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This report on three junior college chemistry conferences includes: (1) new and developing programs in 2-year college chemistry; (2) beginning chemistry offerings--repair of poor backgrounds in chemistry and math; (3) non-science major--chemistry program for non-science students; (4) first-year chemistry course (a) programmed audio-tutorial approach to chemistry, (b) instrumentation in the first-year chemistry lab, (c) future directions in the first-year chemistry lab; (5) second-year chemistry course (a) instrumentation for second-year chemistry courses, (b) biorganalytical chemistry, (6) chemistry needs for health related sciences: (a) ... for the medical school, (b) ... for the dental school, (c) ... for pharmacy school, (d) clinical lab technology chemistry needs; (7) modern teaching aids for college chemistry: (a) tutorial system of instruction, (b) multi-media approach to the teaching of general chemistry, (c) do-it-yourself with 8mm films, (d) do-it-yourself with 8mm films and film-loops, (e) computer assisted instruction in ... college chemistry, (f) molecule-a-go-go; (8) chemical technology, (a) lab program in chemical engineering technology, (b) comparison of community college and technical institute programs. Supplemental information is provided on multi-campuses; small, large, and private colleges; courses in general chemistry and freshman chemistry; and the services of the Division of Chemical Education of the American Chemical Society. (HH)

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ED0 30432

Two-Year College Chemistry Conference

PROCEEDINGS

Sponsored by
Division of Chemical Education
American Chemical Society

1967-1968 Academic Year

9 December, 1967
Second Southern Regional Conference
Marion Hotel
Little Rock, Arkansas

2-3 February, 1968
First Eastern Regional Conference
Community College of Philadelphia
Philadelphia, Pennsylvania

29-30 March, 1968
Eight Annual Conference
City College of San Francisco
San Francisco, California

UNIVERSITY OF CALIF.
LOS ANGELES

MAY 27 1969

CLEARINGHOUSE FOR
JUNIOR COLLEGE
INFORMATION

JC 690 285

Chairman: William T. Mooney, Jr., El Camino College, Torrance, California
Secretary: Robert Burham, Grand View College, Des Moines, Iowa
Editor: Kenneth Chapman, American Chemical Society, Washington, D. C.

FOREWORD

The officers and members of the Division of Chemical Education are both proud and pleased at the phenomenal successes of a variety of committees, who not only are involved, but have made valuable contributions toward solving the multitude of problems plaguing the chemical education program in two year colleges.

Unquestionably, this most significant development is largely a result of the dynamic and tireless enthusiasm of Mr. William T. Mooney, Jr., who conceived and has since chaired the Two-Year College Chemistry Conference. He has successfully attacked the peculiar, perplexing and unique difficulties that confront many chemistry instructors at this level.

The $2YC_3$ has had an amazing commendable growth from the 33 instructors from 25 two-year colleges that met in Chicago at the first conference in 1961 to the 151 attendees from 94 colleges and four other groups who met this past spring in San Francisco.

The enthusiasm evidenced by chemistry instructors in private and public junior colleges, comprehensive community colleges, public and private technical institutes, extension centers and lower division branches of colleges and universities is contagious. It identifies the fact that the $2YC_3$ is a valuable and worthwhile operation and not just another organization. This, too, emphasizes the success they have had in meeting their stated objectives.

A major reason for growth and success is the regional nature of these conferences. This year (1967-1968), chemistry instructors had an opportunity to attend a session in Little Rock (December 9, 1967); one in Philadelphia (February 2-3, 1968); and one in San Francisco (March 29, 1969) along with the annual Spring meeting of the American Chemical Society. Such planning allows for many to attend and participate who could not, for various reasons, attend the national ACS meetings. So the involvement of an increasing number of instructors in this fast developing field has been very beneficial to all concerned.

Our sincere thanks to the Chairman, Mr. W. T. Mooney, Jr., the Subcommittee chairmen, their committee members and Mr. Kenneth Chapman, Assistant Educational Secretary of the A.C.S. for his contributions and particularly his editorial work on the annual PROCEEDINGS.

We would hope that your comments, constructive critieisms and personal involvement will continue to improve the curricular content, the chemistry department facilities, the status and working conditions for the individuals involved in chemistry instruction and the regional conferences of the $2YC_3$.

W. C. Kessel
Chairman of the Division of
Chemical Education 1968

ACKNOWLEDGEMENTS

The success of the Two-Year College Chemistry Conference has been made possible through the cooperation and support of the Division of Chemical Education of the American Chemical Society and, in particular, its Executive Committee. For 1967-1968, the Division's efforts were combined with those of the Executive Committees of the 1967 Southwest Regional ACS Meeting, and the Third Middle Atlantic Regional Meeting. The fine cooperation of Dr. Thomas Shook of Little Rock and Dr. Frank Sutman of Philadelphia was most deeply appreciated.

At Little Rock, Mr. James Edgar of Navarro Junior College and Dr. Shook worked together to provide facilities for 2YC3 at the Marion Hotel. Both, the Philadelphia Community College and San Francisco City College provided excellent facilities for the meetings in their respective cities. Although the staffs of these two colleges worked diligently to provide all the facilities and services needed, Mr. Robert Melucci and Mr. Rufus Cox at Philadelphia and Mr. Eugene Roberts at San Francisco must be given special commendations.

On behalf of the attendees and Planning Committee, I wish to express our appreciation to the many persons accepting formal responsibilities for the various meetings. One of the irritating features of serving as editor is that I cannot properly give credit to each individual for his work before, during, and after the Conference Sessions.

The Planning Committee wishes to thank each attendee for his contributions and the colleges, universities, and other organizations that made their presence possible.

Kenneth Chapman
1967-1968 Editor, 2YC3
on behalf of the Planning Committee

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NEW AND DEVELOPING PROGRAMS AND ACTIVITIES

IN TWO-YEAR COLLEGE CHEMISTRY

Kenneth Chapman
American Chemical Society
Washington, D. C.

Most of the work of greatest interest to two-year college chemistry faculty is taking place within the Advisory Council for College Chemistry and the American Chemical Society. However, two governmental agencies, the U.S. Office of Education and the National Science Foundation are certain to make considerably greater contributions to educational programs in two-year colleges. The National Science Foundation may be expected to undertake additional activities relative to two-year colleges and held a program in March, 1968, to focus attention on the two-year colleges. At the present time, NSF has earmarked portions of its college teachers' programs for two-year college personnel.

