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ABSTRACT

In this publication, issued twice per year, four major topics are discussed: (1) chemistry course content, including chemistry for nonscience students and nurses; (2) using media in chemistry, such as behavioral objectives and audio-tutorial aids; (3) chemical technology, with emphasis on the Chemical Technology Curriculum Project (Chem TeC); and (4) chemistry and environmental pollution, including water, air, and soil pollution. (MH)

2YC

Chemistry in the Two-Year College

1971 No. 1

COMMITTEE ON CHEMISTRY IN THE TWO-YEAR COLLEGE
DIVISION OF CHEMICAL EDUCATION
AMERICAN CHEMICAL SOCIETY

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The Two-Year College Chemistry Conference program completed its first decade this year. During this period, twenty-six conferences have been held throughout the country. During this same period the numbers of two-year colleges and the number of faculty in these colleges have increased significantly. An even more significant development in these ten years has been the increased professional chemical education contributions from the two-year colleges and their faculties.

Commencing with this volume as a response to the growth in the conferences and contributions mentioned above, the Committee on Chemistry in the Two-Year Colleges will publish two volumes a year of papers contributed from the Two-Year College Chemistry Conferences and other sources. The papers are made available as one of the services of the Division of Chemical Education to the chemical education community, primarily to that portion concerned with the two-year colleges.

[illegible] conferences and these publications are possible only because of the work of the members of the 1971 Committee on Chemistry in the Two-Year Colleges listed on the back cover and their predecessors. These contributions have been magnified by financial support from the Division of Chemical Education for the last five years and by the 1971 industrial-commercial and college sponsors, listed elsewhere in this volume.

Much of the value received from the $2YC_3$ programs is derived from the efforts of host institutions and their staffs. Four-year institutions as well as two-year colleges have invited us to use their facilities, frequently at their inconvenience and at some cost. We are deeply indebted to the following host institutions which have not been mentioned in previous $2YC_3$ Proceedings.

Bronx Community College, New York City, New York
Fullerton Junior College, Fullerton, California
Oral Roberts University, Tulsa, Oklahoma
Ohio State University, Columbus, Ohio
Wilbur Wright College, Chicago, Illinois
Delgado College, New Orleans, Louisiana
Catonsville Community College, Catonsville, Maryland
Los Angeles Trade-Technical College, Los Angeles, California

We are fortunate to have Mr. Kenneth Chapman as our editor and wish to acknowledge his work in the preparation of this volume. As chairman of the Two-Year College Chemistry Conferences and the Committee on Chemistry in the Two-Year Colleges, I wish to thank all of those who have participated in the conferences and on the committee for their contributions during this last decade.

We look forward to an even greater second decade and invite all those concerned with chemical education in the two-year colleges to join us in this exciting, stimulating, interesting, and educational venture.

William T. Mooney, Jr.
Chairman
Committee on Chemistry in the Two-Year College

[illegible]

Change and Growth have been synonymous with Two-Year College. The "Proceedings" of the Two-Year College Chemistry Conference have also been susceptible to change and growth.

In the past, the "Proceedings" have been developed to follow the format and content of the conferences being covered. At times, this procedure produced material that was less complete than desired and discouraged publishing of useful and timely material that was of great current interest to two-year college chemistry teachers. With the extension of the conferences to four meetings per year, the volume of information for the "Proceedings" increased to the point that considerable expansion was required if overly severe editting was to be avoided. To ease the Editor's burdens, an Editor is now being appointed for each $2YC_3$ meeting so that he can take charge of collecting papers and information for his particular meeting. The first persons with specific responsibilities for this were Jay Bardole, Vincennes University Junior College (Chicago, 1970), and William Griffith, Hinds Junior College (New Orleans, 1970), and C.G. Vlassis [illegible] College (Baltimore, 1971).

This pressure for expansion coincided with a small catastrophy that coincided with the Editor's move from Washington, D.C. to Berkeley, California. One box of office files was lost in the mails, and yes, it contained a wonderful set of papers presented at two $2YC_3$ meetings.

Thus, we decided to proceed with ideas that had been discussed to publish a "Proceedings" twice per year and organize it more along topical lines. Although a "Rush Job," this volume of "Chemistry in the Two-Year College" is the first publication with the new format. Hereafter, you can expect a volume to become available about every six months.

Completing this volume depended very heavily upon the grand cooperation of chairmen and Conference Editors for the $2YC_3$ meetings that are represented here by papers and articles. For preparation of the copy, our appreciation to the staff members of the Lawrence Hall of Science cannot be sufficiently expressed. On short notice, they worked long hours, through weekends, and got the job done. Lastly, my thanks to the key person for producing this volume, Sandra Manderson, who came through grandly under an unbelievably heavy work load.

Kenneth Chapman
Editor, $2YC_3$
American Chemical Society
Lawrence Hall of Science
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BUILDING A COMPLETE GENERAL CHEMISTRY COURSE PROGRAM

James Hall
W. A. Benjamin, Inc

After reading the returns from questionnaires we mailed this spring to 1340 junior college and liberal arts college chemistry teachers (some of you may have received the questionnaire), I am convinced that there is a great variety of chemistry courses taught throughout the U. S. Naturally, there is some common ground in all these courses, and the variety may indicate only the inherent individuality of teachers and the differences in student needs. The variety of courses causes some to say that the state of chemical education in the U. S. today is chaotic. I do not agree with this, but I do recognize that there is a tremendous effort by teachers today to make their courses meet the needs of today's students. If the results are not too different from course to course then perhaps the variety of courses and curricula supports my contention that it is not as important what you teach, but how.

You may like to know some of the results from the questionnaire. The results show that many students enrolled in terminal general chemistry courses in junior colleges and liberal arts colleges are interested in elementary and secondary school teaching, premedical curriculum, business administration and liberal arts. Areas such as nursing, agriculture, home economics, psychology and sociology ranked lower as student goals. About two thirds of the teachers responding to our questionnaire said that they emphasize traditional topics found in standard general chemistry texts. Most of them further said that they supplement the traditional topics with applications. Such applications include chemistry of human physiology, agriculture, medicine, drugs, air and water pollution, the effect of chemicals on ecological systems, history of chemistry, molecular biology, and foods and food processing.

We asked the question: "Would you like to have included in the text, or supplementary reading material, discussions of how chemistry applies to our everyday living?" Of those responding, 311 replied "yes" and 17 "no".

Our respondents also indicate that if programmed materials, study guides and a teacher's manual were provided, they would use such material. This is encouraging because we did provide these materials for the Chemical Principles Teaching System, published by Benjamin last spring for freshman chemistry students.

Two thirds of the teachers responding said that they use audio or audio-visual material in their chemistry courses. About 80% of the respondents would use audio-tutorial tapes on major chemical topics if such tapes were provided to supplement a text.

Information of this sort is important to a publisher that is interested in helping to develop material to meet the need of chemistry teachers and their students.

But what is the responsibility of a publisher in the matter of cooperative science curriculum development? It might be argued that the only responsibility of a publisher is to publish material as it is presented to him. However, in this day of swiftly changing curricula, I believe that teachers and publishers should cooperate more than in the past so that suitable material is provided as rapidly as possible. I believe further that publishers have an obligation to take their fair share of leadership responsibility in a search that should have maximum cooperation among authors, teachers, and publishers--that search is for ways to make science education relevant to human needs. As a step in the right direction, W. A. Benjamin, Inc., developed a Chemical Principles Teaching System at a writing center during the summer of 1969 in Edgartown, Massachusetts, on Martha's Vineyard. Perhaps it would be helpful to describe briefly the important features of the components of this system, how the components may be used effectively, and how the integrated system was developed. This may serve to guide other projects.

Chemical Principles by Richard E. Dickerson, Harry B. Gray, and Gilbert P. Haight, Jr., is the core text. The text is carefully coordinated to its supplemental aids, yet it can be used independently as a text for chemistry majors and nonscience majors. The prerequisite is a high school chemistry course, but this is not essential.

Programed Reviews of Chemical Principles by Jean D. Lassila, Gordon M. Barrow, Malcolm E. Kenney, Robert L. Litle, and Warren E. Thompson is written for students whose preparation is inadequate. This programed problems book is linked directly to Chemical Principles by cross references to the pertinent section in Lassila and easily identified by the standard head "Before You Go On." Thus, at several points in each chapter of the text the inadequately prepared student is branched out of the text into a programed review of the important concepts. In turn, at the beginning of each review or section of Lassila's book, there are references to the relevant section or chapter in Chemical Principles, plus a brief discussion of the importance of the topics to the students' knowledge.

Relevant Problems for Chemical Principles by McGill University chemists, Ian S. Butler and Arthur E. Grosser, provides problems (with solutions) that will challenge above-average students. There are approximately 25 problems with detailed solutions and answers for topics in each chapter of Chemical Principles. The multiple-choice format for the answers is used in an ingenious way; the authors often deliberately construct incorrect answers that correspond to common errors that a student might make. The authors then discuss "what went wrong" in the student's calculation as part of the solution for that problem. In addition to the problems, there are several examinations, also of the multiple-choice type, so that the student can test his own progress.

A Study Guide to Chemical Principles by Wilbert Hutton will help students understand topics in Chemical Principles. The study guide is practically a text in itself. It gives additional background, when necessary, for the most important topics in each chapter of Chemical Principles. It explains difficult points in greater detail (and in simpler terms), supplies additional worked-out examples and problems, and gives useful hints for problem solving and mastering concepts.

The study guide also includes an introductory chapter that provides a review of relevant mathematics. Included in this chapter are discussions of significant figures, logarithms, and the solutions of simultaneous equations and equations of higher order by successive approximation. There is also a section on the use of slide rules. A short section on the most important phases of problem solving--how to set up the problem--is included. It will help to answer the student's lament: "I understand the chemistry, but I just can't do the problems." The stepwise logical method, factor-label method (dimensional analysis), and unit conversions (such as English-metric equivalents) are also part of this introductory chapter.

[illegible] of the study guide contains material for the first six chapters of Chemical Principles, and [illegible], which will include material for the later chapters of the text, will be made available later, if the additional material seems appropriate. Since students need most help at the beginning of their chemistry course, it may not be necessary to provide study guide material for the later chapters.

Teaching Assistance for Chemical Principles by Wilbert Hutton (in collaboration with the authors of Chemical Principles) is an aid to the teachers using the Chemical Principles Teaching System.

Molecular Models by Benjamin/Maruzen are excellent, inexpensive models that will help students understand molecular structure.

This teaching system has been designed carefully to support several types of courses. For classes of well-prepared students, the first six chapters of Chemical Principles may be a review, and the college course could begin with Chapter 7. This would allow a teacher to supplement the text with more advanced material later in the course.

Social science and engineering students, who may or may not have had a high school chemistry course, may need tutorial or remedial assistance in problem solving and reviews of important principles. For this group we recommend a combination of the text, the study guide, and the programed reviews.

For the full-year course for premedical students and science majors, who need the additional challenge of more sophisticated problems, we recommend a combination of the text, the Butler-Grosser problems book, and the molecular models.

During the 1969 summer Benjamin Writing Center, the publisher's staff worked with five resident authors, a special consultant, and five students to write, review, and produce the integrated package.

Another effort that we are going to make is to give continuing service to the teachers who adopt the Chemical Principles Teaching System. Beginning this month, we will mail periodically material designed to aid teachers and teaching assistants to be more effective in the classroom. This material will include a bibliography of pertinent journal articles, books, and paperbacks, arranged by topics. Also included are tips to teaching assistants on how to present some of the topics, help them to anticipate some of the student questions in recitation sessions, as well as to guide them in the selection of topics that are most important for most courses as well as those topics that can be omitted without destroying continuity. Naturally, we will include errata for all the books in the package. And we also will use this continuing service mechanism to pass along material sent to us from teachers, if they feel that it is appropriate to tell other users of the text. Such material might include a favorite laboratory experiment, lecture demonstration, clever problems, sample tests, and even suggestions on how to re-write a paragraph or two to make a topic more understandable to the students.

Another innovation we plan is to have regional conferences this year with teachers using the books to guide the authors in a revision.

The development of a teaching system, the writing center concept, and the continuing service to adopters of the book are some of the ways that a publisher might help to provide material that is flexible enough to meet the variety of types of courses offered and to make the material as current and relevant as possible.

Whether what we have done is acceptable to the teachers remains to be seen. Some things are clear, however. The books in the system are clearly written and all components of the teaching system are genuinely integrated. We have tried to make a teaching system that will be useful for the classes as the teachers have them, not as they might hope to have them. We believe that our system will help teachers meet the needs of the wide divergence of preparation that they encounter in their classes. Moreover, we have tried to make the material relevant to modern students. Perhaps a quote from the preface of Chemical Principles will serve to summarize how we have tried to reach the student and to indicate some of our philosophy:

> "This text is addressed not only to the person who will make chemistry a profession, but to the many people who will have to make decisions about chemical matters that will affect the quality and sometimes the length of their lives. To paraphrase an old epigram about war and politics, chemistry is too important a matter to be left to the chemists. People who will never operate a reactor, or synthesize an insecticide, or fluoridate a water supply, or design an internal combustion engine, must know the consequences--good and bad--that will result when other people choose to do or not to do such things. We are living in a very small room on this planet, and the more that we see that the neighboring rooms are uninhabitable, the more important it is that we know enough to keep this one tolerable."

When I began teaching freshman chemistry, in 1947, the content of freshman chemistry was quite different from what it is in most schools today. For example, the business of valence bond theory and orbital hybridization was just working its way into the senior and first-year graduate courses. Now these topics are presented in some high schools.

But I wonder if the chemical details included in a course are as important as some of the aspects of the spirit of the science. In other words, maybe it is as the philosopher Alfred Whitehead once said, "the study of a subject is not so much to produce knowledge as to form habits." Important habits in chemistry include the habit of formulating the nature of any problem confronting an individual or society, the habit of scientific analysis, of seeking causes and of classifying similarities, the habit of observation or experimentation with suitable controls, the testing of hypotheses, and the acceptance of successful working theories, which are always subject to rejection, or improvement.

To acquire these habits requires teaching of the methodology and conceptual schemes of science, rather than of facts alone. Today one of the aims of chemistry ought to be to prepare all students--nonscience majors as well as science majors--to meet the known problems that society faces. These problems include population control, the cure of disease, maintenance of an adequate food supply, development of new materials, and pollution control.

To solve the sociological, political, and technical problems we need to develop two breeds of men who are rare in our society--scientists who have had a broad humanistic education and experience in the world of affairs, as well as men of affairs who are at home in the major areas of science. Today the scientist is no longer a political neuter, but rather a mature citizen with special talents. If we listen carefully to the protests of our youth, we must conclude that they may have found the will not only to correct our mistakes but to build a better world with the tools we have provided. If we are hopeful, we might believe Pasteur, who once remarked: "Science and peace will triumph over ignorance and war. Nations will unite not to destroy, but to build, and the future will belong to those who have done the most for human suffering."

So what I am really saying, I suppose, is that chemistry should be taught in such a way that our students become educated men and women--some of them choosing chemistry and science as a vocation. I would suggest that we treat chemistry in the curriculum as one of the several liberal arts. Chemistry should be considered within the framework of the total curriculum, without undue emphasis on the subject. Overemphasis and overspecialization of science is inappropriate. This is why most of my remarks would apply to the science major as well as the nonscience major. How many freshmen really know when they enter college whether they wish to become chemists or scientists? Why shouldn't a potential chemistry major learn first about the broad aspects of chemistry?

Moreover, I think that in many instances our overemphasis on science in the past few years has been brought about largely through our fears. For the past twenty years we have seen science develop into a strong power. Ever since the beginning of the atomic age, governments have seen how powerful science can be, and these governments have helped science to accumulate that power.

We must be very careful to keep power under control and to be certain that our goals are meritorious. Why did we go to the moon last summer? For a variety of purposes--scientific, technological, and human. But the chief reason we were willing to spend $25 billion on this adventure was prestige. We went to prove that we have more new knowledge and thus were a more powerful civilization than the Russians. We have won the battle of prestige, at least for the present.

Although chemistry, and science, is amoral, we must help citizens develop a knowledge of science so that they can apply it with ethics. One of the most important and frightening scientific areas today is the research in human hereditary machinery of life. How are we going to use this new knowledge--this powerful knowledge? For it is how this knowledge is used that determines whether its use is good or evil. As R. S. Morrison said in an article entitled "Science and Social Attitudes" [Science, 165, 150 (1969)], "In a short time we will be able to design the genetic structure of a good man. There is some uncertainty about the exact date, but no doubt that it will come before we have defined what a good man is."

To add another bit of philosophy, I quote from the concluding paragraph in the introduction to the Dickerson-Gray-Haight Chemical Principles:

> "Chemistry is never an end in itself. Whenever we have regarded it in this light we have usually ended by misusing it. We must define our goals on other grounds. But the techniques of chemists, if used wisely and with enough foresight as to the second and third order side effects of chemical applications, can help us to reach goals that are not otherwise attainable. Better living is not achieved by an accumulation of better things.

But better living for the entire human family, if we are wise enough, can be achieved through chemistry."

So let's help our students become wise enough to cope with the many problems that face us today. To face these problems it is necessary for everyone to know something about science, including chemistry. To read newspapers intelligently, for Congressmen to make intelligent decisions that affect all of our lives, everyone must know something of what science is. Thus, I would urge that we deal with chemistry as one of the liberal arts, rather than as a special subject. It is true that there are some distinctions between sciences and other liberal arts as those subjects are generally taught. We have, I am convinced, suffered a substantial loss in allowing education in science to grow away from education in the liberal arts. When experimental science was young, it was part of the liberal arts curriculum. But as science grew, as it became of greater practical and political importance, as it became necessary to train a substantial number of professional scientists, a widening gulf developed between what is usually thought of as a scientific education and what is usually thought of as a liberal education.

The difference has, I believe, been largely the result of a major difference in the attitudes of science teachers and teachers of the humanities, rather than the result of differences in the subject matters involved. To oversimplify, the difference is that science teachers are essentially vocationally oriented while teachers of humanities are not. Generally, the humanities teachers' aim is to produce professional musicians, historians, English scholars, artists, and so forth.

The difference in attitudes leads to different kinds of courses and different methods of instruction. The teacher of a humanistic subject attempts to develop those intellectual virtues that we traditionally associate with liberal arts. First is the notion of breadth. As distinct from training that is primarily concerned with relatively narrow specialization, liberal education is broad in scope. It may include chemistry, or history, or any other subject, but it goes beyond the borders of a single field or even a closely related group of fields. Second, liberal education involves the idea of depth. A course of instruction does not merit the label of liberal education unless it goes beyond the superficial to get a depth of understanding that includes the _why_ as well as the _what_ and the _how_ of whatever is being studied. In the third place, a liberal education gives the student exercise in reasoning and thinking for himself. It teaches him to ask questions, to criticize, to examine his own thinking, and to form conclusions that he can discuss and defend, but that he can also change.

The teaching of chemistry and science may also exhibit these characteristics, but frequently it does not. The more immediately useful a field is thought to be, the greater is the temptation to teach practical information. And when this fare seems dull, the temptation is to compound the fault by making the teaching even more down to earth and practical. So in college catalogs we see that they are crowded with such courses as household physics, chemistry for nurses, psychology for salesmen, and mathematics for consumers. Rarely, perhaps never, in such courses does the student gain much in breadth or depth, nor through skillfully handled discussion is he led to an understanding of how and why he reached a conclusion.

To the extent that chemistry teachers are preparing their students for scientific work, they frequently get so obsessed with the importance, the complexity, and the vastness of science that they dislike to see a student graduate with any gaps in his knowledge. So the textbooks get thicker and thicker, the print gets smaller and smaller, and the courses fuller and fuller. The teacher is so busy giving information that he has no time to explain, to evaluate, and to criticize; the student is so busy learning facts that he has no time to question, to digest the information, and to think critically. This is a serious shortcoming of much science teaching, and it represents an objective that is impossible to attain. The ever growing body of scientific knowledge makes it increasingly impossible to teach all of it to any students, and the attempt to do so is a self defeating effort.

These are serious shortcomings of much chemistry teaching, but they are not necessary shortcomings. For the truth is that the characteristics of liberal education are also characteristics of science; not of all the people who call themselves scientists, and not of all the courses in science, but of science itself, of what we call the scientific method, and of the thinking of the great scientists. Important scientific advances exhibit the penetrating depth, the critical inquiring attitude, and the logical reaching of conclusions that we hope to achieve as products of a liberal education. And frequently, too, they exhibit the scope and sweep of imagination that we attribute to liberal education at its best. The teaching of chemistry can be broad, it can provide depth in selected areas, and it offers almost unequaled opportunities in the development of reasoning.

If we are to achieve these characteristics, however, many of our chemistry courses must be changed, and so must the thinking of many of our chemistry teachers. To start with, let us accept the fact that most students who enroll in freshman chemistry (or biology, or physics) are not going to become scientists; they are sampling a subject in which they think they may be interested, or they are fulfilling a requirement that says they must have a certain number of hours of science. In a liberal arts college or a junior college the students who are never going to become scientists constitute the large majority.

And the challenge is greater for the two-year schools than for others. In 1969-70 there were 7.25 million post-high school students. In this same year there were 1.7 million freshmen enrolled in two-year schools. While there was a 10% overall increase from 1968-69 to 1969-70, there was an 18% increase for two-year schools.

What is it that will contribute most to the education of these students who will not become scientists? Although I cannot answer this question in detail, let me suggest the lines along which I think it should be answered. In the liberal arts kind of science course, we must select a limited number of areas of science to be included. There is no need to try to cover everything. Selected topics can be used to teach what science is and how the scientist works, to teach something of the history and philosophy of science, to give an understanding of the nature of science and of its beauty and elegance.

I have come directly to this meeting from Aspen, Colorado, where I have been directing a summer writing center for Benjamin. We have just completed a text for general chemistry that we hope will meet the needs for a large number of students in junior and senior colleges. Titled Models in Chemical Science, the text is unique in that it emphasizes the concept of models in teaching chemistry. It is written in a language that is simpler than most of the better general chemistry texts. It includes only the essential topics, thus it is shorter (about 500 pages) than most freshman chemistry texts. The book has been written by George Hammond and Harry Gray of Cal Tech, Janet Osteryoung of Colorado State University, and Thomas Crawford of the University of Louisville.

To supplement the text, we will have a problems book written by Butler and Grosser of McGill University. This book will contain problems of the type in their successful book Relevant Problems for Chemical Principles, which I described previously. We also plan to have a set of the Benjamin/Maruzen models, a laboratory manual, and a paperback on descriptive chemistry and qualitative analysis. The entire package is planned for publication next spring.

FUTURE TRENDS IN BEGINNING CHEMISTRY COURSES

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I. Introduction

I feel honored that Dr. Mooney and Dr. Cucci have asked me to come here and talk with you about beginning chemistry courses. I feel that I am among friends, for this group probably contains the most devoted of all teachers of beginning chemistry. At the same time I feel very humble about trying to tell you very much about this topic. If it is worth your time to listen to what I have to say, it will probably be because of the questions I raise rather than the answers I give. I do not intend to pose as a prophet of the future, and I do not plan to discuss the gimmicks of the profession. I gather that the title given in the program, "Future Trends in Beginning Chemistry Courses," has been stated rather broadly for my convenience. In fact, Dr. Mooney told me over the telephone that what was expected was a presentation of my philosophy of chemical education for beginners. Therefore, the future trends that I shall be discussing are simply an expression of the hopes and wishes that arise from my personal philosophy.

II. What is "Beginning Chemistry"?

"Beginning Chemistry" has different meanings for different persons. To the student who is taking a chemistry course for the first time, "beginning chemistry" is the course that he is taking, whether it is in high school or in college. We who are teachers of college chemistry use the expression "beginning chemistry" to refer to the first chemistry course taken in college. A great deal of confusion arises from the fact that some of our freshman students have already had chemistry in high school, while others have not. Even greater confusion results from the great variation in the quality and the quantity of the chemical knowledge acquired by students in their high school chemistry courses.

Confusion also arises from the fact that students taking the beginning course are taking it for so many different reasons. Some intend to major in chemistry or in one of the other sciences, and some have their hearts set on a career in medicine or in one of the branches of engineering. Others are nonscience majors who may be taking the course from exploratory motives because they have not yet decided upon a major or a career; still other nonscience majors have already reached a fairly firm conclusion not to major in any of the sciences, but are hopeful that a knowledge of chemistry will be helpful to them in the careers to which they look forward — for example, in the practice of law.

During my teaching career I have witnessed among the students taking freshman chemistry a steadily growing proportion of those who have already studied chemistry in high school. In more recent years I have observed an improvement of the quality of the high school background of the average student in freshman chemistry. But it remains true today as in the past that there are freshman chemistry students who have a very poor chemistry background or even none at all.

Still another source of confusion in beginnning chemistry is the great variation in the general scholastic abilities of the students. This is so involved with the socio-economic background of the students, with their inborn blessings and shortcomings, and with their motivation for scholarly effort that it is difficult to know what to do about it.

3. Different Courses in Beginning Chemistry

Some colleges and universites have a large variety of freshman courses, but the criteria for dividing the students are not uniform. Some have a course for chemistry majors, a course for majors in the other sciences, a course for engineers, a course for nonscience majors, and so on. Another plan that is sometimes followed is to separate the students who have had high school chemistry from those who have not. The general scholastic ability of the student is frequently employed to determine his eligibility for an honors course.

Only a very large school can afford to schedule a variety of different courses in the same subject. Even in a school with 2000 freshman chemistry students, if each section has approximately 300 students and seven different courses are offered, that means only one class is available to any one student -- assuming that it can be clearly established which one of the seven courses a particular student belongs in. Anyone who has helped students with the problem of scheduling classes knows that it will often prove to be impossible for a student to take the chemistry course he is supposed to have if only one section is available -- especially if all the other disciplines were to plan their offerings in the same manner.

Most chemistry departments follow the practice of using the same text in all sections of a particular course. This usually means that some of the instructors have no great enthusiasm for the text they are using, because they have been outvoted by their colleagues. One advantage of having a large number of different freshman courses is the opportunity it may provide for each instructor to choose his own text and do his own thing. On balance, this does not seem to justify the disadvantages that result from a multicourse offering.

