphasize the past achievements of chemistry and its accompanying technology in solving problems. For example, the development of medicines, pesticides, fertilizers, etc., take on paradigmatic status. The chemical industry generally receives a favorable endorsement and the nuclear energy debate is couched in terms of the industry's past and present safety record rather than its potential danger. It is argued that even a rudimentary understanding of chemistry will improve one's ability to make a rational decision. We believe that this line of argument tends to re-enforce the belief that every problem admits of either a scientific or technologic fix. They reflect the belief that a given problem presents difficulties in so far as the scientific community lacks sufficient knowledge to understand all of its ramifications, or because it cannot, at present, develop a sufficient technological innovation to resolve the problem. For mere convenience and to acknowledge its 19th century heritage of a belief in progress, we have called the subclass of science and society texts, the "truth and progress" approach.

The second group and its pattern of organization reflect a different understanding of relevance, but as we shall see, the dominant presupposition of the scientific fix remains unaltered in the end. Here the emphasis is on the issue itself, not as a mere example of abstract chemical principles, but rather as one of the salient, possibly irritating or threatening features of life in our society. It is assumed that the student already has, or shortly will, confront problems such as drugs, alcohol, pollution, etc. The notion of relevance governing this approach might be called "experiential" in that it assumes a student will bring some interest to the issue itself, and probably will be more interested in it than she or he is in the chemistry which underlies the problem. Chemistry becomes relevant once its connection to an individual's experience or interests becomes clear.

In chemistry the experiential approach appears and is possibly most successful at the introductory non-major level. It concentrates in showing that chemistry underlies the swarm of issues which confront even a moderately informed student. Because this pattern of organization keeps a constant focus on issues which might stimulate a desire to learn chemistry we have called it an "issues" approach.

Certainly no textbook can fulfill every requirement of an open concept like relevance, and possibly none are completely devoid of each of the two patterns just mentioned. One can look at chemistry (or any discipline) as giving the basic facts which shape a certain way of thinking about problems. Then, as examples of this way of thinking, one selects topical social and personal issues. Or, one can think of the student as a person facing a host of difficulties and concerns. These can be described in such a way to show the importance of chemistry. Here there is no assumption that one could not make decisions, or "right" choices without a knowledge of science, but simply that it is difficult to be fully informed without a knowledge of basic chemistry. By its very nature the issues approach reaches out to other disciplines because those disciplines can make the same claim with respect to being fully informed and also because most issues require more than just a knowledge of chemistry.

Each approach has its strengths and weaknesses. As a matter of personal style most teachers probably have an unconscious preference for one or the other. The "truth and progress" approach builds on a foundation of recondite facts and thereby conveys the belief that most, if not all problems, await the discovery of new scientific facts or the development of innovative technology. The "issues" approach builds a strong case for a knowledge of chemistry as a universal prerequisite for improving the art of living because almost every issue has a chemical side to it. In our opinion the "issues" approach extends this sort of reasoning to unbounded lengths. It ultimately results in endorsing the "scientific fix", just as its companions in the "truth and progress" approach did; however, the reasoning is usually a bit different. To show the ubiquitous nature of chemistry and its input into every problem, authors, quite naturally, select examples which have a strong component of scientific achievement. As our comparison charts show, many of the same issues are covered by both groups, and both give the lessons of the technological fix. In only one textbook, Roger Gymer's Chemistry and the Natural World, did we find the suggestion that some problems could be handled if people adjusted their lives, or appetites, rather than expecting technology to produce the solution. This might be called the "natural fix". Gymer's textbook contrasts dramatically with every other text and for this reason it stands in a class by itself. We called it the "naturalist approach". Another book, Fine's Chemistry Decoded, sufficiently different to raise questions about some of the new directions in textbook publication, is also put in a separate class. Classes of one member show that no taxonomy is completely precise or exhaustive, and if we were merely grouping textbooks in terms of their dominant presupposition almost all would be circumscribed by the belief in the "scientific fix".

TRUTH AND PROGRESS APPROACH

Science has a history rich enough in personal and public struggles to generate an ideology of truth. It was common in the late 19th century to describe the aims of science and even the personalities of scientists, in terms of a pure and selfless search for Truth. The history of science, so it went, shows the sacrifices of enlightened minds to defend reason against prejudice, to win individual freedom from tyrannical authority, and to launch humankind on the road to progress. In the 19th century the aim of this ideological message was to secure for the discipline of academic science an independent but equal place in the departments of the university. Scientists labored to distinguish their work from that of philosophy, theology, philology, and other accepted fields of inquiry. The result was an ideology of truth which treats science separate and distinct from other kinds of inquiry and which espouses a kind of moral innocence befitting a dedicated pilgrim. Scientists are disinterested truth seekers who sacrifice for the sake of higher goals. This sentiment can be found in many texts. It has been said that World War I shattered the moral innocence of science and that the ideology of truth cannot be the sole foundation for academic science. No one who has seen the close connection between research and the economic and technological markets can seriously uphold the moral innocence of pure research. Nonetheless, the ideology of truth is frequently invoked in introductory texts. Here are some sample quotes to show how it is done:

> It is quite easy to imagine a situation in which a technological process can introduce into our environment, drastic and irreversible, changes which set a chain of events into action before we can stop them. (p. 241)
>
> The vast majority of mankind has no knowledge of the scientific principles upon which technology is based and accordingly must accept the opinions of others on technological matters. This dependence upon experts, in turn arouses fears of these experts and the damage they can do either by error or by evil intent. (p.243)
>
> This fear, in some people, is an unreasoning, blind, driving force which leads them to condemn all technology. The only antidote to such fear is an understanding of the technology based on study. Mankind's perennial enemy has been ignorance and the prejudice it generates. Human progress has always been the result of activities of that small percentage of people who accept neither the ignorance nor the popular prejudices of their fellow human beings. (Jones, et al, Chemistry, Man and Society, p. 243)

What we see here is a blending of the ideals of academic science, ideals of objectivity and rationality, with those of the technology. There is no attempt to distinguish between science and technological applications, nor is there any indication of how one would go about assessing the differences.

Inevitably, current technology and industrial practice are endorsed in terms reminiscent of the values attached to academic science.

> The chemical industry produces an amazing array of products of great value both to the economy and the general welfare, but obviously this work must be carried out in harmonious balance with environmental considerations. Considering the huge scale of operations and their many built-in hazards, the record is moderately good. (Compton, Inside Chemistry, p. 376)
>
> . . . all reactors are designed with second level containment systems built in behind

the radiation shield. Such an accident (melt down) would require costly and time consuming repairs, but it would not result in widespread contamination. (emphasis added) (Kieffer, Chemistry Today, p. 268.)

The failure to make some sort of distinction between academic science and the technocratic and economic conception of applied science stems from a deep confusion about the relationship between the accumulation of facts and the meaning of "progress". It is certainly true that we know more now than people did 50 or 100 years ago. There has been an accumulation of facts, a growth in knowledge, but to identify all of science's activities and its products as "progress" is to attach a label which works like a persuasive definition. It, in effect, defines what is, as what ought to be. Whatever is, is good. Since the historian Herbert Butterfield adopted the phrase "Whigish interpretation of history" to describe the tendency to see science as developing along linear paths of progressive development, we can readily adopt this phrase to describe the most prevalent conception of science found in textbooks. On the topics of science and technology most authors are whigs, and of course this view is dangerously one-sided; it ignores the complex economic (and political) connections between research and applied science, it fails to recognize that experts have economic motives, and that resources of funding guide research aims as much as inherent significance.

As Ravetz has observed,

> Applied science has become the basic means of production in a modern economy. Prosperity and economic independence does not rest so much in its factories as in its research and development industries. Industry has been penetrated by science. (Ravetz, p. 21)

Understanding the problems raised by applied science are or should be a significant concern of the educated layman who will influence or respond to governmental and corporate policy decisions. We do not see how the blending of the accolades of academic science with a faith in progress can contribute to this understanding; nonetheless, this dominant value, to reiterate, is the conviction that science and technology are set upon inherently progressive and bettering paths of development and that most if not all of our problems, social, economic, and even moral problems, only require more knowledge and more innovative technologies for their solution.

One irony in the camouflaging of applied science with the ideology of truth is that it ignores one of the students' basic motives for studying science. Most students, and certainly all science majors, recognize the economic opportunities which are associated with a career in the applied sciences, and presumably they would benefit from a clear understanding of the differences between "kinds of science". Some authors do know that what their students want is an acquaintance with enough science to enter the applied science fields, particularly allied health fields. These authors do not discuss the differences between academic science and applied science, but they do take great pains to introduce major facts in immediate connection with technological applications. For example, a leading chemistry book for majors, Masterson and Slowinski's Chemical Principles, takes a topic like hydrocarbons and explains their properties by illustrating a process for coal-gasification. (Vide p. 32 of this study) Applied science is always in the atmosphere at least by way of example, even though its special problems and difference from academic science are never mentioned.

The texts in the category of "truth and progress" are: Compton, Inside Chemistry; Jones, Netterville, Johnston and Wood, Chemistry, Man and Society; Kieffer, Chemistry: A Cultural Approach; Kieffer, Chemistry Today; and Seager and Stoker, Chemistry A Science for Today.

ISSUES APPROACH

Books in this category start with the fact that students will have divergent interests and will import concerns from other fields. The response is to show how science is intimately related to other fields. In particular, Jay Young's book Chemistry, A Human Concern, carries out the project with a high degree of enthusiasm. Since there are no two things which are not similar in some respect or another, the crucial question is what kinds of similarities will knit up a bundle which includes poetry, religion, art, and science? Young's answer is to stress imagination and creativity. This permits a very interesting definition of chemistry, to wit,

> The study of sensual, delightful, facts that demand intellectually imaginative explanations. In this chemists are not different from others. Almost everyone likes to solve puzzles, for example, and chemists even take some pleasure in the occasional foul odors generated in their kind of work. (Young, Chemistry, A Human Concern, p. 43)

The playful quality of this kind of writing has something endearing about it. It suggests a harmony among the disciplines, a commonality and a reconciliation between humanities and science.

But the knitting together of all disciplines can be taken too far, as with this example on the synthesis of morphine.

> Chemists began with nature itself, since morphine originally comes from poppy seeds. The first problem was to elucidate the molecular shape, very much as a sculptor brings to light the shape of a statue that exists inside a block of stone. Once

> this has been done, the molecule became a sort of canvas or poetic expression ready for further artistic modification. Just as the change of a single word can alter the thrust of a poem, the change of a single atom can alter the properties of a molecule. Who really knows why a poet changed that word, or a chemist substituted another atom? (Young, p. 71)

Perhaps only a purist would raise violent objections to this way of speaking. Certainly this approach seems to cultivate the favor and the virtues of good company. Poetry is certainly a good thing, but is the commercial production of drugs equally a "good" thing too, since this approach says "Chemistry is intimately related to every profession" (Young, p. 412)? It is not surprising that there is a great difficulty in separating the chemical industry and its technological applications from that purer science which cavorts with art and poetry. We are told that the "chemical industry is not precisely definable" (Young, p. 375) because like chemistry itself it is intimately linked with so many fields. The logic of this is suspect, for even if something is intimately linked there certainly should be some way of defining, at least thinking about, its distinguishing characteristics in a sensible way. Again, in this approach the virtues of one enterprise rub off on another. The chemical industry shares the stature of pure academic chemistry, which in its turn is like art, poetry, religion. All are good things. To return to our example:

> Molecular artistry is expensive in terms of time and materials and sophisticated instruments used to obtain the facts that lead to the indirect conclusion that the molecule has been changed in the manner originally planned. (Young, p. 71)

> To recover the investment, a pharmaceutical manufacture might understandably decide to market a modified drug molecule that, in fact is not very much better than the original drug or that similar drug manufactured by a competitor. The result of this practice is that physicians receive information about a very large number of "new drugs, each one touted to be superior in some way to any other ever produced". Naturally this is confusing to the physicians and pharmacists and gives the public an unpleasant image of the pharmaceutical industry. (Young, p. 71)

To many this would seem to be an ideal place to consider questions regarding the practices of selling and advertising drugs to professionals, and further issues about testing and regulation of the pharmaceutical industry. But what in fact happens is a return to an unjustified assertion that industrial research is truth-seeking and progressive.

> With each failure and success of a modified drug molecule now, a few more facts are obtained. Ultimately, these observations will lead to a more informed, surer molecular artistry. At that time it will not be as necessary to attempt to sell such a profusion of varied drugs in order to attempt to recover an investment. (Young, p. 71)

We do not wish to comment on the economic misunderstanding here except to say that if the profit motive created the confusion which beguiles the public, what shred of evidence is there to suggest that further research will resolve that confusion? The reasoning that says accumulation of facts leads to greater progress and that this progress will intrinsically eliminate the problems which confuse the public and the health professions is simply an expression of faith in the scientific or technological fix.

A related notion is the assertion that science is morally neutral and that its knowledge and discovery is "amoral". Here is an example of that belief.

> This [Van Scott's discovery of a treatment for skin cancer with nitrogen mustards] is indeed a striking case of the <u>amoral nature of science</u>. The knowledge that we have of the properties of molecules us neither good nor evil. How we use that knowledge does involve morality. The knowledge can be used either for our benefits or for our destruction. In this respect, science is no different from the social sciences or the humanities. (Hill, <u>Chemistry for Changing Times</u>, third edition, p. 331) emphasis added.

The conviction that science is "amoral" rests covertly upon the distinction between academic science, which is seen as a pure, and hence amoral, quest for truth, and applied science which is corruptible because it can be put to malevolent ends. The difficulty here is two-fold: authors who advocate the "moral neutrality" thesis do not distinguish between academic and applied science. One wonders if this is even remotely possible given the penetration of government and industry into all aspects of research and development. Secondly, the whole question of "how we use knowledge" and what that really means is never discussed in any detail. Clearly a detailed case study would go a long way to explain how people use knowledge, particularly its societal controls, and it is likely that a case study approach would dispel the outmoded notion that academic and applied science must be distinguished by possession or lack of a "moral" nature.

To conclude this section it is appropriate to mention a curious remark, which may be the result of an unrestrained belief in the scientific fix.

> Moderate use of certain psychoactive drugs

probably will be shown eventually to be safe for most individuals, when the drugs are prepared by reputable pharmaceutical companies and are used under the direction of trained personnel. Unfortunately, it is not known at the present time which drugs will be found safe; furthermore, illegal sources of drugs are unreliable with respect to purity and concentration. (Clark and Amai, Chemistry: The Science and the Scene, p. 245)

The textbooks in the "issues" category are: Clark and Amai, Chemistry: The Science and the Scene; Hill, Chemistry for Changing Times, third edition; Wade, Contemporary Chemistry; Science, Energy and Environmental Change; Wolke, Chemistry Explained; and Young, Chemistry, A Human Concern.

NATURALIST APPROACH

This approach rests on controversy because it takes ecological questions and principles as a means of organizing chemical and scientific knowledge. Ecology has emerged as a discipline along with a growing public awareness of environmental problems. It was, in a sense, born into controversy and from inception it had to face clusters of economic, political, and social as well as scientific problems. It is not surprising, therefore, that a text emphasizing ecology would have a more systematic, even a more metaphysical context for its value assertions. Nature as a whole is after all the subject matter. Roger Gymer's Chemistry and the Natural World opens with a philosophic definition.

We find in nature a grand architecture in which smaller, less complex structural units come together to build even larger and more complex units. (Gymer, p. 1)

Nature must be understood in terms of hierarchies, levels, and cycles, and each level or cycle has its own intrinsic value and its own distinctive set of properties.

Although the author does not use this word, he is talking about what philosophers call emergentism, the metaphysical doctrine that universe is stratified into levels of increasing complexity. Each level has unique distinguishing properties or characteristics which cannot be reduced to the properties and characteristics of its simple components. Emergentism makes room for a sort of ethical naturalism because it suggests that some distinguishing characteristics of each level may be values. Values, are, therefore, objective and discernible because they are intrinsic to each level in Nature's hierarchy.

For example, Gymer discusses the carbon molecule as the "Most Fit" for building life, and he offers this definition of the key term "fitness".

If we leave out questions of what the composition of the earth's crust might have been when and if life originated on earth, we can say that the availability of the elements did not govern the constitution of living things and that some other quality (or qualities) of these elements especially suited them for participation in life processes and structures. The sum of these qualities has been called fitness. (Gymer, p. 53)

Technology is discussed exclusively in terms of what its effects will be upon the biochemical "cycle". Some cycles are more basic, more "natural" and thus intrinsically more valuable, than the processes which disrupt those cycles.

It is intrusion into some of the basic biochemical cycles by human activity that causes many of the pollution problems of today. (Gymer, p. 99)

This definition permits the author to reject a narrower definition of pollution than that which says pollution must be defined in terms of what is detrimental to human interests, economic, medical, or so on. In opposition to the human centered approach, this ecological view asserts,

". . . pollution is viewed as any deviation from the normal in the natural composition of the environment that adversely affects not just us, but life in general." (Gymer, p. 117)

One advantage of this kind of reasoning is that it does not lead to the debatable and doubtful strategy of attempting to derive value conclusions from descriptive statements of fact. In the ecological approach we begin with a value premise, namely, that certain cycles are "natural", and intrinsically valuable. These ought to be maintained and preserved. This value orientation might be called Aristotlean, because it uses a notion of teleology, (viz. "fitness") and it gives a privileged status to certain cycles and organisms, each of which has a place in the well-ordered hierarchy of nature.

We have used the atmosphere as a "sewer" almost from the time of prehistoric man. (Gymer, p. 118)

But we know that people can affect the sea, and one of the ways we do this is to regard it as a gigantic waste basket. When nature uses it as the ultimate waste basket, natural processes keep it from overflowing. We should realize that we do not have the same privileges that nature has and so we should be especially careful of our treatment of coastal waters. (Gymer, p. 230)

The author indirectly re-enforces an image of society's relationship to the natural world which has a great deal of appeal to many. Humans are the caretakers or stewards of nature. The human species is that part of nature which understands and comprehends nature, and in this role mankind takes responsibility for controlling and preserving natural cycles in so far as it is within his power to do so; in other words to apply the "natural fix". This orientation can be translated into some practical pedagogic assignments. One of these is the example of reading and compiling an Environmental Impact Statement as a means of understanding the meaning of technological assessment.

> The proper application of technological assessment could help us avoid an unthinking exploitation of scientific knowledge and attain a better technology. In this way those who now enjoy a high quality of life (not to be confused with a high material standard) and wish the same for their children, may continue to do so, while the disadvantaged of the world may still hope for a better life. (Gymer, p. 550)

> If a truly participatory technological assessment is to be achieved, laymen must have some basic background in a number of disciplines to help them participate in and evaluate the argument for technological assessments. The goal should be to create a society whose members can discriminate and assess, who have enough knowledge and insight to guide them in the rejection of bad ideas and acceptance of good ideas. (Gymer, p. 550)

THEORY AND PUZZLE APPROACH

A number of science teachers believe that the traditional fact stating mode of textbook writing does not engage or stimulate large numbers of students. In a time that has witnessed a general decrease in the reading, writing, and interpretative abilities of incoming students, it is not surprising to find texts which have wide margins, large print, pictures, cartoons, and caricatures - all with the avowed purpose of getting students interested in scientific ideas. The strategy seems to be that significant theoretical information and some puzzle solving ability can be conveyed or inculcated by these devices. Can one learn the atomic theory by picturing atoms as disco-dancing partners? Can students be inveigled into working problem sets? Is curiosity and imagination really stimulated by graphic illustrations? An affirmative answer to these questions will lead to special pedagogic problems.

One of these problems has been concisely stated by Leonard Fine in his textbook, Chemistry Decoded.

> "What to do, what to teach?. . . . Should one's first exposure be the kind that shows the more correct but more complicated law, or should one first use slightly less honest lessons which do not require the more difficult ideas? The bigger thrill lies in the perception of the newer reality; but the older theory is easier to get at, easier to understand, and perhaps best opens the road to an understanding of these newer ideas. Many old theories, because of their overwhelming utility and relative simplicity, are happily retained within the basic scientific curriculum - and we do not think any less of them for their limitation. This predicament of pedagogic license and judgment presents itself time and time again." (Fine, p. 3)

"The predicament of pedagogic license and judgment" is an apt phrase. It suggests more than the conflict between old and new, which Fine mentions. There are deeper problems in the neighborhood. Must the teacher sacrifice a rigorous and accurate, but difficult, formulation of scientific ideas in favor of a thrilling and intoxicating, but superficial, exposure to the same ideas? This is a different issue than the conflict between older and new ideas. Pedagogic license reaches into the very heart of scientific education. How far should a teacher or publisher go in using "gimmicks" attractions, cartoons, or other misrepresentations in the name of engaging student interest before the subject is debased or degraded.

While it is true that today's student has grown accustomed to television and print media which specialize in presenting ideas and images in glamorous tones and with an illusory celerity, and while it is true that those media try to create interest and even drama where there is little or none, must science education imitate these approaches? One acquaintance of ours, upon hearing of this study, asked us to investigate old textbooks, at least those of his generation. "They were real tomes", he said, "800 pages of straight facts, no frills." He was right about the size, and right, too, in pointing out what a vast change has occurred. Clearly some science pedagogues have embarked upon a path which creates an ethical issue. If it is true that, as a way of thinking, science requires careful formulation of facts, a rigorous deduction of consequences, and a patient testing of hypotheses, can such a subject be taught using passive methods of quick impression, oversimplification, and facile association? Is scientific knowledge a commodity which can be dismembered and packaged? At what point does the moral question of corrupting the subject become the responsibility of the teaching profession?