NSF Programs and Openings for College Chemistry Teachers, 1968-69

Program Description	Participation		Openings	
	Total Programs	Including Two-Year College	Two-Year College	Unspecified
Research Participation for Teachers--1968	21	11		
Programs accepting two-year college faculty				
Pre-doctoral.............				34
Post-doctoral............				44
Summer Institutes............	6	3	41	
Short Courses................	6	4	36	
Academic Year Institutes.....	2	1	3	14*
In-Service Seminars..........	2	2	7	150**
Total............	37	21	87	242

A booklet is available that gives a thumbnail description of Congressional acts relating to education and an address for obtaining further information about each particular act. The booklet is entitled "Guide to Grants, Loans, and Other Types of Government Assistance Available to Students and Educational Institutions." It is available for $1.00 from Public Affairs Press of Washington.

*Openings for women intending to become college chemistry faculty.
**California.

Representatives of both the National Science Foundation and the U. S. Office of Education express the attitude of knowing very little about the two-year colleges and their problems and wanting to learn a great deal about them. Both agencies have supported programs that have benefited two-year colleges and their faculty but usually have not recognized them as a separate entity in the educational field. One factor, which is cited with considerable dismay by these agencies, is the very small number of two-year college faculty who are participating in leadership roles through committee membership and active participation in their professional societies.

The U. S. Office of Education has few programs that it considers specifically useful for two-year colleges at the present. Of course, many of its programs for both secondary and higher education have been important to two-year colleges. Officials of USOE are trying to make policy decisions about certain parts of the most recent legislation extending Title V of the Higher Education Act of 1965. Until these policy decisions are reached, it is impossible to determine what programs USOE will design for two-year colleges. It is appropriate to note that the recently appointed Planning Coordination Committee for the Educational Professions Development Act includes Kermit Morrisey, president of Allegheny Community College, Pennsylvania.

A relatively new development sponsored by USOE is the Educational Research and Information Clearinghouse, or ERIC. An ERIC center for junior colleges has been established at UCLA and provides a means of giving access to recent reports of interest to two-year colleges.

On June 8, 1967, the National Science Foundation delivered a report to the Subcommittee on Science, Research, and Development of the Committee on Science and Astronautics of the House of Representatives entitled "The Junior College and Education in the Sciences." I would strongly recommend that you obtain a copy of this report. This report primarily provides a large quantity of statistics about two-year colleges, their students and faculty. Without providing specific answers, the report seeks to give the background necessary to consider the following questions:

1. Should the junior college segment of higher education be singled out for special treatment as a resource for education in the sciences?

2. What kinds of science programs are appropriate for this universe of entities?

3. What needs to be and can be done to improve the quantity and quality of faculty?

The report probably raises more questions than it answers, but it will serve as an important part of the bases used as Congress considers educational bills for higher education in the next few years.

A new program at NSF that may have some effects on two-year college chemistry in some areas is the Sea Grant Program. The first funded projects should be announced in early 1968. As viewed by the program's director, Dr. Robert Abel, the program is extremely encompassing and will be concerned with educational programs for two-year technologies through post-doctoral programs, as well as be involved in many other activities.

Most of you are probably familiar with the Manufacturing Chemists' Association. In the educational area, they prepare and distribute guidance and counseling literature on chemistry and chemical engineering career opportunities, including a recent booklet entitled "A Bright Future for You as a Chemical Technician." They

also have safety posters available, which are widely used in college laboratories. For the past several years, MCA has been getting a publication effort under way that they call "Chemistry in Action." The purpose of this is to prepare a series of topical books that will relate the modern chemical industry with chemistry being taught in the classroom. Two books are now available: "Chemical Engineering" by Dave Kilafer and "Silica and Me" by Guy Alexander. The second book traces Dr. Alexander's career from college to retirement. All of the books in these series should be useful at the high school and first-year college level.

Other than the well-known Summer Institutes and graduate support programs, NSF's greatest contribution to two-year college chemistry (and possibly its most important) is its support of the college commissions like the Advisory Council for College Chemistry. A meeting of the second Intercommission Panel on Science in the Two-Year College was held in Washington, D. C., in November, 1967 and was supported through joint efforts by several of the college commissions.

Other than the programs of AC_3, two study reports from other commissions should be of immediate interest by two-year college chemistry faculty. One is entitled, "Survey of Programs in the Mathematical Sciences," and was prepared by the Commission on the Undergraduate Program in Mathematics. Another activity is a study undertaken by the Commission on Science Education concerning the teachers of science in a selected group of two-year colleges, which should become available during 1968.

AC_3 has several things underway that are of great importance. As you should be aware, an extensive questionnaire survey of chemistry faculty in two-year colleges is nearing its completion. A vast amount of information on both the profiles of chemistry programs and chemistry faculty has been obtained and examined at an AC_3 conference in January, 1968, to determine the Council's future activities to assist chemistry instruction in the two-year colleges. This information will also be used by the ACS.

A library resource project is nearing completion. A list of 375 titles recommended as the basic library list for a two-year college program has been developed. Over 200 two-year and four-year college chemists have contributed to this activity.

AC_3 has developed a Consultants Bureau to be available for considering almost any problem a department might have except that of facilities planning. The Consultants Bureau includes five individuals from two-year colleges.

It may be obvious from the discussion up to this point that AC_3 is concentrating its attention on the transfer and general education problems of two-year college chemistry. AC_3 has avoided, insofar as desirable, the occupational program in chemistry or chemical technology. The reason for this is that the American Chemical Society has been deeply involved with this area of chemical education since 1964 and currently has very active committees working on several fronts of problems connected with chemical technician education. Since there is no organic connection between AC_3 and ACS, care is exercised by both organizations to avoid duplication of effort whenever this is desirable. ACS added a staff position of Assistant Educational Secretary--Two-Year Colleges in June of 1967. Since that time, ACS and AC_3 have worked very closely to coordinate activity in the two-year college area.

The ACS presently has an ad hoc committee that was appointed by the Board of Directors to study the "Chemistry Core" content of a chemical technician's curriculum. Recommendations have been made relative to this area and are available. This

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committee is investigating ways to implement these recommendations with attention being directed toward student recruitment into two-year chemical technology programs and development of teaching materials prepared specifically for chemical technology programs. A very useful conference on chemical technicians was held in Brooklyn, New York, on October 27 and 28, 1967, to examine curriculum content and student recruitment techniques. Copies of the Proceedings are available from the ACS Education Office.

An ACS Committee on Chemical Technician Affiliation with the Society is looking at the problems of the practicing technicians. The committee was initially given ad hoc status by the ACS Council, but its problems have been such that it now has a longer-term life like several other committees of the Council. It has prepared an affiliation brochure that applies to local sections and divisions and has sponsored Chemical Technicians' Symposia to encourage technicians to deliver technical papers. Additional symposia have been planned.