In addition to the difficulty students have in scheduling a one-section course, there is the disadvantage that a multiplicity of courses causes administrative complexities in the logistics of the laboratory. Many more hours of service are required of the storeroom staff if each laboratory is to be occupied by students doing a different experiment each time another laboratory period comes around.

My own philosphy is that the number of different freshman courses offered should be kept to a minimum. I think we would be wise to ask, regarding any proposal for a proliferation of courses, "How necessary is this? Is it really worth doing?"

4. Facts to Remember in Setting Up Different Courses

We often hear it said that traditional introductory chemistry courses are likely not to be very interesting or challenging to a college freshman if he has had a well taught modern chemistry course in high school. All too often, students who have had a poor high school background have been dumbfounded by courses that were pitched to those who have had a superior background. I think it is desirable, therefore, to have an honors course available for the students who have the exceptionally strong background. This ought to be a course of greater depth and intensity than the course taken by the other students.

I have noticed on several occasions that a student who expresses the intent to major in chemistry may be only an average student. Sometimes this is because of a poor high school chemistry background; in some cases it is a consequence of scholarship potential that is only average. Many of these students decide during their first year of college that they had better choose a different major -- and this is often, unquestionably, a wise decision. But among this group there are some courageous souls who persist in going on as chemistry majors. Some of them do better in their advanced courses than in their freshman course. All such students would be eliminated in their freshman yea: if they were forced to take an honors course or a course of extra difficulty designed for chemistry majors.

I believe the student himself should be the one to decide whether he should take the honors course. I do not believe that the intent to major in chemistry should be the reason for taking such a course. And I do not belive the honors course should be limited to those who plan to major in chemistry. If the honors course is to be successful, the enrollment in individual sections must be restricted to reasonable numbers. If admission is made voluntary, there will likely be no problem of excessive class size. And yet it provides an offering for those who need the challenge that it afford.

We like to pretend that we know which students are chemistry majors and we like to assume that they should be in a course that is especially for them. But we all know that large numbers of students change their plans during their college years -- especially during the freshman year. I dare say that some students who started college with the intent to major in chemistry have decided not to do so as the result of being placed in one of those courses for chemistry majors, where they became disillusioned and discouraged by the difficulties resulting from acceleration and a premature emphasis on abstruse theoretical topics. Conversely, I know it is true that some freshmen decide to become chemistry majors because they enjoy the freshman chemistry course.

My conclusion is that a student should not be forced to decide in high school what his major will be in college; that the freshman chemistry program should be sufficiently fluid that a student can decide in college that he wants to major in chemistry without losing a year's time; that no student should get caught to his disadvantage in a terminal chemistry course from which he cannot emerge to major in chemistry without taking another year of freshman chemistry for chemistry majors.

Occasionally there are students who enter college with such a superior background that even the honors course would be a waste of their time. Every school should have an advanced standing program that would enable students to go ahead with sophomore courses in their freshman year if they are qualified.

With an honors course and an advanced standing program in operation, I see little need for any further proliferation of freshman chemistry offerings. Having taken care of those excellent students who would be bored by our regular freshman course, I think we can handle all but a very few exceptionally poorly prepared students in one group. I think the assumption that each student should be in a class where all the other students are just like him is a fallacy.

5. Economics and the Encouragement of Chemistry Majors

In a time like the present, when opportunities for careers in the chemical professions seem limited, the teacher may feel that he should try to limit the number of students who aspire to be graduated as majors in chemistry. Thus, he may feel it is appropriate to establish a freshman course especially for chemistry majors and to make it a difficult course. And he would violently disagree with my belief that he should be delighted when students in the regular freshman course develop an interest in becoming chemistry majors.

I have seen the economic demand for scientists and engineers go up and down several times during my teaching career. Every time such a reversal occurs, it catches a generation of students at some point between their freshman year and their senior year. There seems to be no way of predicting what the situation will be at the time of a student's graduation. If we advise students to think of entering or staying out of a profession on the basis of economic conditions, we will usually do this on the basis of the economic conditions that prevail at the time we are giving the advice. Perhaps conditions will have reversed by the time of the student's graduation. Anyway, if a student wants to major in chemistry and the economic outlook for chemists is not good at the moment, what would you recommend that he do?

Regardless of how many or how few different beginning courses are offered, each of them ought to be taught in such a manner that each student will derive the maximum amount of chemical education from the experience. No chemistry course should fail to include such basic chemical concepts as acid-base reactions, oxidation-reducation reactions, the meaning of atomic weights as averages, the kinetic theory and -- if I may dare to include it -- the concept of entropy. The question of how many freshman courses shall be offered should be decided on the basis of the single criterion that what results in the most effective chemical teaching for all is what should be done. The question of what subject matter should be included in the courses should be decided on the same basis. My own philosophy is that all chemistry courses are for the purpose of teaching chemistry and that it is a mistake to try to make the course so difficult that the students cannot comprehend the material, or to try to make it painless by extracting most of the chemistry from it.

In general, I do not think we can predict which individual students will succeed in the study of chemistry -- either in a particular freshman course or in the curriculum for chemistry majors. Even those who were excellent students in the freshman year may lose their grip before completing the requirements for graduation. When this happens it is cometimes difficult to discover why it happened to this particular person. Whatever the reason, it is not likely that we could predict who it would be. I think it would be absurd -- and also inhumane -- to make the freshman chemistry course unnecssarily difficult in an attempt to stop these persons sooner. If we did succeed in stopping them at the freshman level, we would almost certainly catch in the same trap those students who would have done better in the higher level courses if they had had the opportunity.

Even with the freshman course adjusted to the proper depth and speed so that practically all the students who are willing to exert themselves will at least pass the course, it is still true that there is a small group at the bottom of the pile whose presence in the regular course would result either in their being ignored or in their making it extremely difficult to keep the class moving at the desired depth and speed. Some of this group are virtually unteachable, but others are slow and uncomprehending at first only because of a combination of intellectual shyness and total unfamiliarity with the subject matter. There probably should be a short preparatory course for such persons. Most of those who have had no high school course should take the preparatory course, and probably all of those who had high school chemistry and thought they got little from it. As with the honors course, I believe the students themselves should be the ones to decide whether they need the course. Many students of high scholarship potential who have had no high school chemistry would find it quite unnecessary to take this course -- provided the regular beginning course really starts at the beginning.

6. Picking the Right Depth and Speed

Assuming that the students with superior chemical background and those with exceptionally good scholarship potential have the option of taking the honors course or advanced standing, and that those with no chemical background, or a poor chemical background, or a low scholarship potential have the option of starting with the preparatory course, it ought to be possible for the "regular" course to be breezy and brisk without being too deep or too fast for the majority of the students. The purpose of the honors course and advanced placement options is to take care of those who would find the regular course shallow and too slow. The purpose of the preparatory course is to take care of those who would find the regular course moving too fast.

The regular course contains all students who do not opt for the honors course, advanced placement, or the deliberately slow paced preparatory course. This means that many of the chemistry majors are in the regular course -- although other chemistry majors are in the honors course. But it also means that the total number of chemistry majors emerging successfully from the freshman year is a maximum. We have avoided dashing to bits the hopes of those who really wanted to major in chemistry but had not yet acquired sufficient background to master an extremely difficult "chemistry majors course"; and we have picked up others who decided to become chemistry majors during the freshman year.

Most of the students in the regular course will, of course, be majors in something other than chemistry. A great many of these may need to take one or more additional chemistry courses beyond the freshman chemistry course. But still another group -- most engineers, for example -- may never take another chemistry course. A small number will not major in any kind of science. I don't think the number in this last group will be large. Optimism is offering a course specifically for those who have no profession-related interest in chemistry seems to me not justified for two reasons: first, many of the students we have in mind as prospective enrollees for such a course will avoid it if they can; and, second, nonscience majors who do have a serious desire to learn some chemistry will realize that they will derive more benefit from the regular chemistry course -- if, that is, the regular course is the kind of course I have in mind.

7. The Dangers of Chapter Hopping

The freshman course should be of such a nature that the student can learn the material to the teacher's satisfaction if both of them work at it. Each day's work should build on the achievements of the previous day. Serious thought must be given to the subject matter to be included in such a course. And once the subject matter content of the course has been decided upon, the question of the proper sequence of topics arises.

If you examine a number of different textbooks, you will find that a given set of topics can be taken up in many different orders. But in any text that is adequately organized, later chapters build on earlier chapters. Trouble arises if a teacher starts chapter hopping in a text with which he is not thoroughly familiar. It may well be that there is material in Chapter 12 that is necessary in order for the student to get along well in Chapter 13. If the teacher feels that the subject matter of Chapter 12 is expendable and that he would therefore prefer to omit it, he had better first consider whether the omission will cause the student unnecessary difficulty in his attempt to comprehend Chapter 13.

It is perfectly understandable why some chapters are omitted by teachers. Textbook authors are under great pressure to write books that are too large for the courses in which they are taught. This is the only way that a teacher can have any freedom in the choice of material to be covered. It would be a fortunate thing if authors could anticipate which chapters will be considered optional by the greatest number of users and strive to place these chapters toward the back of the book. For if none of the chapters toward the front of the book are to be omitted, then I see no reason why the teacher would not wish to take up these chapters in the same sequence as the author. Not to do so is to assume that each chapter in the book is a monograph that is independent of all the other chapters. If this were so, one sequence might be as feasible as another.

In general, I think one sequence of topics is as feasible as another, by and large. But when an author writes a book he has to make a decision as to what the sequence of topics is to be. Having made this decision, he has to make sure that the discussion at each point does not assume, as background, material that is yet to be presented in a subsequent shapter. I am sure all authors do the best they can to achieve this result, insofar as their editors and manuscript reviewers will permit them. So I think if a teacher feels a strong compulsion to consider the topics in an entirely different sequence from the author, he ought to adopt a text in which the sequence of topics is more to his liking. Or perhaps he ought to do what so many teachers have done and write another book!

I suppose some teachers like to rearrange the order of chapter coverage so as to correlate the classroom coverage with the order in which laboratory experiments are to be done. It would be much more logical, it seems to me, to change the order in which the experiments are done. If there is any difficulty along these lines, the teacher might be wise to use a text and a manual written by the same author. Presumably the author will see to it that the sequence of experiments in the manual is correlated with the sequence of topics in the text.

It is certainly hoped that the teacher will supplement the text with material acquired from his own personal experience so that the student will feel that the teacher is providing some worthwhile enrichment. But this does not give the teacher license to scramble the topics unmercifully nor to raise the level of difficulty of the course to the point that it is egregiously inconsistent with the level of difficulty of the text he has chosen. The function of the text is to set the tone of the course as to level of difficulty and type of subject matter and to provide a plan for consideration of the different items of subject matter and to provide a plan for consideration of the different items of subject matter in a sequence that has pedagogical merit. The teacher must realize that the author has a plan. With the large number of texts now available, there are plenty of plans to choose from Some texts are very much like the physical chemistry textbooks of yesteryear; some contain a goodly amount of the new physical chemistry; some are slanted toward analytical chemistry; others are topheavy with organic and biochemistry; and now comes environmental chemistry.

8. My Fears

An adequate chemical consideration of environmental problems involves some rather rugged chemistry. An intelligible consideration of biochemistry requires a certain minimal amount of organic chemistry as a background. An analytical emphasis must be based on a solid backgroung of stoichiometry. The presentation of the new physical chemistry is most difficult of all because the student's comprehension of this type of subject matter -- molecular orbital theory, and so on -- depends on a background which the student almost certainly does not have and which cannot be included in the text itself because of lack of space -- nor can it be adequately presented in the lecture room because of lack of time.

I fear that there is danger we may try to teach biochemistry with insufficient organic chemistry as background. I fear we may try to teach more analytical chemistry in the freshman year than the student's inadequate background in stoichiometry and instrumentation can support. I fear we may create frustration and resentment in students by trying to teach such subjects as molecular orbital theory with no background. I fear we may try to deal with the involved and controversial problems of pollution in a group that does not understand what it is all about. I fear we may make chemistry more difficult for the nonmajors than for the majors by trying to include too many of the "goodies" that the majors will have a chance to savor in their upper level courses. I fear the students will be made to feel they are not intelligent because they cannot comprehend the unintelligible fare we are always tempted to serve them.

9. My Hopes

In spite of my fears, I am fundamentally optimistic. The present employment situation in chemistry and the other fields of science and engineering will likely cause continuing decreases in chemistry enrollments. Students will not be falling all over themselves to get into chemistry classes if there is a belief that chemistry is unreasonably abstruse, esoteric, or austere. I hope that the desire of teachers to perpetuate the means of their own livelihood will cause them always to remember that they have an obligation to their students to make the course adequate but reasonable.

The present social concern with the effects of technology upon our environment ought to make students less passive toward chemical education. I am sure that teachers will want their students to be prepared adequately to cope with future problems in this category; they will want to help the students acquire a knowledge of the fundamentals of chemistry rather than merely engage in a dialogue over this morning's headlines.

The tendency of the more idealistic portion of the present generation of students is to turn their backs on those whose devotion to chemistry is conditioned primarily by its relationship to their own incomes. This will make teachers realize that they must give witness to their own genuine interest in chemical education by doing the best teaching to found anywhere on the campus.

In the last half century beginning chemistry has changed from an encyclopedic treatment of descriptive information to a logical consideration of the basic concepts of chemical science. The rapid growth of chemical knowledge has caused some of us to try to cover more and more material each year. Periodically, we subject our course plans to critical re-examination and discover that many topics that we thought were absolutely essential can and must be discarded. We have discovered that the concept of entropy, for example, is more important than a detailed knowledge of the chemistry of chromium. We have discovered that it is possible to teach many concepts to beginners that our predecessors considered to be beyond their grasp. My hope is that we shall continue to improve our ability to make difficult subjects intelligible -- and that we shall remain willing to redefine what is essential and what is not.

FUTURE TRENDS IN CHEMISTRY FOR NON-SCIENCE MAJORS

Stuart Whitcomb, Earlham College

It is indeed a pleasure to have this opportunity to talk to you but I must admit to serious misgivings. As a physicist I would have considerable difficulty in predicting future trends in physics education and yet here I am about to talk about the future trends in chemical education. This appears to be extremely presumptious and I must confess that I would not be here were it not for three added words "for non-science students." The problems of teaching chemistry to prospective chemists are admittedly different from those of teaching physics to prospective physicists. However, the problems of teaching chemistry to students not interested in science are nearly the same as those which I face as I attempt to teach physics to students not interested in science. It is the nature of these problems and some possible solutions which I would like to discuss with you.

Let us first consider some characteristics of these students who are enrolled in our courses in spite of the fact that they have little interest in science. First, why are they there? Essentially they are there because someone requires them to take science courses. If they are prospective elementary teachers, they must meet a state certification requirement. If they are prospective lawyers, sociologists, writers or housewives, they enroll in our science courses to meet liberal arts requirements. I fear that many of our colleagues in the humanities and social sciences, are not themselves convinced of the importance of courses in the physical sciences and they convey this lack of conviction to their students. Secondly, what has been their experience with science? All have had home contact with science in elementary school and junior high school and most have had some in high school. Unfortunately for many students this whole series of experiences has been an unhappy one beginning with an elementary teacher who feels uncomfortable teaching science and ending with a high school teacher who at best aimed at the students interested in science and at the worst tried to cram too much material into the course. What is their attitude toward science? Their unhappy experience has resulted in a very negative attitude toward science. Typically, they dread taking more science courses and tend to postpone them as long as possible.

Given the students with the attitudes and experiences which I have described, we frequently put them in a condensed version of beginning physics given in one semester by a member of the Physics Department who didn't want to give it and a totally separate semester of chemistry, given under similar circumstances. These courses, similar to those which gave the students their distaste for physical science, but faster in pace, are likely to leave them behind from the start and deepen their antagonism. This certainly does not seem to be the direction in which to continue.

Before we consider new directions for physical science courses, let us think for a moment about what a non-science student should get from a physical science course. First, he should experience a change in attitude from confusion and antagonism to confidence and interest. Second, he should realize that the essence of science is observation and wondering and trying to find out about the physical world. Third, he should understand the tentative nature of physical models and their relation to experiment. If we can establish chemistry or physics or physical science courses which will give non-science students these attitudes and understandings, we will have given the prospective elementary teacher a much more comfortable feeling when teaching science to his classes. We will produce lawyers, sociologists and parents and citizens who have a much better understanding of the nature of science and its relation to society.

I have not listed the accumulation of a large number of facts as one of the goals of a physical science course. The goals I have outlined will be achieved only by making use of a reasonable number of facts. If we achieve our goals, these facts will be retained, used and placed in perspective and more important, the right attitudes will be generated for the independent gathering of further facts.

Now for the big question. How can we design experiences in the physical sciences which will produce these changes in attitudes and give this understanding of the nature of science. I would like to present an answer to this question in terms of the guidelines which were used in the development of one particular course "An Approach to Physical Science" developed by the Physical Science for Non-Science Students (PSNS) project. This project was supported by the National Science Foundation and was the outgrowth of a conference sponsored by the Advisory Council on College Chemistry and the Commission on College Physics. Of course, PSNS developed a particular course but the guidelines appear to be sufficiently general to serve equally well for a variety of approaches to the effective presentation of the physical sciences to non-science students.

In view of the student's attitude toward science, it is essential that one should begin by encouraging students to investigate familiar phenomena. There should be plenty of time for this investigation and for discussion. The pace should be leisurely and should deal with simple concepts.

The physical sciences are based upon experimental investigations of nature. If our students are to obtain an understanding of the nature of the scientific enterprise, they must ask questions of nature, that is they must perform experiments. The experiments are a crucial part of the PSNS course as they should be for any physical science course. These experiments must precede the discussion and should form the basis for discussion. This way one observes and then interprets. One may thus find surprising results which stimulate discussion and not demonstrations after explanations have made inquiry unnecessary. Insofar as possible every new topic should be introduced by an experiment.

If one is to provide time for wondering about science, for performing experiments and for leisurely discussion, it is obvious that we cannot include the whole subject matter of physical science. What topics should be included? An obvious way to answer this question is to choose a "theme" and to introduce only topics the knowledge of which is needed to follow the "theme." Thus one establishes "the need to know" as the criterion for the selection of topics to be included. As an example of this procedure the PSNS staff chose as a theme the question "what is the nature of solid matter" and included only topics which contribute to finding answers to this question.

This "need to know" criterion is a pervasive one. It serves not only in the choice of topics, but it may be applied to the manner in which topics are introduced. The "need to know" must be clear not only to the instructor but also to the student. Ideally the student is motivated to perform an experiment because he recognizes the need to know the results of the experiment in order to get on with his investigation of the main theme of the course. Thus, this criterion determines what is included not in terms of what is traditional but in terms of what the student must know if he is to get on with his investigation. This is the way a scientist finds interest in a topic. We should communicate this to our students.

Science progresses by building models based on observations, then uses these models to make predictions, and finally, by experiment, tests to find out whether the predictions are verified by further observations. If non-science students are to experience science they should observe, construct models, make predictions and then make further observations. The models may be visual, mental or mathematical but it is inevitable that some not agree with the experiment. This is the experience of many of us and there is every reason why our students should experience it too. This way they will learn the tentative nature of scientific theories and will be comfortable with incomplete theory.

A course which follows these guidelines does not always proceed smoothly. The experiments are not always immediately explainable and, hopefully, will yield some surprises. This is part of the fun of working in science. In any scientific laboratory a problem may be put "on the shelf" for a while. When a student later comes across something that makes contact with that question which has been "put on the shelf" in the back of his mind, he has the satisfying sense of seeing the parts fit together. This is one of the satisfactions of scientific work.

Following these guidelines is not the fastest way of getting some particular relationship into a student's head, but it is the only way in which he can understand how we know what we know about the world around us. To make time for this important process, it is necessary to eliminate much that is taught in survey courses. However, the results, in terms of changes in attitude and the student satisfaction, make it worthwhile for us to give up our cherished ideas of what should be included in a course in physical science.

As I indicated earlier these guidelines were those used in the development of the PSNS course "An Approach to Physical Science." The student reaction to this course is interesting. During the first two to three weeks the students feel uneasy and insecure. They haven't been given all kinds of stuff to memorize, they haven't been asked to work problem after problem, they have been asked to observe and think and they are not given the answers to all their questions. It appears that few students have had this kind of science course before. However, as the semester proceeds, the students begin to understand and appreciate the approach. Many students who enter the course with a fear of physical science find that they actually enjoy the course. In most, but not all, cases the course appears to achieve its objectives of overcoming the non-science student's antagonism toward science and of giving them an understanding of how the scientific enterprise functions. From personal knowledge I can report that it has produced elementary teachers who use the same approach in their elementary classes. They are comfortable saying "let's find out about this together--what experiments can we do to find out?" If all elementary teachers understood and could use this approach to teaching science, students reaching college would have no need for a PSNS course but more students would be ready for regular chemistry and physics courses.

CHEMISTRY COURSES FOR NONSCIENCE MAJORS

William F. Kieffer, College of Wooster

The only workable premise on which a discussion of this topic can stand is that there is no one best way to handle the problem. One of my strong convictions, based on my own attempts over the years and on conversations with others about their attempts is that the successful course is one in which the professor discusses topics about which he is enthusiastic. This enthusiasm must be combined with a certain amount of missionary zeal which translates into a willingness to start at a level of simple concepts so that students can be carried along (albeit vicariously) to the contemporary growing edge of knowledge about whatever it is that is the chosen topic.

I think the day has passed when we can expect to have large captive audiences in required survey-type courses in science. My own strong conviction is that for the nonscience major, whether declared or just inclined, the best way to instill some appreciation and hopefully some understanding of modern science is with an upperclass course. My own course in a four-year college is populated about half by sophomores, half by juniors and seniors. The success with sophomores is so nearly equal to that with upperclassmen that I feel justified in urging you in the two-year colleges to plan in a similar way. The sophomore is past the major psychological hurdles of adjusting to college-level intellectual activity. He or she has survived the inevitable weeding-out that a freshman curriculum provides. He has begun to give some substance to his interests and even career plans. He has begun to recognize a personal frame of reference on which he can hang some relevant ideas which admittedly may be more "cultural" than utilitar   to his plans.

Today's student demands relevance--we are in no way abbrogating our prerogatives when we recognize this in choosing our topics and planning our discussions. Science is a part of contemporary culture, and we must be willing to be a bit obvious about saying so. Whatever the topic, we can include both the scientific principles and the information about technological applications. One without the other is sterile. The atomic and molecular structure of oxygen and its inherent properties need not be illustrated only with decomposing $KClO_3$ or burning steel wool. Powering rockets with LOX and eutrophication are more to the point. Thermal pollution is the consequence of the second law of thermodynamics. The same chemical equilibrium involving N_2, O_2 and NO is responsible for starting smog that has supplied minerals in our soil for eons of time.

I think there is a crying need for supplying some depth of understanding--in terms of the underlying scientific concepts--to all the present furor over what is happening to our environment. We all know perfectly well that it is not an impersonal technology that is responsible. It is man's use of technology. But non-scientists need to have this spelled out! Men and women can decide collectively only on the base of individual wisdom. That wisdom can be nurtured only by information. Supplying that information and describing its relevance is our job.

My own feeling is that we owe students the additional dimension of some historical perspective and even some philosophical implications. In the nonscience student we have a more sympathetic audience often than with our beginning science-career-oriented students. A whole lecture on the history of chemistry or the philosophy of science still will be deadly. Rather, these sidelights or interpretative interludes belong in every lecture. There is a delightful absence of pressure to cover ground in this course. Some very real advantages in terms of understanding scientific concepts accrue from showing how they have developed. Orbitals and wave functions are a little less mysterious if the shortcomings of the Bohr orbits they replaced are pointed out. The genius of Bohr's break with tradition, the really important contribution, can still be appreciated. Also some historical parallels to modern problems are enlightening. Lead poisoning, a consequence of drinking wine preserved with a grape-sugar syrup cooked in leaden pots may have contributed to the debilitation that led to the fall of the Roman Empire. In just the same way today we may be victims of a technology based on incomplete information. And it may not be too late to remove lead tetraethyl from our gasoline!

My course has shifted its topics every year for twenty years. Fifteen years ago we spent a long time on nuclear energy and fallout. Five years ago the major emphasis was on the chemistry of life and heredity. Now the latter has shifted more toward the problems man's profligate use of resources has created for the maintenance of a satisfactory balance of life on our planet. In every case, I think it best to deal with the contemporary questions in students' minds. They need the information--not just the empirical facts--but also some understanding of the underlying broad scientific concepts. Then--and only--then will they be able to distinguish facts from opinion, to recognize faddism in popular reactions to current dilemmas and hopefully to develop the wisdom for decision in our present-day world.

Discussion with Professor Kieffer.

Professor Kieffer's textbook will be out in March published by Harper and Row, Publishers. He starts his class with assigned readings outside of the text. A useful reference is Young's Mystery of Matter (Oxford), which is a collection of interesting papers and articles [illegible] by the people who were responsible. The rest of the time is filled in by lecturing.

Question: There is a mixture of interests in the class. What do you teach heterogeneous groups, and how?

Answer: Determine student group interest, avoid process chemistry, and hit upon economics and social interests. Use the "Gee--Look at this!" attitude. Stress should be placed upon the broader implications. Discussions should be in such terms as H_2SO_4 that could be produced from coal. Get the students involved in the discussion. Exam questions can ask for discussion of potential positive economics of pollution control rather than ask for the H_2SO_4 preparation equation.

Question: What class size does this work for?

Answer: Up to 50 to 60 people. Calling on students by name is essential for rapport. The teacher should try to draw out the quiet student and hold down the overly responsive student. "Mini" research projects could be assigned to students to get them to answer their own questions.

Question: How do you determine which students will register for this course?

Answer: There should be no prerequisite. Since transfer of courses is a difficulty, a two-year college might have a problem with this course. The course will not transfer as a laboratory science. It is not intended to be a first course leading to further science. It was suggested that it be transferred as a Humanities or Social Science elective.