There is certainly room for further study of these questions especially when the role of the publisher is under examination. The trend towards glossy gimmicks may be a process which is fostered and promoted by publishers. Do they insist on "dressing up" a textbook with the unnecessary paraphernalia in order to attract student interest or that of teachers who are looking for some new window dressing for the standard introductory course? How much of the soaring costs of texts is attributable to unnecessary color graphics and photo reproductions? This study does not investigate those questions. We can only raise them in the hope that others will pursue the answers.

These developments can be seen as improvements and as ways of making the discipline "fun", but again what is the true "fun" and where is the true excitement to be found? The danger of pedagogic license is that the pivotal role which science plays in developing skills of careful thought as well as the mastery of facts, may be lost in a wash of appealing, but vapid, graphics. The coming decades will tell. The result may be a degrading and a debasement of science education itself. Every educator should be troubled by the declining achievement scores of students at all levels. Some believe that a contributing fact for this decline is the lifelong exposure of students to passive media such as television. If this thesis is correct, a great irony emerges - that the textbook industry imitated, and therefore perpetuated, the very weakness which a science education should overcome!

BIBLIOGRAPHIES OF SCIENCE AND SOCIETY TEXTS

Clark, Ronald D. and Amai, Robert L.S. Chemistry: The Science and the Scene. Hamilton Publishing. Santa Barbara, Calif. 1975. 355 pp. ISBN 0-471-15857-7.

Scientific Method. The authors give a narrow inductivist account and they add the further claims that we use this method in everyday decision making. One example appears on page 7.

History. The history of science is not treated in detail; however, some historical figures are discussed in connection with their experimental or theoretical contributions. This procedure gives some sense of the debt which chemistry owes to its predecessors.

Technology. The authors attempt to draw a sharp distinction between science and technology. "Science is not the solution to all man's problems, nor is it the cause of them all. Actually science should not even be directly involved in the discussion. Science is merely a systematic search for knowledge.... Knowledge alone cannot pollute the atmosphere or devastate the cities. These problems often arise when knowledge generated by science is applied thoughtlessly or carelessly by man in an effort to gain benefits for himself or for a special interest group. In other words it is technology that is responsible for the great benefits man has received from science as well as the great problems that have been created by scientific discoveries." (p. 2). The authors do point out the potential harm of some technological discoveries, e.g., "The fields of biochemistry and pharmacology have not progressed to the point that drugs can be made with complete safety." (p. 230). They also sing the promise of a brighter and better future through biochemistry. "The results might be eradication of cancer, muscular dystrophy, and other fatal or crippling diseases. It may even be possible to extend the human life span by chemically delaying the aging process..." (p. 221). When issues are discussed, the authors try to present both sides of the question, but solely in terms of effects, and not in terms of who or how decisions should be made. In other words, issues are divorced from actual social situations. There is no attempt to point out how various interest groups clash around a given proposal. "It is the responsibility of all people, scientists and non-scientists alike, to weigh the advantages and the disadvantages of a technological advance before applying it to the service of manking." (p. 345). But there is no discussion of how to do this or how it is being done. "The distinction between science and technology is more than semantic.... Evaluation must be done by man. To make intelligent decisions man must be informed of both the advantages and the disadvantages of technological advance. This means that a technologically oriented society requires a technologically aware population." (p. 2). It is not clear if awareness is to extend beyond some factual acquaintance with a problem as opposed to an awareness of how risk assessments and decisions are made.

Value Orientation. The authors are impressed with science's promise for the future. There is mention of space travel, prolonged life, creation of "synthetic living entities" through genetic engineering. (p. 223). "Biochemists might develop a new 'superman' that is stronger and more intelligent than any existing man. Again we must ask whether society wants this." (p. 224). In discussing drug issues, as with others, the authors take the line that individuals must be educated and make their own decisions as a matter of enlightened self-interest. "Moderate use of certain physchoactive drugs probably will be shown eventually to be safe for most individuals, when the drugs are prepared by reputable pharmaceutical companies and are used under the direction of trained personnel. Unfortunately it is not known at the present time which drugs will be found safe; furthermore, illegal sources of drugs are unreliable with respect to purity and concentration. For these reasons, it is safest to avoid the use of illegal drugs...." (pp. 45-46). [emphasis added] Two important points are overlooked here. First, some researchers have data to challenge the first statement. Second, the authors do not mention that some drugs are controlled substances and that alone is sufficient grounds for abstention. While not precisely an argument for the use of drugs, this position makes their "purity and concentration" the primary cause of concern. This may be the inevitable result of failing to show that experts do disagree, or of merely warning of some potential harm without detailing what it is.

An additional topic area listed in Table I is chemistry and space.

Compton, Charles. Inside Chemistry. McGraw-Hill. New York. 1979. 569 pp. ISBN 0-07-012350-0.

Scientific Method. The author stresses the tentative and revisable character of laws and theories. "The laws of science are frequently found to be in need of revision in the light of new facts, or sometimes abandoned altogether, but this does not invalidate their usefulness.... Laws of science are generalizations which express fundamental relationships between factual observations. They are formulated by those who have the background of information and high intelligence to recognize the critical observations. Laws are assumed to apply to all comparable situations beyond those already observed, but since there is always a chance that the future observations may not be in agreement with a law, the provisional nature of a law is never removed." (p. 133). "A correct theory is one which successfully embraces the relevant information of its own time." (p. 136). Broadly speaking the author has articulated and applied an instrumentalist view. This approach avoids the pitfalls of the narrow inductivist account and also gives the sense of science as a revisable body of knowledge.

History. The text has a strong historical orientation. Interspersed throughout the book are anecdotes about the achievements of important historical figures. Nearly a dozen biographical sketches are put in illustrated margins. No women are mentioned. Although only those components of past achievements which survive today are discussed, the historical emphasis does contribute considerably to the reader's impression that chemistry is an ongoing human activity.

Technology. The author does not draw distinction between science and technology. In fact there is such a balance between the treatment of scientific information and technological achievement it would be difficult for the reader to think that there might be important differences. The book contains a long chapter on the chemical industry (Chapter 13) which presents a very favorable picture of industry's accomplishments. Far more space is devoted to its accomplishments than to its liminations. It is described as "beneficial", "flexible", and as possessing "extra ordinary ability" - in short, a series of success stories. "One of the most striking characteristics of the chemical industry is its capacity for innovations." (p. 368). " The Haber Process is a notable example of the extraordinary ability of the chemical industry to bring about new and far reaching solutions to pressing problems." (p. 370). The author does not mention that this prolonged WW I. Potential harm is merely mentioned and not explored in any detail while achievements are touted. "For the most part, the activities and products of the chemical industry are far removed from the public's general knowledge, even though the scale for operations is often huge and the social and economic impact substantial. ...The chemical industry produces an amazing array of products of great value both to the economy and the general welfare, but obviously this work must be carried out in harmonious balance with environmental considerations. Considering the huge scale of operations and their many built-in hazards, the record is moderately good." (p. 376).

This favorable view of the chemical industry is somewhat mitigated by a discussion of the thalidomide disaster, by pollution problems, and the energy crisis. The chapter on energy lists pros and cons, but there is no discussion of any problem in its economic, social or political contexts. The section on population and food production deals solely with technological solutions.

The role of the expert has a great deal of emphasis and is re-enforced by terms like "food experts", "authorities", and "experienced investigators". The reader's role is to be well-informed in scientific matters, to seek or appreciate expert advice, and to understand issues from the layman's point of view(p. 15). No further attention is given to the student's or citizen's role in decision making. The author does mention a few instances where experts disagree, but these are not interpreted as fundamental aspects of the interchange between science and society.

Value Orientation. Chemists appear as a great hope for solving future problems and a boon to mankind. "nowhere are the contributions of chemistry to the general welfare more striking than in the relief of disease and discomfort." (p. 331). Not surprisingly, existing technological solutions to energy problems are endorsed. "Such abundance (of coal) eliminates the need for any imports and gives the nation plenty of time to develop renewable sources of energy. Coal is a relatively low-cost fuel, and the techniques for using it are already in place." (p. 421). There is a tendency throughout to emphasize how the chemical industry can raise production, produce rapid change and growth, and increase quantity. Correspondingly, there is less emphasis on how the industry is regulated, the importance of environmental impact statements and the involvement of the common citizen. Warnings are given, but these are not pursued or explained in detail.

Additional topic areas listed in Table I are the chemical industry and philosophy of science.

Fine, Leonard W. Chemistry Decoded. Oxford Press, New York. 1976. 446pp. ISBN 0-19-501886-9.

Scientific Method. Scientific method can be described in terms of "rules or guidelines for the practicing of science". "Classically one begins by collecting information on data, by observation and experiment. But simply collecting facts is no more than accounting; no science here. The crux of the matter lies in the systematic ordering of information." (p. 14). Since training and practice are required for observation, "perception in a scientific sense is more than perusal". "Science is organized common sense", and this amounts to more than a simple inductivist account. Also, though unnoticed by the author it is not a matter of rules and guidelines.

The author explicitly mentions "the problem of pedagogic license and judgment" (p. 3) which must affect every writer of science textbooks. It is, "Should one's first exposure be the kind that shows the more correct but more complicated law, or should one first use slightly less honest lesson which do not require the more difficult ideas?" In this book there is a move toward capturing the curiosity of students by conveying the thrill of some new ideas.

History. The history of science plays an important role in introducing the atomic theory. Greek science, early atomists, and the phlogiston controversy provide examples. The author takes the time to develop the phlogiston controversy as a scientific issue between theory and evidence, but then dismisses phlogiston as "nonsense". Dalton and Lavosier bring out the "right" answer. Having missed the opportunity to show the plausibility of older views, the author gives the overall sense of linear historical progress. Dalton is given considerable attention (pp. 53-57) and is called "modern".

Technology is not distinguished or mentioned in this book. Specific problems, such as water pollution, are discussed from a point of view which requires little more than understanding some facts. The author lists the eight kinds of contaminants in water and describes them, but these are not discussed specifically in a commercial or social policy context. General warnings emerge. "The demands of industrialization and the consumer society swell the word need out of all proportion. Our modern water needs are all but insatiable." (p. 301).

Discussion of the nitrogen cycle brings up the Haber process. As with other books the life and statements of Haber cause some concern. While others pass by these concerns, this book mentions them indirectly, "...it was Haber who suggested that in times of peace, the scientist belongs to the world, but in times of war, to his country." (p. 325). When Haber was awarded the Nobel prize in chemistry, "...many people at that time criticized the choice of Haber because of his scientific involvement in World War I." (p. 326). This is as close as we come to the issue of the social responsibilities of scientists.

Value Orientation. This book has a large number of pictures, cartoons, caricatures, diagrams, and drawings. The desire to arouse curiosity in the student and to show that chemistry is closely tied with new scientific ideas in physics and biology explains some of the variety of graphics. Still there is the question of how much graphics is too much.

Gymer, Roger G. Chemistry in the Natural World. D.C. Heath. Lexington, Mass. 1977. 573 pp. ISBN 0-669-00343-3.

Scientific Method. Since this text uses chemistry as an interdisciplinary foundation and bridge to ecology and related environmental issues, it treats science as a means of discovery and inquiry into the levels and cycles of natural systems. "We find in nature a grand architecture in which smaller, less complex structural units come together to build ever larger and more complex units." (p. 1). Science tries to understand these levels and cycles by means of theoretical models, but these always have limitations.

A model is a simplified and idealized representation of the real system. A model cannot take everything into account, or its analysis will become unduly complicated. "...Most of the ecological problems we are having today are the result of the use of crude, oversimplified models that neglect too many interrelations within and among natural systems. These systems may be social, economic, or political, as well as the physical natural systems of atoms, molecules, and gases we are concerned with right now." (p. 83). The author strives to keep a large picture before the reader. Nature is the subject matter here, not just chemistry, and it is nature understood in terms of hierarchies, levels, each with its own special properties. Moreover, each level or cycle has intrinsic value or worth. Implicitly a philosophy of nature guides this book and makes it unique. That philosophy might be called "naturalist" or even Aristotlean because it admits emergent non-reducible properties and teleoloical descriptions and explanations.

History. The history of science has a low priority. The overall tripartite organization into Air, Earth, Water, recalls the Greek philosophical tradition with which the author identifies his philosophy of nature.

Technology is understood in a quite different sense in this textbook. Technology and its effects are discussed in relation to the central idea of a "biochemical cycle". Some cycles are more basic, more natural and thus intrinsically more valuable and worthy of preservation. Technology becomes dangerous, undesirable, and even morally culpable when it or human agents interrupt, disturb, or overburden the natural capacities of these cycles. "It is intrusion into some of the basic biogeochemical cycles by human activity that cause many of our pollution problems today." (p. 99). The author rejects any definition of pollution which would define it solely in terms of what is detrimental to human interests. "...pollution is viewed as any deviation from the normal in the natural composition of the environment that adversely affects not just us, but life in general." (p. 117). The belief that humans are stewards of nature and are responsible for care and preservation whenever possible might well describe the leading principle of this view of technology.

The author asserts that educated lay persons have an important role in technological assessment, that citizens have responsibilities to create a good society.

> The proper application of technological assessment could help us avoid an unthinking exploitation of scientific knowledge and attain a better technology. In this way those who now enjoy a high quality of life (not to be confused with a high material standard) and wish the same for their children, may continue to do so, while the disadvantaged of the world may still hope for a better life. (p. 550).

> If a truly participatory technological assessment is to be achieved, laymen must have some basic background in a number of disciplines to help them participate in and evaluate the arguments of technological assessment. The goal should be to create a society whose members can discriminate and assess, who have enough knowledge and insight to guide them in the rejection of bad ideas and acceptance of good ideas. (p. 550).

To support this claim, the author describes the form and language of an Environmental Impact Statement, and although not complete, this section approaches a case study. This reliance on the technological assessment may put the author at cross purposes which his advocacy of the "natural fix" for, in the end, technological assessment is just a version of the "technological fix." He mentions the population problem and other specifically political issues such as the 1976 California referendum on reexamination of the state's nuclear power plant program. "The important questions we must ask are first of all political, social, and moral not scientific or technical. Their answers will add to our survival as human beings and not merely as organisms." (p. 536).

Value Orientation. The 'naturalist' viewpoint goes a long way toward interweaving factual descriptions and normative judgements once one accepts the pivotal ideas of a natural cycle, fitness, levels, and heirarchies. There is clearly a sense of urgency and a sense of promise in this book. The educated reader is made to feel a responsibility for what has happened to nature and is encouraged to do something about it. The author has no truck with cost-benefit analyses, with a utilitarian, much less a consumer or individualist approach. All technological problems in so far as they disturb natural cycles are social human problems. Humans must be guided and limited by what they know nature to be. "But we now know that people can affect the sea, and one of the ways we do this is to regard it as a gigantic waste basket. When nature uses it as its ultimate waste basket, natural processes keep it from overflowing. We should realize that we do not have the same privileges that nature has and so we should be especially careful of our treatment of coastal waters...." (p. 230). "What is not so obvious is the fact that the modern agricultural ecosystem is an inherently unstable system which tends toward a state of greater diversity (and entropy) a state that does not favor humans above all other organisms." (p. 462).

Topics listed under "Other" in Table I include geochemistry (7?), ecochemistry (25), origin of life, conservation and other miscellaneous topics.

Hill, John C. Chemistry for Changing Times. third edition. Burgess Publishing. Minneapolis, Minn. 1980. 396 pp. ISBN 0-8087-3146-7.

Scientific Method. The author avoids calling science a body of accomplished facts and adopts a much more flexible characterization. "Science is a way of trying to cope with our environment through an understanding of the nature of things." (p. 4). It is clearly stated that scientific knowledge is not absolute (p. 5), that facts are often discarded, and that ethical questions enter science in open ended controversy. The author cites unresolved issues such as Pauling's vitamin C hypothesis, the DES controversy, and the effects of LSD, and marijuana. We have a tremendously useful knowledge through science, but its limitations increase as it is applied to complex social issues which have a large number of variables. Science has given us a better life; nonetheless, this knowledge has created problems which the educated layman must be apprised. The author argues that there is no one method in science, and none is explicitly affirmed in this book. There is a reference to the fictionalist account of theories (viz. models in science are picturable concepts which aid in understanding and making predictions). This reference adds to the general theme about the complexity and uncertainty of science.

History. The history of science is introduced through historical anecdotes about major figures, through marginal pictures which show contributions of famous chemists (including women) and through mentioning the human dimension. Overall, the view of history is "Whig revisionist"--science is seen as progressing from ignorance to enlightenment with each episode bringing us one step closer to the present.

Technology is distinguished from science as historically predating science and as having no independent theoretical foundation (p. 2). Modern technology is clearly grounded on research (p. 3). The motivation for applied research is economic. "Applied research is carried on mainly by industries seeking a competitive edge with a novel, better, or more saleable product." (p. 13). Technology and science are the hopes for the continuation of our life style, and while the problems created by technology are not discounted, there is a faith that science can transcend them. "... science and technology probably will be able to provide us with a plentiful supply of energy for the foreseeable future." (p. 174). "Let's hope that scientists soon develop new sources of energy that do not depend on petroleum..." (p. 137). "Even the problem of handling drug resistant strains of bacteria can be solved. It will take a lot of good science to do the job." (p. 321). This appears to be an endorsement of the "scientific fix".

Decisions involving risk assessment are to be made through government channels and must involve science with well reasoned social action. The author offers a "what we can do section" at the end of some chapters, e.g., (a) energy - individual conservation, (b) water pollution - government action and conservation, (c) food additives - government regulations and research. The author advocates population controls (p. 22).

Much of the text addresses the consumer advocate perspective. Many products are listed by brand name and judgments are made about their effectiveness. Specific recommendation include avoiding high priced, heavily advertised products. (p 297, 313). The scientifically literate person can avoid misleading advertising and economic pitfalls.

The author speaks of science itself as "amoral". "This (Van Scott's discovery of a treatment for skin cancer with nitrogen mustards) is indeed a striking case of the amoral nature of science. The knowledge that we have of the properties of molecules is neither good nor evil. How we use that knowledge does involve morality. The knowledge can be used either for our benefit or for our destruction. In this respect, science is no different from the social sciences or the humanities." (p. 331) (emphasis added).

Value Orientation. This textbook attempts to give a balanced view of science as an on-going human endeavor. While technological problems abound, they can be minimized or resolved by more technology, by informed risk assessment, by educated individual judgments, by government control and regulation. Though less stringent than other texts, there is a definite inclination to embrace the scientific fix, but this does not exclude the author's willingness to discuss potential disasters or mistakes. The book is noteworthy in its attempt to include pictures of women chemists, mention their contributions, and to use the "his or her" form of pronoun reference.

The additional topic listed in Table I is cosmetics and personal care.

Jones, Mark M., Netterville, John T., Johnston, David V. and Wood, James L. Chemistry, Man and Society. second edition. W. B. Saunders. Philadelphia. 1976. 706 pp. ISBN 0-7216-5220-4.

Scientific Method is characterized as "accurate, objective, broadly disseminated and more concisely summarized" (p. 229) and not based on submission. The authors avoid the pitfalls of the narrow inductivist account; the scientific method is largely discussed in terms of "attitudes" which require "intellectual honesty and the arrangement of data in a pattern that reveals the underlying basis of the observed behavior." (p. 231).

History. Although largely a 'skills and drills' text, the book is leavened with historical references to the lives and achievements of major figures such as Dalton. It is claimed that this text "will serve well those who wish to examine the beginnings and growth of the science...." (p. iii). Its discussion of the history of the atomic theory is superior to others, however on many other topics they revert to a 'names and dates' view of history. In a reversion to the Whig interpretation of history, the text has a graph to show the progress of the atomic theory. Surprisingly there is a drop in the curve when Aristotle taught! (p. 48). Thus, while the text points out some of the faults in Dalton's original theory and thereby gives some of the excitement and difficulty of the achievement, this approach is not carried over to other topics.

Technology is distinguished from science as "...the manipulation of our environment" (p. 230) which is "always obtained at some cost". (p. 233). Applications of human knowledge have good and bad aspects and choices must be made by informed rational decisions. The authors do not provide case studies; rather they describe attitudes and speak of "Science and Technology as a New Philosophy". (Chapter 11). In the "New Philosophy" the importance of experts and recognition of their authority in making crucial decisions is frequently emphasized. Ultimately, criticism of technology is seen as the voice of the uneducated, the fearful, and the superstitious who are reacting to rapid changes which they do not understand.

"Understanding nature does not necessarily lead to a better world." (p. 235). "Is technology escaping control? Technology is always initiated by man and is therefore under his control in principle." (p. 242). "It is quite easy to imagine a situation in which a technological process can introduce into our environment drastic and irreversible changes which set a chain of events into action before we can stop them." (p. 241). "The vast majority of mankind has no knowledge of the scientific principles upon which technology is based and accordingly must accept the opinions of others on technological matters. This dependence upon experts, in turn, arouses fears of these experts and the damage they can do either by error or by evil intent." (p. 243). "This fear, in some people, is an unreasoning, blind, driving force which leads them to condemn all technology. The only antidote to such fear is an understanding of the technology based on study. Mankind's perennial enemy has been ignorance and the prejudice it generates: Human progress has always been the result of activities of that small percentage of people who accept neither the ignorance nor the popular prejudices of their fellow human beings." (p. 243). "In all fairness, it must be noted that the benefits of technology far outweigh its disadvantages, and also that its transformation of the human condition is still in its infancy. There is, even now, an enormous number of practical problems facing mankind which can be solved only by new scientific discoveries and the technological advances which they will make possible." (p. 243).