The Council Committee on Chemical Education has responsibility for student affiliate chapters and represents the Council's concern with education. A subcommittee on two-year colleges has been appointed. It should be emphasized that two-year colleges, including those having occupational programs, are potentially eligible for student affiliate chapters.

The Committee on Professional Training, the body that approves chemistry programs in four-year colleges, is now discussing what it should do about two-year colleges. The committee's discussions up to this time have not committed it to any particular line of action.

The Division of Chemical Education of ACS provides the support for this conference and has welcomed two-year college faculty into its committees. One specific program sponsored by the Division is a Small Grants Program, which provides small amounts of funds to examine innovative or creative ways to improve chemistry instruction. The division sponsors Chemical Education Symposia at National Meetings and is responsible for the Journal of Chemical Education. Two-year college chemistry faculty are strongly encouraged to provide support to the Division by joining it and participating in its activities.

This is a brief sketch of many activities that will affect chemistry in the two-year colleges. Please become an active participant in these activities for your professional gratification and to improve the quantity and quality of chemistry instruction generally, as well as in your own institution.

BEGINNING CHEMISTRY OFFERINGS

Second Southern Regional Conference
Keynote - W. T. Mooney, Jr., El Camino College
Co-chairman - Morris Hein, Mt. San Antonio College
Jerome Holmes, Hartwell College
Recorders - Louis Katnik, Cuyahoga Community College
J. Smith Decker, Phoenix College

REPAIR OF POOR BACKGROUNDS IN CHEMISTRY AND MATHEMATICS

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

Chemistry teachers in two-year colleges are concerned about the large numbers of students in their general chemistry courses who are not sophisticated enough chemically or mathematically to have a reasonable chance of success in the course. These chemists would do well to offer a beginning chemistry course and repair the backgrounds of these students before they become sacrificial lambs on the altar of the academic integrity which must be maintained in the college level courses for science and engineering majors.

Contemporary college chemistry courses emphasize the relationship between structure and properties of substances and explain how the structure determines the properties. How many chemistry faculties and administrators have seriously considered the relationship between the structure of the college and the characteristics of the chemistry program of the college?

In a paper entitled "Opening the Doors to Chemistry For All Students: Introductory Chemistry for Two-Year Colleges"[1], it is contended that institutional structure is a significant influence in setting the characteristics of chemistry programs at two-year colleges, liberal arts colleges, state colleges, state universities and private universities. The structure of the college in this sense includes a consideration of the philosophy and functions assigned to or assumed by the institution and the students, philosophy of education in the sciences, faculty and other resources of the college.

Two-year colleges were defined to include public community colleges, public junior colleges, private junior colleges, two-year technical institutes and two-year centers of university systems and the public institutions were characterized as open-door, comprehensive, community colleges. The thesis developed was that the concept of opening the doors to chemistry for all the students is a consequence of the open-door, comprehensive, community college philosophy.

The thesis of this paper is that if an open-door, comprehensive community college seriously considers its structure, its philosophy, functions and student body, then it will include within its chemistry department a beginning chemistry program.

A beginning chemistry program is herein defined as a first course, or other organized program, in chemistry designed to salvage students deficient in high school chemistry, regardless of the type of deficiency, so that these students might enter the college-level, freshman chemistry course, generally entitled general chemistry for science and engineering students, with a reasonable chance of success.

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(1) Mooney, William T., Jr., "Selected Papers from Regional Conferences 1966-67," The Advisory Council on College Chemistry, Palo Alto, California, 1968, p. 67.

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Student deficiencies may be of several types: (1) the student avoided chemistry in high school; (2) the student enrolled in chemistry and completed the course but the essentials avoided him; or (3) the student completed chemistry several years before enrolling in a college and no longer has the necessary chemical mental muscle tone.

"Open-door" means entry into the college is generally relatively unrestricted. It implies that many courses and many curricula must be available. Some courses will be within the range of a student's interests and within the purview of his abilities. Some will be outside his interests and some beyond his ability. The student need not choose what lies outside his interest. He should not be allowed to choose that which clearly lies beyond his ability. Unfortunately, many two-year college administrators and faculty do not realize that the open-door philosophy does not require every curriculum and course to be open door. It does require a variety of curricula to match the potentials of a variety of students.

Comprehensive means a commitment to a multiplicity of educational functions or purposes. Six functions are generally listed: (1) education for transfer, or the lower-division parallel function; (2) education for occupational competence, or the career training function; (3) education for living, or the general education function; (4) counselling and guidance; (5) community service and (6) education for overcoming deficiencies, or the remedial or salvage function.

In considering the development of two-year college chemistry programs, in terms of the open-door, comprehensive, community philosophy and the six functions, seven implications can be noted:

(1) The college must offer a general chemistry course equivalent to that of the corresponding universities and state colleges.

(2) They must offer a second-year chemistry program equivalent to that of these institutions.

(3) The college must provide a means of developing a student's level of performance and understanding so he can enter the general chemistry course with a reasonable chance of success.

(4) The college must provide instructional programs, curricula and courses for the craftsman, the highly skilled, and the semi-professional if it is to fulfill its occupational education function.

(5) The college must provide a general education program in science including chemistry for the non-science and non-technical students.

(6) The college must develop a philosophy and program for the placement of students in chemistry courses at the place where the student has the most reasonable chance of succeeding and where he will obtain the education and training in chemistry best suited for his educational goal. It should be noted here that the two-year college student heterogeneity and curriculum diversity is such that students should not be allowed to enter a college level program when they obviously are not ready and will probably "sink". Much evidence exists to show that through counselling, guidance, and remedial programs large numbers of students can be salvaged and thereby succeed in swimming the whole distance.

(7) The college needs to develop a series of specialized courses or programs related to chemistry, such as a nuclear science course or a water chemistry program, or a science lecture series.

The hypothesis of this paper is related directly to the third and sixth implications, namely the preparation of the student for general chemistry and the placement of the students in the chemistry program.

Two year colleges throughout the country have found it necessary to institute a beginning chemistry course as an integral part of their chemistry curriculum. A study of the 1965-1966 catalogs of the 76 California public junior colleges revealed certain common patterns among junior college chemistry programs. Sixty-six colleges indicated specific courses which may be used to prepare students with background deficiencies in chemistry for chemistry 1A, the first semester of general chemistry; which, in reality, is the second course in chemistry in these colleges. Thirty-four of these courses are designed primarily for this purpose and 43 courses are used for both the preparation for general chemistry and for the non-science major. Some colleges designated more than one such course.