Question: Is this material ever included in a science major's course?

Answer: Don't just consider implications--basic science facts must be worked in. The framework is: Principles make implications clear. Implications lead to the study of principles. Story illustrations should be used. This course is a full college level effort.

Question: What type of exam should be given?

Answer: The exam should be one-third objective with a simple problem, and two-thirds the student's impression. This means their comments on quotations in an essay form.

Question: What about exams for students who do not write well?

Answer: They could draw diagrams, make observations of things that have something in them that is wrong, or do an experiment and report the results as they interpret them.

Question: What about the metric system?

Answer: Go easy on math. "The kids are math tone death." Use commonplace examples. Try to present the course as intellectual fun. Some talks about measurement giving the advantage of any measurement in the decimal system should be given. The course does not force it. Give the student a realization of experimental nature of our science.

CHEMISTRY FOR NURSES

Gerald F. Grillot, Syracuse University

I must admit that I am at some disadvantage in discussing this subject since the course in nursing chemistry that I teach is part of a baccalaureate program leading to a B.S. in Nursing Education. However, for several years I was involved in the teaching of chemistry in a three year R.N. program for General Hospital in Syracuse.

Chemistry must certainly be considered as one of the basic sciences in the field of nursing education. The course in chemistry should not only deal with basic chemistry but should include some elementary introduction to organic and biochemistry. Chemistry must serve as a prerequisite to such subjects as pharmacy, pharmaceutical arithmetic, drugs, nutrition, dietetics and clinical courses in medicine. Further, chemistry should serve as a most useful background to the study of physiology, microbiology, therapeutics and pharmacology. How can any student in elementary biology really appreciate this science which is based more and more on molecular structures if he has no knowledge of chemistry? With such a background, the studies of glycolysis, the citric acid cycle, the role of the nucleic acids in genetics and the biosynthesis of proteins will be much more meaningful.

Today there is a growing pressure for the nursing student to complete a baccalaureate program. Any advancement for the practicing nurse is generally blocked by the lack of such a degree. She generally needs a B.S. degree if she plans to go into supervisory positions, into nursing education or public health nursing or to become a school nurse. In this matter, I do have some experience. I frequently advise our School of Nursing concerning the placement of returning RN's in chemistry courses. Many of these students with inadequate backgrounds in chemistry are required to take our basic nursing chemistry course. Every other year we offer a night section of this course for such students, so they can continue their education while on daytime nursing shifts in our local hospitals. Based on the above facts, I not only recommend an adequate course in chemistry for all nursing students, but it should be acceptable as transfer credit to a collegiate baccalaureate program in nursing.

Although the National League of Nursing, the National Student Nurses Association and the American Nurses Association have deplored the unilateral action of the American Medical Association, when their Board of Trustees announced in the

AMA News that the latter association proposed the use of specially trained nurses in the practice of medicine, I expect that these groups will come to a mutual agreement on such a practice. It is proposed that nurses so trained will be working in the employ and under the supervision of an M.D. The use of nurses and other health professionals should buoy the physician in such a way as to expand markedly the physician's ability to serve his patients. The use of these professionals would permit them to make house calls and provide home health care, which should result in fewer hospitalizations and earlier discharge of those hospitalized. This information has been called to my attention in the most recent News Letter distributed by Alpha Epsilon Delta, the pre-medical honorary fraternity. I hope that no one of our capable nursing students is denied the opportunity to take advantage of a chance to participate in this limited medical practice because of a limited background in the basic sciences.

Our School of Nursing has never had to be convinced of the need of chemistry in the program. They require a high school course or a semester of the standard general chemistry course before the student is accepted in their program. I am sure that admission to the program depends upon the student's performance in her high school course in chemistry. Although a proposal has been made that an alternate New York Regent's exam in chemistry should be established for prespective home economists, nurses and other health sciences that would be much less theoretical and mathematical than the recently adopted curriculum and Regent's Examination, our nursing faculty in clinical medicine and surgery were quite insistent at a meeting on nursing education sponsored by the Board of Education of the City of Syracuse that high school students planning for admission to our school should continue to follow the present Regent Curriculum in Chemistry.

In summary, I must say that our problem is not whether chemistry should be included in our nursing education program, but rather that we must always be concerned with the selection of material from this science that will be most useful for our nursing students. For instance, should we include under our discussion of atomic structure a discussion of atomic and molecular orbitals and their relationship to the structure and properties of molecular structures in organic and biochemistry?

CHEMISTRY FOR NURSES

Bernardine Hallinan, National League of Nursing
New York City, New York

In my visits to various colleges and universities across the country I have noted an increasing concern about the adequacy of the present science courses in meeting the needs of students in health related curricula at the associate degree level. For this reason I was happy to have the opportunity to attend this timely conference.

I would like to introduce my remarks by stating that what I am about to say does not constitute official National League for Nursing policy. The League is a voluntary, membership agency and the membership of the Department of Associate Degree Programs has not made any official statements for or against chemistry in the curriculum of associate degree programs. College administrators and faculty often ask what the League regulations are regarding various aspects of program development, but Mr. Griffin, who is the Director of the Department, and each of his staff firmly believe that each institution must develop a program which fits within the philosophy and objectives of its own school.

Some of the people at this meeting may have had conversations with me or other members of the staff in the Department of Associate Degree Programs of the League. Those who have, undoubtedly know that the general feeling of the present staff is that most chemistry courses as they are presently being taught do not meet the needs of the usual associate degree nursing program.

I was asked to talk about "Chemistry for Nurses," but before I can do that I must define what I mean by a nurse. I am referring to the person who is prepared as a technical nurse or nurse technician. To paraphrase the League's definition of a technical nurse: "Someone who is prepared to give bedside care and to perform [illegible] of a physician and/or professional nurse." The graduate nurse from an associate degree program is not prepared for the functions of a professional nurse as is a graduate of a baccalaureate program.

Now that the level of practitioner has been defined, we can discuss the relationship between chemistry and the associate degree nursing curriculum. In the original, experimental associate degree nursing programs some offered chemistry, but the majority did not. This variability was expected because both state and school requirements had to be met, and the nursing curriculum had to be developed to meet stipulated requirements. The presence of chemistry in the original programs can perhaps also be accounted for on the basis that schools were discouraged from developing courses specifically for nurses. Since chemistry was offered in each of the schools, the existing course was utilized for the new program. The two reasons which were just stated--state and school requirements, and availability of a chemistry course--were further affected by a third factor which influenced the inclusion of chemistry in some programs, and that is tradition. A fourth factor which consciously or unconsciously affected placement of chemistry in the curriculum has been status. The inclusion of chemistry is viewed by some as raising the status of a curriculum which is technical in nature. (We must all admit that in many colleges the faculty and students in technical programs are often viewed as having a lower status than the more traditionally oriented curricula.)

I am sure there are other reasons too numerous to state as to why chemistry has been and is included in many associate degree nursing curricula.

I have been discussing what was and what is, and would like to continue with what it seems "will be." I discussed this with Mr. Griffin, the Director, and the other staff members. I also reviewed the nursing curriculum of all the established programs that have recently applied for N.L.N. accreditation as well as the newer programs that have not yet graduated a first class, and have applied for Reasonable Assurance through our Department of the League. It seems that of the older programs about 32% of them offer chemistry courses, of the newer programs only about 15% offer a course called chemistry. I believe I can safely say that the percentage of associate degree nursing programs which offer chemistry courses is decreasing each year.

Undoubtedly the reasons for not offering chemistry in associate degree nursing programs are as numerous as those for including it, but from conversations with many people it seems that the primary reason is that the traditional chemistry course does not meet the needs of the nursing program, or other health related curricula, at the associate degree level. Studies have been and are being done which indicate that the knowledge needed by this level of practitioner to adequately perform the tasks of his job does require a knowledge of the various sciences, but that traditional courses are not necessarily the best way to present the offerings. It appears that in schools where the faculty have been more concerned with entry-level needs for the job and student needs than they have been for tradition, faculty needs and meeting "requirements" there has been a departure from the baccalaureate type of curriculum development.

What is being substituted for chemistry? The course title which is most frequently seen is "Integrated Science." Most schools include in this course principles from physics, chemistry, anatomy, physiology and microbiology. Some of the schools which offer this type of course have done follow-up studies on their graduates, and found that they have been successful on both the licensing examination and as practitioners in the patient care area.

During conversations with nursing and science faculty members in various schools where they still offer chemistry, the reason most frequently given for not offering an integrated science course is that there would be no one to teach it. I think that reassessment of the present science offerings and proposals for a new approach which would more adequately meet student needs should be viewed as a challenge. How you, as individuals, view the change from the traditional science offerings to a more meaningful approach will vary--but the change will come.

CHEMISTRY FOR NURSES

Virginia Bryan, Jamestown Community College

I am not sure how many of you have Associate Degree Nursing Programs at your colleges or if you are about to start them. Before I get into the role of chemistry in Associate Degree Nursing, I will give a little, quick background on the philosophy of Associate Degree Nursing and why these programs were started.

Mildred Montague, in 1950, due to the shortage or perhaps mismanagement of the nurses that were available then, set about to find new ways to educate nurses that would take less time and would be located in a new educational setting. She described three areas of nursing functions to be performed by three different types of nursing personnel. First was to be the aide or the assistant. This person was to be prepared by the agency itself and I am sure all of you who have been hospitalized or have had someone in the hospital have seen the aides or orderlies or a type of nurse assistant around the institution. The second type that she described was a para or semi-professional person, the technician. This would be the Associate Degree nurse graduate and/or the diploma graduate. (I am not quite sure that we have convinced them that they are technicians yet.) The third group is the professional nurse, the graduate of the baccalaureate program.

While it is the third level, or professional, nurse that makes the major decisions regarding the basic nursing care and who requires extensive preparation to prepare for responsibilities of leadership, it is the para-professional or the technician nurse who is found at the patient's bedside and who must be depended upon to give safe and comfortable patient care. In order to give this kind of care, there is a certain amount of knowledge that must be brought to the patient's bedside by the nurse.

McLean and Gregg define nursing as an art and go on to describe an art as "A body of practical knowledge that tells how to work to produce certain results." They then say that nursing as an art requires a sympathetic heart and willing hands. They also define nursing as a science, "that requires a sound, broad type of education and a thorough knowledge of human nature."

The sciences that lend themselves to nursing are, as I am sure you all know, psychology, sociology, anatomy and physiology, chemistry, microbiology and physics. Because of the limitation of time in Associate Degree nurse programs (and I think that most programs are still contained in a four semester, two year type of setting) all sciences cannot be taught in their entirety. Each nursing faculty must make difficult decisions as to what courses will be included or excluded in the allotted [illegible] thinking process and decisions are made as to which broad concept of nursing can be taught and in which order so that the curriculum develops, hopefully, from the simple to the complex.

Most associate degree nursing programs begin with the normal needs of the patients and proceed to abnormal deviations. Concurrent with nursings' normal needs should also be taught those sciences which lend themselves to normal body functions. Among those would be anatomy and physiology, physics, chemistry, psychology and sociology. If we could include them all, that would be the gamut. Usually anatomy, physiology and psychology are those of choice. Physics and chemistry are frequently eliminated unless they are taught by a nursing instructor as she sees fit in a specific instance. Sociology joins microbiology in being postponed until the second year.

With these definite deficiencies in mind, I would like to emphasize the need that nurses have to understand the normal body functions in order to perceive the care of the patient whose normal functions have been interfered with for some reason or other. In discussing with registered nurses their use of chemistry in their nursing practice, very few could recall specific formulas and/or chemical facts. However, all of them quoted broad concepts that had been used until they had been integrated into their routine knowledge for care. These are the types of chemical concepts that any person in health related fields should know. Probably this is the same information that most non-chemistry majors should have available to them and this would hold true with other scientific knowledge as well.

Some of the broad concepts from the discipline of chemistry that I feel should be stressed deal with the physiological functions of the body as follows: the process of digestion; oxygen's use and transportation in the body; the importance of carbon dioxide; the production of heat in the body (and while some say this relates only to physics, I have a notion that chemistry is involved here); enzymes and their importance; drugs, their use and effects on the tissues of the body; and water balance, electrolytes, acids and bases and the pH scale. These are only seven areas and I am sure there are many major concepts which come to your minds that I have eliminated. No doubt each individual nursing department would add specifics which would be helpful in your college in the health related programs.

At this point I would like to stress the need for a combined science course which would include broad concepts from each science that deals with body structure and function and eliminate the specifics in the discipline. This might be done by team teaching or by developing a core curriculum which could be taught by a member of the science faculty who is particularly interested. This course should not be geared specifically to nursing students, but to all students in health related fields and should also be available to any liberal arts student.

In conclusion, I would like to reiterate that in order to give safe and comfortable nursing care Associate Degree nurses or technicians need some chemistry. They do not need to memorize formulas nor can they become skilled chemists in the short time allotted to their program. They need to understand basic chemistry concepts that will help them understand what is taking place inside their own bodies as well as those of their patients, and why sickness alters the normal functioning of that body.

I would like to challenge someone to seek new and different ways of teaching these concepts of chemistry and other sciences so that we in nursing can concentrate on nursing education and leave the sciences to the prepared science teacher.

CHEMISTRY FOR NURSES

George I. Sackheim, University of Illinois
Chicago, Illinois

I have been asked to speak on chemistry for the health sciences from the author's point of view. However, it is a little difficult to disassociate myself from other points of view. I cannot help but look at it from the teaching point of view, since I taught nurses for about twenty years. I also understand the perspective of the National League of Nursing, since I have also been involved with them for twenty years. I am one of three people who wrote the Chemistry examination for the National League of Nursing. Study of the examination in chemistry shows that there are really two examinations - not one - with an entirely different passing score for the baccalaureate program as compared to the diploma program - although it is still the same examination.

However, I want to discuss this subject from an entirely different point of view. I am going to bring out my crystal ball and make a prediction -- go way out on a limb as it were. You may not agree with what I say, and we could argue about it. But I have a feeling that in about ten years or so we will <u>not teach chemistry</u>. I have a feeling that this will be a course which will be <u>completely outdated</u>. Instead, I am going to propose a new course that we are going to teach, <u>Science for Nurses.</u> This, I feel, will be the thing that we are going to do <u>because it is more</u> practical. Today we not only teach chemistry to nurses in the chemistry program - the chemistry of the various reactions involved in body functions, but they also take a course in anatomy and physiology and they get the same chemistry again. In all the other courses in nursing the same chemistry is repeated again. Except, as I have had my students tell me, when they take a course in chemistry and there is a certain question on the examination you have to answer it in one way, but when they take the course is physiology and the same question is asked a different answer is required. When they take a course in nutrition - the same thing appears again - so the problem really is, "What does this teacher want?" rather than, "What is the correct answer?" So, I propose then, an integrated science which will consist of the chemistry part, naturally, but the chemistry tied in with physics. Physics is an important field which includes gas laws, mechanics, respiration, body production of heat, energy, and other aspects of physics. It is tied in with mathematics. But where does one course stop and another begin. Obviously the integrated science will have to be tied in with anatomy and physiology, body fluids, blood, urine, metabolism, hormones, vitamins, etc. This is chemistry but it is also physiology. Can you teach physiology without anatomy? If these things are all integrated and taught as a science, it means much more to these students.

Then there are new areas such as genetics, a rather new area in chemistry, the chemistry of heredity. Heredity is taught in many biology courses. When you go into the chemistry, how can you separate the biology from the chemistry of the DNA molecule and the various malfunctions that take place in the body because of the lack or excess of certain chemicals? Chemistry must be taught there. Another allied area- the use and abuses of foods, drugs, etc. - with pharmacology. Can you separate the pharmacology and uses of drugs from the chemistry of them? And here we go overboard sometimes in one area and not in another. We read quite a bit about the use of LSD and the effect on chromosomes. LSD breaks chromosomes, but what about other things that also break chromosomes. And there are other agents which fortunately do not break chromosomes in the same amount, but which do break them never the less. One of these is caffein, which is not publicized, but it will affect chromosomes. This is the stuff that we have got to bring into the teaching of science. We have got to bring in the idea of radioisotope technology, the chemistry and use of it. It should include study of isotope for diagnostic and theraputic use and the dangers involved - the chemical and physical dangers. The idea of life expectancy - life expectancy effects due to radiation - which is something that is never mentioned. We are just beginning to talk now of life expectancy due to smoking (one of the things which affects life expectancy) and part of this is chemistry.

Today, with all the emphasis on pollution, how can we talk about pollution without talking about the chemistry of it?

So, as I look at this, I am going to predict that this will be the course of the future. We are going to teach our nursing students science as a whole and not have it taught by a chemist - but taught by a team, including a chemist, physicist, mathematician and a physiologist. As with any type of curriculum, the most important thing will be the feedback we get from the students and the teachers. Then we can go on from there and make our plans. How this integrated program will work, I don't know, but I feel that it is going to have to come if we are to give our students a well-rounded education.

WRITING BEHAVIORAL OBJECTIVES

Ellen Bardale, Vincennes University
Junior College, Vincennes, Indiana

A physics professor gave a new barometer to one of his students and asked him how he would use the barometer to determine the height of a tall downtown building. After a few moments, the student said, "I'll take it to the top of the building, tie a rope to it and lower the barometer to the ground. Then I'll measure the length of rope used with a meter stick."

The profess[illegible] little upset by this and asked the student to think of another solution. After a little thought, the student said, "I'll get a stop watch, go to the top of the building, drop the barometer, time its fall and calculate the height of the building from that data."

The professor admitted that would give a reasonable answer, but that was not the procedure he had in mind. The student had another procedure, "Well, I'll take it to the janitor and tell him that I'll give him the barometer if he'll tell me the height of the building."

With all due respects to Torricelli, the student had identified three procedures which would answer the original request. The professor had simply not stated the request carefully enough to permit only one route being used to get the answer.

Telling the student exactly what is expected of him and what informati he is to use to reach the specified end point is the purpose of behavioral objectives. The term "behavioral objective" is often confused with course description. In general, a course description tells something about the content of a course and the procedures that are to be used. A behavioral objective specifically tells a student how he is expected to behave or respond after a given topic has been covered. Most instructors start a course knowing rather precisely what he intends to accomplish. However, it is frequently difficult to communicate to the student exactly what performance is expected of him. The fact that you will cover Atomic Theory does not tell the student what he must be able to do after the coverage. Must he be able to solve the Schroedinger Equation or do you expect him to draw a Bohr model represention of a Lithium atom? This is the situation which behavioral objectives are meant to simplify.

After the statement of behavioral objectives have helped you determine precisely what you are to teach, then the text, problem books, references, movies, audiotapes, field trips, lectures, problem sessions, experiments and computer assisted instruction aids can be selected and planned. Preparing tests enable you to easily evaluate the progress of the student in meeting your stated goals.

With the stated objectives, the student is able to evaluate himself as he progresses through a topic. He does not find it necessary to psyche-out the instructor.

A meaningfully stated objective is one that succeeds in communicating to the reader the writer's instructional intent. The principle reference for preparing behavioral objectives is Preparing Instructional Objectives by Robert Mager, Fearon Publishers, Palo Alto, California.

Frequently, teachers talk in terms of "to know," "have an understanding of," "have an appreciation for" and "to be able to use chemistry." In chemistry, each of us has our own perspective of what we mean when we use those terms. Thus, we may be able to get a better perspective of their lack of clarity if we look at the field of art. We might even take a course called Art Appreciation. Our goal for taking the course might be "to get an appreciation for!" But are we refering to painting, music or ballet? How will we know when we have gained an appreciation for art??

[illegible] able to communicate by using these "open words." However, for instructional purposes, we can and should be far more precise in identifying our expected outcomes from the teaching or learning process.

When preparing behavioral objectives, we are concerned with:

1. Identifying the terminal behavior.
2. The conditions under which the student will act.
3. Specification of the criteria of acceptable performance.

The Curriculum Committee of the Division of Chemical Education has been working on the development of behavioral objectives for a number of chemistry courses. Some offerings by committee members have shown the difficulty of preparing good behavioral objectives and the advantages of having other persons react to an objective before it is passed on to a student.

Preparing the objectives quickly leads one to the conclusion that there are action verbs that must be used frequently if the objectives are to be precise and informative. As behavioral objectives are developed, it often appears that we are expecting much more from our students than we have suspected in the past. It becomes very important to make statements that convey the message intended and many behavioral objectives must be rewritten many times before they cease to be ambiguous.

WRITING BEHAVIORAL OBJECTIVES

William T. Mooney, El Camino College
Torrance, California

The materials and literature articles suggested as references were "New Directions for Chemical Education in High School" and "Independent Study in High School Chemistry", by James DeRose, and "Academic Program Planning by Network Analysis" by Vargos and Taylor.

When writing behavioral objectives it was suggested that at least two people work together. Objectives should be read, then be acted upon and discussed.

The questions that should be answered about each objective concern the appropriateness for the course, workability, teachability, testability, and are they properly stated in terms of conditions, performance, and center of accomplishment.

A program was reported where objects were written and students were allowed to progress at their own rate by using taped lectures and an available teacher. If the student had not successfully completed the work at the end of a semester, he had a semester to make up an incomplete. Pre- and post-testing were used. As mentioned, this program included an opportunity for interaction with instructors. It was found that this was essential for the success of the program. A few students were able to listen to the tape, take the test, and go on to the next unit; however, most took more time and needed to get help from the instructor.

Some of the teachers found that putting a time limit on a student actually helped a student. It was pointed out that many objectives are given without using the exact form and verbage suggested by the authorities and are generally quite effective. It was suggested that a bank of behavioral objectives be established so that all teachers could draw on them when they needed them. Behavioral objectives make the teacher accountable by forcing him to say what he wants a student to learn before he teaches it. It was questioned whether it was fair to the student to tell the student so specifically and completely what he is expected to know. Will this not weaken the student when he is in courses in which objectives are not used?

BEHAVIORAL OBJECTIVES AND LABORATORY TECHNIQUES

Jay A. Young, Carleton University
Ottawa, Canada

I would like to emphasize the practical utility for the teacher of his specification of the behavioral objectives. Too often, when behavioral objectives are not alluded to beforehand by the teacher, there is a tendency to give the student more to do than the student is able to accomplish in a reasonable time. This is particularly evident in the teaching of laboratory technique. The number of different behaviors that we expect the student to achieve in even the simplest series of related exercises is clearly more than we can reasonably expect to be acheived within the brief time of the typical laboratory period unless these are carefully planned, in advance.

Today, with the availability of all kinds of multi-media, some people have suggested and practiced the teaching of laboratory technique by the use of motion picture films or TV tape. It is clearly evident that with few exceptions, real motion is unnecessary for the effective teaching of laboratory technique. That is, the time required to learn the rudiments of even a simple technique is usually much longer than the time the student is exposed to that detail when a film or TV tape is run. Since students are not inclined in general to rerun a film or tape more than perhaps twice at most, the details are not learned. On the other hand, with the use of slides, the student can dwell on any particular point for as long as he pleases and can in addition easily go back in the slide sequence to review that matter (instead of having to wait until a loop of film recycles [illegible] the appropriate place for him). Additionally, slides are much more [illegible] and inexpensively edited than films or TV tape. Once a motion has been permanently inscribed on film or tape, the author of the material is reluctant, and understandably so, to undertake the relatively difficult and tedious step to reshoot the erroneous segment in a proper way. It is relatively easy on the other hand to remove a slide or two from a sequence and insert replacements.

Additionally, it is well known that although some inexperienced professors and teachers can indeed make excellent films, in general this is not the case. It is less of a problem for the inexperienced professor photographer to produce really acceptable slides than it is for him to shoot acceptable motion picture film or even TV tape.

All these arguments suggest that the use of slides and audio tape (with accompanying small inexpensive booklets) is the superior way to instruct students in laboratory technique. Examples of this use of multi-media for pre-laboratory instruction on techniques such as glass working, weighing, estimation and measurement of pH, generation of gases, determination of molecular weights, and others was presented.

NEW TEACHING AIDS OR NEW USES FOR OLD ONES
(Abstract)

W. Robert Barnard, Ohio State University

For the General Chemistry course, [illegible] has instituted a number of programs to answer the problems for improving instruction in the face of large enrollments and the demands of teaching from a body of scientific knowledge which is increasing in complexity and size.

The first program has been to facilitate the presentation of demonstrations to large lecture sections. Each general chemistry lecturer meets 250-300 students in a 350 seat auditorium. A student may sit as far as 60 feet from the lecture demonstration bench. In order for the students to have a close-up view of experiments or demonstrations which the instructors may use to give substance to complex topics, a large screen TV projector was installed. A 13 foot wide TV picture is projected directly over the head of the instrucor. Demonstrations can be performed in front of a compact, self-contained TV unit permanently mounted in the lecture bench. A portable video tape recorder and camera can be moved into the research laboratories to make video tapes of elaborate experiments using expensive research equipment which would never be seen by the average undergraduate. The video tape recorder is connected to the TV projector with a single cable connection and operated by the instructor with no more difficulty than a motion picture projector. "Live" TV presentations can also be made directly from a laboratory to the auditorium.

The instructor also has the capability to insert into the lecture at any time a slide or segment of a motion picture film at the touch of a button. All projection is accomplished with sufficient room illimination so the students can take notes easily. The projected images are large enough so that thermometer readings for example, can be taken from any seat. All equipment is under control of the instructor and is available on an unscheduled basis.

In the freshman laboratory program a project has been developed to facilitate the pre-laboratory instruction for fourteen thirty-student sections which meet for three hour periods throughout the day.

Previously, each of the laboratory sections was under the direct supervision of a graduate teaching assistant, but in the new program a specially trained undergraduate student assistant is assigned to each of the laboratories. Under the direction of a graduate laboratory supervisor the student assistants carry the burden of routine laboratory problems.

Each of the laboratories is eqipped with two television monitors, and the pre-laboratory instruction is carried into the laboratories through a three channel TV distribution system. The goal is a consistant level of instruction at a uniform time throughout all sections of a particular course. Three courses in chemistry meet simultaneously, and each uses the TV on an assigned channel. A telephone connects each laboratory with the central TV unit which is located in the laboratory area, and any instructor can call at any time for a re-run of a particular TV tape of film.