Value Orientation. The authors recognize that technology creates problems and they discuss some of them in detail. They frequently rely upon the distinction between the educated (or the expert) and the ignorant masses. One might think of this as an elitist principle. It is explicitly stated that the vast majority are ignorant of the scientific principles which govern technology. This fact makes the role of the expert crucial. There is no discussion of the fact that experts disagree, that they serve their own economic interests or those of their employers; nor is there any mention of the fact that complex environmental problems can be understood in quite different ways, especially by those who are directly harmed or immediately involved. There is no discussion of consumer advocates or consumer rights. Ethical issues are presented as if they were entirely matters of individual personal choice. Thus there are extended treatments of topics such as fluoride in tooth paste and aluminum compounds in deodorant at the expense of larger social issues. A goal of the book is a desire to make highly personal choices as rational as possible. (p. iii). This highly individualistic and consumer centered goal clearly predominates over a view which sees environmental issues as a matter of complex social, economic, and political interaction. Science (particularly chemistry) and inherent values in the scientific method are the best way for an individual to run his or her life. Science is a guide to a better way of decision making and of living. The citizen's role and the interaction of political and economic forces in complex social questions are conspicuous by their absence.

The additional topics listed under "Other" in Table I are cosmetics and natural waters.

Kieffer, William F. Chemistry: A Cultural Approach. Harper and Row. N.Y. 1971. 461 pp. ISBN 06-043638-7.

Scientific Method. The author outlines the narrow inductivist account of scientific methodology and then proceeds to note it is not the exclusive method of science.

"Any method the scientist uses is essentially combining curiosity with imagination to seek answers by experimentation." (p. 10). Science's method is best characterized by the attitudes a scientist has which include "dynamic curiosity, skepticism and ruthless objectivity." (p. 11). While not prescribing a specific method, the author, nonetheless, indicates that science works by the most demanding of ethical principles.

History. Several of the chapters in the text have a strong historical slant. Contemporary understanding of reaction stoichimetry is given by a 'case history' on combustion (Chapter 3). Similarly, the periodic table and the development of the gas laws have a strong component of historical narrative. Each of these accounts is told from the bias which we have called the 'Whig' interpretation of history. For instance, the modern periodic table appears as linear progression in successive enlightenment from Dalton to Mendeleev. He does attempt to tone down the mockery of outdated theories which is often found in texts. In Chapter 2, the Greek view of the elements is told with some sympathy. Thus, an historical development appears to be the result of the continual accretion of more and more enlightenment instead of successive triumphs over intellectual paupers.

Technology. The relationship between science and technology is explicitly discussed. The author makes it quite clear that science is the value free search for truth while:

"Technology is the application of science, especially to industrial or commercial objectives (p. 14). "The goals of technology are solutions to practical problems" (p. 15). The author's discussions of several kinds of technology demonstrates that technological problems do occur. While discussing and then advocating nuclear power, he explores the hazards of nuclear wastes and says in a somewhat alarmist tone:

"An informed citizenry should consider it an obligation to keep informed (about the problem of nuclear wastes)" (p. 200). Several stances on issues are explicitly taken: nuclear disarmament is favored (p. 207), conservation of resources is advocated (p. 392 and elsewhere), and the restricted use of pesticides is outlined (p. 417). In each case, the author makes it clear that more science and technology can solve any problem.

> Existing technology (on disposal of nuclear wastes) must be applied fully and research pursued to find new and better methods for assuring that this form of environmental pollution never be allowed to exist. (p. 200).

Responsibility for control over technology ultimately rests with the individual (see p. 396, pp. 422-423). Hence, there is a necessity for an informed citizenry to be able to direct the government in regulation.

> It is important that human beings thus recognize their responsibility as individuals and not act in an uninformed or emotional way against an impersonal technology as the demon responsible for the destruction of a beneficient environment" (p. 396).

> Ultimately, means of control over what is deemed undesirable will have to be established by government regulation (p. 423).

Value Orientation. The author's general value orientation is typical of most texts in this category. He favors scientific knowledge as superior knowledge, subscribes to the truth and progress view of science and technology and sees the progress in science as a linear accumulation of knowledge. What is unique about this text is that the author makes all these presumptions explicit in his discussions of various topics. There are several sections in chapters that address ethical problems in science: "Ethical Imperatives of Nuclear Energy" (pp. 204-207), "Science and Religion" (p. 367-68), and "Does Science Contribute to Ethics?" (p. 425). The author takes the well tempered, open-minded scientific view. Perhaps the most obvious judgment rendered is the ultimate superiority of science and its methods

"The striving for the highest precision in communication is an attribute of science that could have important consequences if carried into all other segments of society" (p. 95). The internal values of science are of the highest character and deserve to be included in all facets of human activity.

> These values, the dynamic curiosity that seeks and attacks problems, the denial of nihilism, the awareness of all experience, the striving for completeness in communication, and the avoidance of provinicialism, are some which science holds high. ...But the emphasis science gives these suggests that they are worthy of

inclusion among the values upon which all human activity is based (p. 427).

Kieffer, William F. Chemistry Today, Canfield Press. San Francisco. 1976. 596 pp. ISBN 0-06-384550-4.

Scientific Method. This text claims to stress the "interdependence" between science and technology. The author's definition of chemistry: "Chemistry is a human activity which studies the transformations of matter and energy. (p. 1). "Science articulates laws and theories which are inventions of the human mind." (p. 16). Its method is special in that scientists seek theories to answer questions and they test before they accept answers. There is no one scientific method; consequently, the author does not repeat the familiar litany of the narrow inductivist account. The emphasis is on science as a way of asking questions and testing the answers.

History. There is little mention of the history of science in this book.

Technology is a major subject of this book. It is defined thus, "Technology is the application of the scientific knowledge and methods to solving the practical problems of commerce and industry. Technology, like all forms of human activity, such as social structures and systems of government, can be used for good and bad ends." (p. 18). The author points out that government spends tax dollars to regulate technology (p. 20) but does not mention that tax dollars are also spent on research. Although claiming to emphasize the "interdependence" of the two, this book has very little on the ways that commerce, industry, and technology influence and direct the goals of research and the efforts of scientists. Holding to the distinction is more difficult than stating it, especially when it is not clear what is meant by "interdependence". The book is really an introduction to some of the scientific knowledge which underlies existing technology (not an interdependence), and it frequently attempts to justify the status quo with respect to nuclear energy and other extant technologies.

"...all reactors are designed with second level containment systems built in behind the radiation shield. Such an accident (i.e., melt down) would require costly and time consuming repairs, but it would not result in widespread contamination of surroundings." (p. 268). (emphasis added). "The potential dangers from fission reactors cannot be overlooked. Certainly, a public awareness of these is essential. But it is also essential that this awareness does not generate a fear that totally blocks balanced consideration. The nuclear power industry now has a safety record far superior to that of any other industry." (p. 269). The author does not hesitate to affirm, "A look toward the future assures us of one inescapable conclusion. The fossil fuel of the future will have to be coal." (p. 211). He endorses coal gasification. As in some other texts, the author sees science and technology threatened by an irrational, emotional, and fearful public. On the topic of nuclear energy there is no discussion of the plausible and reasonable objections against nuclear energy. Likewise, there is no discussion of the fact that experts disagree. In short, it is arguable that with these omissions the author fails to provide the "balanced view" which he himself finds necessary. There is little on the dangers of nuclear power plants, and a great deal on their commercial benefits. "The possibility of accidents always exists, and we must be sure that steps are taken to minimize such a possibility. The same is true in our private lives; for example, we defy the statistics demonstrating that most home accidents occur in the bathtub! Risk can never be totally avoided. However, sensible awareness and careful planning can decrease any risk. The rewards are worth the planning." (p. 269). The bathtub risk analogy seems very poor. It compares a situation in which individuals have control with one in which they do not.

Value orientation. As noted this text concentrates much of its effort on presenting, understanding and justifying existing technologies. It does not present case studies, nor does it examine incidents in which either the lack of scientific information or the malfesiance of technology has caused human harm.

Students are urged to see science as a guide to living their lives. "Obviously, the more we learn about the way the natural world works, the more we must plan to bring human activities into line. Here is one more illustration of what is meant by saying that scientific information must be the basis on which human society develops a wise plan for the future." (p. 307). This statement is unclear and obscure. At one level it suggests a dangerously one-sided view of how issues are to be understood and resolved. Implicitly it puts forward the expert as a kind of mentor or problem solver. What and how "human activities are to be brought into line" are questions which could undermine many of societies other values. One is lead to think of science as providing a plan for the future if one does not see it as a complex social activity in which there is disagreement controversy, and conflict, just as there is in other institutions.

Spencer, L. and Stoker, H. Stephen. Chemistry A Science for Today. Scott, Foresman. Glenview, Ill. 1973. ISBN 0-673-07808-6.

Scientific Method. The authors introduce the atomic theory early and marshall evidence to convince the reader of its correctness. Theory is distinguished from observation. "A large amount of supporting evidence has led to the general acceptance of the atomic theory as fact, although it is still a theory because no one has seen an individual atom." (p.18). There is no treatment of the scientific method; consequently, not even the narrow inductivist views are found.

History. There are a few references to historical figures and these occur primarily in the chapter on "Chemistry and Medicine". These references are very brief and they do not give a sense of the importance or significance of the achievement.

Technology is not distinguished from science in this book. In fact the words are seldom used despite chapters on so called "high interest" topics, i.e., environmental chemistry, biochemistry, chemistry of the body, and medicinal chemistry. (p. iii). Explanations of technological process are treated in the same way as basic scientific facts. The treatment is so even handed that there is no suggestion of differences between pure and applied research. The reader is left with the impression that the problems created by technology can be solved by technology as causes and solutions become known. (Vide Chap. on air pollution). In the chapter on "Water Pollution" various pollutants are discussed and hazards are listed, but nothing further is said about resolution of these problems. The fact that experts disagree, that many points of view influence decision, and that parties are motivated by a variety of interests are not mentioned.

Value Orientation. The aim of this book seems to be a "value neutral" presentation of basic facts which are relevant to understanding contemporary problems. The supposition is that educated people will use their knowledge as they see fit and presumably basic information is all such people seek. "We feel that educated people...should know something about themselves and their environment. In addition, they should be able to relate to and function in that environment in a way that is satisfactory (to themselves)" (p. iii). In pedagogical matters the authors explicitly state that they "...have used terms or concepts that are a little less than rigorously correct but are more familiar to the student or more easily understood." (p. iii). (i.e., using weight instead of mass). Clearly another sort of selection process has gone into the selection and treatment of technological issues and related social problems.

Wade, Charles G. Contemporary Chemistry Science, Energy, and Environmental Change. Macmillan. New York. 1976. 457 pp. ISBN 0-02-423650-0.

Scientific Method. An announced goal of this text is to stress the limitations of our scientific knowledge of the environment, "...but emphasizes the importance of scientific input when attempting to formulate policies..." (p. vii). Accordingly, it criticizes the popular idea that science is "exact" and that it always has precise answers for every data, the construction of a model or theory that is consistent with the data and useful for making prediction. "...what science really does is provide answers that are consistent with the input data and with the constructed model. A scientific prediction is not more exact than the data and the constructed model. If either or both of these are inadequate or inaccurate, the prediction can be no better." (p. 1). In keeping with this view of the scientific method the author frequently stresses the fact that the environment is extremely complex, complete solutions to environmental problems are beyond man's intellectual capabilities, therefore "...the complexity of the environment makes the data inadequate, dooms the model to a simplified approximation and leads to genuine disagreement among scientists about the validity of scientific predictions. It would be a mistake to assume that science has all the correct answers to the problems we shall discuss." (p. 2).

History. As the title indicates, the book concentrates on contemporary issues. The history of science is not introduced into these discussions. The sense that issues involve people and their opinions is reenforced by the author's assiduous habit of mentioning names, corporate affiliations and dates. Numerous small 'stories' involving the work of these individuals adds an interesting perspective to issues. One of the most interesting is the discovery of juvabione which is a tale which shows the role of accident in scientific discovery.

Technology. There is no sharp distinction between science and technology and the issue orientation of this text can easily lead to the impression that science is the same as its application to problems. Technology must serve social ends, promote conservation, and ensure the habitability of the earth. Technology is seen as providing answers, e.g., solid waste problem can be solved by recycling, water pollution by existing technologies. The author concentrates on population as a problem and advocates birth control (particularly the pill). He discredits the rhythm method. The scientific fix position is tempered by frequent interjection of the political and economic dimensions of various problems. The author covers many issues which lead to questions of moral obligation, e.g., DDT, the kepone disaster, the use of herbicides in Vietnam; however, the moral dimension is not pursued.

Value Orientation. The author never loses sight of his basic assertion that scientific knowledge is limited and technological innovations are not miracle solutions. Cost benefit analysis appears, but never as the decisive voice which override political, social and possibly moral considerations. Each chapter shows a willingness to make value judgments and urge for solutions which involve more than merely facts. "Whether or not we improve the system efficiency, depends more on our collective wills and judgments than on scientific and technological breakthroughs." (p. 259). This approach tends to draw the reader towards an awareness of policy decisions. Of course, students are not policy makers, but the final chapter, "Legalities, Politics, and the Future" gives the reader a sense of urgency because it forecasts the collapse of the world's resources (viz. the Forester-Meadows model). "World must switch to a steady-state economy" (p. 435) otherwise there will be "Hell on Earth". (p. 437). Throughout the book the author questions the popular conception of "Progress", and his concluding chapter is commensurate with the challenge. It leaves the impression that a concerned citizen must not simply act for himself or herself, but rather for the common good to prevent a bleak and catastrophic future.

The additional topics listed under "Other" in Table I are transportation and legalities of technological control.

Wolke, Robert L. Chemistry Explained. Prentice-Hall. Englewood Cliffs, N.J. 1980. 561 pp. ISBN 0-13-129163-7.

Scientific Method. This book is written in a chatty, conversational style which seems to ease the reader from one topic to another. "Pure science is humankind's effort to understand the workings of nature." (p. 4). "Science is absolutely, iron-clad double-your-money back guaranteed to be responsible, sensible, and understandable." (p. 52). While trying to stress the variability of the scientific method, the author ultimately falls back upon the narrow Inductivist account and spells it out (p. 53). In other passages the author attempts to shake off some stereotypical views of experimentation and method. "There are few crucial experiments in science, no scientific experiment gives an unambiguous answer unless all the conditions are spelled out." (p. 30). "There have been errors in the development of science (p. 109), but these can be transcended, i.e., historical development runs in fits and starts and sometimes even in circles." (p. 86). Our increased confidence in what we know leads to Realism with respect to theories. "At what point does faith (in atoms) become certainty?" (p. 98).

History. The history of science is covered in a storytelling fashion. Historical figures are addressed by their given name, i.e., Joseph Proust is "Joe". Although conceding that history does not show a linear development of progress, the author subscribes to the 'great figure' view of his discipline. There are frequent references to Nobel prize winners. In general, the author takes the 'Whig' view.

Technology. "What humankind does with the new knowledge that science uncovers is an entirely different story. That's technology." (p. 4). Pure science is valueless". (p. 6). Applied science is not. There is a need for technological assessment by lay people. Our salvation is through people working through "social tools available for shaping fate." (p. 8). Moreover, technology may save us from itself. "With the single exception of fusion, we already have the technological knowhow for clean methods: solar, nuclear, and ocean thermal. Now what's needed is more engineering development studies...." (p. 316). Fluorcarbon's problem is told as a story of technological fix. (p, 317). "All things considered, I think we are doing just fine." (p. 530). Some of the optimism of the author is balanced by the recognition that the chemistry industry is economically motivated, i.e., food additives. (p. 452).

To show some of the differences between basic research and industrial applications the author explains how research is funded, and writes a narrative about funding a university research project. (p. 11-12). "The necessity for basic research is its eventual probable applications". (p. 8). "Science aids progress. There is no substitute for knowing what's really going on. And that, in a nutshell, is science's value to society." (p. 203).

The fact that experts disagree receives attention. "Although scientists are indeed ordinary people with ordinary human weaknesses, they most certainly didn't choose their careers out of a lust for money and power. There are much better ways of getting them. They choose to become scientists because, for them, science is fun." Thus, they "are just not the type to succomb easily to bribery.... No, deliberate deception cannot explain so many disagreements among scientists on important technological issues that affect our society. The real explanation is that these issues are so complicated that all the hard scientific facts are not yet known" (p. 21). The author argues for serious consideration of Kantrowitz's proposal for a Science Court, (cf. American Scientist, Sept.-Oct., 1975).

Value Orientations. The author sees basic science as value free; normative questions arise in connection with technology. Experts disagree because they must extrapolate from incomplete facts (p. 20), not because self-interest clouds their judgment. While attempting to give a balanced view of many issues such as drug use, food additives and nuclear energy, the author succeeds in making his own view clear. (p. 462, p. 81-82). "There are strong economic motives in the drug industry, look for generic name." (p. 452). In a debate between Prof. Pro and Prof. Con on the hazards of nuclear energy, the author quite unfairly caricatures the con with a cartoon of a scruffy bearded radical, while Prof. Pro is a smartly dressed businessman. The pro-nuclear side wins in virtue of its great safety record, but the reasoning that reaches this conclusion is far from reliable. "The air pollution caused by a typical coal-burning power plant kills about 1000 people over a 40 year period. A typical nuclear power plant kills about 2 people over a 40 year period with its radiation." (p. 167). This is not an assessment of potential harm. Stereotyping the nuclear energy debate in this fashion has its own dangers because it creates the impression that all sides of the question are stuck on fixed points. As is true of many books, this pitfall could be solved by including at least one inclusive case study which shows the complexity of an issue.

The author is aware of the fact that books like his own must face the students expectations and attitudes about science directly. In fact, he presents a 25 question test of "your science attitude", the answers to questions like, "A scientist is just as likely to possess the necessary skill for holding public office as a lawyer or someone in business", reveal whether one has an "open minded" attitude towards science." (p. 24-25). The merits of this idea probably need further testing.

The additional topic listed under "Other" in Table I is food additives.

Young, Jay A. Chemistry, A Human Concern. Macmillan. New York. 1978. 439 pp. ISBN 0-02-431160-X.

This book is difficult to summarize under almost any category but its own. Its purpose is to demonstrate that chemistry is a human discipline with important similarities to all other disciplines including art, poetry, religion and economics. Considerable portions of the text set up comparisons between disciplines through global similarities such as the role of creativity, the imagination, the need to satisfy our curiosity about the world, and the desire to communicate and to understand our surroundings. "Faith and logic" can bridge science and religion (p. 416). Science and economics join on the common ground of developing "...an ordered set of known, or knowable, interactions between mankind and the environment." (p. 417). In a very important sense the excellent detailed bibliographies in this book are crucial to developing the thesis that science and chemistry are closely related to other human concerns and disciplines. These bibliographies also fit the author's avowed goal to involve the self-motivated student and to recognize that not every student will learn the same thing from a chemistry course (p. ix).
Scientific Method. Chemistry is defined as the study of "sensual, delightful facts that demand intellectually imaginative explanations. In this, chemists are not different than others...." (p. 44). It is argued that science is primarily observationally based. This view is reenforced by a lengthy reprint from the famous Farrady lecture on observing a candle. Theories are called combinations of fact and imagination (p. 45), the atomic theory is an "imaginary model" (p. 57). In comparing art and science a slightly different methodology is described. Artist and scientist separate a fact from illusion, they recognize contradictions, search for unifying ideas that show contradictions to be only illusions (p. 413).

The tentative character of certain theories and the limitations of our knowledge are indicated by frequent qualifying phrases, "...for reasons that are not well understood..." or "...poorly understand processes...." Theories are derivable from facts and observation by powers of imagination which resolve apparent contradictions.
History. The book does not mention the history of science in any substantial way with the exception of the Farraday lecture.
Technology. The author does not attempt to distinguish between science and technology in any systematic way. As science is related to many other disciplines, so too is the chemical industry which is "not precisely definable" (p. 375). In a short chapter on the chemical industry (Chap. 13) the author gives a favorable appraisal of that industry's performance. He points out its "flexibility", its "complexity", and its ability to innovate. There are some disclaimers such as, "Not entirely to their credit, some members of the chemical industry have presented these developments as though they were altruistically conceived for the benefit of the consumer. Of course, as in any other industry, the return on investment under the pressure of competition was actually the primary motivating consideration. However, the consumer has benefited also, as is obvious from one glance at your surroundings compared to what it was like only a few decades ago" (p. 381).

In discussing applied chemistry there is emphasis on energy, drugs, air pollution and the environment. Problems raised by these developments and review of potential harms are not covered extensively except in the case of energy. The bibliographies show more balance than the text. The author calls for direct conservation programs, immediate development of solar energy, and wise resource management. There is an implicit assumption of a technologic fix or save. Moreover, there is an explicit call for the richer nations, which are consuming such a large percentage of the worlds' resources, to share with the poorer nations. Not to do so is "foolish and immoral" (p. 193).
Value Orientation. The author does show that there are value issues in the application of research knowledge. Instead of leaving the issue at a list of pros and cons, the author summarizes an issue in terms of the difficult choices between technological alternatives, moral, ethical and philosophical considerations, e.g., genetic engineering (p. 305) and nuclear energy (p. 202). No attention is given to the ethical problems raised by research itself although the author comes close to this problem in talking about the Haber process and WWI. "...it may be possible to conclude that there was some justification (for Haber's motives)..." (p. 165).

It is acknowledged that experts disagree and individuals must make their own choices. Advice on how to judge between experts is given on p. 207-208. The author uses the "his or her" terms of reference.