In the beginning chemistry courses the unit spread reported was from zero to five units with an average of four. The class hours required range from two to nine per week. Two colleges require completion of intermediate algebra and five colleges allow concurrent enrollment in this course. In the combined courses the units range from three to eight, the hours required range from three to 12, and only one college requires more mathematics than elementary algebra. Twenty-three colleges do not require any mathematics to enter these courses.

In effect then, colleges with beginning chemistry programs are saying that the student entering the college with a background in chemistry such that he will have a reasonable chance of success in the general chemistry course will be able to complete the chemistry year course in two semesters, but the student deficient in chemistry will require three semesters. Considering the heterogenity of the student body and the level of mathematical and chemical sophistication necessary in the general chemistry course to be equivalent to the four-year colleges this does not seem at all unreasonable.

When a college considers courses designed to repair the science and mathematics backgrounds of its students, there are three basic questions to answer. These are:

(1) What are the standards of achievement on performance which will allow a student to cross over the entrance boundary to the first-year college-level courses?

(2) How can the college determine if any given student has sufficient background and ability to satisfy the standards mentioned above?

(3) What curriculum or courses must be provided for the student who does not have sufficient background and ability to satisfy the standards mentioned above?

How does a college determine the suitable standards of achievement or performance which would allow students to cross over the entrance boundary to the first-year college-level courses? Unfortunately, there is not at the present time any single source that one can turn to for an answer. In developing an answer at the local level, one should look at the last three or four forms of the ACS-NSTA High School Chemistry Examination; the various forms of the Toledo Chemistry Placement Examination; the various forms of the Educational Testing Service Cooperative Chem-

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istry Tests; the College Entrance Examination Board Chemistry Examinations; copies of the recent New York Regents Examinations in chemistry; the problems at the ends of the chapters in the CHEM Study textbook, which has about one-third of the national high school market; and the problems at the ends of the chapter of the Dull et al text, which has about one-third of the national high school market. Such a review should give the college chemistry teacher a good idea of the topics, or scope, and the depth, or level of sophistication found in high school chemistry courses around the country. The Preparation for General Chemistry Project of the Advisory Council on College Chemistry is developing materials to communicate what might reasonably be expected from a "B" student in a better than average high school chemistry course when he enters college chemistry.

What should be the characteristics of an instructional program or course designed to prepare the student deficient in chemical background for general chemistry? An NSTA workshop group in 1965 devoted to the Repair of Poor Backgrounds in Science and Mathematics concluded that courses which were established for the repair of backgrounds in chemistry and physics prior to entering the college level course for science and engineering majors should be characterized by the following:

(1) An emphasis on problem solving which requires an analysis approach so mathematical operations are applied to the study to chemical and physical systems. This is most effective if the chemistry and physics of the system are well in mind first.

(2) An emphasis on inquiry which requires the approach in the laboratory to be that of asking questions of nature. Laboratory experiments should involve more quantitative types of experiments which have greater meaning and which require the taking of data and the utilization of data handling and interpreting techniques.

(3) The course should emphasize the vocabulary and nomenclature of the science.

(4) The course should be organized in such a way that it shows the structure of the science concerned and the scientific enterprise in general.

What are the characteristics of the El Camino College preparatory chemistry program? El Camino College has been administering a chemistry placement examination for nearly twenty years. During the first ten years students deficient in chemistry were required to satisfactorily complete the chemistry for the non-science majors course before enrolling in general chemistry. In 1957 we noted that the overriding concern in this introductory course was the preparation for the general course but that neither the preparatory function nor the chemical education needs of the health-related occupational groups, the non-chemical technicians, nor the non-science majors were being properly serviced. We decided one should not dominate at the expense of the other. Therefore, the introductory course was split into two separate courses; one entitled beginning chemistry, primarily to prepare students for general chemistry and the other, chemistry for the non-science majors, to serve the health-related occupational groups, non-chemical technicians, and liberal arts students.

Students are considered deficient in chemistry if they have not satisfactorily completed one year of high school chemistry or a one-semester beginning chemistry course in college. Students who have completed high school chemistry must validate their proficiency on the El Camino College chemistry placement examination to qualify for Chemistry 1A. Students who enroll in the beginning chemistry course in college must pass the course to qualify for chemistry 1A.

Table 1 shows the manner in which high school chemistry and mathematics grades are combined with placement test scores to obtain placement points for general chemistry. Placement, in terms of placement points, is as follows:

8-14 General Chemistry (for Science and Engineering Majors)

0-7 Beginning Chemistry

For a period of six years, 1959-1965, student performance in general chemistry was carefully studied in terms of beginning chemistry grades and method of qualification for general chemistry. Tables 2 and 3 report this data. A study of these tables reveals the following:

(1) A and B students from beginning chemistry have been remarkably successful in general chemistry.

(2) The C student's success is considerably less than that of the A and B.

(3) The study of the success in 1959-62 and subsequent changes in beginning chemistry made at that time improved student success in 1963-65.

(4) Students qualifying directly from high school for general chemistry by the placement test do slightly better than those entering from general chemistry. The closeness of the success of the deficient student group to that of the better student group is sufficient testimony to the success of the beginning chemistry program.

We have found it to be very important to have the beginning chemistry student view his study of chemistry with the following ideas in mind:

(1) The Particulate Nature of Matter.

(2) Structure determines properties and properties determine uses of substances.

(3) Energy is associated with all changes in matter.

(4) Chemical changes involve a rearrangement of the atoms of the reacting substances.

(5) Information concerning the properties of substances is obtained from experimental observations.

(6) Men construct models to communicate their state of understanding of the structure and behavior of substances.

(7) Many relationships in chemical and physical systems may be expressed in mathematical (quantitative) terms.

TABLE 1

CHEMISTRY PLACEMENT POINT SCALE
FACTORS AND PLACEMENT POINTS
1964-1965

P.P. Placement Points	P_C High School Chemistry Grades	P_M Advanced Algebra, Trigonometry etc., Grades	P_{E1} (A) Total Test Score or (B) Multiple Choice Exam. Score*	P_{E2} Completion & Problems Exam Score (Pts. II & IV of Iowa Test)
4	-------	-------	(A) 121 or above (B) 49-60	61-93
3	AA, BA	All A grades	(A) 91-120 (B) 37-48	46-60
2	-------	All B and A grades	(A) 81-90 (B) 25-36	-------
1	BB, BC, CC, AC	If any C grades or if only advanced algebra completed with C or better	(A) 66-80 (B) 13-24	31-45
0	If any D or F grades included	If any D or F grades or if neither course completed	(A) 0-65 (B) 0-12	0-30

$P.P = P_C + P_M + P_{E1} + P_{E2}$

*During 1963 and 1964 the score used for P_{E2} was the total "Iowa Training in Chemistry Test" score. During 1965 a 60 question multiple choice test composed of Part I of one form of the 1959 A.C.S. High School Chemistry examination, plus some locally prepared questions, was used for P_{E1}. (Note: During 1969-68 the tests were again revised.)