All of the television equipment, video tape recorders, film chain, and switching apparatus was selected so that the entire operation could be run by undergraduate assistants as well as by the instructors.

Two courses prepare their laboratory instruction directly on video tape with the camera work and presentations being done by the instructor in charge of the laboratory program. One course has all their instruction on color film. Films can be shown directly over the TV system, but in practice the film workprints with the editing marks are converted to video tape. After the video tapes have been shown to the labs for one week, a careful evaluation is made and the instructors comments on the effectiveness of the film noted and corrections made e.g. scenes are shortened or lengthened, added, corrected, etc. The final film prints are striped for magnetic sound and are approximately 16 minutes long. Narrative sound is used and is added at the TV central by the instructor. A camera position was established for the film series. We call it "zero angle" photography--the camera is positioned over the shoulder of the demonstrator and the viewing angle is such that only the hands or close-ups fill the screen. On the TV screen the viewer has the impression that he is doing the manipulation as the procedures for each experiment is outlined. Only apparatus used by the students is in the film. Close-ups deal with the techniques of instrument reading, etc. Care is taken that data are not presented such that a student can anticipate the outcome of an experiment from the films.

Each of the films is divided into four sections: introduction to the experiment, nature of the problem, experimental procedure, and treatment of the data. Each section can be used independently of the other. Sections of the films are reduced to S-8mm cartridges for the MPO projector and distributed to the branch campuses of the university. Examinations covering techniques could also be video taped and used as "trailers" on the TV.

The TV laboratory installation of film chain, two video tape recorders, 28 TV monitors, with all necessary switching apparatus and cables cost approximately $21,000.

The basic classroom equipment: TV projector, wireless microphone and film projector controls are on each day from eight to five o'clock. The instructor is encouraged to use the equipment because it is always there in front of him ready to go; however, the use of a teaching aid in a chemistry lecture may mean a three minute demonstration with TV, or a 30 second film clip. It is not expected that the equipment will be used every hour of each day.

Computer general displays are being used in the classroom. In a large classroom, a CCI 301 computer graphics generator has been used to interface the TV projector with an IBM 360-50 computer, such that the computer is under the control of the classroom instructor. Data are calculated and displayed on an 8 ft. screen in such a fashion that the students can have immediate access to alphanumeric information or their graphic interpretation at their seats.

In cooperation with the Bell and Howell Corporation the department has been engaged in a project to evaluate low cost color television, camera and recorders. Several of the chemistry color pre-laboratory instruction films have been converted to one inch color video tape format and transmitted into the laboratories to gage initial reactions by the students.

DEVELOPMENT OF AN AUDIO-TUTORIAL PROGRAM IN CHEMISTRY FOR USE IN A PREPARATORY CHEMISTRY COURSE

Paul Santiago, Harford Junior College
Bel Air, Maryland

Many, if not all, of us who have taught within the framework and philosophy of the open-door policy of a comprehensive community college have had problems with placement in freshmen chemistry courses, and/or the development of some type of remedial program to prepare a student to take the freshmen chemistry course.

At Harford Junior College I was given the opportunity of trying to design a course for students who did not take chemistry in high school or did poorly in high school chemistry, but needed chemistry for their college curriculum choice. I decided to include and stress the problem solving topics characteristic of the first semester. These topics I have found to be the biggest downfall for most students.

The course consisted of twenty-two lessons and a set of programmed textbooks.

#1 Lesson Number | Lesson Name

Lesson Number	Lesson Name
1	Metric System
2	Signed Numbers and Solving Simple Linear Equations
3	Definition of Chemistry
4	Chemical Classification of Matter
5	Sub-Atomic Structure of the Atom
6	Isotopes
7	Periodic Table
8	Bonding of Atoms
9	Writing Formulas for Ionic Compounds
10	Calcula ng Formula Weights and Percentage Composition
11	Calcula on of the Simplest Formula for a Compound
12	Balancing a Chemical Equation
13	The Mole Concept
14	Weight-Weight Problems
15	Kinetic Molecular Theory of Matter and the Gas Laws
16	General Gas Law Equation
17	Volume-Volume & Weight-Volume Problems
18	Solutions
19	Definition of Electrolytes, Acids, Bases and Salts
20	Single Replacement Reactions
21	Double Replacement Reactions
22	Neutralization

During three summers -- 1967, 1968, 1969 -- I offered the course four times. The course was taught using the traditional lecture, discussion, recitation and demonstration approach, stressing a large number of drill sheets with problems. The course was for non credit, but met as if it were a three credit course. In five weeks we met about forty-five hours.

In order to obtain some kind of indication of whether or not the course was bringing the students up to a level where they might succeed in a freshman course, I used a pre-and post-testing setup using the Toledo Chemistry Placement Exam.

#2 Toledo Chemistry Placement Examination Form 1963

Make-up of Exam

Part		Items	Points
I.	Arithmetic and Algebra	15	15
II.	General Knowledge	25	25
III.	Formulas & Nomenclature	10	10
IV.	Equations	6	12
V.	Algebraic Formulations	6	18
VI.	Chemical Problems	5	20
	Total	67	100

Order from: Research Foundation
The University of Toledo
2801 West Bancroft Street
Toldeo, Ohio 43606

The developers of the exam suggest a score of 40 on the test as a cut-off score; below this a student would be placed in a remedial freshman chemistry course; over 40 will be placed in regular freshman chemistry course. I used a score of 49.5 or the 40th percentile rank as my indicator.

#3 Toledo Chemistry Placement Examination

Percentile Rank	Score	
99	88.8	
95	80.2	
90	74.4	
85	70.5	
80	67.3	
75	64.5	
70	61.9	
65	59.3	
60	57.4	
55	55.2	
50	53.5	
45	51.6	
40	49.5	Used
35	46.6	
30	45.0	
25	42.6	
20	40.3	Suggested
15	37.2	
10	33.6	
5	28.1	
1	19.1	

The final grade in the course was determined by the total number of points a student obtained on the quizzes given for each lesson and a final exam made up of the Toldeo Chemistry Placement Exam and five other problems. If a student got 70% of the total number of points possible, he would get a "C" or, since it was non-credit, an "S". All students below the 70% mark got "U".

Table #4 shows the results of the pre- and post-testing for forty-five students for four summers.

#4 Using Traditional Approach
Summary of Results for 45 Students

	Percentile Rank		Change in Rank
	At Start	At Finish	
Average	9.1	39.4	+30.3
Median	5	30	+25.0

As indicated by the summary data, the average rank at the finish of the course was 39.4 which is very close to the desired 40. In terms of numbers, 20 out of 45 students (44.4%) reached the desired grade ranking at the 40th percentile. The results for a particular year seem to be influenced by the average starting grade of the class.

During the summer of 1970 I put each lesson on tape with a guidesheet for each tape and worksheet. Each lesson had a set of objectives in behavioral terms and a quiz setup in terms of these objectives.

The audio-tutorial lab was a reel-to-reel set so I could only put two lessons per night on the tape lab. I also used classroom discussion and demonstrations. This was a modified audio-tutorial approach. Class time was used to go over the previous night's lessons and to give quizzes. The remaining time was spent in the audio-tutorial laboratory where students went through the tape lessons.

#5 Results Using the Modified Audio-Tutorial Approach

Student Percentile Rank on the Toledo Chemistry Placement Exam
Summer 1970

	Percentile Rank		
	At Start	At Finish	Change in Rank
Average	1.33	23.7	+22.3
Median	0	25	+25

Comparison of Students in the Traditional Approach Scoring at the Zero or First Perentile to Those Using the Modified Audio-Tutorial Program

#6

	Average Percentile Rank		
	At Start	At Finish	Average Change in Rank
Traditional	0.5	20.0	19.5
Modified Audio-Tutorial	0	18.8	18.8

The results, compared to the students who started at "0" percentile in the traditional course, were not significantly different.

For this semester (Spring 1971) I have put each lesson on a cassette and put the guidesheets, worksheets and answersheets into a book. The tapes are in the library and class time will be used in discussion and quizzes. At times I had to re-teach a complete lesson if, in the discussion period, I felt that the students did not get the material.

I hope to revise this as a result of this Spring's work and submit the tapes and guidesheets for publication.

RECORDED INSTRUCTION FOR PHYSICAL SCIENCE

James J. D'Amario and Salvatore J. Rodano
Harford Junior College, Maryland

We at Harford, like physical science instructors at many colleges and schools, are concerned with making our physical science course a more interesting and palatable experience for the student. To do this we have begun providing audio and video tape recordings in the laboratory and individual interviews and pre-tests outside the laboratory. Topics important to the course and the experiment are presented on tape, as are examples which try to make the laboratory experiment meaningful and relevant.

Our physical science course consists of 3 main divisions: Discussion sections, Laboratory sections, Interview sessions. These can be described in more detail:

Discussion Sections	Laboratory Sections	Interview Sessions
Dialogue concerning the nature of solid matter	Audio and video tape instruction	Individual student-instructor talks about interpretation of laboratory results
Experiment-demonstrations	Performance of experiment	
Pre-tests and Tests	Quiz on experiment performed	

This combination of recorded instruction, pre-tests, quizzes, and individual interviews allows a considerable degree of flexibility. Since basic information is recorded, students can do experiments outside of scheduled laboratory times. The recordings often encourage student curiosity by limiting student frustration, since necessary information is usually available on tape.

The pre-tests let the student know definitely what is important before the test. And the individual interviews help clear up student problems and develop the ability to analyze experimental data and observations.

The efffect of tape usage has been to informalize class discussions, to improve student performance especially in the laboratory and to provide more individual instruction for each student.

We have developed this approach to physical science to minimize the difficulty, apprehension and confusion that many non-science majors experience in required science courses.

Through careful selection of text, cultivation of attitudes, new methods of evaluation, and much experimental work with audio and video techniques, we feel that our physical science course is no longer the dreaded trip into the unknown, but rather an enlightening apprecation of science, its beauty and its usefulness.

Consideration of the various physical science texts available led us to believe the PSNS course (Physical Science for Non-Science Students) would be flexible enough to adapt to various techniques and methods of presentation. The philosophy of the PSNS approach paralleled our own feelings of the importance of the experimental method and the need of the student to understand the scientific method of investigation.

The physical science student often has a poor attitude toward formal science courses coupled with a poor or non-existent background in mathematics. Perhaps the most frustrating aspect of these students' attitude about science is the feeling that science is quite irrelevant to them for they intend to enter fields, which from their points of view, are far removed from any contact with science. The preceeding comments cannot be used to describe all or nearly all of our non-science students; yet most instructors of physical science will agree that a large percentage of their students can fit the foregoing description.

The experiments for the physical science course are conducted in the audio-tutorial laboratory. The laboratory consists of 24 individual booths, each containing an audio tape deck, head phones for audio and TV listening and foot-switch controls. Closed circuit television monitors are placed around the laboratory for the viewing of the video tapes. Near the beginning of each laboratory period students pick up the equipment necessary for the experiment from tables at the end of the laboratory and return this equipment to the tables at the end of the experiment.

To improve attitudes and reduce irrelevancy feelings, we begin the course by providing a video tape on the mathematical methods and techniques that are utilized throughout the course. The mathematical background for the PSNS requires a knowledge of some basic algebraic manipulations, and the ability to work with power of ten notation. The instruction consists of a 40 minute video tape with an accompanying worksheet to aid the students in using these mathematical techniques.

The methods of problem solving is illustrated by the instructor on the video and the student follows along with his worksheet. The tape concludes by asking the student to complete problems provided with the video worksheet and to check their solutions with the posted answers. An instructor is present to confer with the student on any question or difficulty he may have. The student is encouraged to view the tape as often as he deems necessary to become familiar with the concepts presented. Student reaction to this particular tape has been very positive, and the constant semester-long complaints about math difficulties seem to have almost disappeared.

We attempt to prepare and provide a video tape whenever a situation or concept appears to give the students a difficult time. Sometimes our video tapes deal with theoretical concepts, such as the mathematical video tape just described, and at other times the video may illustrate a particularly difficult or tedious part of an experiment the students are doing. On occasion we have produced a video tape to demonstrate an experiment that would be dangerous or difficult to perform during a lecture session, such as the combination of hydrogen and oxygen.

Audio tapes are provided for each laboratory experiment performed. The student listens to a summary of pertinent information necessary for each experiment to be performed; he then does the experiment at the pace he chooses while listening to more detailed instructions. Criteria which allow the student to judge the success of his experiment are also included. The students feel that these tapes are useful and we have found considerable improvement in overall student performance.

There must be a better method of evaluation! The thought became more persistant the deeper the authors got into the staggering pile of laboratory notebooks and reports. The necessity of laboratory work evaluation is obvious and needs little justification. Laboratory experience constitutes a considerable portion of most science courses and becomes particularly significant in a course like PSNS. A semester grade would, and should, be strongly influenced by student competency in the science laboratory.

The traditional method of evaluation is to require some type of written laboratory report. Despite attempts at inventiveness in our laboratory and classroom presentation, up to the beginning of this year we were still relying on this traditional type of evaluation to measure student achievement. Our first attempts to improve laboratory evaluation seemed merely to revolve around improving the written laboratory report so finally we decided to break away from the written report entirely.

At present our students leave a carbon copy of their data and calculations, and perhaps some pertinent comments, with the instructor when they have completed the experiments suggested for the particular week. The instructor collects, files and uses these carbon copies as a basis for discussion during an interview session.

Three times a semester we meet privately and individually with each student to discuss the laboratory work he/she has been doing for the past several weeks. These meetings are informal and students are asked to discuss or explain various aspects of their laboratory experiment. The students respond to the individual attention and instructor interest in a manner that increases and broadens the learning experiment offered by the course. The fact that their laboratory experiences will be discussed with them by the instructor seems to increase their questioning attitude towards the experimental situation and also appears to encourage the students to utilize the "open endness" of some of the experiments and to explore and experiment past the suggestions put forth by the text and audio tape. It is apparent to us that this technique has incresed communication between student and instructor.

The verbal laboratory reports indicate a higher level of understanding than normal, indicating that more students than usual understood the fundamental ideas and techniques associated with the laboratory experiments. Also, every student was directly involved in each experiment to the extent that each student had prime responsiblity for performing each experiment. In the conventional laboratory, students always work in groups and there are always some who participate passively in the experiment by just watching others work. The audio-tutorial laboratory pressed each student into an active laboratory role.

The individual performance of laboratory experiments in the conventional laboratory is prohibitive. This is because there is not enough time to work and instruct those students who would just watch and also to answer the reasonable questions of other students doing the experiments. The A-T system tended to eliminate routine questions and to increase questions of a more perceptive and probing nature. So the slower students were able to get some experimental results and the better students were able to discuss more meaningful questions with the instructor. Further, preliminary discussion on the audio tape prior to specific experimental instructions provided an excellent opportunity to review and reinforce previous ideas and concepts important to the course and to the upcoming experiment. Also, in the preliminary discussion it was often possible to tie in examples of common occurences similar to the experiment and to place the particular experiment in proper perspective with respect to the course as a whole. In the conventional laboratory, information like that in the preliminary discussion is greatly de-emphasized or eliminated because emphasis must be placed on specific instructions and precautions for the experiment about to be performed.

We attempt to include in each of our audio-tapes the following:

1. Review of pertinent topics already discussed.

2. Appropriate examples and possibly interesting information related but not essential to the experiment.

3. Essential ideas and techniques for performing the experiment.

4. Purpose of the experiment.

5. Criteria for judging the experiment successful where appropriate.

6. Step-by-step experimental instruction (not necessarily explicit in every detail) intended to encourage student curiosity.

Students taking this course have been surveyed twice to determine their attitudes toward this laboratory. The results of these surveys strongly indicate favorable student reaction to the system. The unanimous responses in both surveys that A-T was useful and that it should be continued clearly emphasize that A-T is a valuable instructional tool as used in our physical science course and that it should be further developed.

A-T's greatest advantage is its rewind capability, which allows students to listen to instructions as often as necessary and to work at their own speed. Its disadvantages arise from two sources. One is related to the nature of the A-T system and can not be remedied except by the use of considerably more sophisticated equipment; this refers to the inability of the A-T system to answer student questions on a real-time basis. An instructor or aide in the laboratory at all times effectively corrects this situation.

The second disadvantage arises when taped instructions and comments are unclear. This is of course a fundamental problem of any system of this nature. Tape instructions and comments must be regularly reviewed and improved when necessary.

However, survey results show that these A-T disadvantages were considerably outweighed by the A-T advantages.

It is worthwhile to note that the preparation of the audio-scripts is very time consuming. A reasonably good script of approximately 15 minutes duration, with clear and relevant information requires on the average about 12 full hours to prepare.

At this point it is clear to us that if an instructor decides to embark upon this type of program his college or school must strongly support his endeavor. An ideal situation seems to be for the instructor to be hired for the summer session to devote full time to the development of a program.

MEDIA ASSISTED INSTRUCTION IN ORGANIC CHEMISTRY

Roy Sonntag

This program developed to assist in lecture classes, but no attempt was made to extend it to the laboratory. He developed this method to change lecture so one wasn't limited to transmitting data, but could incorporate more discussion and get the students to participate.

The equipment used in this program was:

(1) A cassette tape recorder, because it was the least expensive and was convenient for audio-tutorial. This was also convenient for student use.

(2) An external power supply, simply because the battery powered recorder wasn't strong enough.

The unit cost was $65, which included a recorder, head set, and ten tapes. This was used in an organic chemistry class and has been in use for three years with no major difficulty. He suggests using a unit, which includes the above listed parts, for every ten students. The material used on each tape was outlined in detail and is approximately twenty-five minutes in length. This material should be closely correlated to lecture. However, using this method the student could be exposed to more than one text as a reference and could follow a mimeographed supplement while listening to the tape.

The tapes that have been made are:

(1) Nomenclature - By giving the detailed information on the tape, the instructor doesn't have to transmit all the facts in lecture.

(2) Problem Solving - This was probably the most effective, in that each step and the rationale for each could be given. Being on tape, the student could stop and repeat material. Problems included: Elementary Analysis, Functional Groups, and Reactions.

(3) Synthesis - This was very good in that more detail could be covered as to why the reactions occurred as they did.

(4) Library Instruction - This hasn't been developed fully, but has great possibility in correlating research and library for the student.

There are certain conveniences which contribute to the success of the tape recorder. To have a reading or reference room, preferably in the science building, where the student can use the recorders is of great benefit. A student having a text and mimeograph material with which to follow the taped lesson adds to the success.

The disadvantages are:

(1) The cost of the equipment, but using cassettes drastically reduces this problem.

(2) The time required for lesson preparation on part of the instructor is much more than one might expect.

(3) The maintenance of equipment could be a problem, but the equipment described has been used for three years with no breakdown.

(4) If large classes are involved, the availability of the equipment could present a problem. It might be impossible to have recorders readily available at the students' conveniences.

The advantages are:

(1) This method allows the lecture period to be used for other instruction.

(2) It allows topics to be expanded.

(3) Students can repeat the material if they do not understand it the first time through.

(4) Synthesis problems can be outlined in more detail and each reaction or step explained.

Most students thought the tapes were helpful and worthwhile.

A TUTORIAL APPROACH TO ORGANIC CHEMISTRY

Joe Vikin, Corning Community College
Corning, New York

When in the course of human events -- to paraphrase the unanimous declaration of the thirteen United States of America -- it becomes necessary to part with a traditional teaching method, a decent respect for the opinions of my colleagues requires that I declare the causes which impelled me to the separation. I hold these truths to be self-evident: that every person that comes to our institutions should have a chance to first-rate education; that even though all men are created equal, they learn at different rates; that teachers should adopt a teaching method that allows them to give the best possible education; that the use of Gutenberg's invention is a better way to transmit knowledge; that lectures are not to be rehash of written material, and that students deserve to receive an education at a sane and reasonable rate.

Because I accept those "truths" I think the traditional teaching method -- e.g., lectures, occasional examinations, no objectives -- is inadequate to meet the needs of the different types of students that we encounter in our classrooms.

Donald Starr described a tutorial system of instruction in the Proceedings of the Two-Year College Chemistry Conference, 1967-1968, and the August 1967 issue of the Advisory Council on College Chemistry Newsletter describes a few more.

The impact of these techniques was not clear to me until I visited Meramec Community College, Kirkwood, Mo., where Dr. Rudolph L. Heider developed an audio-tutorial approach to general chemistry.

When I was there I talked to many students and only then I became convinced that the new approaches were vastly superior to the traditional, lecture-oriented teaching methods.

Before I describe the approach I use at Corning Commjnity College, let me say that the important thing is not the technique per se, that is you can adopt any and modify it so suit your tastes, but rather the important thing is the attitude of the teacher.

The first attitude is to believe that every student is capable of learning. If you are not convinced about the necessity of holding this attitudde, please read the book "Teaching as a Subversive Activity." If one does not hold such an attitude the pupils will fail simply because the teacher expects them to do so.

The second attitude is that of skepticism about the content of our courses. Skepticism is a trait every chemist should develop. It was not by accident that the first modern treatise of chemistry was called "The Sceptical Chymist."

Those attitudes led me to re-examine my teaching practices. As a result I adopted the integrated appraoch to organic chemistry, in which the first half of the course is devoted to principles and the second to the application of those principles.

I then divided the course into six units per semester, as shown on Table I. There is an examination after each unit. This frequent testing is an improvement over the practice of one mid-term and a final.

When a student obtains a low grade in an examination, he can request a retest to show he learned the material he failed to lean previously.

There is one hour of "lecture" per week and two tutorial hours. During the lecture I clarify the work to be done during the week, bring to the students' attention work published in the current literature, give them additional references and answer their questions.

During the tutorial hours there are not more than six students, a fact that allows me to individualize the instruction. I encourage them to do the homework assignments during the tutorial hours when they can obtain help if they need it.

For each unit they receive behavioral objectives, some of which are shown in Table II. The objectives describe in detail what the students are expected to learn and how they will be tested. Robert Mager's "Preparing Instructional Objectives" is an excellent book to help learn how to write them.

Because students are allowed to take examinations over and over agian, it is possible for a slow student to obtain an A after repeated tries, thereby getting the same grade as a fast student. This situation does not seem fair, and is a relection of the letter grading system we use. Adopting plus and minus signs is an improvement, but ultimately this grading system should be replaced. This has been done in some schools, such as the one my son attends, where in lieu of grades the teacher issues progress reports. Issuing such reports is a more valid way to judge a person's performance, as it is done in industry.

I use two textbooks: Kice and Marvell, "Modern Principles of Organic Chemistry", and Hendrickson, Cram and Hammond, "Organic Chemistry."

The students are free to choose either one. I recommend that students in the Chemical Technology program adopt the first one and those in the transfer program the second one.

The examinations are divided into two parts: a closed book, based on the objectives, and an open book section, based on the homework assignments. The students have unlimited amount of time to complete each examination.

The laboratory is open for 15 hours each week. The students are welcome to come as often as they want, but very few accept this invitation: the majority are there for only three hours per week.

We give them a sense of discovery by having them work with unknowns.

In the first semester they receive a solid unknown they must identify using physical and chemical data, as shown in Table III. For the remainder of the first semester they perform a Grignard and Friedel-Crafts synthesis. They must also identify the synthesized substances.

In the second semester they select an experiment from each of the following categories: extraction from natural sources, synthesis of an unknown, kinetics and multiple step synthesis.

For the first two experiments they must identify the unknowns. For the third, the reaction rate is the unknown. For the multiple step syntheses they either devise the synthetic scheme or look it up in the library. If they do the former they receive extra points.

Table IV shows the results using the tutorial approach: not only the grades improved using this system but the drop-out rate decreased discernibly. Also the method is flexible to allow us to teach the first and the second semesters of the course every spring.

I am convinced the tutorial approach is the one to use. I hope you agree.

TABLE I

ORGANIZATION OF THE ORGANIC CHEMISTRY COURSE - TUTORIAL METHOD

FIRST SEMESTER

Unit	Topic	Hours
I	Introduction and chemical bond	3
II	Nomenclature of organic compounds	7
III	Reactions and synthesis of organic compounds	5
IV	Laboratory practice of organic chemistry and spectroscopy	8
V	Resonance, hyperconjugation and tautomerism; stereochemistry	7
VI	Reaction mechanisms; sturcture and reactivity	8
	SECOND SEMESTER	
VII	Elimination, addition and stubstitution Reactions	9
VIII	Carbonyl compounds; carboxylic acids and derivatives	7
IX	Molecular rearrangements and aromatic hydrocarbons	8
X	Carbohydrates, amino acides and heterocyclic compounds	6

SECOND SEMESTER (cont.)

XI	Isoprenoids and steriods; polymers	5
XII	Literature and history of organic chemistry; uses of organic compounds	3

The number of hours include lecture and tutorial periods but excludes time devoted to examinations.

TABLE II

SAMPLES OF BEHAVIORAL OBJECTIVES

UNIT IV. LABORATORY PRACTICE AND SPECTROSCOPY

OBJECTIVES. THE STUDENT SHOULD BE ABLE TO:

1. Draw a picture of the folloiwng apparatus and describe their use in the laboratory: Vigreaux column, suction flask, powder funnel, Soxhlet extractor, Thiele tube, Hirsch funnel.

2. Describe the following techniques in terms of apparatus uses, capabilities and limitations of each: atmosphere, vacuum, steam and fractional distillation; recrystallization; gas, paper, thin layer and column chromatography.

3. List the hazards associated with the following substances and the precautions to be taken in working with them: isopropyl ether, acetic anhydride, benzene, acetone, ethyl acetate, carbon tetrachloride, chloroform, methyl alcohol, dioxane, phenol, demethylsulfoxide, phenylhdrazine and 2,4-DNPH.

4. List the functional groups detected by the following tests and reagents: Baeyer, Fehling, phenylhydrazine and 2,4-DNPH, Lucas, ferric chloride, aluminum chloride-chloroform, Tollens, ceric nitrate, Benedict, Hinsber, Ninhydrin, haloform, formaldehyde-sulfuric acid.