In the chapter on chemical industry there is no mention of such mistakes and disasters as, tallidomide, PVC, DES, or the flurocarbon controversey. It is regretable that this section did not prompt the same questions the author takes up in other subjects.

"SKILLS AND DRILLS"

Many of the introductory textbooks for non-majors bear a striking similarity to each other. This is certainly no surprise to the science teacher. Books in this category share a common pedagogical goal, which despite various formulations, can succindtly be be expressed as, "To know the rudiments of chemistry is to know a certain repertoire of skills and the best way to acquire those skills is through problem drills." There is a remarkable consensus among authors and, presumably, across the whole profession, regarding what these facts and skills are. The aim of each text is to transmit these facts and inculcate the basic skills as clearly and as directly as possible. Differences emerge in the organization of material, in the quality of the writer's style, in the inclusion of ancillary material, (such as the history of science) and in the perspicacity of illustrations, diagrams, and figures; nevertheless, despite these variations, even a naive reader could see that the subject matter is defined by a common content of facts and skills in which there is little variation. Recognition of this class of introductory textbooks suggests a label for easy reference, and we will use the appellation "skills and drills" to do so.

In the "skills and drills" approach, applied chemistry and topical social or environmental issues receive little or no attention. Applied science usually enters as examples of principles. For instance, the lead storage battery frequently appears as the example of choice for the theoretical explanation of electrochemical cells. When applied science appears in a purely illustrative role, there is little or no mention of the problems generated by the interaction of science, technology, and society. Authors do not raise ethical or moral issues, even when mentioning topics where there is obvious and recorded public concern. A typical example is the cursory mention of nuclear power debate in a section on radioactivity. It appears that textbook authors have decided to avoid political and moral controversies by ignoring them whenever possible. In cases where issues simply cannot be by-passed, textbook writers indulge in a truncated reference. They will say, in effect, "there is a grave problem here with serious consequences," but refuse utterly to say what they are. Many examples of this could be cited, but one from Chemistry for the Health Professions (Henderson and Byrd) makes the point.

> The potential benefits of recombinant DNA are enormous, but at the same time the risks can also be great. The possibility of producing a new and deadly bacteria or virus, or even a human mutation, has turned recombinant DNA research into a highly controversial issue with strong social and political overtones. (p. 689).

Precisely what these "overtones" are and what heights the controversy reaches will not be found in the text. In sum, skills and drills books either avoid issues entirely or they mentioned them in a tangential truncated way.

Another feature of this group is an emphasis on simple quantitative work. The gas laws do not merely receive mention and theoretical explanation, they are also illustrated with numerous examples. Often considerable space is devoted to problem drills. Authors present rules or standardized approaches to problem solutions such as a dimensional analysis method for concentration calculations or a step-by-step procedure for balancing redox equations. Like the presentation of facts, the procedures, problems, and drills are virtually the same in all of these books.

Some Examples of Standardization

There are two important global features in the growth of scientific information[1]; first, the personal dimension of research requires craft-like skills, and secondly, the cumulative items constituting scientific knowledge are the result of a complex social process. A scientist learns his or her research skills by a long apprenticeship to experienced leaders. Many of the skills and value judgments learned are not communicable as rules because they involve the tacit acquisition of laboratory and tool handling know-how. Through apprenticeship, scientists learn how to judge good and bad data, how to follow a good hunch or when to abandon one, how to judge the work of peers, and how to spot good research, and much, much more. The results, but not the manner of exercising these judgments, reach the public in the form of a research report. Even at this stage, the information in the report is vastly transformed from the raw data in the laboratory. The items of laboratory data are tabled or graphed to fit some pattern of regularity. United in a way which antecedently did not exist, the "facts" of a research report represent a major conceptual transformation. What once existed in the tacit judgments of the investigator has taken on the fixed language and the form of a conventional vehicle of communication. Once the research report is prepared, its content enters in a complex social process of evaluation by journal editors and referees. These professionals play the important role of monitoring the quality and significance of research. Further value judgments are made. Publication of a piece of research gives it access to the audience which shapes its evolution.

The information contained in the original report will not live on unless it is recognized by someone and used in further research. The first function of a transmitted fact is to be a vehicle for citation. Removing the information from its original research context

1. These distinctions come from Jerome Ravetz's immensely rich and complex book, Scientific Knowledge and its Social Problems.

constitutes the first step in its transformation. It is now used to support or augment the research of others. As the information is used by others in new situations to do new work, its meaning is altered to fit its role in the new context. It has a "meaning in use" which is quite different from the original. It is the "fact as cited" and not the "fact as first formulated" which becomes the information understood and shared by the scientific community. Thus, if a useful bit of information becomes widely circulated and exploited, it eventually takes on a fixed character. Repetition through citation brings uniformity. At this stage the fact is so far removed from its context of discovery that it has lost all the subtleness and suggestive richness associated with its birth. Repeated application has exposed all the pitfalls inherent in its application. Rules of use and qualifying theoretical statements chart and disclose difficulties in its use, and they give the practitioner an understanding of the fact which is much different from that of its discoverer.

Since at this stage the fact may be readily summarized and since it is invariably associated with a set of <u>solved</u> problems, it is no longer the subject of a theoretical debate. The scientific fact is seen as a paradigmatic answer to a problem. Its meaning no longer includes what was merely suggestive in the original research problem because its meaning has been trimmed and tailored by the set of problems which the fact helped to solve. The first standardizing move is the uniform meaning which a scientific fact achieves when it is associated with a set of solved problems. In this sense the meaning is its solution-history. Ravetz summarizes this process in this way:

For a standard fact is not only something which performs a function in the solution of problems; it is also an assertion about classes of things and events, intended to relate to the external world. Now, as such assertion passes into the social phase of its development, after its original appearance in a research report, its content inevitably changes. Even in the descendant-lattice of problems, its increased precision and sophistication will frequently be achieved by the sacrifice of the deep analysis which enable its first formulation, but which was either unnecessary or incapable of retention in subsequent work. . . But when the fact undergoes standardization, not merely the nuances of its first intimation, but even some important but subtle aspects of the assertion or its objects, are smoothed over and especially when the end-product is examined by an expert in the corresponding descendant field of research. But it is quite necessary, if the fact is to be useful to those who lack the time, skill, or inclination to master the elaborate theoretical context in which its sophisticated versions are comprehensible. (Jerome Ravetz, <u>Scientific Knowledge and Its Social Problems</u>, page 201.)

Standardization does not stop here. Some of the facts which are widely understood among the scientific community are used in teaching. These facts take on a didactic role which involves further standardizing moves. First certain facts are selected as basic or fundamental to <u>learning</u> the discipline, and this is quite different from being basic or fundamental to doing research in the discipline. The core group of basic facts is taught through drills or exercises which bear a remote resemblance to the set of problems for which the fact was a solution. Divorced from their history the basic facts require illustration and examples which are easily understood and easily taught. Teachers create drills and exercises. The meaning of the fact becomes the set of problems, exercises, illustrations and examples which are most efficacious in meeting the demands of pedagogy. As Ravetz has said, it would not be a mistake to call the textbook fact a "standardization of a standardization."

Here is an example from the study of the structure of molecules. Nearly every general chemistry book written includes the concept of the "octet rule" and the Lewis dot structure in a discussion of covalent bonding. This scientific fact was first published in 1916 by G. N. Lewis, although he noted that much of the paper had occurred to him as early as 1902. (cf. G. N. Lewis, "The Atom and the Molecule," <u>Journal of the American Chemical Society</u>, 38, 762-785; 1916.) The original fact, as it appeared in the research report, is embedded in a matrix of the theoretical speculation. In this article Lewis offers the theory of the <u>cubical</u> atom and how its structure explains many material facts. He assumed that an atom consisted of an inner core or kernel with a positive charge which is the same as the group number of the element in the periodic chart. The kernel was not involved in chemical change. Outside the kernel, the valence electrons were arranged at the corners of the cube (except in the smaller atoms like carbon where they "pair" along the edge to form a tetrahedron). Compounds were created when an atom's electrons were shared to complete the cube of each atom. Lewis introduced the notion of differing degrees of sharing to create an explanation of the categories of polar and non-polar compounds and their intergradation. See Figure 1 at the end of the text.

Certainly, Lewis proposed his static, cubical atom in the spirit of scientific realism. It was not a mere fiction. He claimed it best accounted for empirical fact, and he cited the work of a Mr. A. L. Parsens who postulated the electron had both electric and magnetic properties. Evidently the magnetic attractions would stabilize the electric repulsions. In this view, eight electrons would find their most stable position at the corners of a cube. Lewis was also able to explain color on the basis of the vibrations of the electrons; strongly bound electrons would radiate in the ultraviolet; whereas, weakly bound electrons would radiate in the visible. Interestingly, Lewis disagreed with Bohr's hydrogen atom and claimed his static model could equally well account for the spectral series.

In this context, Lewis introduced the dot structure as a symbol for the cubical atom. To Lewis, the letter stood for his kernel, the surrounding dots were the electrons in the outer shell. The closeness of the shared dot pair to the letter symbol signified the differing degrees of polarity, thus Cl_2 is Cl:Cl while NaI is Na :I.

The famous "octet rule" was a postulate, "The atom tends to hold an even number of electrons in the shell, especially to hold eight electrons which are normally arranged symmetrically at the eight centers of a cube." (Lewis, p. 768). This was verified by counts of the valence electrons in various formulas, which nearly always came out in multiples of eight.

It should be apparent that the notion of a dot structure was a notational convenience for the Lewis static, geometric atom. It had a subtlety of interpretation in that the coaction of the dot pair could symbolize the degree of polarity or electron sharing. The octet rule was a theory laden postulate with certain empirical support. Thus in the original research report, the dot structure had rich significance and much attached meaning.

The Lewis dot structure in its standard form, as it appears in textbooks, is considerably transformed from the original report. The notion of the dot structure and the octet rule are introduced in the section on chemical bonding, usually in conjunction with a discussion of covalency. The dot structure concept is used to rationalize why a certain molecular formula exists, i.e., why water is H_2O instead of H_3O. It is also used to do electron accounting in covalent molecules and hence to determine the number and location of multiple bonds. Its introduction usually follows a discussion of electronic structure of atoms, so the dots carry the significance of the outer valence shell electrons linked intimately with orbitals not a static cubical atom. Often, writing the dot structure for a molecule is reduced to a set of rules (e.g. Kroschwitz and Winokur, 252-254). Even the examples given in the texts are standardized. Out of eight books, six used CH_4 and NH_3, while H_2O and N_2 were used in five. Other standard examples are Cl_2, NH_4+, C_2H_4, HCN, H_2SO_4, CO_2, and SO_2. Thus, in its standarized form, the dot structure is immersed in modern valence theory and becomes an explanatory tool.

The change in dot structure concept is a good example of the information decay process that accompanies standardization. Several things have happened here. First of all, the idea is taken from its original theoretical matrix (the cubical atom) and transplanted into a completely different one (modern electronic valence theory). In this case, it is worthwhile to note that Cl_2 for G. N. Lewis is a completely different thing than for a contemporary chemistry teacher.[2] For Lewis, the dot structure was a research tool used to catalog facts in a new and exciting way. It had a richness of interpretation, such as location of the dot pair closest to the "more negative" kernel symbol. As a standard fact, it has a rigorously prescribed location in a text. What was once an original way of thinking has been reduced to a set of rules applied to the same compounds (even the examples become fixed!). The subtleness of the dot pair location is but one obvious example of what becomes lost in this process. The end result is a rather simple, robust concept capable of being used in explanations even by students not well versed in chemistry. However useful this standard fact may be, the point is that an enormous transformation has occurred in the process of standardization. In a real sense, it is a misnomer to call it a "Lewis dot structure" since it bears only a visual similarity to Lewis' dot structure. The static atom became a static fact (of quite a different sort).

The companion concept, the octet rule, is similarly transformed. What was originally a postulate in a theory is now a calculational tool in a textbook. In the original research report, the rule of eight received modest experimental support. As a standard fact, its validity derives from the modern electronic structure of the atom. On the introductory level the octet rule is explained in terms of a set of filled <u>s</u> and <u>p</u> orbitals. For Lewis, the octet concept was intimately linked to the structure of his atom, a cube with eight corners. Obviously the original interpretation is completely unthinkable, even nonsensical, when juxtaposed with the current theoretical support for the octet rule.

The history of science affords another example of the divergence between seminal hypo-

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2. Psychologists, philosophers and linguists have long understood the intimate association between the theoretical presumptions one has and how one sees the world. For an illuminating account of this distinction in science, see N.R. Hanson, <u>Patterns of Discovery</u>.

thesis and descendant textbook formulation. Every introductory text teaches Boyle's law, and most do so in a mathematical form such as $PV = k$, $P_1V_1 = P_2V_2$ or $V \propto 1/P$. The verbal analog appears along the following lines, "At constant temperature, the volume of a fixed mass of a given gas is inversely proportional to the pressure it exerts." In its original form the rule was extracted from a series of observations of air trapped in a U shaped tube. Boyle stated his law in terms of the reciprocal proportion between the "spring" of the gas and "its density." Translation of these concepts into the current terms "pressure" and "volume" did not occur until much later, and indeed the difficulty in making that conceptual change is apparent if one recalls that while "spring" and "pressure" have similarity, "volumn" and "density" do not. Since Boyle did not recognize the constraint of constant temperature, his law underwent further transformation many years later. Boyle probably would not recognize his descendant fact, and he certainly would have difficulty in accepting the notion that his law is not a universal expression of all gases but rather descriptive only of a hypothetical construct called an "ideal" gas.[3]

With evolution (or information decay) as a model for the process of standardization, one might expect to find a propagation of non-lethal anomalies or mistakes. And indeed this is so! One example will suffice. Some texts, in the presentation of the shapes of atomic orbitals, depict the p orbital as a distorted figure 8 with the two lobes touching like two pencil points. These figures are presumably derived from the angular probability plots of the wave function or its square. Anyone who has ever done these will instantly recognize the pencil point plot as grossly incorrect. In spite of such an error, these diagrams continue to be repeated in many of the skills and drills cluster.

The word, "standardization" suggests as part of its definition that there are discrete units or parts of uniform dimension and size which are indefinitely interchangeable with one another. Textbook facts are like interchangeable parts in a number of respects. First they carry a large component of invariant meaning when moved from one theoretical context to another. Examples are the law of multiple proportion and the conservation of masses. Interchangeability of discrete parts permits a variety of rearrangement and this is borne out by the fact that there are many ways of ordering and organizing the material in a introductory chemistry textbook. Order, in a sense, doesn't matter, textbook facts are like beads on a string. Each to be mastered in its turn, but which comes first is relatively unimportant. Curiously, errors such as incorrect probability plots remain invariant under almost any ordering of material. Here, of course, is the first indication of the value question inherent in standardization - it propogates falsehoods.

The Value Dilemmas of Standardization

By its very nature standardization misrepresents science as it actually is; that is, as it is actually understood and practiced by working scientists. It is surprising, if not shocking, that not one textbook in this survey reported, explained, illustrated, or even mention the existence of or the role of research experts. One could easily gain the impression that the nature of scientific discovery and communication differs not a bit from the form and style of the textbook itself. There is an important value issue here. To what extent is the teacher or writer obligated to give a more realistic picture of the scientific enterprise? Another way to put the question is in terms the internal values of science itself. It is often said that scientists must be open-minded, rational, and truth seeking. If so, is it not incumbent upon teachers and textbooks writers to demonstrate how these praiseworthy attributes are articulated, developed, and supported by the scientific community? To show how science's internal values function, the student must learn something other than the standardized version of fact precisely because the standardization process either eliminates or obscures the social process which re-enforces those attributes. Any enterprise which espouses rationality and honesty as its cardinal virtues must, on pain of inconsistency, make some effort to inform its students of the truth about itself. Following the highest principles of rational inquiry is incompatible with telling what Plato called "the Royal lie"; that is, telling a falsehood which is safe, or palatable, more convenient, and easier to comprehend than the truth. Put in the harshest way possible, it is arguable that the exclusive reliance upon standardized facts in the skills and drills texts creates a royal lie about science. It misrepresents what science is in order to present material which is misleading but easier to master.

Standardization has created a pedagogic situation which inherently produces a misrepresentation of the nature of scientific activity. Surely one need not abandon the many pedagogic advantages of standardized facts in order to introduce corrective or counter-balancing measures. Here are some suggestions. By turning to the history of

3. Boyles law is also discussed by Ravetz, p. 208, n. 18, also an excellent paper by C. Webster, "The Discovery of Boyle's Law and the Concept of the Elasticity of Air in the Seventeenth Century," Archive for History of Exact Sciences, 2 (1965), 441-502.

science and investigating one case history in detail, students could be brought to an appreciation of a research problem, its development and eventual transformation. The previously mentioned cases of Boyle and Lewis might do handsomely; others could be easily found. Another possibility is to give students a brief acquaintance with in situ research reports. Even if these reports largely surpass their comprehension, they will, nonetheless, learn something about the internal values of science. The instructor can point out the style and form of the reports, the role of referees and editors, the communicative aspects of publication. Students will see the numerous citations in a research report. The role of authority, the importance of giving credit where it is due, the significance of honesty, replication, etc.--all could profitably be discussed. A report must distinguish its contribution from previous work. Giving credit where credit is due is a version of the moral imperative of telling the truth. Moreover, the student could see the research reports are the products of human enterprise, shaped and acknowledged by human judgments. Attention to the processes of communication within science will resolve the sense, which so many beginners have, that the discipline before them is a pyramid of facts, staggering in complexity, and mysterious in the apparent lack of a social context, remote in their lack of a historical context, neutral in their lack of value of value judgments. Standardization makes one's view of science dangerously one-sided, but it needn't be so, the corrective antidotes are the history of science and actual scientific practice. Both resources can enrich the impoverished skills and drills category.

Another value dilemma seems to stem from pedagogic lethargy and license. On some very important topics, the skills and drills texts perpetuate incorrect and discredited pictures, models, and facts. A prime example is the seeming immortality of the Bohr model of the atom. Why should the planetary model, which has been discredited for over 60 years, be so frequently and faithfully repeated? No working scientist thinks in those terms. Teachers know it is wrong, and yet it endures with few or no critical disclaimers. Again, isn't a discipline whose pivotal values are rationality and truth-seeking obligated to put these misrepresentations in some sort of corrective light? Another example is the enduring standardized version of the law of multiple proportions. Should an instructor state it as an inviolate law or should the true mysteries of nonstoichiometric compounds be adumbrated? At some point the "truer" version will be difficult, but does mere difficulty require that the very existence of a truth be ignored entirely?

One response might go something like this? You are right in pointing out the "skills and drills" group makes a resplendent use of standardized facts, but you cannot fault these books for misrepresenting science and misstating certain facts until you understand what pedagogic goals guided the organization of these books. After all, standardized facts do serve a didactic role and that role cannot be understood without considering pedagogic aims.

To meet this response, our survey collated various statements of the authors' purpose. We found six descriptions of pedagogic goals with many books subscribing to several on the list. They are:

1. To create a scientifically informed laity.

   "...to make rational decision about chemical problems." (Ault and Lawerence, p. iv)

   "to understand this scientific age in which we live." (Maier, p. iv)

   "...to improve our scientific literacy ..." (Cherim and Kallan, p. v)

2. To know about science and its methods

   "...while providing an explanation of its methods and principles." (Kostener and Rea, p iii)

3. To know the history of a science

   "...to give the student an appreciation for the significance and development of science..." (Kostener and Rea, p iii)

   "...an appreciation for the rich historical aspects of chemistry can generate a desire to inquire more deeply into our physical world." (Cherim and Kallan, p iii)

   "...the opportunity to glimpse the complete development of scientific thought..." (Kroschwitz and Winokur, p. xv)

4. To understand chemistry in order to use it

   "...students will have the background skills and the motivation for further study of chemistry or other sciences." (Pottenger and Bowes, p. iii)

   "Chemistry, then, is the central science. It is important and relevant to anyone who wants to become a professional or para-professional in any area of science, medicine or engineering." (Roach and Leddy, p. xviii)

5. To develop tools and skills for thinking and doing

"We believe that the mastery of problem solving techniques...can generate a desire to inquire more deeply into our physical world." (Cherim and Kallan, p.iii)

"...the opportunity...to develop their own reasoning skills..." (Kroschwitz and Winokur, p. xi)

"...students will have the background skills...for the further study of chemistry or other sciences..." (Pottenger and Bowes, p. iii)

6. To have an appreciation of science and chemical knowledge

"The study of chemistry can... gratify our intellectual curiosity about the nature of the physical world..." (Cherim and Kallan, p. iii)

"...should enable students to understand and appreciate much more of what goes on around them." (Maier, p. iii)

"Now, chemistry can be more to you than a requirement, in fact, some people even find it so fascinating that they devote a lifetime to it..." (Seese and Daub, p. 2)

"...few callings are more noble than the humanization of college chemistry.". (Yablonsky, p. ix)

In sum of these six pedagogic goals;

1. increase scientific literacy,
2. learn the methods of science,
3. learn the history of science,
4. learn to use chemistry,
5. to develop skills for thinking and doing, and
6. to appreciate science,

it is not possible, in our opinion, to achieve (2), (3), (6) and possibly (5) without coming to grips with, or at least mentioning, the limitations of standardization. The value dilemmas of misrepresentation and misstatement are permanent obstacles to (2) understanding the methods of science (as actually practiced), to (3) the history of science (as something more than names and dates), and to appreciating and social dimension, the internal values, and the complexity of the scientific enterprise (as a social reality). It is likewise doubtful that (5), developing skills for thinking and doing, can be realized if the inherent limitations of standardizations are never pointed out to the student's questioning mind.