TABLE 2

SUCCESS OF BEGINNING CHEMISTRY (CHEMISTRY 3) STUDENTS IN GENERAL COLLEGE CHEMISTRY (CHEMISTRY 1A) AT EL CAMINO COLLEGE, 1959-62 AND 1963-65

Chemistry 3 Grade	Number of Students		Number receiving "A", "B", or "C" grade in Chemistry 1A		Percentage Success	
	1959-62	1963-65	1959-62	1963-65	1959-62	1963-65
A	52	36	46	32	88	89
B	218	110	151	83	69	75
C	428	234	175	105	41	45
TOTAL	698	380	375	220	53	58

TABLE 3

SUCCESS OF STUDENTS IN GENERAL COLLEGE CHEMISTRY (CHEMISTRY 1A) AT EL CAMINO COLLEGE IN TERMS OF METHOD OF QUALIFICATION, 1959-62 AND 1963-65

Method of Qualification	Number of Students		Number receiving "A", "B" or "C" grades in Chemistry 1A		Percentage Success	
	1959-62	1963-65	1959-62	1963-65	1959-62	1963-65
Qualified by Placement Test	194	122	113	76	58	62
Qualified by Chemistry 3	698	380	372	220	53	58

Discussion Points

1. Beginning, or remedial, chemistry courses have existed at a few colleges for many years and are much more common as more poorly prepared students are admitted to colleges. For the "late bloomer," this course offers an opportunity for increasing the probability of success in the regular chemistry courses. For some students, this course will prove sufficient to meet needs in liberal arts, physical education, etc., but the transferability of the course depends upon the college to which the student wishes to transfer and the program of study he wishes to follow.

2. Some colleges have about the same numbers of students in the Beginning Chemistry as in the more standard General Chemistry. The loss of students amounts to twenty-five to forty per cent of the initial enrollees. Many of the candidates for this course have no interest or little ability and frequently lack both. Many students have been out of school for several years and need Beginning Chemistry to get readmitted.

3. Students receiving grades of A or B in Beginning Chemistry usually do well in the regular General Chemistry course. Students receiving C's may expect difficulty in General Chemistry and students receiving D's will usually be admitted to General Chemistry only if they pass a placement test.

4. To facilitate student movement between Beginning Chemistry and General Chemistry, the courses can be scheduled at the same time periods. Students are encouraged to take mathematics simultaneously.

5. Frequently, Beginning Chemistry is a one semester course - five credit hours with two laboratory meetings per week - which is followed by two semesters of General Chemistry.

6. Colleges offering Beginning Chemistry frequently require high school chemistry as a prerequisite and intermediate algebra as a corequisite for General Chemistry. A placement examination, such as the Toledo Chemistry Achievement Test with a 45th percentile cut-off, is frequently required for General Chemistry. Good ACT scores correlate well with a likelihood of success in chemistry.

7. Students seeking a second semester of science may consider science courses other than chemistry after completion of Beginning Chemistry.

8. Textbooks for Beginning Chemistry have been written by both M. Hein and J. Holmes.

9. Students for Beginning Chemistry lack mathematical facility. Poor manipulation skills are less of a problem than the mathematical reasoning which enables the student to properly interpret the difference in meaning between AgCl and 2AgCl.

10. Among the topics covered in Beginning Chemistry are:

Nomenclature	Stoichiometry
States of Matter	Equilibrium (qualitative)
Thermodynamics (basic concepts)	Measurement
Solution Chemistry	Atomic Structure
Bonding Concepts	Organic Chemistry

11. Among the aids used in teaching these concepts are:

Mole Concept	Proportion Methods
Laboratory Emphasis	Dimensional Analysis
Crystal - Order	Emphasize Process

12. The Beginning Chemistry course should be laboratory oriented. High school experiments are usually inadequate. Both quantitative and qualitative experiments should be included. General Chemistry experiments are more mathematical and delve more deeply into the nature of chemical interactions.

THE NON-SCIENCE MAJOR

Eighth Annual Conference

Keynote - J. J. Lagowski, University of Texas
Co-chairmen - Milton Cooper, The Chicago City College, Wright Campus
Herbert Bryce, Seattle Community College
Recorder - Celia Mae Scott, Shoreline Community College

A CHEMISTRY PROGRAM FOR NON-SCIENCE STUDENTS

J. J. Lagowski
University of Texas, Austin, Texas

I should like to spend a few minutes with you this morning discussing, in a general way, what many consider to be an important subject - science for the non-science student. This is a subject that often receives lip service with the overwhelming real effort in education being expended on science students. Generally speaking, science students receive the lion's share of teaching effort and expenditure of funds in chemistry courses - even though we might not think these students receive all they deserve. Thus, we find ourselves faced with an anomalous situation; a significantly smaller amount of money and effort are expended on the students who will eventually receive benefits from, or be effected by, the efforts of science; these students eventually will directly or indirectly control the purse strings of science.

I would hope that the teachers of chemistry would be sufficiently perceptive to realize the long range consequences of teaching apparently "irrelevant" science to students of this type; the term "irrelevant" is used, of course, from the students' standpoint. I do not at all imply that science teachers believe that their subject is irrevelant; the suggestion is made that the students believe it to be irrevelant. Undeniably, it is difficult for the scientist to understand how the science he attempts to teach the non-science student can be described as "irrelevant." It is imperative that more good scientists engage in the struggle to understand the basis of the "attitude of irrevelance" of non-science students or the schism between scientists and non-scientists described by Lord Snow will widen further. It is perilously wide now!

Being good scientists, perhaps we should begin by asking several basic questions. Is an exposure to science necessary, let alone good for the average student? (I should like to note that my use of the term "average" is not related to the grades a student makes.) Placed in a more positive way, we might ask what does science offer, if anything, to the general student. I believe science, and chemistry specifically, has much to offer to this type of student, but it often gets lost or distorted in the process. The distortion usually takes the form of a watered-down science major's course in which every aspect of the major's course is included to a lesser degree. Surely we can do better than this.