5. Define the following terms and illustrate with examples: group frequency, chemical shift, tetramethyl silane, spin-spin coupling, coupling constant, tau and delta system, non-bonding orbitals.

6. Describe the techniques, limitations and capabilities of the following methods to determine molecular weights: Signer, Rast, ebulliscopic and gas density.

TABLE III

LABORATORY WORK

CHEM. 221 ORGANIC CHEMISTRY I

I. Melting temperature determination

II. Boiling temperature determination

III. Freezing temperature determination

IV. Solubility determination

V. [illegible]

VI. Polarimetry

VII. Qualitative Elemental Organic Analysis

VIII. Molecular weight determination

IX. Chemical properties of the unknowns

X. Preparation of derivatives

XI. Grignard synthesis

XII. Friedel-Crafts reaction

CHEM. 222 ORGANIC CHEMISTRY II

I. Extraction of unknowns from natural scources

II. Syntheses of the unknowns

III. Kinetics

IV. Multiple step syntheses

TABLE IV

GRADE DISTRIBUTION

Grades	TRADITIONAL METHOD 1967 Fall 221	1968 Spring 222	1968 Fall 221	1969 Spring 222	TUTORIAL METHOD Summer 1969 221	Summer 1969 222	1969 Fall 221	1970 Spring 221	1970 Spring 222	Summer 1970 221	Summer 1970 [illegible]	1970 Fall 221
A	1	0	4	1	6	7	8	1	4	7	10	8
B	2	3	6	6	4	5	7	4	5	1	0	2
C	6	3	4	1	2	0	0	1	3	1	0	[illegible]
D	5	3	3	4	1	0	0	0	0	0	0	7
F	0	1	1	0	0	0	0	1	0	0	0	3
W or X	4	0	8	6	1	0	0	4	2	0	0	3
Inc.	0	0	0	0	1	0	0	0	1	0	0	5
%A & B Grades	16.7	16.7	38.5	39.0	71.5	100.	100.	45.4	69.4	89.0	100.	50.0

The grades were computed as follows: average of the term examinations, 60%; laboratory work, 30%; and final **examination, 10%. The letter grades** have the following numerical equivalents: A = 90-100%; B = 80-89%; **C = 70-79%; D = 60-69%;** and f = 59% or less. W indicates officieal and X unofficial withdrawal from the college; **Inc. means incomplete.** *221 is the first semester and 222 is the second semester of organic chemistry.*

CHANGE THROUGH THE CHEMTEC PROJECT - Spring 1970

Kenneth Chapman
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In the non-physical world the one real constant is change. Change is frequently invoked as always being good, but change can be either bad and destructive or good and constructive. Teachers in particular are major change agents even if they make no attempt to maintain their technical competence or make no use of new teaching techniques or new media. Simply coming into contact with students on a day-to-day basis induces changes that can be either constructive or destructive. In the United States growth has always been the subject of considerable pride and has been placed alongside motherhood, the flag and Mom's apple pie as part of the American tradition.

Today growth is being viewed with a different perspective. Growth must now be balanced with those things that promote a good Quality of Life. This may mean a decrease in the rate of growth or possibly, zero growth.

As technically trained teachers, we have broad responsibilities. We must be responsible as citizens that are responsive to need within society. As technically competent people, we must strive to avoid obsolescence in our technical background. As teachers we have the responsiblity of molding attitudes as well as disseminating information and conducting training. All of this means that we have very critical responsibilities which must be accepted while we exploit our abilities and talents. In accepting this kind of responsibility, we must determine when we are successful and what criteria can be used to measure success. Personally I am not at all sure we always use the right criteria to measure our teaching success or the lack thereof.

Now let us narrow our focus to the specific arena within which we work and which provides the basis for this gathering.

Technical education programs can provide major benefits in two areas. It can meet the personal need of individual students, particularly those who generally would be considered non-academic types but who have a genuine interest in the applications of science and technology and who have sufficient academic ability to satisfactorily relate to mathematics and science taught in a proper manner. These individuals can take programs in technical education that will virtually assure them of reasonable incomes and an increasing status in today's and tomorrow's world.

Technical education programs also meet society need through satisfying some of the personnel needs of industry, government and academia. Meeting these needs helps assure that our society is provided with the necessities and luxuries which must be produced through synthetic products. The technically trained person can serve society through his contribution to production efforts, through research activities and through monitoring our environment and assuring that it becomes more livable.

Recognizing the needs and desires of individuals, society and industry, the American Chemical Society deliberated on its responsibility for chemical technician education for several years. In 1968, a proposal was developed to seek support for a major curriculum project in this area. A grant was received from the National Science Foundation in 1969.

The Chemical Technician Curriculum Project has the goal of constructive change in technical education. It seeks growth but not growth for the sake of growth but for expansion to the point where individual needs and society's needs come into a far better balance than they are today. The Chemical Technician Curriculum Project, which we refer to as the ChemTeC Project, actually began in 1964. The American Chemical Society holds biennial education conferences and the one in 1964 discussed the problems of chemical technician education. After this conference a committee was appointed which produced a very broad curriculum outline for chemical technology programs and suggested that another committee be formed to investigate the chemistry core of the two-year associate degree program. In 1967 the second committee, chaired by Dr. Carleton Roberts, published its recommendations concerning a topical outline in chemical technology education and outlined some of its thoughts of how a chemical technology program should be handled. The problem with the topical outline was that it was interpreted in widely different ways by different people. Some of those who have had long connection with chemical technology programs looked at the outline and decided that it was about what they expected from the high school graduate coming into their program. Other people looked at the outline and decided that it was ideal as the course work for the Ph.D. program. Thus, it is obvious that communication was not occurring in the manner which was most desired.

In 1967 contact was made with the National Science Foundation to determine the degree of their interest in technical education and whether or not they could entertain a proposal for a curriculum project in this area. After considerable discussion and preparation of a pilot proposal, the Foundation decided that it could entertain a formal proposal and the American Chemical Society eventually became the recipient of the Chemical Technican Curriculum Project grant on July 1, 1969. The ChemTeC Project has as its purpose, the preparation of textbooks and associated materials for the chemistry core content of two-year associate degree chemical technology programs. The material is to be designed for the middle one-half of the graduating classes and not presume any prior contact with chemistry. It has the very narrow purpose of preparing instructional materials for the preparation of technicians. It is hoped that most of the programs interested in using the ChemTeC materials would be able to add an additional one, two or more courses in chemistry to provide for specific area needs or take care of specific problems as seen by the college faculty. The student completing the ChemTeC program should not find his base too narrow but rather he should be well trained for convenient and efficient retraining when he finds it necessary to leave one area of chemistry and go to another.

Preparation of the ChemTeC materials calls for a two-fold integration. We intend to do away with the traditional subdiscipline boundaries in chemistry and present chemistry as a unified whole. We also intend to integrate lecture and laboratory material far more extensively than is normally the case today. Ideally the laboratory work will lead the lecture work rather than the reverse which is typical of today's chemical instruction. Recognizing the short amount of time, the vast amount of material and the need for our kinds of students, we want to see concepts used in different situations and preferably several different times. We have taken the initial steps toward developing underlying themes as the primary focus of a student's attention. We would envision a number of underlying theses--probably twenty or more. Each theme would have a number of topical areas on which it would concentrate. The result would be that the student would have his attention focused more on a theme while the teacher was focusing to some degree upon the individual topics that would serve as tools for understanding the theme. This approach enables a given topic to be discussed under several different themes with a steadily increasing sophistication to get to the point where the student understands what he really needs to know about a given topic. He will also have seen the topic's application to real chemistry and be in a better perspective to use what he knows about a given topic in other applications.

The ChemTeC Project is generally administered through a steering committee composed of representatives of industry and academia, both two-year and four-year college people. The writing team consists of twenty-five people, twelve of whom are representatives of two-year colleges, three are industrial representatives and ten are noted writers and teachers from four-year institutions. The project is being directed by Dr. Robert Pecsok, Vice-chairman of the Department of Chemistry at the University of California, Los Angeles.

The writing team met for the first time on the 2nd, 3rd and 4th of April, 1970, and quickly came to agreement on a large number of important points. The ChemTeC Project will intend to provide sufficient instructional materials for the first year's portion of the chemical technology program by the end of the summer 1970. These materials will then be evaluated in twelve pilot colleges to determine what changes need to be made and provide a basis for writing the second year materia[l] in the summer of 1971 as well as revising the first year materials. We intend to make one set of the first year materials available to institutions for review purpos[e] sometime in the Fall of 1971. It should be noted that instructional media may play a very large role in the ChemTeC Project and will, of necessity, not be produced as rapidly as the textbooks. As a matter of fact, the current grant does not include money for the specific development of high quality materials such as 16mm films.

The initial work that resulted in the ChemTeC Project began at a very fortuitou[s] moment of changing attitudes in Washington. The National Science Foundation was reviewing its science education support activities and deciding that more of its attention needed to be focused on technical education. Various societies such as the American Association for the Advancement of Science, the American Institute of Biological Sciences, the American Association of Physics Teachers and the American Institute of Physics were becoming involved with technical education for the first time. ChemTeC has given encouragement to groups such as AAAS, AIBS, and AAPT to proceed with other developmetns of technical education.

The ChemTeC Project is expected to influence chemistry at both the high school and college level as well as provide a good educational program for the chemical technician. Through the problems we will have in teaching topics of chemistry, we should be able to provide some good ideas of how to work more descriptive chemistry into high school and college programs. If our integration approach to the subdivisions of chemistry is successful, then we should promote changes which some people are examining now for the education of scientists and engineers.

We are extremely concerned with evaluation of the ChemTeC Project. We want our materials to be as useful as possible for the students and would like to develop a technique which allows a student to evaluate himself privately. The same material could then be used by the teacher to determine the parts of the instructional program that need improvement and the ChemTeC Project, in turn, can use the same materials f its own evaluation purposes. If we are successful in implementing an evaluation approach that is currently being discussed, we could influence textbook publishers to give a great deal of attention to this area.

As we look at chemical technology we hope that the ChemTeC Project is able to provide a much clearer definition of what chemical technology education should be. There is a need for making a distinction between the level of chemistry and the kind of chemistry. It appears that we are in the beginning stages of distinguishing technicians as practicing a partiular variety of chemical activity that is different from the practice of a chemist. Both are very strongly interrelated and overlap to a considerable degree, but both have unique features and capabilities which should serve to distinguish between them more effectively than is currently possible. Thus, we are not particularly concerned that the ChemTeC materials will have less mathematical sophistication than the four-year programs and less than some of the existing chemical technology programs. We are very much concerned that the ChemTeC students have the kind of background they need to function effectively as technicians and advance to a level consistent with the individual's ability. Our explorations to date do not provide any justification for concentrating on mathematical derivations or using calculus in a formal sense. A superficial view of the ChemTeC materials may well produce the impression that we are not approaching concepts with the sophistication with which we have become familiar, but we do intend to provide a sound basis for continuing education for the ChemTeC graduate. The ChemTeC Project is avoiding the problem of teacher training for the time being. We hope that some members of the Writing Team will be able to develop institutes for ChemTeC teachers in the summer of 1971. Our pilot schools are limited to twelve because we felt that the faculty member who would be teaching from the ChemTeC materials in 1970 would have to be intimately familiar with their development and their intent. We recognize the problem that the preparation of teachers in technical education is an extremely critical problem and is not receiving adequate attention at the current time. There are some programs which offer real promise in this area and the AAAS is starting to look into the problem of teacher training for the science technologies.

The ChemTeC Project cannot deal directly with the problem of recruitment of students. We will be working very carefully with the pilot schools, hoping that we can arrive at some good models for getting information to students in a manner in which they can make legitimate decisions about whether or not chemical technology can be a good career for them as individuals. Many factors influence the recruitment problem but we still are faced with the fact that many thousands of more technicians are needed than we are able to attract to today's chemical technology programs.

Recognizing that change can be constructive or destructive, we have to say that we are taking our chances with ChemTeC. All of the existing chemical technology programs in the country may be considered successful if we view the small number of graduates that have gone into industry. Regardless of the level of the program, graduates of chemical technology programs have always been able to get jobs and have, in practically every case, been pleasing to their employers. Thus, ChemTeC's objective is to find a way to reach a much larger number of students with appropriate training materials. We, of course, are convinced that what we will do will be constructive.

As previously mentioned, the ChemTeC Project should influence much more than just chemical technician education. Its influence may well go outside the realm of chemistry and influence other educational efforts as well. Evaluation may prove to be the most critical part of the whole ChemTeC Project. As we look at evaluation we must ask ourselves this question: How do we measure the success of ourselves as teachers and of our courses and programs?-- By how well the students say they like us? By how much material we cover? By how rigorous and demanding a course we teach? By emulating our colleagues in four-year colleges? By the number of students who decide to follow in our footsteps? By the number of students for which our programs are advertised? By sceening out, through failure, students who have little appreciation for and understanding of the beautiful, logical development of chemistry that was created by tens of thousands of chemists during the past two centuries? Candid answers to these questions are difficult to obtain but the questions provide a focus for evaluation.

We seek criticism and comments on ChemTeC's approach and the material that [illegible]

THE CHEMICAL TECHNOLOGY CURRICULUM PROJECT: AFTER A SUMMER OF PREPARING MATERIALS

Kenneth Chapman, Lawrence Hall of Science
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The American Chemical Society started looking at chemical technology education in 1963. A need was identified for materials for Chemical Technology. In 1969 a grant from the National Science Foundation to write this material was obtained. Work with a team consisting of 12 two-year college teachers, three industrial chemists and 10 college or university professors was started in the summer of 1970.

To help the Writing Team members develop a clearer, more distinctive approach to writing material for chemical technology, a model of chemical education was suggested with emphasis on the technician's desires and needs.

Many chemistry teachers have used a single view of chemistry to determine their approach to teaching regardless of the characteristics of the students they teach. The only change they make for students not taking the "standard" course is to water-down the standard course. The result is an obviously watered-down course that satisfies no one.

For teaching chemical technicians, the result of this approach is catastrophic. Many chemical technology programs have produced many more chemists and chemical engineers than chemical technicians. The <u>failures</u> from these programs have become technicians. What has been missing is the acceptance of the idea that different student groups need <u>different kinds</u> of chemistry rather than watered-down versions of standard offerings.

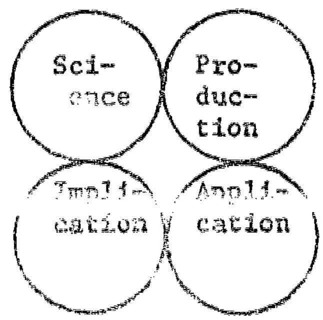
In an attempt to provide a clear perspective of the differences between the approach to chemistry instruction for the professional and the technician, an Orbital Model of Chemical Education has been devised. For maximum appropriateness, the diffuseness of electron orbitals in atoms and molecules needs to be applied to this model.

The model is displayed by the following diagrams:

The "Nucleus" of Chemistry Instruction

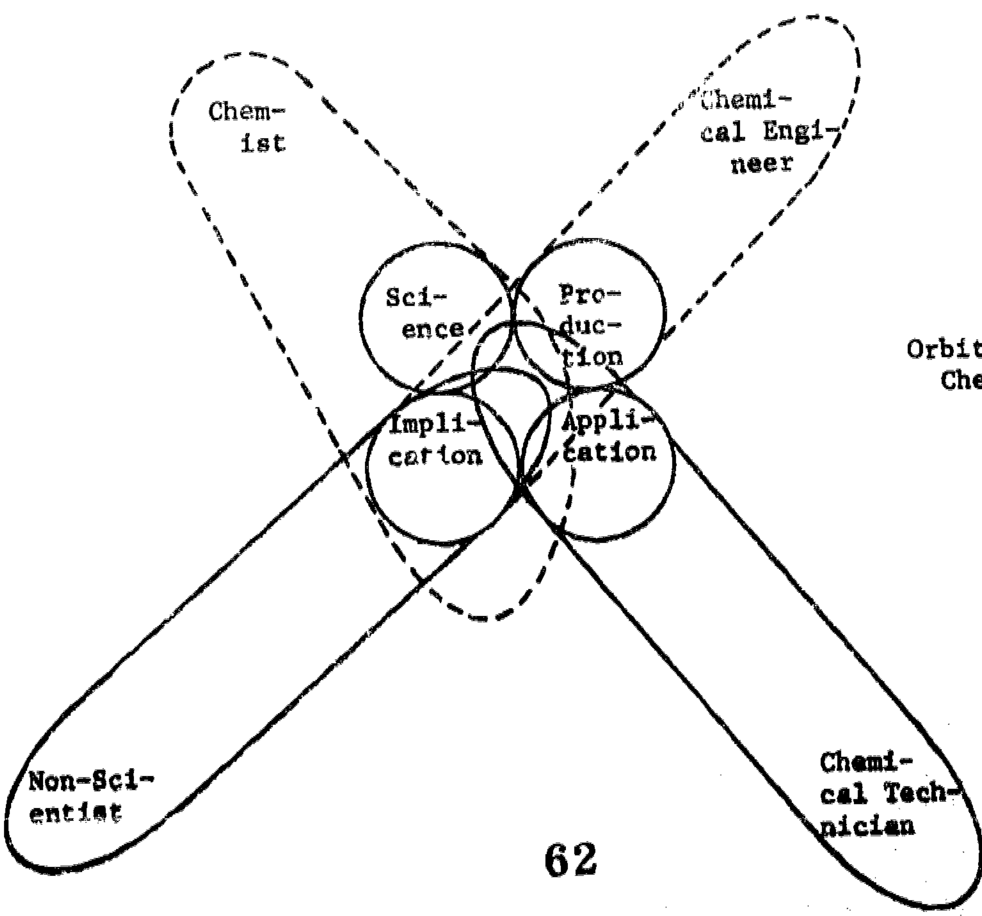
The models and theories of chemistry. Interpretation of data to clarify structure and properties

Macro properties principally of interest to engineers



The impact of chemistry in a technological society

The "bench-work" of chemistry. Experimentation and production of data. Interpretation to assure that data is valid and applicable to tests being performed.



Orbital Model of Chemical Education

Interpretative points applicable to technology education:

1. The chemical technician must be an individual who is applications or laboratory centered. To him, the science of chemistry is a tool which makes it possible for him to operate effectively and efficiently in a laboratory.

2. The chemist (and chemical engineer) must be thoroughly knowledgeable about the applications of chemistry. To them, the applications are tools which enable them to effectively function by planning and evaluating excursions into the science or applying it in new or unusual ways.

3. The chemical technician cannot be adequately trained by using a watered-down professional chemist's program. Neither is he adequately trained by taking part of the professional chemist's program.

4. By virtue of an orientation toward the solution of purely laboratory-type problems, most chemical technicians will have difficulty becoming fully operative as chemists. Obviously, many individuals are able to make the transition, but they are the exceptions and programs should not be designed only for them. Being the exceptional person, they are most able to make the transition.

5. It is obvious that many persons trained as chemists eventually function very effectively as advanced chemical technicians. Thus, it is likely that many of the individuals enrolling in professional courses would be best served by a technology oriented program.

6. If this model is reasonably correct, the difficulty of preparing technology teachers from chemists becomes evident. A reorientation of the individuals's view of the use of technically trained personnel is required as well as the usual preparation for teaching in the classroom. If the reorientation is not accomplished, any course is going to become a watered-down version of a chemist's course regardless of the teaching effectiveness of the instructor.

This model can be fruitfully extended to more specifically examine the educational problems (in chemistry) for chemists, chemical engineers and others to whom chemistry is taught. The general model should also be applicable to other science areas, engineering and non-science disciplines as well.

The result of the 1970 work session was 900 pages of manuscript. The content can be described briefly by referring to the list of chapter titles:

GUIDEBOOK FOR
CHEMICAL TECHNICIANS:

Ch. 1 Safety in the Chemical Laboratory
Ch. 2 Personal Protective Equipment
Ch. 3 Fire Safety and Explosions
Ch. 4 Electrical Hazards
Ch. 5 Toxicity of Chemicals
Ch. 6 Compressed Gases
Ch. 7 Special Hazards
Ch. 8 Notebooks
Ch. 9 The Path From School to Job

VOLUME I:

Ch. 1 Things Around Us
Ch. 2 More About Separation
Ch. 3 Some Experiments in Gas Chromatography
Ch. 4 More Experiments in Gas Chromatography
Ch. 5 Other Tests for Purity
Ch. 6 Properties of Gases
Ch. 7 Gases and Their Measurement

VOLUME II:

Ch. 8 Elements and Compounds
Ch. 9 Liquids and Solutions
Ch. 10 Chemical Formation of Light
Ch. 11 The Structure of the Atom
Ch. 12 The Formation of Molecules - Covalence
Ch. 13 The Formation of Ionic Compounds - Electrovalence

VOLUME III:

Ch. 14 The Periodic Table
Ch. 15 The Names of Inorganic Compounds
Ch. 16 A Look at Organic Chemicals
Ch. 17 The Chemistry and Detection of Some Common Metals
Ch. 18 The Chemistry and Detection of Some Common Nonmetals

VOLUME IV:

Ch. 19 The Techniques of Sampling
Ch. 20 The Techniques of Weighing
Ch. 21 Sample Preparation
Ch. 22 The Measurement of pH
Ch. 23 Gravimetric Analysis
Ch. 24 Preparation for Titrimetric Analysis
Ch. 25 Titrimetric Analyses

VOLUME V:

Ch. 26 Oxidation and Reduction
Ch. 27 Coordination of Compounds
Ch. 28 What is Organic Chemistry?
Ch. 29 Classes and Functional Groups of Organic Compounds
Ch. 30 Classifying Organic Compounds
Ch. 31 Reactions of Hydrocarbons

VOLUME VI:

Ch. 32 Alcohols and Phenols
Ch. 33 Alkyl and Aryl Halides
Ch. 34 Ethers
Ch. 35 Aldehydes and Ketones
Ch. 36 Carboxylic Acids and Derivatives
Ch. 37 Organic Compounds of Nitrogen
Ch. 38 Organic Sulfur Compounds
Ch. 39 Optical Activity

In Volume I, purity was studied in Chapter one by using paper chromatography. The student looked at both pure and impure samples. In Chapter two, separation was studied using gas chromatography. This is to serve to motivate the student and insure success in this early endeavor without requiring a background in either chemistry or mathematics. The work with gas phase chromatography continued with the students injecting the samples and working with data. In order to maintain interest, real samples are used whenever possible. With there still

... for chemical formulas, other tests for purity are introduced. Melting point, boiling point and thermodynamics from the point of view that heat is energy are introduced. By Chap 6 the properties of gases are being studied. The students do experiments with PV and VT and then are asked to interpret the results. At this time Avogadro's number and molecular weights are introduced. An effort is made to let the student lead into a concept by working on an experiment and then drawing data from his notebook to arrive at the important concepts. Notice that in Volume I there has been little or no chemistry. In Volume II, the chemical nature of matter is studied. Stoichiometric relationships, solutions, spectrophotometric measurements, atomic structure and bonding are introduced. The extent of theoretical coverage is less than in many general chemistry texts.

Volume III continues with the Periodic Table, nomenclature of inorganic and organic compounds. The qualitative analysis and chemistry of metals and nonmetals is introduced.

Volume IV concentrates on non-instrumental quantitative analysis with much greater emphasis being placed on sampling than has become commonplace.

Volumes IV and VI largely cover topics considered to be organic chemistry. Infared spectrophotometry is used to introduce organic chemistry.

A guidebook was developed for the chemical technicians which includes safety and their problems as they move from school to the job.

The materials are being classroom tested in twelve colleges across the United States. Evaluations will provide the basis for revision of the materials prepared in Summer, 1970. In addition, there is new material to be prepared in Summer, 1971.

THE LABORATORY IN THE CHEMICAL TECHNOLOGY

CURRICULUM PROJECT

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Before describing the laboratory, perhaps a brief background of the "Chemical Technician Curriculum" Project (better known as ChemTeC) might be in order.

1. In 1969, the National Science Foundation granted the American Chemical Society $621,000 to develop instructional materials (including audio-visual aids) for the chemistry core of a chemical technology program.

2. The purpose of the ChemTeC Project is to train graduates for immediate industrial employment after approximately 65 semester-hours with roughly on-half the credits coming from the ChemTeC chemistry core.

3. Students are recruited primarily from the middle one-half of their high school graduating classes. Returning servicemen and employed chemical technicians are also attracted to the program.

4. High school algebra I is the only prerequisite with no previous chemistry required.

5. This two-year program with its emphasis on laboratory techniques <u>is not designed</u> to be directly transferable to a four-year (B.S.) program in chemistry or chemical engineering. There is the possibility of transferring to one of the developing baccalaureate (B.T.) programs in technology which seem to be increasing in number. However, I must again point out that the real purpose of the program is to be terminal with the preparation of chemical technicians.

6. The ChemTeC Project itself involves:

a. A 17 member Steering Committee of industrial, academic and governmental chemists.

b. A 27 member "writing team" which consists of :

(1) 10 university instructors selected because of their writing or other special abilities.

(2) 12 junior college instructors served on the writing team and as pilot school instructors for the project.

(3) 3 industrial chemists were employed full-time on the writing team plus visits were scheduled for other industrial chemists to evaluate the ChemTeC materials.

(4) The last and not necessarily least important members of the writing team were the editors, Bob Pecsok from UCLA and Ken Chapman from the A.C.S.

c. The writing team met last summer (1970) for the first time for 8 weeks at the Lawrence Hall of Science in Berkeley to produce the first year's materials. Seven volumes were produced and are currently being evaluated by the 12 pilot schools. The writing team will convene again in Berkeley next summer (1971) to complete the second year's materials.

d. All of the experiments to be used in the first year's materials were performed this past summer by various members of the writing team and each experiment was tested by using actual chemical technology students from Merritt College in Oakland, California.

A discussion of the <u>ChemTeC Laboratory</u> can perhaps be done by pointing out some of the basic <u>objectives</u> or goals.