The goal of "increasing scientific literacy" may be fairly argued to be realized in the acquisition of standardized facts. Certainly such facts are a part of the meaning of "literacy"; however, if literacy is to include an understanding of the social dimension of science, it is doubtful that the skills and drills texts achieve that goal. Likewise, if number 4 is understood as the manipulation of standardized facts, it appears that textbooks are achieving that goal; however, there is a vagueness in what it means to "use" chemistry. Does it mean the student should use his stock of chemical facts in everyday life and thereby increase his practical knowledge, or does it mean that as a physical science chemistry exhibits a certain pattern of rational analysis which is applicable to many problems not explicity discussed in textbooks? If the latter, that is if 'using chemistry' is part of learning to follow the method of science, then standardization contributes very little. The skills and drills textbook appeal primarily to one mode of learning--namely, memorization. The drills and exercises of these texts make it abundantly clear that the preferred way of learning is the assimilation-regurgitation model. This is certainly important, but, again, is it one-sided? Solving a problem, learning to think and to "use" chemistry involves memorizing ways to solve drills and exercises. There will probably be no change in science education, and possibly no change in the low scientific literacy in this country until educators and writers address all of a student's cognitive abilities. Certainly scientific literacy must involve more than memorization.

Technology

In examining the skills and drills texts, we found that there is virtually a complete lack of applied chemistry. There is no mention of the distinction between basic science and its technological applications. The content of these books is standardized facts from academic science, and even the examples, diagrams, and illustrations are taken from abstract models rather than from the concrete details of industry. There are one or two exceptions, Pottenger and Bowles devote a chapter to science-technology issues. Scientists must gain, "the ability to predict and control some natural phenomenon", while a technologist solves, "human problems through the production of goods and the providing of services." (Pottenger and Bowles, p. 469). But on the whole, most authors do not make an attempt to clarify the relationship between scientist and technologist. One could easily draw the conclusion that no distinction exists, or that all practitioners of science share a uniform attitude and responsibility in virtue of their shared knowledge.

To put the matter a little differently, in the absence of any discrimination between the complex roles and different positions of research and technology, we find that the general ethos of truth and progress emerges. The activity of science is to pursue truth and to produce knowledge which is truth's artifact. This knowledge has resulted in the betterment of mankind, and it will continue to do so, so long as there are no restrictions on free inquiry. Some examples:

> There is such a thing as 'better living through chemistry' because chemistry has been a conspicuous contribution to the progress of civilization and to the quality of our existence. (Kostiner and Rea, p. 4).

> Chemists are helping to gain information needed for solving the problems of tomorrow while providing us all with better lives today. (Ault and Lawrence, p. 5).

> Our technological capability and our rapidly expanding information reservoir provide the basics for even greater progress in the future. (Ault and Lawrence, p. 2).

By suggestion, but not by example or argument, the skills and drills authors transfer the ideology of truth and progress, which was characteristic of 19th century science, to the science and technology of today. Many years ago the advertising slogan of "better living through chemistry" was purely the coin of the chemical industry and its commercial advertisements. Now we find writers who have completely assimilated the supposed economic and material benefits of technology with the moral requirements of pure research. The ideology of truth and progress, which was once defended as the way to attain knowledge for knowledge's sake, now appears as the justification for a belief in the inherent benefits of technology.

This assimilation or obfuscation of differences between research and its economic applications contributes substantially to the subsidiary idea that there is a technologic (or scientific) fix for every human problem or social issue. Thus when a text does mention that science and technology create problems, they immediately express the connection that sustained research will eventually solve the problem. It is a matter of time, money, and more research. Some examples:

> Similarly, many of these problems can best be solved by the proper applications of other scientific knowledge. (Kostener and Rea, p. 3).

> The specialist of our society-the economist, the engineer, the lawyer - can join with the citizen to anticipate the problems that will most likely arise out of new technology and help provide solutions that will limit future problems. To a major degree, we can select today the problems we want to confront tomorrow. (Pottenger and Bowes, p. 471).

One text, Cherim and Kallan, does acknowledge the real problems created by science:

> Chemistry, the science concerned with the structure and behavior of matter, has provided more than an adventure in living. It has been and still is the basic tool for death and destruction in war. (p. 4).

This is not followed up. The "scientific fix" is obviously dangerously one-sided and misleading. It obscures the fact that economic, political and social interests influence decisions about funding research and implementing technological solutions, there must be more explicit recognition that science, particularly chemistry, and industry and government are closely allied. There must be some indication of the economic realities which shape both the practitioners and the practice of science. Furthermore, the fact that experts disagree should not be hidden; it is no weakness in science education to see the perspectival nature of a technological issue. It is a weakness, we believe, to study a discipline and to read only the noble rhetoric of its successes, ignoring its relationship to the social issues of our time.

Chemistry is, of course, very much an applied science. As such it can be immensely beneficial in expanding a public awareness of disasters such as Love Canal and potential "miracles" such as interferon. As mentioned earlier, one thorough case study of a complex social-technological issue, would go a long way towards restoring a proper balance between science and its applications. Even if such a study did not have a neat and tidy resolution, so long as a diversity of experts, motives, values, and information appeared, it would remedy the one-sided deception of the "technological fix".

On other points our study of "skills and drills" texts showed that "affirmative action" considerations have made some headway. We found little evidence of racial or sexual bias. All books published after 1978 use "him or her" (but not "her or him") for personal reference. With one exception, there is no evidence of sexism in cartoons, diagrams, or pictures. (Vide Yablonsky, pp. 318, 284, 266). One might raise the question of how far authors should go in discussing the role of minorities in their profession. Since there are few women chemists, it is difficult to cite examples. Authors might make greater use of women in non-traditional roles such as laboratory scientists. At present, most texts show men and women in traditional roles, although there are some important and interesting exceptions. Maier and Kroschwitz and Winokur, use a balance of minorities, men and women in pictures. Roach and Leddy are the only ones to cite George Washington Carver. Seese and Daub mention that all nationalities and ethnic groups have made contributions to chemistry. Moreover, they cite some cases.

Image of Science

Like every introductory textbook the "skills and drills" group convey an image of science. One's global impressions are, like beauty itself, difficult to define but certainly not ineffable. In this section we describe the remarkable uniformity of notions about the nature of science. Science is rigorous, rational, observationally based, demonstrative and certain. Most importantly, it is "organized and systematized knowledge." (Seese and Daub, p. 2.) (Also Ault and Lawrence, p. 4, Pottinger and Bowes, pp.5-6, Krischuritz and Winokur, p.5.)

In philosophical terms the theory of science which lies in background is a curious amalgam of "narrow inductionism" with respect to the methodology and positivism with respect to the finished result. As with the science and society texts, the narrow inductivism and empiricism of the 19th century, particularly that of John Stuart Mill, plays a formative role the image of science in skills and drills texts. The essential outlines of Mill's view are incorporated into textbook discussions. It goes something like this: Chemistry is a collection of achieved facts woven together with threads of theory. The edifice of science rests solidly upon an observational foundation. Scientists proceed by (1) observing facts, (2) making a hypothesis, (3) experimentally confirming or rejecting that hypothesis. Now the mistake in this view is, of course, no one has ever been able to show how all of theoretical constructs of science can be reduced to or derived from the vagaries of observation. But even putting aside this false epistemology there is a pedagogic flaw in a textbook espousal of "inductivism." Ironically, none of the material in an introductory textbook is organized or presented inductively, on the contrary, skills and drills texts present material deductively. They give the essentials of atomic theory, the evidence for it, and a set of problems successfully resolved by that theory. In problem drills the student learns ways of deductively proving things given the premises supplied by the theory. There is no induction and little observation in this procedure. Even laboratories are extensions of deductive drills and exercises. Laboratory exercises do not retrace steps of the scientific method, nor do they improve inductive reasoning. They teach one how to follow directions and how to search for a "right" answer known in advance. Talk of induction is merely an old myth about science. One wonders why it even occurs at all.

The emphasis on deductive reasoning and organization shows a strong positivist orientation. The textbook is a rational reconstruction of selected items of knowledge. The actual evolution of such knowledge is irrelevant since what counts most is a perspicacious organization and presentation of standard information. Science in this form is the body of achieved knowledge containing inviolable truths and predictions. Theories exist, as convenient instruments (even fictions) to make predictions and help us control nature. "A good theory has the power to direct prediction and new experimentation." (Pottinger and Bowers, p.6.) Curiously a theory's power to deepen our understanding or satisfy some inherent desire to know is not mentioned. In keeping with positivist ideology, the strength of chemistry is in its ability to predict and control nature. The pragmatic dominates the contemplative; the practical over the absolute.

Interestingly we found that there was some disagreement on the question of whether science was organized common sense or an entirely different non-ordinary way of thinking. (Vide, Kroschuritz and Winokur, p. xv.) The pursuit of organizing and systematizing facts naturally leads to a removal of the supposed extraneous elements. Thus, skills and drills books make no explicit mention of value questions or social issues. By implication science is morally neutral. Neither is there a word about the economics of science, nor anything about the fact that experts disagree, are subject to human frailties, and so on. Exclusion of these extraneous elements also accounts for near exclusion of any examples of applied science or technology. Standardized facts stand pristinely aloof from values and from practical applications.

The value neutrality of science is not a new theme recently created by textbook authors. It is a 19th century defense of academic science's right to pursue research without societal, particularly theological, interference. A modern society, which no longer fears the cross currents of theological and scientific debate, but lives instead with concerns of atomic warfare, pollution, health hazards, etc. will find that the value neutrality thesis is another myth.[1]

To think otherwise is to ignore some obvious facts about contemporary science. First research programs have internal criteria of value which are used to sort good data from bad, sound work from mere hack work, the significant from the merely adventitious. Most academic research is mission oriented and funded by governmental agencies with specific outcomes in mind. This brings research goals within the web of the politics and its accompanying values. The ethical neutrality view ignores the obvious fact that research has its fads and trends and that a particular topic of research may be determined by the desire for economic gain or professional prestige rather than an inherent thirst for truth. If it is possible to separate academic research cleanly from applied science, and in chemistry it

1. Vide. Ravetz, pp. 414-422

is doubtful that one can because of its close connections with industry, the applications of research knowledge will raise further value questions which are completely ignored by the value neutrality thesis. There has been a cry in some chemical circles that there is still too much separation between academic and industrial sectors. In some universities there are programs to bring chemical education even closer to the industrial realm. This development underscores the falsity of the positivist's claim of a value neutral science.

History of Science

The inclusion of historical material in "skills and drills" is a rather common occurence. In their prefaces, a few authors even claim to organize the book in an historical manner. For example, Pottenger and Bowes say ". . . the sequence of topics introduced in this text roughly follows the order of their appearance in the evolution of chemistry" (Pottenger and Bowes, p. 1), and Kostner and Rea put together, ". . . a coupling of the historical development of the concepts of modern chemistry with an essential 'nuts and bolts' approach" (Kostner and Rea, p.iii). There appears to be two ways this is done. First text may, in its discussion of a principle like Boyle's Law, mention the name, date, and place of the discovery, e.g. "In 1660, British physcist and chemist Robert Boyle, carried out experiments on the change in volume of a given amount of gas with the pressure of the gas at constant temperature" (Seese and Daub, p. 246). A second and somewhat more elaborate technique adds a little story to the factual material, e.g., the discovery of radioactivity by Becquerel (Cherim and Kallam, p. 410) or Kekule's dream suggesting the ring structure of benzene. (Kostener and Rea, p. 169). Both the name/date and anecdotal techniques treat history as appendages to standard facts. There is no mention of the intellectual, metaphysical, or religious traditions which motivated the great men of the discipline. The process of the development of science appears to be a continual steady rise, by accretion, to the enlightment of the present day. The past is always presented as if it must have been progressing towards today's understanding. Almost any historian, and particularly historians of science, will be quick to attack the "history as progress" hypothesis. Thomas Kuhn's, The Structure of Scientific Revolutions is rightly praised for giving the counter balancing notions of "normal science," which is a phase of fact accumulation and "revolutionary science," which is a phase of redefinition and re-interpretation. Ravetz has shown why the misunderstanding of the history of science as "progress" attaches so easily to the standardized version of facts found in textbooks.

> In general, the standardization of the materials of a field necessarily kills them. What was created in a succession of turbulent and frequently confused waves of advance, and then abandoned before being fully clarified when the frontier shifted elsewhere, must now be given a tidy organization. It must be presented as if it all started with the discovery of an elementary fact by elementary techniques, and then grew by a linear, logical development with the injection of new elementary facts at the appropriate places. It matters less that such a presentation destroys the actual history, than that it implicitly purveys a false and deadening picture of scientific knowledge and of its achievement, and presents its materials in truncated and vulgarized form. (Ravetz, p. 206.)

Clearly there has been an accumulation of fact, but it is an error to interpret this with the profoundly ambiguous idea of "progress," because use of the word "progress" can easily shift from being a description of the growth of a discipline and its institutions, to an evaluation and approval of its present practices and directions and of the institutions and interests which support it. The history of science can show many conflicting ideas and forces at work in science, just as there are many at work in the present, but it does not show a linear or even a logical development. An important textbook which does show how the history of science can effectively aid the understanding of science is Introduction to Concepts and Theories in Physical Science (by G. Holton and S. Bush). The skills and drills texts have far to go in reaching the real resource that is the history of science.

SUMMARY

Given the pervasive influence of the phenomena of standardization, it is surprising that it is not discussed and debated in the journals of science education. To our knowledge despite much attention to novel strategies, reform programs, and various "crises," there has never been a sustained analysis of the strengths, limitations, advanges, and disadvantages of the standardization of facts. The chemistry profession is now undergoing a reappraisal of its methods by debating the merits of descriptive chemistry as opposed to theoretical chemistry. Without adding fuel to any fire it should be noted that this debate has gone on in past decades. An examination of older textbooks would show that the main features of the debate between theoretical and descriptive modes have been worked over in the history of science of education. An old addage of scholastic disputations tells us that when a debate re-emerges, when the pendulum starts to swing in a direction it has previously traversed, it does so because no one has questioned the fundamental assumptions which generated the issue in the first instance. There is one universal feature common to all skills and drills texts - the standardization of facts.

The polarity between descriptive chemistry and theoretical chemistry does not alter that. In fact, descriptive chemistry and theoretical chemistry differ only in the kinds of standardized facts which they emphasize and exploit. It is a debate entirely within the framework of the standardization process and it is not fundamentally about that process. Consequently, there is little that is genuinely original and novel in this debate and quite possibly in science pedagogy as a whole. It is tempting to speculate that the "crises" wave which flood through science education may be perpetuated by a neglect of the phenomena of standardization. We shall return to this speculation in the conclusion.

While stressing the importance of a critical scrutiny of standardization, it is equally important to emphasize that this must be done without making textbook authors and classroom teachers the subject of criticism. The particular ways that writers and teachers present standardized facts is not a primary issue, it is the phenomena itself which must be understood. Ravetz states the position of teachers with great fairness and understanding.

> It is easy to single out schoolteachers as the prime targets for a critical analysis of standardization. Their social isolation from research activity cuts them off from the stream of sophisticated discussion of the facts and their objectives; and in any event their discussion of the facts will usually have little similarity to those used in current research. Hence they are generally forced to retail standardizations of standardizations, or vulgarizations of vulgarizations, as the case may be. These inherent limitations of the school teaching situation, along with its function of imparting basic craft skills rather than 'understanding' must be recognized if there is to be any fundamental improvement in its quality. (Jerome Ravetz, Ibid. Page 207.)

We need to address the question of what information is important for the student in an introductory course? The pedagogic goals outlined on pp. 25-26 might win universal approval and endorsement, but if it is true, as we have argued, that the intrinsic structure of standardized facts not only undermines but also inhibits those goals, then the teaching profession must face a major reassessment of its primary vehicle of instruction. The presence (or absence) of the kinds of values mentioned in this study ought to be taken as a symptom of an underlying problem and also as an indication of possible avenues of solution. A day may come when the basic facts and drills of chemistry will be mastered through an interaction between student and his computer program. When this day comes, the teacher will have more free time. Will it be used to intensify the absorption of more standardized facts, or will this time be used for the exploration of the real history of the subject and for the discussion of the values and conflicts which guide its present practice? The teaching profession will give its answer in the near future.

In judging our appraisal of standardization it is important to recall that nearly all the textbooks reviewed in this study were written for undergraduate students who will not major in chemistry or physics. A required course in physical science may be the whole of their exposure. Students who do not pursue a major seem to us, at least, to have a right to expect a mastery of basic information and also an understanding of the role of science in the art of living. Up to a certain point standardization meets the former, but it fails, by being one-sided, to meet the latter. In some way the didactic role of standardized facts must be expanded or supplemented by an interpretative or evaluative one which meets the requirements of educated citizens. Here there is need of much solid work in pedagogy.

Ault, Frederick K. and Lawrence, Richard M. Chemistry: A Conceptual Introduction. Scott, Foresman and Co. Glenview, Ill. 1976. 262 pp. ISBN 0-673-07903-1.

This brief text attempts a nearly completely value neutral approach to chemistry. It is notable for more applied scientific examples than usual in this group. The text has an intentionally ahistorical approach, but it lacks even the cursory citation of the name and date of the 'discoverer' of a law or effect. The comments in the standard analysis apply to this text.

Cherim, Stanley M. and Kallan, Leo E. Chemistry An Introduction, second edition. Saunders College. Philadelphia. 1980. 484 pp. ISBN 0-03-056762-9.

This text emphasizes fact acquisition without any applied examples except from nuclear science. Even the illustrative examples for chemical principles have been chosen from the laboratory instead of the technological realm. The usual standard analysis for value presuppositions should be tempered since the authors explicitly mention the esthetic dimension of science; however, this avenue is not pursued in the text itself. The authors, in their introduction, recognize the social problems generated by science and technology. They return to this theme only once in the section on nuclear chemistry.

Kostener, Edward and Rea, Jesse R. Fundamentals of Chemistry. Harcourt, Brace, Jovanovich. New York. 1979. 472 pp. ISBN 0-15-529430-X.

"The text is self-contained, coupling the historical development of the concepts of modern chemistry with an essentially "nuts and bolts" approach to calculations and manipulations of chemical quantities" (p. iii). This is one of the few texts that explicitly promises an historical development. The method of presentation is merely by citing a name and date or by the insertion of a brief anecdote into a traditional fact stating sequence. At least one error of historical fact occurs: Plank is credited with quanitizing light (p. 101). Poor grammatical construction makes it appear that Boltzmann and Maxwell developed the kinetic theory together in 1860 (p. 221) and that Mendelejeev misordered Te and I (p. 134). The comments applicable to the 'Whig' interpretation of history apply to this book.

Kroschwitz, Jacqueline I. and Winokur, Melum. Chemistry A First Course. McGraw-Hill. New York. 1980. 554 pp. ISBN 0-07-035531-2.

This text is a good example of standard facts type text and meets nearly all of those definitional criteria. The style of the text is slanted toward definitions followed by explanation. Interestingly, the authors choose to approach each topic by "complete, logical explanations which include all necessary steps in the deductive process."

Maier, Mary. Introduction to Chemical Science. Willard Grant Press. Boston, Mass. 1978. 435 pp. ISBN 0-87150-722-6.

Here the major emphasis falls on constructing mathematical skills and developing problem solving schemes; consequently, the historical and value considerations are down played. The writer uses a relaxed informal writing style to temper the mass of facts and skills which are presented as chemistry. There appears to be a deliberate attempt to include women and minorities in the numerous marginal cartoons scattered throughout the text.

Pottenger, Francis M., III. and Bowes, Edwin E. Fundamentals of Chemistry. Scott, Foresman and Co. Glenview, Ill. 1976. 494 pp. ISBN 0-673-07876-0

The distinguishing features of this book are the lack of any applied chemistry and the inclusion of a chapter (chapter 21) which discusses science and technology. The authors also claim to have organized the topics roughly in an historical order. Chemical history is presented in the usual manner of name and date citing. The discussion of technology and science is noteworthy for a text in this group. Science is to predict and control nature by experimental and theoretical knowledge, while technology solves human problems through the production of goods and the provision of services. The standard analysis applies to the text.

Seese, William S. and Daub, Guido H. Basic Chemistry, second edition. Prentice-Hall. Englewood Cliffs, N.J. 1977. 576 pp. ISBN 0-13-057513-5.

The standard analysis applies to this text. Some interesting features are the list of contemporary chemists and their contributions and the citation of foreigners and minorities as great chemists. No women are listed in this introductory table. Applied chemistry is introduced mainly in illustrative examples, followed by a footnote explaining the utility of the chemical (see chapter 7).

Roach, Don and Leddy, Edmund, Jr. Basic College Chemistry. McGraw-Hill. New York. 1979. 636 pp. ISBN 0-07-052987-6.

While the authors portray chemists as problem solvers (p. 1) and provide a table of technological achievements of chemistry (p.5), few applied examples are used in the body of the text. When they do appear, it is by way of an illustrative example for some principle. The text mentions three chemical disasters without any analysis. A brief section is devoted to the history of chemistry to Dalton, presented as gradual progression to today's understanding.

Yablonsky, Harvey A. Chemistry. Thomas Y. Crowell Co. New York. 1975. 401 pp. 0-690-00223-8.

The author states that "...there are few callings more noble than the humanization of college chemistry." (p. ix), and he attempts to achieve this goal by seeking to "minimize student distress" by using common place analogies to introduce difficult concepts, (e.g., gas laws are described in terms of the rules of evidence that prevail at a court trial) and by putting mathematical exercises beyond basic arithmetic in an appendix. There are few drills but the standard analysis of chemical facts prevails. The book is leavened by many cartoons and unusual analogies.