Chemistry occupies a unique position in the hierarchy of sciences in that it acts as a vehicle for the dissemination of basic princples into every aspect of the complex physical world. If mathematics is the queen of sciences, and physics is king, chemistry is certainly their prime minister. Chemistry pervades every aspect of modern life; it is the source of many of the problems which beset man today - it is also the means by which these problems will be solved. Because chemistry pervades every corner of the physical world, it should be possible to use it as a medium in which to give the general student an appreciation for science. Musicians and artists have appreciation courses, why can't chemists? There are a sufficient number of different aspects of

chemistry so that almost every general student can find something of interest and value. However, I would venture to say that the general student and the science student would find different values in different aspects of the same object. That is, the same subject could be treated in one way to appeal to the science student and a different way to provide benefit for the general student.

Chemists are practical scientists. That is not to say that chemists are not interested in theory, but even in theoretical things, chemists realize the practicality of dealing with very complex systems that are not easily treated by first principles. It is this ability to deal with practical problems which chemists should harness in their attempts to give the general student an appreciation of science.

Let me illustrate by using several examples of the types of subjects which could form the basis for courses that could be useful for the general student.

Students might be given an appreciation of science by choosing an in-depth study of a single topic as the focus for discussion. The modern student is familiar with many topics from his high school work which could serve as the basis for college work. Topics such as water, the atmosphere, or carbon could serve admirably as vehicles for (1) discussion of basic principles of chemistry, (2) the exposure of students to more advanced (and usually more exciting) material, (3) an illumination into the general methods of science, (4) the logical structure of science, and (5) the impact that science and technology has made on their lives. By the latter point, I do not mean recitation of the wonders of chemistry or an attempt to promulgate the general attitude "gee whiz, isn't chemistry great because it has brought you synthetic fibers, high test gasoline, synthetic rubber, etc." Students who have been brought up in an environment steeped in the riches brought forth by science are little impressed by those riches. In fact, I would venture to say that they are bored and find no challenge in these subjects. The general student of 20 or 30 years ago would be excited by prospects such as the creation of synthetic fibers - indeed, we are living in a world probably created by a generation of students who have responded to such challenges.

The present day challenge lies in understanding the nature and impact that science and technology have on our environment, understanding that this impact is inevitable, and understanding the factors which bear on the solutions to the problems brought about by science and technology. Lake Erie is essentially dead; Lake Michigan is dying; the air of our cities is heavy with pollutants. These are the problems of a successful science; these are the problems which must be solved by science. It should be possible to engage the general student in such topics, show them the scientific principles on which solutions can be based and discuss the economic, political, and sociological implications of these solutions. It should be apparent by now that I am pleading for the creation of courses for the non-science student that will give him an appreciation of the position that science occupies in the world without necessarily diluting the science we teach him. I ask only for a shift in emphasis.

Another possible way to make science, and especially chemistry, more relevant and understandable to the general student is the development of sequential science courses which form a unity. Often we expect the student to synthesize the relationships between several courses himself. This process requires a mature mind with the ability to maneuver ideas across disciplines - a characteristic not usually found in the beginning student in college. I am certain most of you are familiar with attempts to develop such a unity in one course which is usually entitled physical science. However, I am of the personal opinion that such courses are eventually bound to fail because their development depends upon the effort of one extraordinarily gifted individual or lacking this, a collection of dedicated individuals from several disciplines working in concert. Once such a course is out of the hands of its creator

or creators, it immediately deteriorates in terms of its viability.

It would appear more reasonable to develop a collection of courses that cover rather broadly defined areas, but that are arranged in a sequence that is logical with respect to the total effect on the student. Thus, a general student could take courses in biology, mathematics, physics, and chemistry in a random sequence; after completing these science courses, it is left to him to organize the relationships among them. However, every one of us could order these subjects in a way which would present the student with a unity of thought without having to specifically alter the detailed subject matter in each course. I am fully aware that there are several useful ways in which the courses mentioned previously could be presented and that a sequence I could suggest might not be acceptable to some of you. That, however, is not the issue here; it is more important that we realize that an ordering of the general student's science subjects can have a profound influence on that student's understanding of science as a whole. If the chemistry instructor knows that his course is a part of an overall pattern, he also knows what he can expect of his students when they come to his course and what will be expected of his students when they leave his course. Thus, he may still teach the different subjects associated with chemistry, but he may do it in a way that is different than in the traditional course. The placement of a chemistry course taught by a Chemistry Department in a specified sequence of science courses which are to form a unity, has the additional advantage that the chemistry the student receives is professionally acceptable to the department.

With this simple idea in mind, it should be possible to organize the existing science courses into a variety of different sequences. Each sequence would reflect a unity, and each sequence could be biased toward a different area in science.

I have attempted to show just a few ways in which science, and specifically chemistry, can be made more meaningful to the general student. Surely the profession that gave us Lavoisier, elucidated the principles of chemical combination, gave us the tools to investigate, understand, and make use of the principles of atomic structure, can rise to the challenge to make itself relevant and comprehensible to a young mind that is eager to learn. I have confidence it can if it will only try.

Discussion Points

1. Stimulating exposure of children to science will come through elementary school teachers, den mothers, and leaders of similar groups where sole exposures to science will be the courses for non-science majors. These people must have a pleasant and effective exposure to the lowest activities of science; otherwise, they will only be able to convey negative attitudes which will function to the detriment of future attitudes toward science.

2. The seriousness of the need for a genuine non-science majors' chemistry course must be communicated to the administrators of two-year colleges. Development of such courses should present a challenge to two-year college faulty who have both the qualifications and the resources needed for such a project.

3. The chemistry courses taken by potential elementary school teachers frequently offer little of real future value in the elementary classroom. Yet, this teacher is expected to merge the innate curiosity of young students with some early exposure to scientific principles. Proper design of the non-science majors' course should help build the prospective teacher's confidence in his basic understanding of chemistry. In turn, this would encourage a more positive atmosphere regarding science in his classroom.

4. The instructor of the non-science majors' course should frequently ask himself the following questions. What implications of science am I conveying to the students through this course organization and my presentation? What impressions will the non-science major student have upon completion of this course?

5. Laboratory work should convey the investigative nature and procedures of science and answer the following questions. What is science? What is a reaction? How is a reaction used? How can a reaction be controlled? How do reactions differ? With proper examples, the elementary teacher might be able to take from the course the beginning of a program to be used in subsequent work.

6. Experimentation should be as simple as possible to avoid diluting the principle by the process.

7. Laboratory manipulation should be built around interesting things. Selection should be dependent upon student goals. Special laboratory work can be introduced for various groups of students.

8. If complexity of equipment, safety of procedure and simplicity of basic principles can be the guiding basis for the selection of laboratory experiences, much could be achieved to encourage further experimentation in a simple form as future opportunities are presented.

9. The mixing of non-major science students with the majors introduces problems which could be discouraging to the non-major while imposing too many restrictions on materials for the major. The demand for more rigorous experimental background for future work is apt to overwhelm the non-major.