1. A major ChemTeC goal or objective is to <u>integrate the laboratory into the lecture</u> more completely. The laboratory, especially in a laboratory-oriented course like this one, should be an integral part of the text, not an afterthought. There is no separate laboratory manual in ChemTeC to supplement the text. The text and laboratory materials are completely integrated into a unit. For example, as we discuss colligative properties in the lecture, the students are performing the related experiments (freezing point depression, boiling point elevation, purity, molarity, etc.) in the laboratory. There is always a follow-up discussion of the laboratory results in the text. Many conventional chemistry courses seem to divorce laboratory work from the current lecture topics. Most chemistry texts and laboratory manuals are not designed for training chemical technicians, but are designed for aspiring chemists or non-science majors.

2. <u>To study chemistry through experimentation using an underlying theme or concept approach</u>. The ChemTeC laboratory is the primary means for teaching basic chemical and physical concepts. The same basic concept or theme is taught using many separate, but related experiments. For example, the concept of "purity" is presented by using the conventional experiments (freezing and boiling point studies) as well as perhaps more graphic techniques like paper and gas chromatography. The laboratory work is repetitious enough with the various experiments to explain the underlying concept, even if any one of the experiments fails its purpose. The experiments are not only designed to explain or reemphasize the underlying concept but also to give practical laboratory experience.

3. <u>To Integrate the Subdisciplines of Chemistry</u>. Qualitative chemistry is generally introduced as a separate chemistry subdiscipline. In ChemTeC, qualitative chemistry is introduced using a "spot test" approach as needed instead of devoting a large segment of time to the conventional qualitative scheme approach. The formal qualitative chemistry scheme has not been used in industry for many [illegible] analysis with its speed and high degree of reliability has replaced it. The specialized training, for example, to operate an atomic absorption spectrophotometer is not normally given to most freshmen and sophomore classes at four-year schools. We will teach basic atomic absorption techniques and the necessary chemistry (solubilities, interferences, etc.) to supplement it. The same basic qualitative chemistry can be taught but its laboratory applications have been modernized. We do not advocate teaching "specialists" on one instrument, but plan to expose the chemical technology student to as many different methods as possible.

Historically, organic chemistry has been presented as a large and unrelated subdiscipline of chemistry. Organic chemicals are used in the ChemTeC laboratory from the first day to demonstrate such abstract concepts as equilibrium (ester exchange) by gas chromatography without treating them as something different or special. A working knowledge of nomenclature and structure are introduced at the end of the first semester along with the unique positioning of carbon in the Periodic Table. Later in the first year and after several basic infrared spectroscopy experiments, the students are introduced to the functional groups in organic chemistry. This is accomplished by giving each student a set of ten different polymer film samples to analyze by infrared. Physically the films all appear to be similar, but of course their infrared spectra are not. Thus, the somewhat difficult concept of functional groups can be presented using a more interesting, yet practical, instrumental appraoch.

4. <u>Greater Flexibility in Lecture and Laboratory Schedules</u>. The large block of integrated laboratory-lecture time in the ChemTeC schedule can be used from many remedial and extra-curricular activities as selected by the instructor. For example at Florissant Valley, we have 4 hours of lecture and 12 hours of laboratory scheduled per week (for 8 semester hours credit).

Options might include:

a. <u>Guest Speakers</u> from industry can be brought in on laboratory time for specific topics, seminars, to demonstrate certain types of analytical equipment, etc.

b. Field trips can be taken to give the students a better understanding o. the chemical industry. (Side benefits in that industry becomes more aware of this new professional-type technician).

c. Audio-Visual Aids on laboratory time such as the ChemStudy Series or speciality films on NMR, Mass Spectroscopy, or ChemTeC productions. We have, for example, an elementary film on gas chromatography with a blank sound track which the instructor himself narrates.

d. Remedial Math which could include the slide rule can be discussed in the laboratory especially dealing with chemistry problems. Even with advanced mathematics course work, students sometimes have unit cancellation and translational problems in chemistry.

e. Special Projects can be assigned to increase the students' interest and self-reliance. Open house displays and demonstrations are an excellent opportunity and purpose for the special projects. The students seem to take great pride in their knowledge and ability to operate an instrument.

f. Time can be made available for both actual and simulated trouble-shooting experience on instruments and experiments. Older (industrially donated) instruments can help serve this purpose because the student can be allowed to disassemble them.

g. Safety can be practiced on laboratory time by actually teaching the students how to handle large compressed gas cylinders, fire extinguishers, vacuum apparatus, breathing equipment, etc. ChemTeC has devoted a complete volume primarily to safety and toxicity.

h. The Art of Sampling is taught although it is sometimes completely omitted in conventional chemistry courses. It is very necessary to make a chemical technician aware of the importance of obtaining a representative sample.

i. The Notebook with good record keeping practices is taught very early in the laboratory, however, not on the first day. We allow the students to go for a week writing on paper towels, the floor etc. and then offer a free Handbook of Chemistry and Physics to any student knowing an important yet perhaps obscure past piece of laboratory information. Another aspect of the notebook is the concept of "honesty". Point out that literature values are not absolute and not to report anything other than the tr.. experimental findings - they may be correct.

j. Laboratory work should be flexible eno. gh to include local industrial needs. It is a difficult task to define what a chemical technician does primarily because the chemical industries themselves are so varied. We must therefore give our ChemTeC graduates a general chemistry background without specializing them. However, cert.. types of chemistry can be emphasized if local industry does specialize. For example, a ChemTeC program in Akron, Ohio, might emphasize rubber

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and polymer chemistry, while the Houston area might warrant some additional petrochemical specialization. Several of the pilot schools offer as many as 16 semester-hours of electives; thus, a specialization in medical or environmental technology (for example) could be pursued by taking different specialty courses, but using ChemTeC as the curriculum core.

5. Laboratory Work Should Be "Real". In the conventional chemistry laboratory, many of the "unknowns" come directly from the stockroom. However, in industry, the samples that a chemical technician receives are far from being reagent grade. Thus, to keep laboratory experiments more relevant for a chemical technician, commercial products are used as experimental reagents. For example: Iron in Geritol tablets Fat in butter and oleomargarine; Calcium stearate in cup grease; Carbonyl compounds in peach brandy; Nicotine in tobacco; Basicity of an antiacidtablet.

INDUSTRIAL REACTION TO THE CHEMTEC TEXTS

Robert Hofstader
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Linden, New Jersey

I am going to make my comments this morning relatively brief to leave more time for discussion. I think this is the kind of topic which warrants discussion far more than it does presentation of facts because there aren't any facts. There are opinions. I am going to give you some of my opinions this morning about the ChemTeC program, about how the ChemTeC program should undertake the training of technicians and about the job of the technician.

I think that before we can discuss ChemTeC, curriculum, or anything that has to do with chemical technology, we must first arrive at a definition of the kind of person we're talking about. I'd like to start with a statement of what I believe a technician is not.

I believe a technician is not a junior chemist. He is a technician. He is part of a team. He is part of a team which solves problems involving chemical technology. I've developed my own relatively comprehensive definition of what a chemical technician is. I see a chemical technician as one who works with a professional to develop technology and/or one who carries out already developed technologies. If we can go back and look at our team approach to solving problems, we find that we don't need two people doing the same thing on a team. We can then say that the professional chemist is trained to develop these technologies, to theorize, to explain, to understand, and to be able to give directions as to what experiment must be done in order to fulfill these technologies and to develop them. The chemical technician is the one person who is available as part of the team to carry out these directions, to do the job. This person is a very vital man, and a very different member of the team from the chemist.

The problem of many industrial organizations in addressing themselves to chemical technology is that they see only one part of this definition. Some will say, "We want this person to be capable of working with a professional, capable to be there as one of his people." Then you'll find another group of industrial people who will stress the second part of the definition which I just gave you - one to carry out the already developed technologies. "All we need is a person who can run a specific test. All we need is a person who can read a recipe and follow it." Neither fits into what I believe a chemical technician is. But there is one thing that both of these areas have in common - laboratory skills. I don't think that we can question the fact that a laboratory technician needs laboratory skills in whatever function he is performing. Just what kinds of skills are we talking about? Just about any kind of laboratory skill that you can mention a laboratory technician will need. He must also have the necessary knowledge to use these skills effectively if he is to help develop a technology.

Let's address ourselves to the curriculum which should fulfill both of these needs. I think we should look at what has been happening historically. The curriculum, as you people know much better than I, has varied from state to state, from school to school. But it has had one thing in common. It was a watered-down chemistry curriculum. For example, in a local college in the area where I live, the same courses are given in chemistry for technicians as for those persons who are going on to become chemists. What are some arguments for this approach? Local schools with which I have worked have often argued "transferability." They don't want to have students go through without the ability to transfer easily. The second argument which you will hear is that the student will need an appreciation for the theoretical content. This is probably true and they might also say that this type of an approach gives the chemical technicians an ability to discuss chemistry with a professional chemist.

Obviously I have some criticisms of these approaches. That is why I am talking to you today. What basically are my criticisms of these approaches as someone who looks at these people from an industrial point of view? We are, in fact, by this approach, educating junior chemists, not technicians. Let's go back for just a moment to the definition I presented. How well equipped is this person to do laboratory work for the development of a technology? It is his job, I believe, to work in the laboratory and to be able to do the work well. Many of our professional chemists today are not the same type of chemists we were familiar with even ten or fifteen years ago. Professional chemists coming out of colleges today aren't trained, in fact, for the diversity of laboratory operations which have to be done. We no longer have the professional chemist who can use the laboratory skills needed for problem solutions which he is able to develop at his desk. He has very often spent more years than ever before in school, working on a rather small segment of a problem, and when he is employed, he brings with him only those things necessary to solve that small part of the problem. Industry, on the other hand, is very diverse, and is becoming more and more diverse.

Let's take a typical example of how I see a chemist and a chemical technician interacting through a typical dialogue on the job. A professional chemist might say, "You need to perform the following experiment..." I think the chemist can probably be assumed to have understood the various problems, such as the equilibrium, of what goes on in the experiment to be done. The technician, who should be able to properly follow literally hundreds of procedures, might say, "O.K. I'll go into the laboratory and set up the equipment." He probably knows enough about the operating conditions and kinds of materials he is using to be able to set up the necessary apparatus, take samples, perform analyses, compare properties, do syntheses, and prepare proper reports.

I very often bring up a commentary on the type of education situation we have had. About four years ago, our company hired a group of 15 laboratory technicians for summer work from the local schools, because these people wanted to get on-the-job summer training. And we brought in these students and asked them to work in the laboratory along with the professionals. We tried to give them exposure to both parts of the definition which I gave you. At the end of the summer we asked our people, the professionals, to rate these chemical technicians according to the way they performed as technicians. We weren't trying to grade people on a school work context at all. We were trying to decide, as industry always does in its efforts to make a dollar, which of these people we wanted to hire when they became available. We got all of these ratings compiled. The following year when recruiting time came and we were going to look for laboratory technicians, we went to the local schools and said that we would like to see our five top-rated students. Well, to our greatest dismay, the top two of these five people had flunked out. Of the third the instructor said, "Well, she's a girl and she wants to stop her education now so she might be available for work." The fourth one on the list had also dropped out. The fifth one had transferred to another school - a four-year school. And so, after the second year of a Chemical Technology program, only one person out of these five top-rated technicians was available.

I don't really feel so badly about the one who transferred because he was probably in the wrong curriculum from the beginning. However, I do really feel very badly about the three that were lost. They couldn't keep up with the theoretical content that was being presented, and yet in the opinion of professional chemists who use chemical technicians, these were the top-rated people in the group on a performance basis.

What can be done about this situation? One answer might be to train technicians so that when they go into a laboratory, they would just use skills that are used in the laboratory without any regard for understanding the basic principles. If you talk to industrial people today in a group, you would probably get more response to this approach than any other you might offer. However, I think this is frightening. But industry is not composed of educators. We really don't know and are not interested in education. We are interested in the products of education.

For the last five or six years we have seen people coming out of the two-year programs who are very often incapable, who have not gotten any basic skills and who are certainly "watered-down" as far as their chemistry goes. You might very well say, "Well, let's take a complete reversal. Let's train people just to fill test-tubes, just to weigh, just to pipet." Obviously, so far as I'm concerned, this is as frightening as the other extremes of training junior chemists.

To some extent, this man who was trained just in laboratory skills could carry out a developed technology, but I don't think he would be able to work as part of a development team. I think there is one tool which he is would not have - one that we really want. I don't think he would have enough understanding of chemistry for communication with these professional chemists. He would have been schooled in the trade but he would not have the understanding necessary to know what's going on.

Let's step back a moment. We've talked about the traditional approach. We've talked about a brand new approach of the extreme opposite, the laboratory skills approach. We figure there are people in industry pushing for this kind of approach and there are schools for this, too, in some areas. So we might say, "What are you guys doing in industry to train technicians?" I think that you people teaching chemical technology in the schools deserve an awful lot of credit. Probably this is the only career-oriented field which has been pioneered by education, at least in technology education. When the two-year colleges became extraordinarily popular, they could borrow from RCA a reasonable curriculum for electronics and build from it. They could go to IBM and build a data processing curriculum. But chemistry, believe it or not, started in the schools. There is no industrial organization which started a chemical technician training program, which produced people to go out and work somewhere else. Most industrial organizations have their own internal training program. However, these programs keep very near to the specific industry at that time at that place. These are programs where many people begin new careers. Rather, they are trained for a specific job. How does industry train its lab technicians? Take, for example, laboratory technicians who stroll into a gas chromatography lab for the first time. They've never seen a gas chromatograph. The way it would happen in our company, and I'm sure the way it would happen in many other industrial organizations, would be that they would work with someone in the laboratory, probably with a chemist. However, chemists with a tremendous amount of skill, as I said before, are becoming less common and are really not available. So very often, it is another laboratory techncian who teaches the newcomer how to fill a syringe, how to make sure the entire sample is injected, how to make sure that the columns are working, how to look at a base line, how to calculate a chromatograph, etc. He learns how to do all of these things, he developes the skill, he learns how to use it.

Then if he is reasonably bright, he becomes curious about what he is doing and how he is doing it. As his curiosity becomes aroused and he asks questions, he learns what is going on. But he has first done it and then he has learned about it. This is kind of opposite to the approach that I see in chemistry courses. Most of the time the teachers discuss theory and then they go into the laboratories. Well, this probably doesn't turn out well with the good potential technicians, because they probably have been so frightened of what they are going to do from what they've learned about it that they never get a chance to relearn what they are doing.

What is ChemTeC? ChemTeC is a laboratory-oriented course for chemical technicians. It gives the students chance to perform laboratory operations with an understanding of basic principles. As I see it, it will train the technician so he will be able to fulfill either of the two types of jobs we talked about before. He will be able to work with a professional to develop a technology; he will have learned communication. He will have understood what he is doing. On the other hand, he will also be a person who is available to work out a technology which is already developed, which is so tremendously needed.

Discussion

Question: The program of overspecialization needs to be considered. A good example is offered by new two-year programs in Environmental Science. What should be included in such a program?

Answer: Probably a course in sampling and analysis of the environment and understanding environment should be included in connection with the chemical technology program, because there is nothing in chemical technology that comes under Environmental Science. It should be obvious that a person must know something about the chemistry of the environment and analytical techniques in order to be able to sample it. A three or four-credit course some time in the second year, emphasizing these goals is absolutely beneficial. However, to work up a two-year course around it will be detrimental to a student. Suppose three-year programs had been developed around organic synthesis a few years ago when it was so very, very popular? In 1970 and 1971, we find out that synthetic, organic chemistry is down at its all-time low. It would have been a lot better to have given them a truly basic course and then advised them to take a night-school course or something in a special area, if this is what their problem is.

One school has found its problem to be with people or recruitment. They historically have been able to fill their biological technology programs, which is a laboratory technology, with about 30 or so students and yet the chemical technology program has something from 4, 5, or 10 people that would register. They are giving these two programs a common first year. During the second year, students can branch out. The first year offers a laboratory-oriented chemistry course which will cover the equivalent of the first part of ChemTeC. The second year, they will either be able to specialize in the biological or the chemical technology. Based on statistics, we should get more in chemistry because the salaries are higher than in biology.

Question: To provide a different perspective, let us note that it might be desirable for a keypunch operator to have some knowledge of the computer program, but this is not required. The basic responsibility lies with the person who wrote the program. Why can't chemists of the organization take full responsibility for training their technicians?

Answer: The professional chemist hasn't been trained to do that. We might go back and criticize the whole graduate school program for training people who are not capable of doing this. We could say that the professional chemist should have the total responsibility to produce a pair of hands to operate in the laboratory for him. In chemistry today, we have an extraordinarily diversified field. The chemical technician has a whole career. He is a whole person. He has a whole job which must be done properly. If the chemical technician sets up a chemical appartus incorrectly, I think the responsibility is in his hands.

Unfortunately, it is becoming very typical to have people coming from some universities with Ph.D.'s who have done nothing but look at NMR spectra for years. There are fewer and fewer universities that are trying to offer a bachelor's degree and a master's degree has become sort of a consolation prize for those who can't make it all the way. The Ph.D. is a research degree. The faculty, or rather the importance of the faculty, is judged by the number of entries they have in publications. These are counted and tabulated and there should be several if a person wants to get tenure. This does give rise to a high degree of specialization and the products which the universities are now producing are entirely incapable of coming into a research organization because they don't know how to do a lot of these experiments themselves. One of the things that I do with my new Ph.D.'s is put them with a senior, experienced technician so that they can begin to learn how to do some of the things they need to know. And I don't presume that the technician is an extra pair of hands for this brilliant Ph.D. chemist. It's almost the other way around. It will be some time before the Ph.D. chemist is any use to me at all, and if he doesn't learn some laboratory techniques from this technician, he will probably <u>never</u> be of any use.

Michael O'Neil
Tennessee Eastman Company
Kingsport, Tennessee

We call a high school graduate a technician; we call a man who is a graduate from a chemical technology a technician. That is one of the big problems we have in industry - we call people doing the same thing by different names. In our case, we try to keep the technician's occupation filled with people with at least the equivalent of a two-year college degree.

Our needs are such that last year when we received the personnel requisition for chemical technicians to do research and development, I compared it with the numbers of graduates at schools where we had been visiting and I found that our needs actually exceeded the number of graduating seniors. This gets more complicated when we notice that out of a class of ten we may actually be interested in five. We'll invite them and hope that four will accept the invitation to visit our plant. When they get to the plant they are interviewed and get a chance to meet our people. We may then make offers to two of those that are acceptable and eventually get one of the original ten. When your location doesn't have a two-year college nearby, the needs are more complicated. Then we have to go out to schools and recruit. It costs money for us to visit the schools and for students to visit the plant. We then reach the point where we think, "Well, is it better for us to try to develop our own program and produce our own technicians than to go out and try to get recruits?"

The ChemTeC program is already having an effect because it is making industry take a closer look at what kinds of technicians it has. I'm just saying that we are taking a closer look and trying to set down some of the work items a technician should be able to do. You really reach a point where you've got to have more trained, qualified people that can do work of a broad nature and as a result we have broadened the classification of technicians. We have a Beginning Technician and then we go on up to a Senior Technician. A Senior Technician can get even more complicated assignments than some chemists.

For a man to move from a technician position to the chemist's position, he must have a B.S. degree in chemistry. Maybe this isn't such a good example, but when a man wants to go from his freshman year to his senior year in a single step, you don't allow him to make that move. If it is fair to draw that line in the academic insiitution, it must follow that you have to have a series of steps in industry to allow the people who have the desire to advance to have a meaningful opportunity to do so.

I'm surprised personally that students find their way into the chemical technology programs. There is no information available for most potential students except through industry. We don't see them ever getting any information about the two-year programs other than information that we give them. I would suggest that you go out to the schools and work with the teachers, and it may be surprising.

Q.: What is the probability of a person with an associate degree in chemical technology working with a chemical engineer in a plant? I always hear about the laboratory technician. How about a production technician? Is there much opportunity along this line?

A good deal of opportunity exists, but to be in production work one is not restricted to chemical engineering work. At the beginning levels, we need the man who has a knowledge of chemistry, knowledge of what reactions take place by turning a particular valve leading to a new line. Most of the time in industry, these people come up through the ranks and are promoted and use the chemistry they have learned on the job.

Q.: Are chemists and chemical engineers coming to your company and seeking work as technicians?

I personally feel that it is not a good idea to hire a person for a job for which he is over-qualified, just as it is not a good idea to hire him for a job for which he is not qualified. If a man is over-qualified, he is bored and unhappy.

Donald Keyworth
Tenneco Hydrocarbons, Chemicals Division
Pasadena, Texas

It is always stimulating for me to get with a group of people like this and talk about subjects which I think are of mutual interest. I'm going to try and discuss salaries, training, promotions, job satisfaction, and the future for technicians very briefly. I will do it initially from the point of view of my own company, which of course is the logical way to start.

We have to recognize that just as there are many different kinds of technicians there are many different kinds of chemists, and there are just as many different policies with regard to industrial employment of technicians. Our company has its own policies. I will cover them and then I will cover, in a broad sense, how I think they differ from other companies in our area.

I suppose the biggest single factor in a discussion of this sort is whether or not the company has a union for technicians. If the technicians belong to a union, we have a different world. (My company is a non-union, private company.) The whole ballgame is dictated by the contractor who signs with the union. This may be used where men have specified certain kinds of training. The company and union may not agree upon many classes for technicians and define what they are to do and try to define qualifications. These contracts can become very, very sticky. Many times an opening will occur in the laboratory and then people in other areas of the plant will bid for this job. Many who know nothing at all about the laboratory and who have no training in the laboratory will, if they have the appropriate seniority, get the job. When we talk about this kind of a situation, I don't know if we can make it very relevant in terms of what people at universities and colleges are trying to do in order to train people. It may be that 50 percent or even more of the technicians employed are members of unions.

However, we will be concentrating today on the other group. The other group, like my company, will hire a man based on interviews and references. We insist that he be a high school graduate. We look at him in hopes that he might have 8 hours of college chemistry. I am always pleased if they come with an associate degree. Because people will be in training when they start, they will be on trial for three months, and are initially paid $677 - that is $3.90 an hour. After the period of approximately three months, they will be evaluated.

They are given a number of assignments to do during the training period. They are shown where all the sample points are in the plant. Our company has the philosophy that the technicians will learn how to do all of the analyses which support and control products which we make.

I really should say that we have four major classifications of technicians - Control technicians, Analytical technicians, Research technicians, and Development technicians. Requirements for these people are quite different. Their duties from day to day are quite different. But I like to get all my technicians from the Control Department. So I follow the applicants as they come into the Control Department. They are trained there but we share a lot of work, and it makes it much easier if they have gone through the training program of this other group.

After about three months, the new technician has been acquainted with all the sampling technicians do in the plant. He picks up a total of 29 samples. He has a little truck, or bicycle, and the samples are all picked up in about 45 minutes. Most of them are being analyzed by 7:30 am. We're talking about shift work. For my company a man may start on Friday on the day shift. He has four days off and then works five days through for seven days. He has four days off and then starts the whole thing over. A lot of people really don't like shift work. A plant must run 24 hours a day and you can't shut it off on Saturdays and Sundays.

Our technicians understand that this is the kind of job it is, and they understand the overtime, too. They get a lot of overtime and they go around for other people, cover each other for their vacations, help each other for training, help each other for sickness, and cover each other for unusual events, some of which are part of the normal business operations. Unfortunately if the technician doesn't know what he's doing, he can get in a whole lot of trouble just taking samples. We're very careful to show our technicians how to sample safely. We have a variety of difficult samples to get. Sometimes we have to climb up towers 200 feet high. After three months, the technician knows how to sample well. He must then learn the tests which are run in the test laboratory. This includes learning to run a mass spectrometer, a gas chromatograph, a computer input, etc. He must put calculations in appropriate formats to get them ready for the shift supervisor. There cannot be any mistakes because the shift supervisor doesn't have time to catch all the mistakes. Thus, there is plenty of responsibility.

If the new technician has made it this far, he is no longer a trainee; he becomes an assistant technician and gets a raise to $4.21 an hour. He stays in this position for approximately 8-11 months. If the man has been employed for 11 months and has not been recommended for the job of Technician, then somebody has failed him, or somebody has not trained him properly, or we found somebody that was not qualified. He is tested over this period of time by the shift supervisor and evaluated to see how he is doing. If he makes it (and he should) he gets promoted to the level of Technician. A Technician makes $804 per month, or $4.54 per hour. When we have overtime, it is offered to a man and he is expected to accept it. A man can refuse it, but he must have a very good reason.

One of our lab control supervisors was promoted from Technician. He does not have a bachelor's degree, but now he is training technicians. However, many of our technicians do not particularly want to be promoted to positions of supervision. If they want to, our technicians can apply for a job as an operator in the plant. Some people do transfer in that way. They can also transfer into other departments. Many of the control laboratory technicians don't want to work in my research laboratory, and I don't blame them. My technicians work hard. They have a great deal of responsibility and they do a lot of very dirty, messy, hard work. They don't have the same continuity in jobs. In control work at least they know, a year in advance, where they are going to be. They know what work they will be doing. They know very definitely the kinds of things they must do, the patterns they must run through in order for the responsibility to be completed. The technician has job satisfaction, and he knows that the plant has to run and that he is going to be doing it, for his job must be done. So he's got job security. His great satisfaction is in working with his hands and in doing things with his hands. He is very bright. He is not a man who would have made it through college for four years, but could have gotten through a two-year program. We want somebody who has attributes of working with his hands and being able to repair things. We want somebody who can really learn from his work. He will be doing a very important job.

Q.: What are the sources of your technicians?

For my research laboratory, I don't have any interest at all in seniority. The main criterion, as far as I'm concerned, is that the technician understand what my job is. I already know if they're qualified or not and I want to be sure they understand what I'm going to ask them to do. If I could get three Ph.D.'s for my two technicians, I couldn't use them because they don't have the quality and the capabilities of doing what a technician does; they have other qualities and capabilities that should be used.

I find an inverse correlation between a good technician and long periods of time in school. If the person has really been in school for four years and really passed the four-year B.S. program, he will never make a good technician. There are very few people who are good technicians who can survive in the academic world. I'd like to get them with two years of education. If they can stick to it for two years, they've got a lot of grit and should make good technicians. There are few Ph.D.'s who are good technicians. They tend to be abstract thinkers and report writers. They do well with designing experiments and calculations. Technicians and Ph.D.'s complement each other beautifully. My technicians and my senior staff cooperate. They couldn't operate without each other.