(pp. 7, 11, 15, 71). Many of the cartoons are sexist and overtly so. Two short chapters on applied chemistry focus on basic facts and do not discuss issues or problems. A chapter on consumer chemistry does make the following generalization,

> The motives of the Borgias for employing their additives are easily imagined: revenge, jealousy, fear, and other such basic human emotions. Cynics might say that the motives of modern food processors for using additives are similar: greed and ambition. The more fair-minded, however, recognize that modern processors are acting in the interest of improved business, aiming to increase the saleability of their products and thereby increase their profits. Their motives are thus more subtle than the Borgias, and the effects of their additives are, happily, less lethal. (p. 332).

The problem of pollution is encapsulated with a homey analogy.

> The problem is that man, for all his advancement, does not in fact differ so radically from apes who throw today's banana peels on the ground to be slipped on tomorrow. Pollution is yesterday's discarded peels. Its solution is not abstinence from bananas, but beneficial utilization of the peels. (p. 381).

The use of LSD for psychotherarpy is favorably mentioned (p. 348), freon is characterized as presenting "no hazard" at this time (p. 365), and the food additive controversy is confined to one old issue, the "butter yellow" story (p. 334).

EVALUATION OF A MAJOR LEVEL CHEMISTRY TEXT

While the thrust of this bibliography is on textbooks designed for students that are not destined to become science majors, we couldn't refrain from looking at a text designed for students who are likely to be science majors. A leading textbook in this class is W. L. Masterton and E. L. Slowinski's book, Chemical Principles, fourth edition. It may be the most widely adoped textbook in the field. The fifth edition of Chemical Principles, with a new coauthor, C. L. Stanitski, arrived in time to also be included.

The fourth edition of Chemical Principles (CP) is in many ways intermediate in its overt characteristics between the science and society and the skills and drills texts. As Table 3 (see end of text) indicates, it has a large amount of material dealing with subjects that have potential for value discussions. This is a characteristic of the science and society texts. However, like the fact acquiring texts, there is an emphasis on the acquisition of chemical facts and problem solving skills. Stressing the latter material would be expected in a text designed for science oriented students who might be asked to use their knowledge in future courses. The inclusion of large amounts of potentially perscriptive issues is somewhat surprising.

Overall, CP does not present any new issues in terms of its value presuppositions. Its treatment of the scientific method is on par with the more enlightened science and society texts like Hill or Young. Masterton and Slowinski avoid the narrow inductivist trap, chosing to emphasize the method largely in experimental terms. This approach certainly downplays the role of theory in scientific investigation. CP shares the general view of technology as outlined under the truth and progress rubic on page 5. More than most other texts, CP unites the factual exposition of technological processes and chemicals into mainstream of skills acquisition. For instance, in a section on solubility, DDT is used as an example or in a discussion freezing points, ethylene gycol is the chemical system examined. This unity reenforces the assumption that pure research and technology share the same goals. CP does not, however, avoid devoting space to topics with evident value concerns as do most of the skills and drills. Limitations on the availability of natural resources are explicitly mentioned (e.g., p. 81, p. 167). Substantial sections of chapters are devoted to air pollution, water pollution and energy sources.

In many ways, CP handles the history of chemistry better than any other text. True, the end impression given is still that the history of science is a culmulative record of achievement. Nonetheless, CP has several redeeming features which tend to temper that perspective. The text follows the usual practice of interweaving names, dates and short anecdotes into the skills and drills material. Even here, Masterton and Slowinski have done a much better job in making these more unusual and interesting. As an example, in the section on Charles and Gay Lussac's Law (p. 96) it is revealed that their motives were linked to hot air balloon flying, not pure knowledge. In the same section, we find out that Lord Kelvin (p. 97) really had more to do with formulating the law as we know it than did either Gay Lussac or Charles. Clearly, accounts like this, if carefully read, do address some of the real issues in the development of a science. Another interesting feature is the 'historicl perspective'. There are five short essays focusing on biographies of scientists or on retelling the story of a development of an idea. The perspectives on atomic weights and the periodic table are loaded with issues. They show the errors of great scientists, how facts are slow to develop and how ideas, even in science, have an ebb and flow.

> Scientists, even great scientists, are capable of mistakes in reasoning. Sometimes they continue to maintain a point of view in spite of an overwhelming weight of evidence to the contrary. Perhaps we can illustrate the human qualities of scientists and the tortuous path that leads to scientific principles if we follow the atomic weight concept as it evolved in the 19th century. (pp. 37-38)

They do deliver on this. However, since the perspectives are always located at the end of a chapter (even set off on a colored page), we wonder how much the students would carry over into the main text. The biographies, while revealing the human qualities of great scientists, do end up portraying them as men of heroic dimensions. Certainly discussions of these perspectives by the students would go a long way to counterbalancing the Whig interpretation which is so uniformly used in chemistry texts.

A comparison of the fourth edition with the recently published fifth edition is inevitable. The fundamental value structure remains the same. We did perceive some changes, but they come in shades of gray, not black and white. The revision increased the amount of descriptive material in the text (see p. v). The net effect of this is to decrease the amount of material which has value content (e.g., the chapter on water and water pollution is gone) and to increase fact stating. Inspection of Table 3 shows how this change of content has affected the distribution of topics. The increase in technological chemicals and processes is all in the fact stating mode. The introductory paragraphs have been changed from a listing of technological and environmental problems in the fourth to an attempt to define chemistry in terms of the activities of chemists. The total effect is move the text slightly away from the diversity of the science and society texts to the more rigid formal view of the skills and drills books.

TEXTBOOKS WRITTEN PRIMARILY FOR ALLIED HEALTH AND RELATED FIELDS

In our review of introductory texts we found a class of books with a rather narrowly defined purpose: to relate relevant facts and principles to students who would presumably need to use these concepts in their chosen occupation. For the most part this means students interested in what has become to be called in educational jargon the 'allied health' professions, i.e., nursing, clinical technology, physical therapy, etc. The books all feature extensive sections on general chemistry, organic chemistry and biochemistry and are obviously often used in chemistry courses intended for agricultural science, physical education and other vocational programs. The singular goal of providing information of supposed direct utility in an occupation places these texts in a special category for value orientation.

There are a large number of texts in this group. We have reviewed seventeen in this analysis. Perhaps a clue to the number comes from the estimate by Sears and Stanitski (Aspects of Chemistry for Health-related Sciences, pxv) that there are about 400,000 students majoring in a health-related science curriculum requiring some chemistry. Such a large market would certainly be an incentive to an author and publisher, and it would also seem to encourage diversity in the pedagogical modes, content and style. However, as we have remarked on many occasions previously, the chemical education community is hide bound by the merchandising of standard facts. Thus, instead of diversity we have found a striking uniformity.

The books in this section contain large masses of standard facts and drills. In fact, the general analysis we have given for the skills and drills texts (see pp. 20-30) can be applied in toto to these books. We feel, however, given the special mission of this category that certain questions of value arise which do not exist for the other texts. The most striking claim of these texts is that the material covered in the books is directly relevant and useful to the student audience.

> ...(1) presenting systematic methods of dealing with the quantitative aspects of chemistry, and (2) relating, as much as possible, the topics to those situations encountered in daily life and in the health professions.
>
> (Bauer and Loeschen, pxiii)

> (The text) is consistently and directly related to life.
>
> (Hill and Feigl, p iii)

> Because the principles of chemistry are presented in the context of their clinical and biological applications, the relevance of these concepts to the students personal and professional life is constantly emphasized.
>
> (Bloomfield, p vii)

> It (the text) provides thorough, systematic coverage of the chemical information related to health...
>
> (Ucko, p.v)

> The basis for maintaining and restoring humans to good health lies in the chemical principles presented in this text.
>
> (James, Schrek, BeMiller, p 1)

Given this bold mission, we can ask how is this relevance revealed to the students? The answer is in the form of standard chemical facts. These standard facts are chosen from areas of the life sciences where chemistry has been particularly successful. For instance, the topic of osmosis is made relevant by discussing kidney dialysis. Coverage of diabetes occurs often in the section devoted to the chemistry of carbohydrates. The anesthetic properties of ethers are, predictably, reviewed in the section on ethers; as are amphetamines and barbiturates in the organic nitrogen compounds chapter. In each instance, the nature of the relevance is communicated by factual recitation of a chemical cause and effect relationship between a disease and its symptoms or of a listing of the physiological properties of some chemical. In other words, the concept of revelance in these texts is rather narrowly and precisely defined as follows:

A standard chemical fact is relevant if it can be used in a standard explanation in the general field of medicine or biology. These explanations have been highly standardized themselves by the educational community.

Let us illustrate this by a few examples. Nearly all texts treat the physiological symtoms of acidosis and alkalosis either in a chapter on simple acids and bases or in a section devoted to the biochemistry of extracellular fluids. The symptoms are elaborated; then an explanation is given in chemical terms of the shifting of blood system buffer reactions. This is often followed by a description in mechanistic terms of how the body copes with the imbalance. Phenylketonuria (PKU) is another standard example which appears under hereditary diseases in the genetics section or in the chapter devoted to amino acid metabolism. An explanation of PKU is given which depends on the knowledge that the lack of ability to metabolize phenylalanine causes developmental imbalances, particularly in the brain. The cure is mentioned as a diet low in phenylalanine. The acidosis-alkalosis case displays the relevance of simple acid-base theory to a physiological system, while the PKU case supposedly shows the meaning of amino acid theory to metabolism. The notion of relevance used here is highly restrictive. First of all, the examples themselves are truncated. These standard examples displaying standard facts can not reveal the complexity of the problem as it would occur in a clinical situation. If a nurse were to encounter a case of respiratory acidosis, how relevant would the above explanation be? Immediate questions would arise like what is the clinical cause, what tests should be done and how severe is the case? None of these can be answered, in a clinical context, by a chemical buffer theory. Our point is this, the notion of relevance used here is extremely limited to an interconnection between a standard fact and a clinical example.

It is possible, we believe, to argue that standard chemical facts are actually irrelevant to the practice of allied health sciences. The point might be made with the acidosis case in the previous paragraph. The relevant knowledge needed by a nurse presented with the symptoms would be experience in recognizing the overt symptoms of acidosis and knowing how to respond. The response would include whether to alert the doctor, whether to call for tests, etc. These responses are all based on skills acquired by experience, not by a chemist's understanding of the underlying mechanisms. Even the drugs administered are fixed by standard practice. The chemistry of the drug is irrelevant to the practitioner; he or she only needs to know how to recognize the correct drug and when to use it. The same analysis can even be extended into the clinical laboratory. Of all places where chemistry ought to be relevant, this is the place. Actual chemical procedures and analyses are carried out. However, basic chemical facts seldom surface here. The analytical procedures are routine and are not selected by the technologist but rather are established by accepted practice in the field or by law in some cases. Instruments are used which have been, supposedly, carefully designed and manufactured to chart around any chemical ambiguities. The relevance of chemistry is confined to the manipulation of chemical glassware and to the adherence to specific directions; both skills are learned in the laboratory and not the lecture hall or from a textbook. This notion of the irrelevance of basic chemistry is certainly stretching the point. However, it does suggest that what is and is not relevant to a practitioner in the allied health sciences has been established in the confines of chemistry department office and not from the floor of an emergency room.

In order to establish the idea of relevance in a broader sense; we suggest that authors consider the case study approach. For instance, diabetes mellitus is often used as a standard example in sections on carbohydrate chemistry or hormone functioning. An author might construct a case history here which would follow a patient from symptom to diagnosis to treatment. The human complexities as well as scientific principles could be revealed and discussed. It would be possible to discuss the ambiguity of clinical tests, the need to cross-check a diagnosis, and the role of counseling to change nutrition habits. At the same time, chemical principles could be illuminated. Why is the glucose tolerance test run? What biochemical processes created the symptoms? etc.

Two issues from the philosophy of science arise in these books. The first is the claim by some of these texts that there is an exact parallel between the scientific method and medical diagnosis. This is made explicit in texts such as James, Schreck and BeMiller (p. 6), Sherman and Sherman (pp 9-10), and Ucko (p.1). All of these authors display the scientific method as the narrow inductivist model. They then proceed to force medical diagnosis into the same mold. We have already exposed the faults of the narrow inductivist account of scientific activity. Those same comments apply to it as a mode of medical diagnosis. This does leave unanswered the intriguing question of whether the practice of medicine is scientific. An answer will certainly require a much more sophisticated analysis than looking for similarities in methodology.

The second philosophical issue we have noticed is that all the texts in this group espouse scientific reductionism, namely, that fundamentally all of biology (therefore medicine) can be reduced to chemistry.

> It (the molecular basis of life) is the common thread woven through every chapter from start to finish. We aim to see a few ways in which life and health do have a molecular basis and some consequences when something goes wrong at the molecular level.
> (Holum, p. 2)

> Since living cells function because of the great variety of chemical reactions, a study of biochemical principles is important for students and practitioners in health-related fields.
> (Bauer and Loeschen, p. xiii)

> The basis for maintaining and restoring humans to good health lies in the chemical principles presented in this text.
> (James, Schrek and BeMiller, p. 1)

Even the titles of the texts suggest this view: Living Chemistry, Chemistry and Life, and The Elements of Life to name a few. Reductionism may seem axiomatic, especially in light of the rather spectacular success that chemistry has had in giving cause-effect explanations to many biological processes and systems, but it is also a promissory note to be redeemed by future research. From a philosophical point of view, reductionism is but one of many ways to view the relationships among disciplines. For instance, one could take the position that scientific knowledge is produced by the scientific community selecting information and applying it to produce standard facts and techniques. Thus, when a fact is taken from one discipline and applied in another the nature of that standard fact must change because it is being used in a situation where all the difficulties surrounding its use are not known. In this view, reductionism is impossible since the very character of the knowledge changes as it is applied in other disciples. An example of this is the fact that the organic chemist's penchant for correct compound nomenclature topples into a jumble of acronyms in biological chemistry.

When the reductionist concept is applied to medicine, it produces a judgment on what medicine can be and how disease is to be treated. The whole focus, in this view, is on the chemical or biochemical explanation of disease and the attendant chemical response resulting from the administration of drugs. This ignores whole traditions in modern medicine that claim that there is a psychological as well as a physical basis to disease, and that adequate treatment may not call for drugs. The reductionist view also denies as valid the concept of 'wholistic' health which has gained some currency in recent years.

More than any other area, the application of chemical technology to the human being raises all kinds of ethical questions. It is more than a little surprising that none of the texts targeted toward students who will be working with the technology have any discussions of the moral implications of the technology. We have found that the best these books can do is wave the flag. For example,

> Already chemists are forcing E. coli to produce human insulin. Could hereditary disorders be cured by manipulation of human genes? Could highly virulent microorganisms with no natural enemies escape from the laboratory and contaminate the earth? The moral and social implications of artificial genetic recombinations are certain to create political controversy.
> (Fessenden and Fessenden, p. 451)

This is pedagogical cliff hanging. Presumably the controversy hinted at would include the issue of when and under what circumstances society would impinge or restrict the scientists right to investigate. When authors limit themselves to merely indicating that there is a moral problem in the neighborhood without giving any context or perspective, we find the sort of truncated intellectual vision which pictures scientific knowledge as logically independent and conceptually separable from moral and normative ideas. Such a view is certainly dubious (and possibly nonsense) especially in the allied health fields.

ANNOTATED BIBLIOGRAPHY OF ALLIED HEALTH TEXTS

The basic value analysis of these texts is the same as we have applied to the 'skills and drills' texts (see pp. 20-30). See that section for a general treatment. The annotations here relate to specific issues raised by texts or point out unusual features or problems.

In the paragraph counts under the category "Other", we have placed topics which did not fit under the listed categories. Most prominent in these texts is what we have loosely called "Body Chemistry", including such discussions as the functioning of respiration, the blood and urine, etc.

Bauer, Roger D. and Loeschen, Robert L. Chemistry for the Allied Health Sciences. Prentice-Hall. Englewood Cliffs, New Jersey. 1980. 601 pp. ISBN 0-13-129205-6.

This is a good example of a fact acquiring text in almost every way. While drawing on some examples that might be called relevant to allied health, these are sparse (usually only a single paragraph or two at the end of a fact giving section). This deemphasis extends to the illustrations. There are no pictures of allied health personnel or of medically related subjects.

There are no explicit sections devoted to the structure and method of science or to the interrelationship of science and technology. Only occasional references are given to technological problems and these are brief. Chlorinated and fluorinated hydrocarbons, DES, vitamin A, and recombinant DNA are only topics where there is more than a short reference to a complexity. The authors project a positive view of science and technology, with an occasional qualification.

> The study of biochemistry is that endless search to apply the principles of chemistry and biology to both this level of understanding and its application toward improving the quality of life." (p. 556). This is being done (plant breeding) and is a splendid example of applying basic understanding of scientific principles to a practical problem facing mankind. (p. 505).

> Unfortunately, our demands are always high, and our commerical chemical experiments are on such a scale that they can go beyond our ability to curb them before damage is inflicted on our environment. (p. 361).

> Because of their biochemical potency, and important physiological response, the hormones deserve careful study and judicious application. (p. 368).

The discussion of recombinant DNA (one paragraph) implies value neutral science.

> The experiments, regardless of their application, remain landmarks of biochemistry. This series of experiments is the culmination of years of painstaking research, and represents an example of man's effort to unravel some of the mystery of living processes. (p. 532).

The standard analysis for fact acquiring texts applies to this book.

"Other" topics include 7 on body chemistry.

Baum, Stuart J. and Scaife, Charles W.J. Chemistry A Life Science Approach. second edition. Macmillan. New York. 1980. 828 pp. ISBN 0-02-306610-5.

The explicitly stated goal of this book is to provide facts and skills for allied health students (p. v). As such it has many of the features typical to a fact acquiring text. No discussions of science or scientific methodology are given. Very little space is devoted to defining chemistry (see five paragraphs on p. 1). The first eleven chapters on general chemistry are very much in the skills and drills format. The history of chemistry is treated mainly through the citation of names and dates, although more elaborate anecdotes are found in the biochemical section. No distinction is drawn between science and technology; no space is devoted to value judgements in science.

What distinguishes this text from the skills and drills health science books is the amount of applied chemical material covered in the last part of the text. Numerous citations to technologically important compounds are used as illustrative examples. Substantial space is devoted to pesticides, street drugs, recombinant DNA and nutrition. The last topic has an entire chapter devoted to it, (this is a reprint from Chemical and Engineering News) which, in an even handed way, outlines the various dietary and medical controversies surrounding many nutritional substances, e.g., vitamins. The reader would get some ideas about the ambiguity in chemistry as it is applied by the controversies that are aired in the text. There is little in the way of value judgments in the text, though. One of the strongest statements to be found is as follows:

> Until the cause and effect relationship of pesticide exposure and human disease is understood, it is necessary that we prevent their excessive use. (p.359).

Even in the street drug section, the authors resist preaching. They do predominantly feature the hazards of drugs use so that the reader might well conclude that it is not a good idea. This is then a hybrid text, being a cross between a typical skills and drills texts and a science and society type.

"Other" topics include 6 paragraphs on body chemistry and 8 on natural products.

Bloomfield, Molly. Chemistry and the Living Organism. second edition. J. Wiley and Sons. N.Y. 1980. 599pp. ISBN 0-471-04754-6.

The text has the announced purpose of presenting chemical facts in a biological context. The mode of presentation is to give the standard facts usually found in these texts with the usual factual recitation about the uses of certain substances. What distinguishes this book from others is that each chapter is introduced by a case study concerning some event involving (except in two cases) some human medical malady. The case study is not used, however, for the usual intense analysis but rather to show the relevance of the chemical facts in the chapter to the allied health sciences. This gives a strange tension to the text. Each of the case histories is an invitation to ask myriads of normative questions, but only in the case of the nuclear explosion does the author raise, let alone examine, any value questions. The analysis for the skills and drills texts holds for the material and presentation in this text.

"Other" topics covered include 30 paragraphs on Body Chemistry.

Brown, William H. and Rogers, Elizabeth P. General, Organic and Biochemistry. Willard Grant Press. Boston. 1980. 703 pp. ISBN 0-87150-732-3.

This text is basically in the fact acquiring mode. The authors claim to show how the functioning of living systems depends on chemistry; that is, the relevance of the text is supposedly through its applicability to areas of student interest.

The view of science presented is the usual one for this type of text. It is explicitly revealed through a conventional description of the narrow inductivist account of the scientific method (pp. 2-3). A simplistic notion of confirmation is given on p.33:

> Regardless of how many experiments have been done to test a given theory and how much data have been accumulated to support it, one experiment that can be repeated by other scientists and whose results contradict a theory forces the modification or even rejection of that theory. (emphases added).

Additionally, this quote emphasizes the singular, bed-rock solid nature of empirical scientific truths. The general analysis for the skills and drills texts applies to this one, tempered somewhat by the inclusion of what the authors call 'mini-essays'. These narratives stand in contrast to the conventional text. The recounting of the periodic table (pp. 94f-94j) clearly shows how science can make mistakes, refuses to see a fact when encountering it, and can go backwards. The story behind the work with juvenile insect hormones (pp. 448a-448f) sets out the human nature of scientific research.

The history of science is also treated in a manner typical to the fact acquiring texts in general. Again, however, the usual Whig view in the text itself is countered by the 'mini-essays'. The history of the periodic table (pp. 94f-94j) does show that science does not progress linearly. It is curious that these two views co-exist side by side.