Second Southern Regional Conference
Keynote - Rudolph Heider, Meramec Community College
Co-chairmen - Rudolph Heider, Meramec Community College
Anne Stearns, Columbus College
Recorder - J. Smith Decker, Phoenix College
First Eastern Regional Conference
Keynote - H. A. Neidig, Lebanon Valley College
Co-chairmen - Edward Fohn, Green River Community College
Paul Santiago, Harford Junior College
Eighth Annual Conference
Keynote - Robert Plane, Cornell University
Co-chairmen - Edward Fohn, Green River Community College
Robert Bowlus, Pasadena City College

A PROGRAMMED AUDIO-TUTORIAL APPROACH TO CHEMISTRY

Dr. Rudolph L. Heider
Meramec Community College
Kirkwood, Missouri

One of the promising ideas of the decade for improving science instruction has been an audio-tutorial approach, as spear-headed by Dr. S.N. Postlethwait of Purdue University. This teaching method has the following advantages:

a. Permits students to pace themselves and allow them to learn at their individual rate.

b. Capable of utilizing a wide variety of teaching techniques.

c. Maximizes personal contact between an instructor and the student.

Meramec Community College Program

While, we at Meramec Community College are, of course, drawing heavily from the work at Purdue and from research in learning, training and education performed by various U.S. Bureaus, colleges, and institutes, we are more concerned with programming, educational objectives and immediate response and reinforcement than previous audio programs. Essentially, we employ the educational technique of a programmed text, utilizing all types of effective media. Further, in chemistry, we are -- for the first time -- bringing a fusion of activities that are normally isolated and disconnected.

Traditionally, the students attend a one-hour lecture three times per week, have one hour of discussion in a classroom situation, and once a week have a laboratory work session for several hours. Along with each of these formal sessions are homework assignments. Feedback to the instructor on an individual student's progress occurs only two to three weeks later, usually too late to rectify major problems that some students have encountered, since his problems frequently cannot be readily identified at that time.

B. F. Skinner, et al, have shown the importance of immediate response to the effectiveness of learning and we feel that the learning elements in the traditional approach are too widely separated in time for efficient learning. This leads us to view all phases of the study of chemistry as components of the whole system. When information transfer is required, this is given via magnetic tape, printed matter, or visual aids. In order to demonstrate how a given principle is derived, it is helpful to do laboratory work at that time; thus, laboratory work and information transfer are interspersed. In essence,

we use a learning situation, which may be at any time what previously was a separate lecture, laboratory, discussion or homework period, to effect a fusion of all these functions with feeback information to inform the student of his step-wise progress. This has another important advantage, i.e., after the curiosity of the student has been aroused and he is motivated, he may immediately do laboratory work, perform a demonstration, or work a problem to experience what actually happens. Contrast this to having a lecture at 9:00 a. m. Monday and a Friday afternoon laboratory period covering the same subjects wherein he might satisfy his curiosity--if any still remains!

The audio-tutorial teaching procedure as developed by Dr. Postlethwait for teaching Plant Science has four main parts: These are the class meeting, the independent study, the seminar period and the quiz period. We do the following in our General Chemistry instruction:

The class meeting on Monday morning is a one-hour per week meeting of all the students in a large lecture hall, which in our case seats 150. The instructor in charge of the course sets the stage for the week's work. This includes guest speakers, motion pictures, etc., with the primary purpose of integrating and orienting the subject matter so the student may appreciate its overall significance. The major purpose of this meeting is to motivate the student by convincing him that the topic is one he should take the time and energy to learn and not to "lecture". The topic is discussed so that it relates to the student's desire to know about himself and his environment.

Independent study is done in laboratory--which is open from 8:00 a.m. to 5:00 p.m. each work day. A qualified instructor is on hand at all times to guide and give personal assistance to all students. The student has access to the tape recording for the unit, has his laboratory equipment at hand, and brings necessary workbooks, graphs, and other supplies for both laboratory or desk work. The student interacts with the audio program on magnetic tape. The audio instruction is designed to lead the student carefully through a programmed series of learning experiences. Typically the student works problems, collects and organizes data, performs experiments, makes observations, views films, reads reference materials, discusses the chemistry, and works through programmed materials as guided and suggested by the taped audio program.

The student is charged with the responsibility of completing the week's work by Friday noon. This gives him more than four and one-half days in the week in which he can pace himself and choose the time he wishes to do his work. Obviously he proceeds at his own rate and so proceeds through the unit for that week's assignment.

During the week, after the student has had an opportunity to interact with the program, groups of six of eight students are scheduled into 30-minute seminar periods where questions may be raised by the instructor or the students, and a general discussion take place. This seminar period serves to acquaint the instructor with each student on a first name basis and is particularly effective in exploring a wide range of subjects, including career and counseling questions of interest to the student.

We have attempted to eliminate the seminar period in an effort to conserve time, but experience has shown that this is a vital part of the system and we have now re-instituted the seminar. Attendance is mandatory; otherwise, we found that those students who are well motivated and doing well invariably attended the seminar, but those who needed it most, tended to drift off after several weeks.

Our seminar period differs from some audio-tutorial programs in that we do not attempt any graded oral quizzing at this time. We feel this tends to inhibit free-and-easy discussion which might lessen interest in the subject and create a hostile atmosphere.

Finally, at the end of the week, the entire class assembles in a large lecture hall for a short written quiz lasting from 20-30 minutes.

ERIC

To reinforce learning at the quiz session, we make use of NCR two-part carbonless paper. When the student receives the quiz, each page has a duplicate yellow NCR paper page. As he writes on the top white sheet, a carbon copy is generated. After he has completed the quiz, he tears off the yellow carbon, turns the white copy in to the instructor and leaves the room. In another lecture room, or in an adjoining laboratory, the correct responses are posted, an instructor is on hand to answer questions, and the student grades his quiz. After checking his answers, asking any questions and recording his grade on the yellow copy, he leaves the yellow copy with the instructor and proceeds on his daily schedule.

The instructor has both the white and the yellow copies and can quickly scan each quiz to ensure that the grading was correctly done. This procedure offers immediate reinforcement for the student thereby enhancing learning and, at the same time eliminates considerable grading by the instructor.

Resource Materials

The student is required to purchase a textbook, which currently is General College Chemistry, 3rd Edition, Keenan and Wood (Harper and Row), a laboratory notebook which consists only of cross-section paper and a Workbook for each unit, by Dr. R. L. Heider. A paperback on problem solving in General Chemistry is also strongly recommended.

Each student also has a complete kit of laboratory equipment for his use in doing demonstrations and experiments.