COMMENTS ON USE OF CHEMICAL TECHNICIANS

Chairman, Richard Shreve
Corn Products Company

A panel was composed of seven representatives from major companies and the following questions were used as guidelines:

1. What are the needs of industry for semi-professionals and chemical technicians?

2. What are the major shortcomings that you find in the college texts at present?

3. What new requirements can the panel members see for our future needs for chemical technicians?

In regard to Question 1, one panel member felt that people of these types are needed in research and development. He felt that a good generalist in chemistry would be the result of this program, but felt that there could also be good generalists in chemistry from the B.A. program.

Further questions were asked and discussed:

1. Does industry need a generalist? Is there room for generalists? A specialist in one field may not do a company much good. These can be used only in specialized companies. They felt the chemical technician program suggested by the Department of Health, Education and Welfare makes the chemical technician look like the chemical engineers, which in some ways is good. Industry, in many instances, is looking for a technician who is a generalist.

2. Why do we need a new course? In answer to this question, panel members felt that general chemistry courses would work and do work just as well. They wondered how the administration of junior colleges might feel about starting new programs.

3. How much in-service training do companies do? Some companies have complete training programs as of now, that is, on-the-job training. For example, as jobs of distillation, crystallization, etc. arise, training is done.

Some wondered if students would wonder, why stop with a two year training, why not go on for a degree?

Primarily what the companies want are the following:

1. Employees who can handle some mathematics.

2. Someone who has an appreciation of mechanical equipment and care of such. Someone who will have a general knowledge of the maintenance of equipment.

3. Employees who have had glass working not necessarily glass blowing.

In the technical education area the administrations have backed small enrollment courses. Both two- and four-year schools train highly technical personnel to do sample preparations and analyses to help the professional man. These technicians are well paid.

One problem is telling industry just what the technicians do. Industries' perspectives of technicians range from dishwashers to preparative experts. Industry wants people with some college, because they take less training. Industry wants manipulative skills, lab techniques, ability to hand record data properly, since lab books are important for patent purposes.

What is industry willing to to in helping schools start chemical technology programs? Schools have problems of recruiting students and offering them grants, part-time and summer work, and the schools need instruments. Industry could possibly help by allowing schools to run sessions on the industry instruments. Help could be used in the placing of people upon completion of the program.

Ways industry could help people after completion of the program:

1. Advance the person on the basis of experience and education. Perhaps, industry needs to re-evaluate their advancement program.

2. Advance the person only on his ability, not on a seniority plan. Advance the person when jobs are open, making advancement individualized.

3. Good technicians should start at a salary level that recognizes their education and experience.

4. Some industries may need career technicians, that is, people who want or need to stay as laboratory technicians.

SYMPOSIA ON THE ENVIRONMENT AND CHEMISTRY
An Introduction

William T. Mooney, Jr., El Camino College
Torrance, California

College chemistry programs for students majoring in the sciences and related technologies have undergone considerable change in recent years. There has also been an increasing diversity in the content and organization of college chemistry programs for non-science majors. The increasing interest in inter-disciplinary courses and in the inter-disciplinary aspects of chemistry associated with these changes appears to be related to the call for relevance in all aspects of the college careers of contemporary students.

The changes in the courses for science majors have been introduced primarily to meet certain needs of the chemist, biochemist, and chemical engineer but there has been an increasing proportion of students enrolled in college chemistry courses, especially the two-year colleges, who look forward to careers in the biological or health science area or in an engineering or material science field. The proportion of students enrolled in college chemistry courses who are non-science majors is increasing, while the science major enrollments stay approximately the same or decrease. One of the new inter-disciplinary fields, environmental science, has been growing rapidly in recent years and is seeking to entice qualified scientists, engineers, and technicians with backgrounds in the basic sciences and mathematics to devote their time and energy to areas concerned with the problems created by man's pollution of his environment.

These developments have come at the same time that the content and organization of college biological sciences and engineering courses, for majors in these fields, are undergoing considerable change in terms of the requirements for additional knowledge of chemical, physical and mathematical concepts and techniques.

Students of the biological and engineering sciences who are required to take chemistry search for the relevance of chemistry to their particular fields. Contemporary students in chemistry may actually enter industrial or research situations where they are concerned with the problems of water, air, soil, or other forms of environmental pollution. These problems may be related to the source of the pollution the transmission of the pollutants in the environment; the interaction of the pollutant with an environmental unit, such as the human being; the effect of the pollutant on these environmental units over a long period of time; or the control of the pollutant.

Two year college chemistry faculty members are concerned that their modern chemistry courses do not become sterile, ivory tower subjects, so abstract and divorced from physical reality and so out of the main stream of our everyday lives that they have little relevance to the interests of most beginning chemistry students. They want to make chemistry relevant to the student and still show it to be a subject worthy of scholarly attention for its own sake. Their goals are to increase the interest of students in chemistry; to increase the students' competence in dealing with the abstract concepts of chemistry; and to increase the students' ability to analyze natural and technological systems in terms of their chemical nature.

There is, however, a shortage of clearly identified and available examples of technologically important chemical phenomena that illustrate the chemical principles that are important in modern chemistry. There is, especially, a lack of knowledge of the chemical aspects of the environmental pollution problems faced by our country today. What is needed are examples which are applications of chemistry that are important in the world around us, especially in the environmental pollution and control area, and which relate to the student's everyday experience, especially those aspects of environmental pollution and its control that the student has contact with and can easily identify. They must also be illustrations of the principles which he is studying.

The applications-illustration type of example needs to be identified, collected, and made available to teachers of chemistry. As applications, they must be something new and novel and exciting to the student and which can be related to his everyday experience or to his future professional activity. As illustrations they must be very carefully related to specific concepts from the subject of concern to students -- thermodynamics, chemical equilibrium, solid state chemistry, mechanisms of reactions, structures and bonding, etc.

Symposia, such as those dealing with environmental pollution, are organized to help chemistry faculty in two-year colleges [illegible] familiar with new areas of concern. In environmental pollution, systems approach [illegible] environmental science and technology shows five phases to pollution problems:

(1) The source and emission of the pollutant from the source into the environment.

(2) The transmission of the pollutant in the environment from source to other environmental units.

(3) The interaction of the pollutant with environmental units on contact.

(4) The long term effects, including magnification, of the interaction of the pollutant and environmental units.

(5) The control of environmental pollution through suitable measures taken during any one of the earlier four phases.

There are significant chemical, as well as biological and physical, aspects in each of the five phases mentioned above. This five phase approach to the study of environmental science and technology is valid whether or not one is talking about water pollution, air pollution, soil pollution, or any other type of environmental pollution.

1. What chemical concepts and techniques generally associated with general chemistry, analytical chemistry and organic chemistry should a student have knowledge and command of to have a reasonable chance of success in a professional career in environmental science and technology?

2. What are some of the specific examples in the applications-illustrations sense of the use of or reliance upon these concepts and te[illegible] in each of the five phases of the environmental pollution and co[illegible]ld?

3. What topics or techniques not generally associated with these courses should be added to improve the student's background for work in this field or to better prepare him to understand the chemical nature of pollution and its control?

CHEMISTRY OF WATER POLLUTION

Walter Chamot

Probably the principle polluters of water are those of us living in urban areas. Who does the polluting and what goes into waste water? Industry and urban communities are the primary polluters and the type of pollutants are:

1. Sewage, primarily human -- We do have sewer systems in cities and good treatment plants can remove 85-90% of the organic matter. Less sophisticated plants remove 50-60%, but at best, 10% of human waste is still poured into rivers and streams. Some sewer systems are used to collect rain water and those that bypass the treatment on rainy days allow all human wastes to flow into our rivers and streams.

2. Organic matter.

3. Pathogenic organisms.

4. Phosphates, primarily from laundry compounds.

5. Non-biodegradable detergents, but this has become less of a problem.

6. Pesticides, such as DDT, because they are not biodegradable.

7. Food industry wastes, but their contaminants are essentially organic matter.

Industry primarily pollutes waterways with suspended and dissolved matter. One source of suspended matter is the blast furnaces, which produce flue dust. In the reduction of Fe, oxygen is used and the air then contains particles of flue and coal dust. The air is washed with water in an effort to prevent air pollution. The water then flows to our waterways. From the steel mills, we also find clay, titanium dioxide, and other pollutants. From the oil industry, we find such petroleum products as phenols, etc., as pollutants.

Dissolved matter is more difficult and more expensive to remove. Some types are:

1. Acid from pickle liquor, acids of sulfur oxides that are dissolved in the water, and seepage water through coal mining areas, particularly in Pennsylvania.

2. Chromates and similar substances which are used in various chemical treating baths and are very obnoxious.

3. Heavy metals, such as copper and brass mills in New England and mercury from electrolyzing processes.

Heat is another type of pollution. This particularly comes from electrical plants that have large quantities of heat to dissipate.

A natural contaminant we have is the rainwater itself. It causes soap and phosphates to accumulate in rivers and streams and will extract tannin and other organic matter from leaves.

Why do we object to these contaminants? We object to suspended matter primarily because it makes the water look polluted. We can remove this suspended matter by processes of coagulation and/or sedimentation. We object to organic matter because it consumes dissolved oxygen. The solubility of oxygen in water is around 14-15 ppm. Fish need a minimum of 5 ppm and if the level gets too low, we can asphyxiate fish. Organic matter is subject to oxidation and consumes the oxygen in the water. If all the oxygen in the water is consumed, anerobic micro-organisms will still remove oxygen from HSO_4^-, NO_3^-, and reduce these to obnoxious gases, like NH_3, H_2S, CH_4 and H_4. We can remove the organic matter by biological deprivation. Microorganisms digest the matter, then we take these by coagulation and remove them by sedimentation.

Soluble inorganic matter is the worst pollutant. We object to this since most of it is toxic to all types of life, may impart color, odor or bad taste. The phosphates are nutrients to algae. To rid the streams of these, we use coagulation and sedimentation. If we cannot remove them by these means, we use more sophisticated methods such as absorption, electrodialysis, reverse osmosis, or ion exchange. These methods are more expensive and are not used if it can be avoided.

A Sedimentation basin is used most often. Water flows in at the bottom, rises through the center and flows radially in a circular basin. As the water moves from the center to the edge, the suspended matter is supposed to settle. It is then moved by rakes and shoved to the section from which it can be easily removed. The remaining clear water flows into a nearby stream. With this method we are concerned with how fast the solids will settle as compared to how fast the water will move from the center to an outlet. There is a formula which tells us about the speed of settling of solid particles. As the formula indicates, we nt solids to have a high density and large diameter. Some compounds will not settle for days or even weeks.

To promote the settling processes, we try to make small particles into larger particles. Colloidal particles are negative and are normally surrounded by H_2O or ions such as Na^+ or K^+ on the first layer. On the second layer of the diffuse layer, there are more positive than negatively charged particles. These produce an electric field around the particles, which determine how much one particle repels other particles of the same type. Next to the surface, the electric field is high and as we move away from the surface, the field gets neutralized at the edge of the second layer. If there were no electric field, one particle could adhere to another particle by van der Waal's forces. An electric field causes high energy and van der Waal's forces require low energy. If one can remove the electric field, van der Waal's forces take over and particles would adhere to each other by these forces.

We can measure the size of the particle by its charge. This can be essentially measured with a microscope and a high voltage source. Using electrodes, the negative particles will move toward the positive electrods and the positive particles will move toward the negative electrodes. Coagulation takes place at the point where the charge on the particles is essentially zero, the isoelectric point.

We can add a coagulant known as a cationic polyelectrolyte. To coagulate colloids, we can add particles of high charge. For example, if we have Na^+ surrounding a particle layer, replacing it with an ion or higher charge such as Ca^{++}, Al^{+++}, or Fe^{+++} would cause coagulation to a greater extent. This works in theory, but in practice the ions seem to depend on van der Waal's forces to hold the particles together and these forces are not that strong; thus, the colloids fall apart. We have developed cationic polymers which have been polymerized to long chains and are very effective coagulants. These must be added until we have about 10 ppm to be effective. As we increase the quantity of cations up to 10 ppm, coagulation takes place, but beyond 100 ppm we get redispersion. The mechanism is having the cationic ends in polyethylene amine replace some Na ions in the first layer, which should form a stable bond between the polymer and colloidal particle.

Some anionic polymers are used, which contain acrylic acid and a chromate. Acrylic acid contains a carbonyl group and thus gives a negative charge to the polymer. When using these we must also have Al^{+3} or Fe^{+3} as these do not affect the layer, but since they are negative they adhere strongly to the stem layer.

A more sophisticated method uses an ion exchange resin, which is also used to remove chromate. We use polystrene, which has two carbons [illegible] a benzene ring with a double bond between. We polymerize it and end up with a polystyrene ch[illegible]

It is not always possible to use coagulation. Some compounds are difficult to precipitate, such as Na[illegible]. For the[illegible] we use reverse osmosis. This is inexpensive, but we get very low yields: In osmosis there are two mechanisms postulated:

1. We have distillation of base between pores of membranes and since the vapor pressure of pure H_2O is greater than the vapor pressure of the salt solution, condensat[illegible] takes place.

2. [illegible] through the semipermeable membrane [illegible] water of hydration. Water hydrates on the pure surface and trave[illegible] as water of [illegible]ration through the membrane and leaves as [illegible]alt solut[illegible].

[illegible]ost expensive proces[illegible] is electrodialysis. Using electrodes, the Cl^- ions g[illegible] to the negative electrode and the Na^+ migr[illegible]te to the positive electrode. Using a membrane between the cells that is permeable to Cl^-, we can get the negative [illegible] pr[illegible] clean water on the surface.

CHEMISTRY OF WATER POLLUTION

Remo Navone, Bure[illegible] of Sanitar[illegible] Engineering
Los Angeles, California

Water is one of the most abundant compounds on the fac[illegible] the earth, and as such, mankind utilizes it from one extreme in its usefulness [illegible]e o[illegible]. On the one hand, we look upon water for a safe, wholesome, pure sup[illegible] for drinking water purposes, and then at the far end of the spectrum we use water to assimilate and transport the wastes of mankind. In between are, of course, a number of other beneficial uses to which water is put: industrial uses, agriculture, swimming, boating, aquaculture, etc.

I'd like to discuss the two extremes that I mentioned. One of them, drinkin water supply, and the other one, utilization of water to transport and assimilate waste. Most of us give little thought to our water supply; we turn on the tap, we drink the water and [illegible]e don't give it a second thought. However, there are a lot of agencies that do give a great deal of thought to it.

There are a large number of the common elements that we know about and many of them have low concentration levels above which they are <u>not</u> permitted in the water supply. If they exceed the limit, then the water supply is rejected for domestic purposes. For example, we have arsenic at 0.05 mg per liter; barium at 1 mg per liter, etc. When these substances get int[illegible] he water supply, there is really only one way that we can detect them and th[illegible] through the use of chemical laboratories and skilled chemists.

We usually detect the presence of these elements by a variety of chemical procedures. Frequently we will utilize colorimetric procedures. A number of instruments can be used such as the emission spectrograph, the atomic absorption spectrophotometer, and in some instances where the concentrations happen to be higher, the polarograph. If the instrumentation that we have is not sensitive enough to pick up the concentration level, we can concentrate the sample by using evaporation, ion exchange procedures or solvent.

On the other end of the water use spectrum is where people notice the effects of pollution. They can see it by looking at it and they can smell it. But before that point is reached, there are a number of parameters that the laboratories, chemists and engineers can measure to detect the pollution. You will recall problems presented several years ago by detergents entering our ground water supply. There was a time when the detergent level in certain areas rose to about five parts per million. If you had poured that water into a glass, you would have had a head of foam not unlike a glass of beer. You could also detect it by noticing that the water was considerably off-clear. The detergents at that time were called hard detergents - that is, they were non-biodegradable and bacteria would not destroy the molecules. The detergent molecule at that time had branched chains and bacteria could not decompose them. Thus, the concentration of the detergent in water supplies continually increased. In the waste treatment plant itself, there was a real problem. Detergent concentrations rose to 10, 20, [illegible] parts per million and great mounds of foam [illegible] in the sewage treatment plant. Air would pick up this foam and [illegible] it to the countryside along with living sewage organisms. When industry recognized this problem, they went to work and synthesized what is called a soft detergent, one that is biodegradable and the foaming quality disappeared.

Another difficult pollution problem that is with us right now are the chlorinated pesticides. They enter the water through normal usage as well as by accident. The problem is that the pesticides that get into the water system are not biodegradable, DDT, for example. They get into the water supply, still as DDT, etc. Then we have algae which pick up and concentrate the pesticide. Along comes a small fish and it eats the algae because this is the food for the small fish, and there is another concentration step. Along comes a larger fish and eats the smaller fish because that is its food supply - another concentration step. Then bird or man eats the fish. The pesticide is soluble and is stored in the fatty tissue, from the fish to the man. Consequently we are walking around with increasing amounts of chlorinated hydrocarbons of the DDT type. An interesting outgrowth of some of this is the use of these pesticides on sheep, for example, to kill the parasites. As a result, the DDT is absorbed through the skin into the fatty tissue or the lanolin. The lanolin is used to make face creams, hair dressing and many other cosmetic preparations. A concentration of one to eight parts per million of DDT has been found in these products. So through these cycles, man receives the effects of all this pollution.

We can determine concentrations of these pesticides at ten parts per billion or even less by the use of the gas chromatograph. The time that it takes for a peak to appear is a characteristic that identifies the particular pesticide and the area under the peak gives the concentration of the pesticide.

A third type of pollution can be seen disturb[illegible] public. This is the discharge of organic wastes into our water systems [illegible] or lakes, such as discharge from a sewage treatment plant. Here we [illegible]ng with organic ma[illegible] in the form of proteins, fats and carbohydrates. B[illegible]a and dissolved oxygen (at a level of about eight parts per million) attack these kinds of wastes. When this goes well, carbon dioxide and water are produced and there is no real problem, as long as the organic load does not exceed the capacity of the streams that supply dissolved oxygen. Everything goes on very well and it usually follows the first order reactions of chemical kinetics.

If the dissolved oxygen, or the oxygen reserve of the system, is not sufficient to take care of the organic matter, we've got an entirely different picture. Again we have bacteria acting upon the organic matter, but instead of CO_2 and H_2O being principle products we may not, get H_2S and methane. Now people will know that something went wrong. If H_2S is around, the white paint on houses will indicate it if your nose doesn't.

Finally, I'd [illegible] discuss an outgrowth of this kind of pollution, and that is the eutrophication of our water systems or lakes. This simply means "fertilizing the water". This is done by adding to the water supply organic matter, nitrogen in the form of nitrates [illegible] phosphates from sewage discharges, and micronutrients, or trace elements [illegible] concentrations of less than one part per million. When the water supply gets this sort of thing and there's algae and a favorable temperature, there is a sudden increase in the growth of algae and it blooms. Actually, it is called an algal bloom and I'm sure that some of you have seen this on streams or ponds. It is a glassy, yellow green mat on the water. This begins a cycle in the water system that is extremely detrimental. If the algal bloom and the concentration of the algae is up in the millions per liter, then they are concentrated enough to acutally cause a fish kill by clogging the gills of the fi[illegible]

Since all the algae grows and blooms at the same time, they also die at the same time. When this happens, the decomposition of the organic matter causes the decreasing of the dissolved oxygen which is detrimental to the fish. Anaerobic conditions may then arise and you get putrification and the hydrogen sulfide odors.

If the [illegible] bloom does not occur, the mere concentration of algae above certain limits will produce turbidity in the water and will produce disagreeable tastes. The algae may contain oils that have a very distinctive taste of their own. Then if your water supply is further chlorinated, the combination of the essential oils from the algae and the chlorine produces chlorinated phenols which are even worse. They produce a medicinal taste in the water, which is very disagreeable and very difficult to remove.

I'm reminded at this point that pollution is not something that has been here 10, 15 [illegible] 30 or 40 years. I think we can go back to the Good Book and read in Exodus, [illegible], where we have a description of an occurrence which says in effect that the waters of the rivers turned to blood, the fish died, the waters stank and the Egyptians could not drink of the water. I think we might as scientists say, "Now this is explained by the algal bloom (with red algae, because we do have red algae as [illegible]l as green). The algal bloom decreased the dissolved oxygen in the stream, the fish were killed by low dissolved oxygen levels and clogging of the gills, and finally the putrification made the water completely unfit." So in early history, they too had problems of pollution.

Comment

Nathan Gutschaw, Rio Hondo Junior College
Whittier, California

Water pollution is indeed a rather timely topic. I think we've had this emphasized quite dramatically with the recent pelican casulaties as a result of DDT wastes being accumulated. Certainly, this type of pollution is a problem with which we must deal. However, I think that any remedy that we might suggest is going to have to be rather judiciously applied. Recently I have noted that DDT is responsible for the malarial death rate in India, for example, being reduced from about three-quarters of a million per year to a relatively very low figure. Thus, some of our solutions to a problem have created new problems in their wake.

I think the problem of environment pollution is certainly one that must come to the chemists, since both the causes and any prospective remedies are chemical in nature. We might very well couple this problem with the population explosion. When there are very few of us, we don't need to give nearly as much attention to personal housekeeping as we do when there are lots of people in the area. I believe a la[illegible] number of these sources of pollution are things that are very interesting and [illegible] appropriate for chemistry classes such as we have.

CHEMISTRY OF AIR [illegible]

(A Summary)

Jerome Thomas, University of C[illegible]nia
Berkeley, California

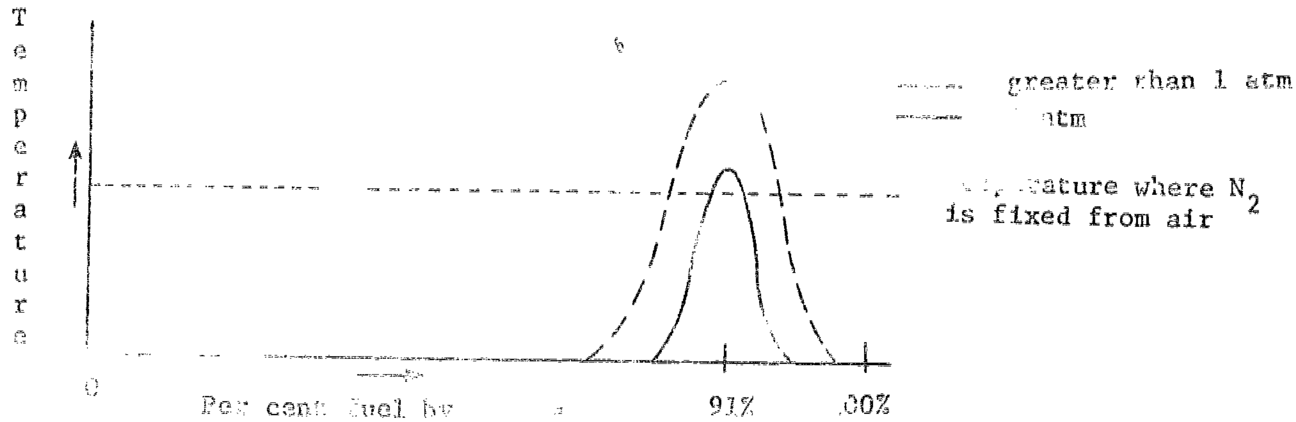
Air pollution can be divided into three parts. They are analytical, the chemistry in the atmosphere and combustion.

[illegible] chemist. The agricultural chemist wants to know what is responsible for plant damage and the medical profession wants to know what is responsible for eye and lung irritation. This type of information is difficult to obtain because concentrations are very small and sampling techniques are complex and difficult. The fate of pollutants after they get into the air is important since the amount of pollutants in the air remains at a steady state. There is natural self purification which is a photo-dynamic photolysis operation. The benzoate pyrines, the most potent of the airborn carcinogens, are in the atmosphere on airborn soot. Their life expectancy is measured in minutes or hours. They are broken down by sunlight; however, the intermediate and end products are not known nor are their effect on man known.

Combustion is the major source of pollution. There are other man-made sources, such as petroleum plants, pesticides and cement plants, as well as some natural sources. This paper will concentrate on three aspects of combustion, including the source, the combustion spectrum and processes that occur during combustion.

There are two basic pollution sources, one being the stationary reactor which may be either domestic heaters or industrial heaters and mobile sources. Mobile sources may be gasoline, diesel or turbine driven vehicles. Stationary sources burn at atmospheric pressure and mobile sources burn at a pressure of about 10 atmospheres. Domestic stationary sources are generally of the pre-mix type where the air and fuel are mixed before they are ignited. The industrial stationary source is classified as a diffusion [illegible]. Here the air and fuel combine in the flame for the fir[illegible] time. Regardless of type, all sources burn fuel to give a maximum thermal yield.

If we examine the combustion spectrum for a methane burner, we find the equation is $CH_4 + 2O_2 \quad 2H_2O + CO_2$. From this we can calculate that the % by volume of fuel necessary for stoichiometric reaction is about 9%; thus, we need about 91% air. Combustion will occur in the range of 5 to 15% fuel. This range is called the explosive region and gives self-sustaining combustion. If there is more than 15% fuel, combustion will not occur. This condition corresponds to flooding in a gasoline engine. If burning occurs between 9 and 15% fuel, this is called the rich region and pollutants like carbon monoxide and soot may occur. If combustion occurs in an excess of air, it is the quenching region. All of the air must be heated, the temperature falls and oxygenated organics are formed. These are aldehydes that may undergo the aldol condensation, polymerize and be a possible source of eye irritation. If we burn in limited air, the equation will be $CH_4 + 1/2\ O_2 \quad CO + 2H_2$. Soot results only if the carbon:oxygen ratio is greater than one. The CH_4 flames will go out under these conditions because it is out of the explosive limit before this ratio is reached; thus, a methane flame is rather free of soot. Larger hydrocarbons can reach this ratio and still be in their explosive limit.