The usual comments on technology apply to this text. The text is definitely 'techno-upbeat'. The essay on ethylene (pp. 371a-371b) is without any consideration of environmental impact or alternatives when the feedstock runs out. Under anesthetics, no space is given to severe problems encountered by operating room personnel by the exposure to halogenated hydrocarbon anesthetics (p. 414). The few mentions of scientific controversy are brief and factual; see nuclear wastes (p. 62), freon and ozone controversy (p. 329), and water pollution (pp. 465-466).

While several of the 'mini-essays' relate directly to topics of interest to the allied health professions, the text itself is relatively free from such examples. Additionally, the authors steer clear of any of the numerous ethical issues that have arisen in the application of chemistry to the health care field. The text is another attempt at the description of a value neutral science.

"Other" topics covered include 68 on body chemistry, 40 on natural products and 8 on clinical chemistry.

Fessenden, Ralph J. and Fessenden, Joan S. Chemical Principles for the Life Sciences. Second edition. Allyn and Bacon. Boston. 1979. 526 pp. ISBN 0-205-06506-6.

This text is in the fact acquiring tradition with a heavy emphasis on organic and biochemistry including a full chapter on chemical and clinical tests relevant to blood and urine. The view of science presented is rather typical: the scientific method is a set of "rules" but the authors avoid stating it begins with observation. They also point out the role of imagination, serendipity and luck in scientific discovery. Pure and applied research are distinguished in terms of the presence or absence of a practical, immediate goal (p. 2). The history of chemistry is incorporated only through references to names and dates. Living systems are to be understood by reductionism.

> Let us look at a living system from this rather prosaic viewpoint. A living system is a chemical machine in which chemical reactions occur. (p. 353).

The authors call their pedagogical approach "descriptive" and "pertinent to today's needs" (p. xi). This is understood as giving answers to questions such as, "How do birth control pills work?" or "Why has the use of DDT been banned?" The basics of 'how' and 'why' do not extend to 'ought and ought not'. The relevant sections often leave the problem areas hanging.

> Already chemists are forcing E. coli to produce human insulin. Could hereditary disorders be cured by manipulation of human genes? Could highly virulent microorganisms with no natural enemies escape from the laboratory and contaminate the earth? The moral and social implications of artificial genetic recombinations are certain to create political controversy. (p. 451).

"Other" topics covered include 14 on clinical chemistry, 52 on body chemistry and 7 on ecological chemistry.

Hein, Morris, and Best, Leo R. College Chemistry: An Introduction to Inorganic, Organic, and Biochemistry. second edition. Brooks Cole. Monterey, Calif. 1980. 761 pp. ISBN 0-8185-0349-1.

The text is another fact acquiring book, distinquished from the other allied health science texts in a greater emphasis on general chemistry (468 pages). Several other features are worth noting; there is a short section on the history of chemistry which is much less chauvanistic and Whiggish than most. It recognizes the achievements of the Greeks, alchemists and Parcelsus as important. While few and scattered, there are historical stories and anecdotes, as well as the usual name and date dropping. Most notable is a section on Bohr's work which is intelligently discussed but is not presented as a viable model (p.70). The narrative surrounding the completion of the periodic table is more complete than most.

The view of science presented is rather typical of fact acquiring texts. The narrow inductivist method is displayed on page 6. "The use of the scientific method is usually credited with being the most important single factor in the amazing development of chemistry and technology." (p. 6). Science is a body of knowledge and its work yields social benefit. "The science (of chemistry) represents a basic body of knowledge...". (p.6). "Ultimately, the efforts of successful chemists advance the frontiers of knowledge and at the same time contribute to the well-being of humanity." (p. 1).

The authors discuss the relationship among the sciences and point to chemistry's role in developing technological solutions to problems (p. 4). At this point, no mention is made of difficulties created by some technologies. Science and technology are distinguished,"...technology represents the physical application of this knowledge (science) to the real world in which we live." (p. 6). Glimmers of problems with technology and of value questions appear through the pages of standard facts. There is a chapter on air pollution which clearly outlines the hazards and, in analyzing what has been done, admits automobile exhaust control has its problems (p. 465). The authors also candidly note that industries had to be coerced by legislation to clean up emissions. "The establishment of controls on industry was hampered by economic, political, technological and legal pressures." (p. 463). A short discussion of the unsolved nuclear waste problem is given (p. 372).

"Since petroleum is a nonreplaceable resource, our dependence on polymers is another good reason for not squandering our limited world supply of petroleum." (p. 607). No explicit discussions are given over to value questions and an extensive pro/con approach to technologically sensitive areas is not used. Almost no attention is given to those applied areas most relevant to allied health. For instance, such common issues as drug use or genetic engineering are covered only by very brief mention.

The book has extensive, fact oriented reviews of important industrial chemicals. These notes are found in the sections of the text devoted to descriptive chemistry of the elements and compounds.

In summary, the text has a heavy emphasis on general chemistry and downplays relevant facts from allied health fields. In many ways, the book has features in common with standard fact acquiring texts. The view of science presented is certainly the same. The use of history is more reflective; however, the text in no way is 'historical'. Technology is viewed, essentially, as good. A few problem areas are cited; enough perhaps to allow a student to question.

"Other" topics include 19 on body chemistry.

Henrickson, Charles H. and Byrd, Larry C. Chemistry for the Health Professions. D. Van Nostrand. New York. 1980. 799 pp. ISBN 0-442-23258-6.

This text is a large compendium of standard facts taken from general, organic and biochemistry. Relevance to the health professions is achieved by the insertion at various places of a few short, descriptive paragraphs indicating the importance of a concept or compound to the medical world. The usual mode of presentation is to list the toxicological or physiological properties of a particular compound. Political, ethical and social dimensions of various topics are carefully charted around.

> The potential benefits of recombinant DNA are enormous, but at the same time the risks can also be great. The possibility of producing a new and deadly bacteria or virus, or even a human mutation, has turned recombinant DNA research into a highly controversial issue, with strong social and political overtones. The National Institute of Health has provided

guidelines by which this type of research can be carried out. With proper controls in place, research may continue with a minimum risk of a DNA accident. (p. 689).

"If (genetic) errors are found, the parents are informed of the possible effects to the child and a clinical abortion is a possibility, but the abortion issue is very controversial." (p. 688). This is the moral cliff hanging approach to controversial issues. The standard analysis for skills and drills texts applies to this one.

"Other" topics include 71 on body chemistry, 13 on clinical chemistry and 7 paragraphs on other issues.

Hill, John W. and Feigl, Dorothy M. Chemistry and Life: An Introduction to General, Organic and Biological Chemistry. Burgess Publishing. Minneapolis, Minn. 672 pp. 1978. ISBN 0-8087-3109-2:

This text is to be distinguished from nearly all others in this general category. It owes most of its concepts and content to Hill's other book, Chemistry for Changing Times, (CCT); in fact, much of Chemistry and Life has been copied in total from it. All of what has been said in the analysis of CCT in the science and society texts (pp. 14-15) is applicable without modification to this book.

Several overt stances are taken by the authors. Not only is the text to provide the necessary knowledge for allied health students, it is also to help provide for a scientifically literate citizenery:

> Your work will be enhanced and your life enriched by your greater understanding. (p. vi).

"It will take an educated, informed society to ensure that science is used for human good." (p. 3). The text, as does CCT, takes a proconsumer posture, revealing false claims about headache remedies (pp. 392-393), and antacids (pp. 216-217) and enzyme detergents (p. 544). A little effort is made in instructing the informed lay person how to make intelligent decisions:

> A concerned consumer can easily look up the properties--such as use, toxicity, and side effects--of these ingredients in a reference book such as The Merck Index. (p. 393).

This text, more than many, integrates the topical material into the factual. The standard analysis of a 'skills and drills' text is considerably modified in this instance by the view of science as seen in CCT.

"Other" topics include 141 on body chemistry and 33 on natural products.

Holum, John R. Elements of General and Biological Chemistry. 5th ed., J. Wiley and Sons, 1979, 571 pp. ISBN 0-471-02224-1.

This text is in the fact acquiring category. His fundamental pitch is for understanding the basic vocabulary and principles to serve as a basis for work later in life. He stresses the role of continuing education in the health sciences and the need for the knowledge of the basics in continuing education (see p. v). His mode of presentation is to give the usual 'value neutral' material in an historical way (a few name and dates are mentioned) in the first sixteen chapters. The material and its organization is typical except for scattered short references to applicability of a concept in the allied health sciences. The final seven chapters cover medically (or biochemically) related topics in more detail. In these chapters, the concepts are presented in a factual way. There is considerable space devoted to respiration; pH balance and diabetes. Outside of a few scattered moralisms on diet (pp. 445-6) and fitness (p. 462), explicit value judgements are absent and the more controversial issues are avoided or the ethical problems are downplayed. For instance, in discussing amniocentosis, he says "The procedure is controversial because of the abortion issue." (p. 509), or in discussing nuclear power, "The problem of safely storing highly active atomic wastes for hundreds of years remains a major unsolved problem of atomic energy." (p. 533). Issues in health science which have obvious value content are not extensively treated--e.g., the section on heredity does not mention recombinant DNA or genetic engineering. Problems with prescription drugs, anesthetics, and over the counter medications are ignored. This is consistent with the general 'value neutral' approach.

The view of science implicit in the text is the usual one of champion of truth. Holum does present a simplistic hypothetical-deductive scheme for the scientific method, avoiding the usual narrow inductivist trap. The fact acquiring view of science as producing immutable truth is evident in his discussion of the beginning of organic chemistry: "In 1844, A.W.H. Kolke (1818-1884), who had been a student of Wohler, made acetic acid from compounds everyone accepted as inorganic. The vital force theory was finally laid to rest." (p. 186). Truth, it seems in this view, is instantly recognized. Confirmation is by enumeration of successful finds: "The data gathered by this work attain worldwide acceptance the more they can be reproduced by independent observers conducting repeatable tests and measurements." (p. 4).

In general, the standard comments applicable to fact acquiring texts are valid for this book.

"Other" topics include 48 on body chemistry, 11 on clinical chemistry and 3 on miscellaneous topics.

Holum, John R. Fundamentals of General, Organic and Biological Chemistry. John Wiley.

New York. 1978. 765 pp. ISBN 0-471-40873-5.

The first four hundred pages of this text contain a straight forward presentation of general and organic chemistry in the fact acquiring mode. The author does spend a short section on the nature of science (p. 3) in which he espouses the traditional view of science as achieved knowledge of a natural world which works by fixed principles (p. 3). He does make an interesting statement that all living things have a commonality based on their similar atomic makeup (p. 2). The only concessions to relevance for students with applied interests (the audience of the text, p. v) are the introductory pictures to each chapter. These illustrate chemical principles to be revealed in the chapter.

The last section of the text is a factual exposition about biochemical or chemical technological topics. The author does not distinguish between science and technology and seems to endorse the technological solutions on occasion.

"High yield agriculture, without which there is not even the slightest hope of feeding the world population, depends heavily, for good or evil, on considerable use of synthetic week killers, bug killers and fungi preventers" (p. 402). Even in the presentation of technological or clinical concepts, the author has chosen to do so in a fact presenting mode.

Everything that was said about the author's other text, Elements of General and Biological Chemistry, fifth edition, would hold for this book.

James, J. Lynn, Schreck, James O. and BeMiller, James N., General Organic and Biological Chemistry, Chemistry for the Living System. D.C. Heath. Lexington, Mass. 1980. 752 pp. ISBN 0-669-01329-3.

While in the tradition of the skills and drills texts, this book does have some differing features. The examples chosen to illustrate standard chemical facts are often chosen from medicine, or applied biochemistry. For instance, Boyle's Law is illustrated with a description of breathing, electrochemistry finds application in the operation of the nervous system and isomers find their utility in insect pheromones. Additionally, this text has a longer section that most on the nature of science (pp. 3-6). The scientific method and medical diagnosis are parallel (p. 6). Scientists are depicted as sometimes disagreeing, even blindly so (p. 3).

"Scientists sometimes read into their results what they hope to find rather than what the results actually suggest" (p. 3). The standard analysis for a fact acquiring text applies to this book.

"Other" topics include 87 on body chemistry and 13 on clinical chemistry.

Routh, Joseph, Eymena, Darrell and Burten, Donald. Essentials of General Organic and Biochemistry. Third edition. W.B. Saunders Co. Philadelphia. 1977. ISBN 0-7216-7762-2.

In a short introduction, the authors discuss scientific methodology. They have steered clear of the narrow inductivist trap. They point our that discoveries are often unexpected, or the result of accident, that theories suggest which observations are to be made, that experiments often need to be redesigned, and that a modern investigator is never "completely satisfied with his explanation." (p. 2). The history of science is viewed from the 'Whig' position:

> Most scholars of the history of chemistry attribute the change from mysticism to science as the result of the scientific method. (p. 2).

The authors implicitly espouse the notion that science is value free and that there is no distinction between basic science and technology.

To make the standard facts (which form the backbone of the text) relevant, the authors have inserted sections entitled "Topic of Current Interest" into various chapters of the text. There are only a few of these inserts, presumably so that the text would remain true to the authors' dictum:

> The overemphasis on these subjects (i.e., environmental problems, etc.) often results in the failure to cover the fundamental knowledge of chemistry adequately. (p. v).

The topics covered are not directly related to the allied health sciences. The method of presentation is to give a recitation of the standard facts surrounding a topic like DES or food additives. At the end is a short paragraph which attempts to assess the pros and cons of the topic relative to human or environmental health. In each case, the authors only reveal the problem.

> The discovery of a carcinogen such as vinyl chloride, after such long-term use and exposure, obviously raises the crucial issue of other potential carcinogens to which we are unknowingly exposed. (p. 263).

> On DES: Again, the controversy over the use of an effective chemical (animal growth) vs its potential harmful effects in humans (cancer) is under question and no easy answer is available (p. 294).

> Concerned consumers will have to decide for themselves whether or not to limit their additive intake by reading product labels, limiting their use of convenience foods (which contain the highest percentage of additives) or not purchasing products that contain additives. (p. 389).

This way of indicating "relevant issues" shows little more than the belief that scientific information can warn or indicate potential harm; it does not show the reader how issues are resolved or what considerations lead to decisions in the consumer and health fields. The cumulative effect is to create the appearance that these questions are decided by fact or by purely individual, and possibly arbitrary, choice.

Seager, Spencer L. and Slabaugh, Michael R. Introductory Chemistry. General, Organic, Biological. Scott, Foresman, Glenville, Ill. 1979. 684 pp. ISBN 0-673-15026-7.

Much of the material presented in this book is in the mode of the fact acquiring texts. It uses the citation of names and dates of historical personages to serve as history of chemistry. Nothing is explicitly said about the structure of science, its methods or even what chemistry is. The standard view of chemistry taken by the skills and drills texts must be implied from the methods of fact and skills presentation.

The problem of making the text relevant to the intended audience of allied health students is handled by sprinkling paragraphs on allied science through the mass of standard, pure chemical facts. The mode of presentation of this material is by fact stating. Certain topics receive more extensive commentary which attempts to present two sides to sensitive issues. Hence, we find pro and con discussions of nuclear power (p. 247, p. 267), insecticides (p. 328) and genetic engineering (p. 508). An attempt at balance is made, although the authors have a bias in favor of genetic engineering. Topics more specifically closer to the practice of allied health professionals is similarily inserted in between the standard chemical facts. These presentations are short and without any evaluative commentary.

The analysis appropriate to the skills and drills texts would suffice for this one too.

"Other" topics include 14 on natural products.

Sears, Curtis T. Jr. and Stanitski, Conrad L. Aspects of Chemistry for Health Related Sciences. Prentice-Hall. Englewood Cliffs, New Jersey. 1979. 409pp. ISBN 0-13-049262-0.

This text is a archetypical skills and drills book. While the standard chemical facts that have been chosen to be included certainly are related to allied health field science, these facts remain unleavened with even citations to applied examples. The only exception is in a fairly lengthy discussion of drugs as illustrative of the principles of organic chemistry. Here different categoris of drugs are given and their physiological and chemical properties are examined.

The standard analysis for fact acquiring texts applies to this one.

Sherman, Alan and Sherman, Sharon J. The Elements of Life. An Approach to Chemistry for the Health Sciences. Prentice Hall. Englewood Cliffs, N.J. 531 pp. ISBN 0-13-266130-6.

Nearly all of what has been said about skills and drills texts can be taken over to this text. The authors treat the problem of making standard chemical facts relevant to health science students by inserting facts from medicine or biochemistry into the usual presentation of chemical facts and drills. In the case of this text, there are two chapters that are notable exceptions. Chapters 16 and 17 offer a clinically oriented review of the facts surrounding the blood and urine. While there is no attempt to transcend the fact stating mode of presentation, the material is certainly of more utility to a nurse or clinical technician than much of what is merchandised as relevant.

This text does present some issues in pedagogical value judgments. More than any other text in this group, it relies heavily on caricature and stereotype to communicate to the students. Prominently featured is 'Professor Emeritus', a doltish cartoon figure who presumably stands for the average chemistry professor. The cartoon character is drawn as a 'head in the clouds' (Figure 1-1), somewhat stupid (Figure 2-2, 6-18), and a bore (Figure 7-9). Cartoons are used elsewhere to demonstrate chemical concepts. Thus, the categories of chemical reactions are depicted as transmutations of animals (Fig. 5-4, 4-6, 5-7, 5-8), pH is described in terms of warfare (Figure 7-14); and the laxative properties of magnesium hydroxide is emphasized (Figure 5-9). The text also uses several unconventional analogies. The progression of realism in atomic theory is explained as being parallel to the evolution of dolls to a more humanlike form (Figure 3-3). The sequence of amino acids in proteins is viewed in terms of tennis shoes tied together (Figure 13-5).

The pedagogical bias that selects this mode of communication raises some interesting issues. We have examined some of the dilemmas in pp. 9-10 of this text. The basic question is this: Where is the point at which this emphasis breaks down and begins to either mislead the reader or mock the discipline? This text seems to waver on either side of the thin line between perpetuating stereotypes and misconceptions and communicating chemical facts.

Worthy of method also in the general value orientation of the text was that it was designed in part as a result of a questionnaire sent to nursing, dental hygiene and chemistry faculty.

"Other" topios include 75 on body chemistry, 21 on natural products and 21 on clinical chemistry.

Timberlake, Karen. Chemistry, second edition. Harper and Row. New York. 1979. 582pp.
ISBN 0-06-163409-3.

The author explicitly states she intends to show the relevance of chemistry to those interested in allied health studies. This is done by using a simplified fact acquiring approach, into which various topics from medicine, physiology, clinical chemical analysis, health and nutrition are inserted. These insertions come in the form of short paragraphs in the course of a long, fact acquiring discussion or as brief, separate sections at the end of a unit. The mode of presentation in these units is very factual. While the examples used are indeed closely related to health science, they are clinical rather than 'everyday'. For instance, in the section on hormones, there is no discussion of birth control pills. Also lacking is a treatment of drugs. The topics in nuclear science are almost all related to the medical uses or effects of radiation, omitting the often found cursory examination of nuclear power.

The text does not attempt to treat value issues explicitly. It is nearly totally ahistorical, leaving out even the citation of name and date of the 'discoverer'. Similarly, a discussion of 'what is science' is omitted; the text begins with a nuts and bolts approach to measurement. This kind of presentation narrowly focuses the book on the chemical facts to be learned and on those health science topics the author has found relevant to them. The book, implicitly by use of this approach, takes a value neutral stance to chemistry and its application. The nature of the relevance of chemistry to the health topics is purely factual or explanatory. However, the human issues created by the interaction between chemistry and the health care profession would remain unknown.

"Other" topics include 69 on body chemistry and 6 on other issues.

Ucko, David A. Living Chemistry. Academic Press. New York. 1977. 593 pp.
ISBN 0-12-705950-4.

The text is distinctive from all other allied health texts by virtue of an emphasis on topics and illustrations drawn directly from the allied health fields. However, much of its approach is typical of the skills and drills texts. It shares with them a traditional view of chemistry:

> Chemistry is a science, a systematic and logical organization of facts that describe our world. (p. 1).

Science works by the narrow inductivist method (p. 1) and the author claims this is the mode of medical diagnosis. No distinction is drawn between science and technology, although there is a considerable amount of applied material in the book. It is nearly totally ahistorical. The text is also very non-mathematical, so the material is mostly a collection of facts loosely held together with qualitative explanations. This approach certainly de-emphasizes the view of science as a rigid deductive system of knowledge.

The unique feature of the text lies in the large amount of medically related material to be found in it. Diseases and diagnostic tests are the largest single topics covered, followed by body chemistry, drugs and common industrial processes. The textual material is re-enforced by the liberal use of photographs. Many of the pictures depict workers in the allied health fields doing various tasks. These are placed in the text where the scientific principle involved in the work is first introduced. Women and minorities are prominently featured in these pictures. Another area of pictorial emphasis is in discussion of diseases. Numerous photographs illustrate people or body organs with some disease present. Finally, illustrations are used to push certain aspects of public health: an anti-smoking stance is taken through a picture of a smoker's lung and an anti-smoking poster (pp. 228-229). Similar combinations are used to draw attention to saturated fat (p. 330), obesity (p. 417) and high blood pressure (p. 419).

Most of the applied chemistry is presented in a 'value neutral' way. Little emphasis is given to exploring technological problems or examining value questions. Some examples might suffice. The author does question the effectives of Darvon (p. 532) and certain over the counter sleep aids (p. 538). Street drugs are to be avoided for their possible impurities (p. 544), not for the legal or moral complexities. The author does mention the hazards of drug addiction by doctors and nurses (p. 535).

All in all, the text is an example of a fact acquiring book which contains a considerable amount of 'relevant' material to the student in the health sciences.