In the above graph, notice that the maximum temperature is reached at the stoichiometric ratio of air and fuel. Notice that at atmospheric pressure only very near the stoichiometric point is the temperature high enough to have appreciable nitrogen fixed from the air. At higher pressures there is a wide ratio of fuel and air that will cause temperatures high enough for nitrogen to be fixed from the air. In old stationary burners, combustion usually occurred far enough from the stoichiometric point that the temperature was not high enough to fix the nitrogen from the air; thus, NO_2 was not a pollution problem. In New furnaces the engineering is good enough that the burners will burn near this ratio and hot enough that nitrogen dioxide will be formed. Now the black plume of soot is replaced by a brown plume of NO_2. This nitrogen dioxide can react with certain organic compounds to yield p... ...yl nitrate, which may be responsible for agricultural damage and eye a... irritation.

...bile sources, the high pressures give high temperatures and large amo... the oxides of nitrogen. Cars burning on the rich side of stoichiometry yie... ...rge amounts of carbon monoxide. ...ile turbines and diesels burning on the lea... ...de give little CO, but much soot.

The process which occurs during combustion involves the complex organic fuels being broken down into gaseous primary fuels which are free radicals. This step is endothermic. As the primary fuels recombine, there is an exothermic reaction, and this is the source of heat.

...any combustion reaction there are four important factors. They are time, temperature, turbulance, and oxygen. Enough time and temperature are needed to break down the complex fuels, then the oxygen as an oxidizer must be present and good mixing is needed so the fuel and the oxygen get together. If any of these factors are wrong, pollution may occur. For instances, if time and temperature are wrong, distillation or sublimation may occur and produce pollution. A good general rule to control pollution is to keep the temperature high, use an excess of oxygen and keep good mixing.

CHEMISTRY OF AIR POLLUTION

Albert Bockian, Air Resources Board
State of California

This presentation contains a number of points of view about the use of chemical principles in air pollut... ...tigation. I wish to discuss some of the instruments that we use and ... instruments are utilized so they can be related to certain subjects y... ...already been talking about in the classroom. I will also cover some typ... ...roblems we investigate and the sort of chemical principles that apply.

One instrument that we use is the atomic absorption spectrophotometer. Basically, this is a device that uses a heated hollow cathode lamp of the particular element that is being sought. It is used primarily for determining metallic elements in the atmosphere. A sample is collected, treated and then atomized into a flame. The hollow cathode lamp is of the element you wish to determine - for example, lead. It emits a light with a characteristic spectra and the lead in the atomized solution absorbs the light proportional to the concentration of the lead.

The whole principle of separation of compounds by gas chromatography depends upon selective adsorption of the compounds. The selection, number and kinds of columns to use in gas chromatographs, is usually related to what substance will adsorb and release the chemical compounds of interest. Also, in a gas chromatograph we're concerned with the equilibrium between liquids and gases because in many cases the sample is injected into the GC as a liquid and then it's vaporized in the instrument itself.

In analyzing atmospheric samples for hydrocarbons, we must have some knowledge of reactivity and structure of the compound, since the gas chromatograph is not a panacea and one or two overlapping peaks can occur. For example, you may find that a straight chain hydrocarbon will come out at the same place as a branched hydrocarbon with one more or one less carbon atom depending on the specific materials, the type of column substrate, etc. So all of these things are factors that we take into consideration in our analysis of atmohspheric materials.

Another instrument we use is the ultraviolet-visible spectrophotometer. Here we are concerned with electronic transitions. We use it for identification of compounds during a spectral span. The other thing where a knowledge of standard chemical laboratory techniques might be very useful is in the preparation of standard curves, where you are investigating one particular known material which produces a colored complex. Then you can prepare a series of standards and make a standard curve, etc.

We are concerned with complex formation that could be related to ligands. One of the analyses in air pollution work is for oxides of nitrogen in the atmosphere. There is a reagent called the Saltzman reagent and this involves a color complex formation. Aldehydes are usually determined colorimetrically in the spectrophotometer. Ozone can be determined colorimetrically by its reaction with an idodide solution. All of these things are done either in spectrophotometers or colorimeters.

The infrared spectrophotometer is used for determining carbon monoxide in the atmosphere and in automobile exhausts. This is done by non-dispersive infrared so simply select the appropriate wavelength from previous knowledge. The instrument simply measures the peak height of one wavelength. We also have an interesting and somewhat elaborate research project going on using the infrared spectrophotometer and here we are interested in the identification of [illegible] reaction products, etc.

There are other instruments that can be used in air pollution work, but these are the four main ones. I am sure you are aware that whenever an instrument can be used in one area, it eventually finds a use in other areas and air pollution is no exception.

Some of the types of problems that we investigate and some of the types of procedures that concern us are problems involving molarity, reagent preparation, salts, peroxides, nitrogen, iodide reagents and things like these. Usually our technicians handle the work in this area after some initial introduction. So far as we know, there is no problem for the education of air pollution technicians. Thus, we end up using electronic technicians or electrical or mechanical people who are interested in air pollution. Then we have to teach them all the chemistry and physics they have to know.

The concept of the mole is involved in pollution of one sort or another, particularly in gas space pollution where people have to know how to go from moles to parts per million to micrograms to cubic meter. Depending on the nature of the material, various people are interested in expressing concentrations in various ways. The technician has to know how to go back and forth comfortably from one to another.

The concept of permeability and diffusion is important. We sample hydrocarbons in gas sampling bags and even though the bags may seem impervious, they are not to a very small molecule. If Saran, Nylon or something of this nature is used, all of the material can leak out; therefore, permeability and diffusion become of some importance to us. Atmospheric transport of pollutants in the outside or ambient atmosphere is to some extent a diffusion process. To another and probably larger extent, it is actually a meteorological transport problem. But there is diffusion involved.

We are concerned with kinetics, particularly gas phase kinetics and gas phase reactions. What goes on in the atmosphere is a kinetic event. There is a lot going right now with atmospheric modeling as people try to come up with a mathematical model that explains atmospheric reactions. There is a lot of kinetics involved in atmospheric models. There is a lot of kinetics involved in reactivity studies, the sort of thing that I mentioned when I spoke about the infrared spectrophotometer. Hydrocarbons plus nitric oxide give all sorts of lovely products. So kinetics is of considerable importance in the field of air pollution.

We are concerned with molecular structure, particularly the size and shape of molecules. We find a lot of aerosol formation and some of our work indicates that it is more the size and shape of the molecule than the chemical; functional group which affects aerosol formation and light scattering. Molecular structure is involved in reactivity, particularly in terms of those reactants which produce eye irritation. It is generally conceded that olefins are more reactant than aromatics and aromatics are more reactant than paraffins. The Los Angeles Air Pollution Control District Rule 66 recognizes this because they limit the amount of each material that can be put into the atmosphere.

We are concerned with oxidation-reductions. The usual practice to analyze nitric oxide is to oxidize it to NO_2 and determine that. We are concerned with this reaction since this is the primary photochemical reaction in the atmosphere. Photolysis of NO_2 under the action of the ultraviolet light will give you NO plus an oxygen atom. The oxygen atom, presumably combining with molecular oxygen, gives ozone. Oxygen atoms, of course, can combine with a number of things. Ozone will then oxidize any number of things that it contacts.

We are concerned with haloids in aerosols. We're concerned to some extent with free radicals. In writing a scheme for what may happen in the atmosphere and trying to write an atmospheric model, free radicals have been hypothesized by a number of people. While this is somewhat more theoretical than what we get into in our organization, nevertheless, free radicals are believed to be important in air pollution work.

Bonding is important, of course. We deal with inorganic materials and inorganic particulates. We deal with hydrocarbons and other organics. We are concerned with bonding and trying to explain the origin of certain materials and trying to explain their reactions. We're concerned with electronic structure as a basis for reactivity and the fact that when you have something like NO where you have odd and even electrons, it is difficult to satisfy the octet rule and write the nice usual structure with eight electrons in the outer shell. There may be ential for bonding that you do not have otherwise.

We are, of course, concerned with photochemistry. The entire Los Angeles smog problem is a photochemical problem and I repeat again, the primary reaction of photolysis of NO_2 gives nitric oxide plus an oxygen atom.

I think this ties in rather nicely with the importance of ambient environment, but I think students in a classroom are not aware of the influence of light. With photochemical smog we have a very nice example of the fact that something in the outside environment, something that we take for granted, may be influencing what ... happening in our test tubes.

We are concerned with transient effects in the ambient atmosphere, such as electrical discharges and automobile engines starting near an aerosol sampling ... These cause effects that can't be related to any other atmospheric parameter like the presence of hydrocarbons or oxides of nitrogen.

What are some of the activities that air pollution agencies pursue? They run source spectra through many sources, smokestacks, production plants, refineries, and test the emissions and the ... ents. Another activity is compliance testing. By law, automobile emissions ... below a certain level. We have a rather large vehicle emission testing lab ... s autos to see if they do comply. And in either of these, since you are ... with millions if not billions of dollars, accurate sample is a necessity , ... good laboratory technique is essential. The Air Pollution Control District in Los Angeles has the auhtority to shut down a plant which is polluting the atmosphere. We in the State of California have the authority to reject automobiles which do not meet state standards, and therefore, people must know that the results are accurate. Frequently there are court appearances by the chemists and the technicians.

The ambient atmosphere is continually being monitored and sampled. We have the question, "Is the sample representative of the area that it is supposed to represent?" There are roughly eight or ten air monitoring stations in the Los Angeles Basin and their pooled results are supposed to represent the entire Los Angeles Basin. So I think we can ask ourselves the same question there that we asked in the chemistry laboratory, "Is the sample selected representative ... the entire population or all the material?"

Finally, an activity we pursue is research and development. We have to know the answers for 1975, 1980 and 1985 and we have to start discussing them now. Knowing the answers for 1971 and 1972 is great, but eventually there is more to atmospheric management than knowing a year or two ahead. For people who are interested in this type of work, patience, meticulosity, and a willingness to repeat analyses are necessary. These ... ain are laboratory skills which people have to get in college or else they just do not get them at all.

Comment

Daniel Eidelson, Fullerton College
Fullerton, California

I think that air pollution is a topic that can certainly help to increase student interest. When I talk to my students with respect to looking at the planets, we notice that we are rare indeed to have this unique thin skin of atmosphere and that

within this thin skin of atmosphere, one fifth is life-giving oxygen. We then stop to consider that we are operating in the lower regions of this skin, maybe in the first ten feet of the atmosphere on the surface of the earth. Then consider the consequences of going about six minutes without a sufficient supply of oxygen. It seems that this approach increases the interests of the students. I've tried usi this example this year in a very elementary course: Our aerial garbage weighs about 143 million tons a year (not including carbon dioxide) of the major pollutants that are listed by the Air Resources Board in the Unived States. This can very effectively be converted to other units such as parts per million and milligrams per cubic meter or even to the moles of carbon monoxide that are emitted in the LA Basin. This comes to about 10,000 tons a day.

Some of the reaction I have had from students on this is that they want to know some of the job opportunities in the field. Where is the testing occurring? How can we learn more about it? Some of their reactions can effectively be used in a lower level chemistry course. I think they can quite effectively illustrate common relationships.

I've found a tremendous wealth of material that could be applied in the [illegible] and much of it is [illegible] from the California Air Resources Board.

CHEMICAL ASPECTS OF SOIL POLLUTION

James Cornelius, State Department of Public Health
San Francisco, California

We all have a picture in our mind of San Francisco. I believe it is one of the most beautiful cities in the world and really love it. However, there is another view of San Francisco that you don't see very often. I am sure you have read about San Francisco's solid waste disposal problem. No tour of Northern California would be complete without taking a look at San Francisco Bay. We have done a lot of sampling on different sites surrounding San Francisco Bay. At some sites, the only thing separating the Bay from the rubbish is a fence. The fence does a good job of keeping the rubbish out but it doesn't do such a good job of keeping the chemicals from leaking out into the Bay.

From a public health viewpoint, we are very concerned about the disposal dikes which have contact with bay waters because we know that these sites have many different things going into them such as pathogenic wastes from hospitals. So public health is certainly concerned about these conditions.

One of the conditions we are concerned about is the disposal of chemical wastes. Disposal of chemicals happens frequently in San Francisco Bay. While taking some pictures, I came upon gentleman unloading something from a truck. He had a big rubber suit on and high rubber gloves on, so he was being cautious for some reason. The reason was that [illegible] the material he was dumping was very toxic. A lot of drainage came out of the material. This drainage ran into a pond adjacent to San Francisco Bay. The Health Department is very concerned about conditions like this. For example, if in a storm or for some other reason that dam should break, we would have a severe pollutant floating into San Francisco Bay.

Another problem is the open refuse disposal sites and these are sources of air pollution for many reasons. They have odors and could have toxic fumes from the open burning of 2,4,D containers or other containers. Some substances released are very toxic to plants.

Two or three years ago I was on my way to Fresno to a conference and saw an enormous tower of black smoke going up. I detoured about 40 miles out of my way because I was suspicious of what it might be and it turned out to be an enormous pile of tires burnings. There are two major areas in California which have outlawed major burning dumps, the Air Pollution Control Districts in the San Francisco Bay Area and in the Los Angeles Area.

Chemical waste has been allowed to be dumped at many waste disposal sites. There are many reasons to be concerned about this. The operator who mixes the material is exposed to extreme hazards. Truck drivers bringing in chemical wastes either do not know or will not tell you what they are dumping.

We have another type of soil pollution problem, pesticides. This is also a health problem. In many disposal sites we find pesticide containers. Supposedly empty containers are not always empty.

The State Department of Public Health, as a portion of our statewide planning study, gathered information from all types of industrial wastes and domestic wastes. One of the categories of waste was chemical wastes. In 1967, something like 11.2 million tons of chemical wastes were produced in the United States. Here in California we only have about 500,000 tons, not a very high percentage of the total. We wanted to put in perspective what the different types of waste are. First we have our municipal wastes. These are from homes and the stores. It weighs about 50.5 pounds per capita per day. Then we have the agricultural waste. That is 9.8 pounds per capita per day. Industrial wastes add up to about 3.9 pounds per capita per day.

Because of the soil pollution aspect, we are particularly concerned about chemical wastes. These chemical and petroleum industries are concentrated in two counties in California, Contra Costa County and Los Angeles County. The amount of chemical waste in either of these two counties is ten times higher than in any other county in the state.

There are two gases that we are concerned about. One is carbon dioxide and the other is methane. Methane gas presents one of the safety problems and hazards that must be considered in the design and operation of a land fill. We are also concerned about carbon dioxide because of the potential of increasing the mineral content of the ground water through chemical reactions.

We do have the possibility of enriching soil with solid wastes. There is a demonstration compost in Johnson City, Tennessee. The potential of composts is something that we do not want to overlook in our determining the proper methods of disposal. Composting has not had very much success in California. Primarily it comes down to an economical evaluation because composting is more expensive than the cost of land fill. However, I think many of our leaders, environmental engineers and people concerned about environment will reach the point where we decide to pay that little extra. Then, instead of causing pollution we can build a soil supplement.

The composting plant starts with garbage and rubbish. It is put through a mechanical treatment, ground and some sewage sludge is added to it. All the sewage from Johnson City is mixed with it because sewage sludge has two things, nutrients (nitrogen) and moisture which is needed for composting. The material is then placed in piles seven feet wide and five feet high. A machine turns the compost to keep it "going" because the bacteria must become aerated so that they keep working properly. They have a number of chemists and biologists doing research there, trying to determine exactly what is happening so that they can make a complete evaluation of the composting process.

CHEMISTRY OF SOIL POLLUTION

Tom Sandiman, Bureau of Solid Wastes

Cincinnati, Ohio

While soil pollution is poorly defined both practically and technically, a workable definition is "an unclean condition of earth that impairs or interferes with its natural use". Air, water, and soil pollution cannot be separated. Unclean soil will yield both air and water pollution. As an example, the spreading of animal waste can rapidly become a source of both air and water pollution as well as soil pollution. Other examples include despoiled strip mines, auto junk yards, land contaminated with pesticides and a littered countryside. A natural pollution is land covered with silt and debris after a flood. In most cases soil pollution results from man's depositing unwanted waste in or on the soil.

Solid waste management is a major problem in urban areas where the solid waste product is about one ton per person per day. This figure is expected to double in about fifteen years. Other than personal wastes, there are demolition waste, agricultural waste and many more sources. Regardless of the source, water must be disposed of. This [illegible] done by incineration and conversion to gas, which potentially gives air pollution. Usually about 25% of the solid becomes ash that must be removed by depositing it in or on the land. About [illegible] of total waste may be salvaged for reuse [illegible] be composted. Incineration is used to [illegible] of about 15% of waste and the remainder [illegible]% goes into a land fill.

The best way to dispose of waste [illegible] with a sanitary land fill. This is best defined as a method of d[illegible] on land without causing nuisance or hazards to public health [illegible] this method employs principles of engineering to compact refuse to the [illegible] practical volume and to cover it with a layer of earth at the conclusion of each day or operation.

If all land waste disposal would follow this method, pollution would be reduced to a minimum. Few land fills operate following these guidelines and instead become open dumps. Only about 5% of all land fills qualify as sanitary land fills. To qualify as a sanitary land fill, the following criteria must be met: (1) no burning at the site; (2) packed refuse must be covered daily; and (3) no detection of surface or ground water pollution.

Water pollution is certainly possible from land fills, but it is not a necessary byproduct. The following must be done to have ground water degradation from land disposal: (1) disposal site must be over, adjacent to or on a water aquifer; (2) there must be movement of water into and through the fill from percolation of precipitation and surface run off or from direct contact with ground water; and (3) a lechate must be produced which is capable of entering the surface.

To obtain maximum protection we must recognize and understand these conditions and be able to avoid or prevent them from occurring. This becomes very difficult in metropolitan areas. There are many things that control whether a site may cause pollution. Guidelines are available from several sources which base their suggestions on possible types of contaminants, types of earth materials, and distance to the points where water will be used.

Potential pollutants are limitless. Certain pollutants must be kept out of land fills, others must be detoxified before being placed in the land fills. Another more general problem is caused by the products of decomposition and leaching after the waste's placement. These products are a function of the specific fill's physical nature . d placement. Problems can be detected by analyses such as B.O.D., alkalinity, biological analysis, and gas products from aerobic or anerobic respiration.

Many of t' problems can be controlled by correct placement of the land fill and by natural of purification, but as . . . becomes greater, nature must have help.

Comment

Gordon Williams, Monterey Peninsula College
Monterey, California

Criticism has been directed to our school about not teaching a specific course labeled "Pollution". We have contended that our position is that the sciences could cover pollution in almost a subliminal type of way and that we can sell that [illegible]

Many of you probably saw the summary of the ACS report from the Committee on Chemistry and Public Affairs, the Subcommittee on Environmental Improvement. It was summarized in C & E News. The report covers not only solid pollution, but also air pollution, water pollution and pesticide pollution. It is probably well worth [illegible] for the library.

CHEMICAL ASPECTS OF POLLUTION AND SOCIAL INTERACTION

Philip Gustafson, Argonne National Laboratory
Argonne, Illinois

As technology has been shipped to underdeveloped countries, both agriculture and health techniques have been improved. However, people are still hungry. As technology has increased in the United States, Americans have developed a hunger for more material things. When these are produced, a great deal of waste is also produced. This waste becomes pollution. It takes a great deal of power to produce these material things.

The growth rate in the nation as a whole is about the same as in the Chicago area. The combined effect of immigration and increased birth rates causes the population to double in 46 to 50 years. Generation capacity of electricity has a doubling time of 8 to 10 years and the amount of power available per person has a doubling time of about twelve years. Power output is increasing more rapidly than the population. In an expanding economy an increase in pollution is unavoidable. Nature cannot absorb all of our pollution. It can clean itself, but it cannot stand the present rate that society is dumping wastes into it. We need to enforce laws on books and legislate new ones as the need arises. Better still we need to minimize processes which cause unwarranted pollution; however, this must be done without causing too much disruption in society. An example is the building of nuclear powered electric plants as Commonwealth-Edison did. Conservation and citizen groups are generally well informed about the generalities of pollution, and their power and knowledge must be respected by [illegible]. Commonwealth-Edison has been criticized for their major contribution of [illegible] in the Chicago area and with the building of the nuclear power plant they are criticized for the nuclear and thermal pollution from this "clean plant".

There are plans to use Lake Michigan as a cooling source for electrical generations. The effect that the heat will have on the lake is unknown, of course, but it is being challenged by conservationists. Those who have studied the problem at Argonne feel that the lake as a whole can endure the heat, but individual areas may be damaged. Many parameters are applicable, such as agricultural chemicals and other forms of pollutants, and it will be difficult to attribute damage to warm water.

An alternative is to put a moratorium on the building of electric plants. But can society stand this change? The environment has the capability to absorb a certain amount of pollution safely and efficiently. It is our responsibility to learn what this limit is and then to live within it, and not shut down all industry or blatantly add unlimited waste into the environment.

CHEMICAL ASPECTS OF THE POLLUTION - HUMAN INTERACTION

Wheeler J. North, California Institute of Technology
Pasadena, California

Of all the physical, chemical and biological kinds of pollution that we have managed to contrive, chemical pollution problems are usually the hardest to combat or correct. We have seen instances today where the pollutant attacks man directly. An outstanding example is smog. Perhaps we do not have smog as bad as people in Southern California. I understand there have been instances where [illegible] deaths have occurred from it, but certainly it is bad enough to cause severe eye irritation and attacks us directly.

Sometimes chemical pollution requires an intermediate agent before it affects man. You may recall the story of the harmless ion, nitrate, which appears in waters as a result of fertilization of soil. The drainage has nitrate in it, it gets into drinking water, and intestinal bacteria convert nitrate to nitrite which in turn reacts with the hemoglobin in the bloodstream and is injurious to man.

We cope with these forms of pollution and have various degrees of success. We are able to recognize them rather early, because they attack us. However, the more insidious forms are those that attack our environment. We do not recognize these until we have suffered serious economic loss or the environment has received irreparable damage. Examples already have been given of some of these insidious forms today. We hear about DDT and how it is concentrating in many marine forms, perhaps affecting the reproductive cycle in many marine birds. Detergents were mentioned earlier.

The pesticides and the detergents are harmful substances, but perhaps we are just beginning to be aware of the most insidious of all substances. These are the substances that are not harmful in the ordinary sense of the word. In fact, in proper amounts, they are required by the organisms that share this planet with us. I am involved in the research of such a situation and would like to make that the principle part of my talk today and tell you a little bit about it. In this case the insidious substance is very vital to all these little creatures. They are amino acids and the associated organic acids that occur in wastes such as sewage.

Our story carries us into the ocean, and I would like to talk about a specific portion of the ocean. This is the very rich, off-shore kelp beds that occur in Southern California. A kelp bed has brown patches and floats through use of little gas bladders. Kelp forms a forest-like environment. It is very much like a land forest and many animals are attracted to it. The productivity of the vegetation feeds many animals. Many other animals seek shelter in the crevices formed by the plants. Still others find a nice solid place to settle. A solid space is at a premium in the ocean and an average kelp forest offers fourteen times as much solid surface for settling as the ocean floor. Thus, fourteen times as many animals can be packed into a given space. As a result, the kelp beds are the richest areas of our coast. Using statistics from the Department of Fish and Game, it has been shown that they are worth about $3,000,000 a square mile to the lucky community that they are near. They contribute much to the regional economy. There are roughly 100 square miles of kelp bed in Southern California, so this is $300,000,000 a year that Southern California receives from being blessed with these submarine forests.

Many animals eat kelp and occasionally we get an imbalance of a rather spiny creature called the sea urchin. It appears in huge numbers. Armies of them congregate and they like kelp more than anything else. When they reach a kelp plant, they cluster in the lower portion, take a few bites, destroy the anchorage and the main part of the plant drifts away and is lost. So it is a rather destructive form of grazing. Nature has a way of controlling this upset in balance. There used to be an animal that ate sea urchines in great quantities, the sea otter. It looks a little like a panda bear, and among other things it eats great quantities of sea urchins.

Southern California used to have tens of thousands of sea otters. They were hunted into extinction for their valuable fur in the 17th, 18th and 19th centuries. Without this natural control, the urchins will destroy a kelp bed and then all the other animal life. With nothing left to eat, the urchins starve to death and eventually the kelp comes back. This is a cycle that lasts anywhere from five to twenty years.

In Southern California some of the kelp beds near our largest cities have disappeared completely. Statistics for the San Diego area show that as the sewage increased, the kelp bed dwindled. The part that disappeared first was the part that was nearest where the sewage came out of the Bay and the disappearance spread northward. Looking down at this bed, we found that the bed was being destroyed by sea urchins. We suspected that they would die from starvation, but they didn't. They just persisted year after year. In the laboratory an urchin starves to death in an aquarium in about three months. These urchins just persisted in concentrations of 100 or 200 per square meter. Nothing could grow or settle there without being eaten.

The urchins are very efficient absorbers of organic substances, such as amino acids, in fact, the amino acids in sewage. We have unfortunately prevented the starvation of the urchins by keeping alive the unwanted prey of the predator. The end result is that we have injured ourselves economically by preventing the return of the kelp beds.

The remedy to this problem is to use the chemical, quicklime, which is very effective for killing the urchin. It is good because it combines rapidly with water and carbon dioxide to form harmless calcium carbonate and it is not a toxic poison lasting for weeks or months. We spread a number of tons of quicklime all over the urchin populations. With the urchins gone, the kelp returns. After a lag of several years, the abalones, fish and the wonderful community that associates with the kelp return and the economic benefits become available to be enjoyed.

Comment

Jerry Flook, Gavilan College
Gilroy, California

I don't think that we can just lecture two days a year and say, "Now we're going to talk about environmental pollution conditions for the next two days or the next three days or even a week." If we are to do the job, we probably are going to have to incorporate pollution problems into the principles and examples throughout the chemistry program. There are many excellent examples available. We can put problems in our weekly or daily problem sheets which include open-ended problems which deal with conditions of the environment.

Some experiments which will emphasize pollution related activities need developing. Projects of various lengths can be fruitfully used.

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