"Other" topics include 29 on body chemistry.

PHYSICS TEXTBOOKS

What of physics textbooks for non-majors? Many of the trends such as standardization, cross-disciplinary comparison, environmentalism, can be found in the wide variety of offerings for non-majors. It goes almost without saying that a large number of physics texts show the effects of standardization in much the same way chemistry textbooks do. We shall not persist in documenting that fact because there are some exceptions which deserve comment. Textbooks in the so-called descriptive approach counter the student perception that physics is a formidable discipline filled with recalcitrant math problems. Being the very opposite of the "skills and drills" format, this genre concentrates entirely on mastery of verbal explanations and definitions. In Physics Without Math: A Descriptive Introduction (Prentice Hall: 1979) Gilbert Shapiro, the author, acknowledges that most non-science students have a low mathematical literacy and a corresponding high anxiety. The teacher must face this fact by presenting a course which does not require calculations, and yet he or she must convey ideas which are "lasting and relevant". Shapiro's strategy is to give carefully worded explanations of phenomena and, when appropriate, physical laws. Each chapter concludes with an extensive glossary and a list of questions. Explanation - definition - questions have an obvious relation in being the minimal prerequisites for science literacy or for recognizing a term or idea as belonging to physics. This is part of the author's intent because he believes that such minimally conversant students will become citizens who "will be called upon to make many decisions, and some decisions may involve scientific considerations". (p. xiii) Two questions arise in response to the notion of increasing "cultural breadth and appreciation". Can one really be said to have learned the concepts of physics when there is no corresponding manipulation of problem solutions? Secondly, doesn't cultural breadth include recognition of the ethical dimension of science? Shapiro would appear to have answered both questions negatively. Physics without Math is also physics without values, or more delicately, physics without an appreciation of the ethical issues which surround science and technology.

Conceptual Physics -- a new introduction to your environment by Paul G. Hewitt (Little Brown and Co.: 1977) exudes the enthusiasm for enjoying physics. Its exercises do not stress mathematics but rather "thinking about the meaning and implications of ideas of physics. . ." (p. x). Thus this book is a modified skills and drills text written in a lively style and supported by cartoons and photographs (mostly of children). The title suggests something in the environmental genre, but this is misleading. "Physics is the basic science", (p. 5), and basic physics is what is here. The author quotes at length, and with approval, Einstein's remarks on the ethical responsibilities of scientists,

> "Concern for man himself and his fate must always form the chief interest of all technical endeavors, concern for the great unresolved problems of the organization of labor and the distribution of goods - in order that the creation of our mind shall be a blessing and not a curse to mankind. Never forget that in the midst of your diagrams and equations." (p. 562)

Ironically the author does not show the reader how physicists or physics students could manifest such concerns. In fact, he uses this quote to lead into a section on the Special Theory of Relativity. Like other textbooks, this treatment of ethical responsibility is merely to verbally acknowledge its existence and then pass on to other subjects. Has quoting Einstein become a substitute for physics teachers addressing the sort of issues which Einstein himself addressed?

Many physics textbooks show a preference for using everyday examples (like bicycles and billiard balls) rather than technological ones. To be sure such examples are common, but they also have the effect of directing attention away from the problems created by technology. The Physics Around You (Wadsworth Publishing Co., 1980) by D.D. Long goes far in the direction of how things work in the household from light switches to can openers. Homey examples show the laws of nature. A drawback here is that one finds very little about the structure of science or its method. By contrast a typical "skills and drills" text such as Physics and the Physical Universe (John Wiley & Sons; 1980) by Jerry W. Marion gives neither everyday examples nor technological ones. In their place one finds the neutral lab examples. There is a fair amount of mathematics included and used in explanations. On the whole, this book gives the "value-neutral" picture of science, save for one short section which explains nuclear reactor safety (pp. 395-9a) The analysis is affirmative and upbeat. There is a short but interesting discussion on methodology which reflects openness and flexibility: i.e., physics is a kind of attitude or philosophy concerning the way nature works (p. 27). Regretably the discussion is too short, and not re-enforced by the organization and content of the rest of the book.

Thinking Physics: Questions with Conceptual Explanations, by Lewis C. Epstein and Paul G. Hewitt (Insight Press: 1979) puts basic physics with basic math in the form of question-answer puzzles. The most interesting feature of this approach is its reliance upon diagrams and cartoons as the major vehicle for stimulating questions and providing explanations. There is no history or philosophy of science in this approach; its predominant goal is to stimulate wonder and inquiry about how things work. Mechanics is the fundamental model for understanding everything. This pedagogic strategy aims directly at that segment of the student body which enjoys problem solving and which might be convinced that physics is the field that satisfies such a craving.

Physics: Principles With Applications by Douglas C. Giancol (Prentice Hall: 1980) is a rather long text in the skills and drills category. With its emphasis on quantitative problem solving, it stands in sharp contrast to the physics without math genre. Although little space is devoted to the structure of science, what there is, is informative and contemporary. The history of science appears as reference to big events, but the author does manage to relate an achievement without falling into platitudes about enlightenment vs. ignorance (pp. 564 and 570). Nuclear processes again bring the reader close to value questions. A short checklist of power generating schemes tells us that "each has its problems" (pp. 480-484). There is a plea for conservation (p. 484) and in general a suggestion that decisions must follow risk/benefit analysis. But we are not shown how to reach such decision. There is a section on nuclear warfare and the moral problems of weapons research are mentioned (p. 743). While these instances are few and possibly superficial, they are not found in other texts. They do show that it is possible for physics textbooks to incorporate value questions.

Physics for the Inquiring Mind by Eric Rogers (Princeton: 1966) and Introduction to Concepts and Theories in Physical Sciences by Gerald Holton and Stephen Brush (Addison Wesley: 1973) share high praise from critics and teachers because they set a standard and have become a model for textbooks in general education which combine physics with history and philosophy of science. Rogers provides more diagrams and illustrations: Holton and Brush give more math and problem assignments. Both give a presentation of Greek astronomy, proceed to examine Galileo's achievement and the growth of modern science. The historical perspective is more than the "name and date" variety and something less than a case study approach. The history of science appears as thematic context for presentation of standardized facts. Such a context sets the stage for dialectical treatment of some of the philosophical ideas of great scientists. Holton-Brush give Newton's famous dictum in Principia, "Feign no hypothesis" and set it alongside his speculations on the ether in Optics. The contradiction between positivist restrictions and speculative theory building emerges as an indication of a basic tension in scientists. The fundamental impulses to "avoid error" and to "seek truth" lie behind the great achievements of science and hence behind every standardized fact. Ironically, the standardized fact covers up the speculative reach toward "truth seeking". Holton-Brush-Rogers use the history of science to show the bold speculations behind standard facts. Regretably neither book deals with value questions other than the internal norms of truth seeking; consequently, the basic neutrality of physics seems to be affirmed. The elegant integration of history, philosophy and physics in these textbooks may have had the detrimental effect of leading all these writers who would emulate Holton-Brush-Rogers successes to think that a general education course cannot handle value questions and science and technology issues. The fact that in the history of pedagogy, liberal arts courses first turned to the history of science as a way of showing their connection with the humanities, should not be taken as a demonstration that such a design is the only one possible. The case study-value issue approach can make an equally valid claim to satisfying general education. If the history of science holds too much of a grip on physics for non-majors (whereas in chemistry it holds too little), it may be opportune to redress an imbalance by following a recommendation from previous chapters, namely give at least one thorough case study of a technological issue along with the historical perspective. The emphasis, as before, must be on doing a complex issue extremely well.

Other conclusions which this brief review indicates are these: In the conceptual space of disciplines, physics stands further from the health science professions than does chemistry and biology. Does this make physics less relevant? Does it force the physics textbook to avoid taking biological or biophysical examples? There is a preference for everyday mechanical examples in physics. Must this be so? Authors may be able to explore a new direction by choosing examples closer to the health professions, and they may come closer to the ethical questions which abound there.

The larger moral questions of weapons development, and nuclear technology do seem to involve physicists and physics directly. Why aren't the ethical and moral responsibilities of scientist given greater attention? It is not enough to cite Einstein and let the matter rest there. Human welfare must be before the mind of the scientists, even tangentially, otherwise there cannot be any talk of the ethical responsibilities of scientists.

POSTSCRIPT

The presence of values such as rationality, truth-seeking, a commitment to free inquiry, an appreciation of scientific progress, the reliability and the authority of scientific and technologic solutions and the importance of these solutions in our economy and society has been documented in this study. Because these values are espoused as guides to solving problems and ways of thinking about societal issues, they become, in their strongest form policy recommendations and in a weaker form they elicit subtle changes in attitude. Since it is intrinsic to the nature of education, particularly higher education, to produce such changes, it would be plainly incorrect to think that teachers and authors are wrong to use the materials of introductory textbooks to present opinions, issues, facts, and policies whose ultimate effect is to change student attitude about science in a free society. The question, therefore, is not whether or not there are value presuppositions and prescriptions in science textbooks, but rather, how should such values be argued, defended, or criticised? Once this question surfaces and receives attention from science teachers "non-major" textbooks may appear in novel and more stimulating formats. If there is a central cluster of values in science pedagogy, and if these are shaped and preserved by the standardization process as well as the author's preference and expertise, then those values ought to be stated in a context or form which is different from, but not incompatible with, the ways in which basic facts and fundamental skills are stated.

In several places our study has alluded to the need for case studies in both the history of science and in contemporary "science and society" issues. The fact that no textbook provides even one thorough case study suggests that textbook writers and teachers have overlooked something. One thorough case study of a given social issue or of a given episode in the history of science could teach more about the interaction of facts and values than superficial summations of numerous unrelated issues and incidents. Decisions about significance will dictate which issues deserve detailed analysis in the case study format. A "science and society" textbook, for example, might contain one very thorough and normatively diverse analysis of a complex issue like nuclear energy. A standard "skills and drills" textbook could cover the development of a standardized fact like the Lewis octet rule, by showing its inception, errors, modification, and transformations. Certainly, it would not be possible to do more than one or two case studies in a semester's time, and this limitation creates a problem of its own when an introductory course, whose avowed purpose is to provide breadth of exposure, must give its time to the depth of detail in a case study. But again, it is our belief that just one case study, whether historical or topical, will do more to show the reality of science's growth and interaction with society than a host of historical anecdotes or a series of sketches of current problems.

The advantages of the case study approach is that it removes the tendency to be glib and to dissemble. Moreover, as much as is possible with the written word, the case study method resembles and portrays the interaction and conflict of dissonant values in actual situations. Experts disagree, teachers disagree, and students disagree. A science student can appreciate disagreement and avoid the easy conviction that some authority has the "right" answer only if he or she can appreciate that scientific knowledge is the result of a process rational disagreement. Students can learn to appreciate pluralism in a democratic society and also the role of rational dialogue in conflict resolution.

Another advantage of the case study method is that it is a kind of teaching which combines precept and example; consequently, it has a certain affinity with the role of laboratory exercises and their attendant reports. Of course, an analysis of a social issue encompasses a far wider range of variables, but even at the broader level of discovering how a social issue takes shape and gains public attention one can learn to record, observe, and interpret how subtle differences of judgment might affect an outcome.

There are risks in the case study method. One must find representative examples. Thalidomide and DDT will not raise the same kinds of issues as Three Mile Island and nuclear energy. The choice of which issues to tackle will be pivotal since it is likely that only one or two case studies could profitably be included in a terms work. An author's or teacher's expertise will, no doubt, determine the selection. No one can cover every issue by the case study method not only because no one has that much expertise, but also because the resulting textbook would be unorganized, unteachable and probably unreadable. A whole series of case studies would add nothing to a textbook already crowded with basic information. One possibility would be to have case studies published separately, but correlated with, existing textbooks much in the manner in which study guides are developed as adjuncts (some would say substitutions) for leading textbooks. Case study manuals like teachers manuals, would be aids to instruction on how to discuss the divergent values implicit in each issue.

If, in the future, computer instruction takes up the role of inculcating basic scientific information, the science teacher and the student may find that they have the time to explore the historical, philosophical, and normative elements in their discipline. At that time there will be no surprise at the many values and issues exposued in science education, for these will have been seen to be the necessary elements of an expanding process of inquiry. At that time it is to be hoped that educational materials which expose and document those elements will be available.

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TABLE I PARAGRAPH COUNT FOR TOPICS IN SCIENCE AND SOCIETY TEXTBOOKS

TEXT	POLLUTION AIR	POLLUTION WATER	POLLUTION OTHER	DRUGS, MEDICINE	AGRI-CHEMICALS	TECHNOLOGICAL CHEM. INDUSTRIAL	TECHNOLOGICAL CHEM. HOME	ENERGY NUCLEAR	ENERGY FOSSIL	ENERGY OTHER	FOOD AND POPULATION	WAR-FARE	NUCLEAR SCIENCE	GENETICS	OTHER[1]
Clark and Amai	54	44	8	65	3	38	39	5	4	23	0	4	12	0	36
Compton		36		139	33	59	0	12	80		48	8	22	0	29
Fine	11	16	0	8	4	40	9	1	2	1	0	3	4	0	11
Gymer	76	102	11	40	26	11	0	19	30	0	23	3	0	6	173
Hill	85	70	0	326	70	66	72	24	26	25	150	28	6	5	48
Jones, et. al.	99	49	0	78	3	160	46	14	31	12	54	0	16	6	94
Kieffer[3]	21	5	12	16	5	94	12	18	25	26	18	0	8	4	9
Kieffer[4]	31	10	15	2	6	31	0	24	13	1	10	0	3	15	53
Seager and Stoker	68	92	0	86	15	114	33	7	19	0	0	10	12	0	0
Wade	130	114	100	67	139	0	3	82	173		75	0	8	0	97
Wolke	61	26	0	60	30	59	51	17	120		0	8	5	11	15
Young	12[2]			39	0	140	3	23	14	43	16	0	0	0	4

1. See individual bibliographies for topic specification over 10 paragraphs
2. Does not include a very extensive bibliography on the topic
3. <u>Chemistry Today</u>
4. <u>Chemistry A Cultural Approach</u>

TABLE II PARAGRAPH COUNT OF TOPICS FOR SKILLS AND DRILLS TEXTBOOKS

TEXT	POLLUTION			DRUGS,	AGRI-	TECHNOLOGICAL CHEM.		ENERGY			FOOD AND	WAR-	NUCLEAR	GENETICS	OTHER
	AIR	WATER	OTHER	MEDICINE	CHEMICALS	INDUSTRIAL	HOME	NUCLEAR	FOSSIL	OTHER	POPULATION	FARE	SCIENCE		
Ault and Lawrence	3	0	0	3	0	26	2	10	1	0	0	0	24	0	0
Cherim and Kallan	0	0	0	0	0	0	0	16	0	0	0	2	13	0	0
Kostiner and Rea	12	6	0	0	1	11	8	3	0	0	0	0	4	0	0
Kroschwitz and Winokur	0	0	0	0	0	0	0	1	0	0	0	0	6	0	0
Maier	8	0	0	0	0	0	7	0	0	0	0	0	0	0	21[1]
Putterger and Bowes	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0
Roach and Leddy	0	0	0	0	0	0	0	0	0	0	0	2	8	0	0
Seese and Daub	4	8	0	0	1	9	1	0	0	0	0	0	0	0	0
Yablonsky	20	15	0	30	0	2	16	2	0	0	0	7	10	0	16[2]

1. Origin of life
2. Cosmetics

TABLE III PARAGRAPH COUNT FOR MAJOR LEVEL TEXTBOOKS

TEXT	POLLUTION			DRUGS,	AGRI-	TECHNOLOGICAL CHEM.		ENERGY			FOOD AND	WAR-	NUCLEAR	GENETICS	OTHER[1]
	AIR	WATER	OTHER	MEDICINE	CHEMICALS	INDUSTRIAL	HOME	NUCLEAR	FOSSIL	OTHER	POPULATION	FARE	SCIENCE		
Masterton and Slowinski	24	34	0	1	9	91	15	13	24	6	0	1	20	0	16
Masterton, Slowinski and Stanitski	24	0	0	5	0	130	10	15	23	6	0	2	6	0	16

1. Mostly atomspherical chemistry

TABLE IV PARAGRAPH COUNT OF TOPICS FOR ALLIED HEALTH TEXTBOOKS

TEXT	POLLUTION			DRUGS,	AGRI-	TECHNOLOGICAL CHEM.		ENERGY			FOOD AND[2]	WAR-	NUCLEAR	GENETICS	OTHER[1]
	AIR	WATER	OTHER	MEDICINE	CHEMICALS	INDUSTRIAL	HOME	NUCLEAR	FOSSIL	OTHER	POPULATION	FARE	SCIENCE		
Bauer and Loeshen	0	3	0	28	0	14	4	1	0	0	10	0	7	1	7
Baum and Scaife	0	0	0	74	19	43	10	0	0	0	141	2	6	5	14
Bloomfield	0	0	0	91	0	10	4	6	0	0	12	0	8	0	30
Brown and Rogers	1	5	0	44	26	33	16	5	4	0	32	0	6	0	116
Fessenden and Fessenden	0	0	0	43	2	13	3	4	12	0	25	1	0	8	73
Hein and Best	69	11	0	26	0	83	22	5	0	0	5	4	7	3	19
Henrkkson and Byrd	0	0	0	104	1	27	7	0	0	0	26	0	13	4	91
Hill and Feigl	13	7	0	217	42	58	25	10	0	0	15	12	7	2	175
Holum, "Elements"	5	0	0	68	0	8	4	4	0	0	0	0	23	0	62
Holum, "Fundamentals"	NOT COUNTED														
James, Schreck and Bemiller	1	0	0	88	6	16	9	0	4	0	61	0	0	4	100
Routh, Eymena and Burton	18	7	0	63	11	26	17		3		49	0	6	5	0
Seager and Slabaugh	17	18	0	32	4	26	12	4	0	0	3	5	5	0	14

1. See individual bibliographies.
2. Includes discussion of nutrition.

TABLE IV Continued

TEXT	POLLUTION AIR	POLLUTION WATER	POLLUTION OTHER	DRUGS, MEDICINE	AGRI-CHEMICALS	TECHNOLOGICAL CHEM. INDUSTRIAL	TECHNOLOGICAL CHEM. HOME	ENERGY NUCLEAR	ENERGY FOSSIL	ENERGY OTHER	FOOD AND POPULATION	WAR-FARE	NUCLEAR SCIENCE	GENETICS	OTHER
Sears and Stanitski	0	0	0	68	0	0	4	0	0	0	18	0	8	0	0
Sherman and Sherman	0	0	0	58	0	18	3	3	0	0	4	3	12	0	117
Timberlake	0	0	0	39	0	25	0	0	1	0	41	0	12	6	71
Ucko	4	3	0	52	0	19	4	2	0	0	20	0	10	2	29

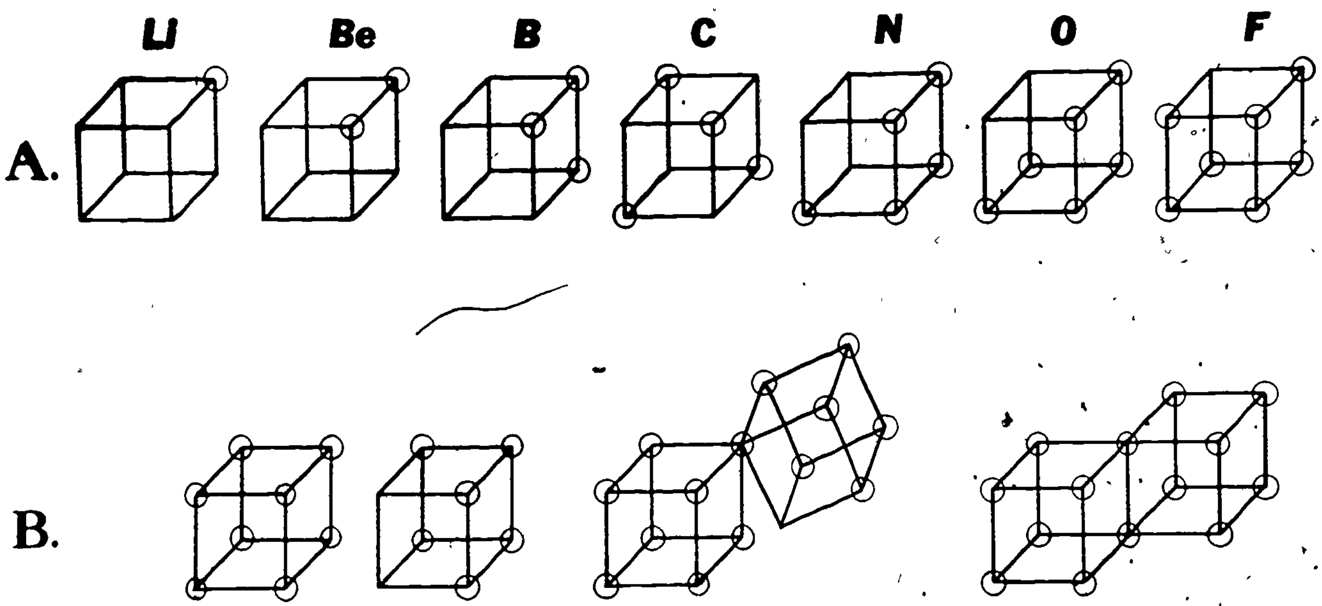

Figure 1. A. Here are 'Lewis' cubical atoms for the first row of the periodic table.
B. This series shows the combination of two iodine atoms into an iodine molecule in a series of three steps. (Adapted from the Journal of the American Chemical Society, 38, 762-785; 1916.)