In the laboratory we have available for student use film strips and film loops for the Unit being studied. We are now using an Autotutor Mark II (Welsh Scientific Co.) with their course in Basis Chemistry on a trial basis.

Textbooks, handbooks and programmed materials are available in bookcases in the laboratory for use either at the student's position or for check-out on an overnight loan basis.

During the year, most of the films prepared by the Chem Study group are used, usually at the end of the Monday morning orientation period. Students find these films interesting and informative. We propose to develop a set of key questions pertaining to the film which the student answers after viewing the film.

The Workbook for each Unit is purchased at the Bookstore and includes detailed educational specifications which form the basis for the evaluation quizzes at the end of the week, drawings, experiments, demonstrations, problems to solve, all keyed to the tape. A selected bibliography is also part of the workbook which lists texts, programmed materials and films for that specific unit.

As the student proceeds through the taped program, he uses his workbooks for notes, problem solving and similar activities. After the completion of the Unit, the student hands in the workbook for grading. The grade is recorded and becomes a part of the semester grade.

Acknowledgment

The financial assistance of the Esso Foundation was invaluable in permitting released time for the development of the audio-tutorial instructional materials.

INSTRUMENTATION IN THE FIRST YEAR CHEMISTRY LABORATORY

H. A. Neidig
Lebanon Valley College
Annville, Pennsylvania

(Professor Neidig discussed experiments for first-year college chemistry which require instruments not frequently found in the older traditional laboratories. Rather than present inadequate and misleading discussions of the various experiments, Professor Neidig provided the following list of references. Most of the articles provide sufficient details to enable the instructor to prepare an experiment outline satisfactory for his students and equipment. The articles are arranged according to the primary instrument required. Ed.)

Potentiometer

1. Jaques, Derek, "Potentiometric Determination of Mixed Halides," J. Chem. Educ., 42, 429 (1965).
2. Moss, S.J. and Hill, D.L., "Heat of Reaction in Aqueous Solution by Potentiometry and Calorimetry," J.Chem.Educ., 42, 544 (1965).
3. Slabaugh, W. H., "Composition of Metal Ammine Ions," J.Chem.Educ.,42, 470 (1965).

Thermistors and Servomechanisms

1. Neidig, H. A., Teates, T.G. and Yingling, R.T., "The Chemistry of Orthophosphoric Acid and its Sodium Salts," J.Chem.Educ., 45, 57 (1968).

Colorimeters (Spectromic 20)

1. Hedrick, C.E., "Formation of the Chromium -EDTA Comples," J.Chem.Educ.,42, 479 (1965).
2. Leonard, C. G., Jr., "A Laboratory Experiment Using Indicators," J.Chem.Educ.,44, 363 (1967).
3. Neidig, H. A., Griswold, R., and Yingling, R.T., "Effect of pH on Chemical Equilibrium in the Potassium Chromate (VI) -- Potassium Dichromate (VI) - Water System," Chemistry, 37, No. 7, 26 (1964).
4. Ramette, R.W., "Formation of Monothio cyanatoiron (III)," J.ChemEduc., 40, 71 (1963).
5. Slabaugh, W. H., "Composition of Metal Ammine Ions," J.Chem.Educ., 42, 470 (1965).

pH Meter

1. Griswold, R. E., "Effect of Amine Structure on the Relative Acidity of Conjugate Acids," J.Chem.Educ., 42, 483 (1965).
2. King, L. C. and Cooper, Milton, "Experimental Approach to Stoichiometry," J.Chem. Educ. 42, 465 (1965).
3. Neidig, H.A. Teates, T.G. and Yingling, R.T., "The Chemistry of Orthophosphoric Acid and its Sodium Salts," J.Chem.Educ., 45, 57 (1968).
4. Yingling, R.T. and Neidig, H.A., "Stoichiometric Relationships in Two Systems," Chemistry, 40, No.1, 35 (1967).

Vacuum Tube Voltmeters

1. Dillard, C.R. and Kammeyer, P. H., "An Experiment with Galvanic Cells," J.Chem. Educ., 40, 363 (1963).

FUTURE DIRECTIONS OF THE GENERAL CHEMISTRY LABORATORY

Robert Plane
Cornell University, Ithaca, New York

(This is a summary of a recording made of Dr. Plane's presentation. Ed.)

It is much harder to teach beginning chemistry than to teach beginning physics or beginning biology.

The reason for this is that the students just do not care about chemistry. Today, students have an interest in the color of leaves or in the nature of animals so the biology teacher has something to build upon. Students also have an interest in cars and things like that and thus have a latent interest in physics which the physics teacher can build upon. It may be a matter that we do not sell enough Gilbert chemistry sets anymore or just do not have any basis for interest in chemistry anymore, We have to create the problems in order to solve them and this creates a very artificial situation and many students resent this. That is, as I see it, the first problem we face - the nature of our subject.

The second problem that we have to solve is not unique to our subject. I believe that, today, chemistry is undergoing a real revolution as one age of chemistry is about to come to an end and a new age is almost upon us. We have barely caught up with the ending age of chemistry in chemical education. The present age is one I like to call Status Chemistry where we are learning about the structure of molecule. Now, we are ready to move on to the reactions or the dynamics of chemistry. We are also ready to move on with chemistry to be used as the basis for biology. Both of these developments are factors which will have to be reflected rather quickly by the teacher of beginning chemical education courses.

We must treat our subject clearly and fairly to the students. We must be completely honest with them. The basis of our subject is that it is a laboratory science. The only way we are going to get students to understand our problems and get them excited is to get them doing experiments to see what chemistry really is. Twenty years ago, chemistry was largely industrial chemistry and we primarily covered descriptive chemistry. Since then, we have introduced theory into the beginning chemistry course, and many people agreed that this was much easier and much better than requiring extensive memorization.

The theoretical aspect of chemistry has moved well, but unfortunately this is rather sterile. It has not helped the student at all. He does not see the problem any more clearly when we talk about orbitals than when we talk about balancing equations for the Bessemer Converter. The point is that the student still does not know <u>why</u> he is studying chemistry and the only way he is going to find an answer for this is to get into some interesting subjects and then he has got to get into the laboratory and do some experiments.

Now we are approaching the central problem because laboratory instruction has not changed at all in the past ten years. I doubt that it has changed significantly in the last forty years. Laboratory teaching has not kept pace with other advances. Students are now less able to do chemistry laboratory work than they were forty years ago. Then, most students had grown-up on a farm; they had fixed bicycles and other equipment. Today, they know how to run a television set and that is about the extent of their mechanical ability. We throw them into the laboratory, tell them to do an experiment and it does not work so well. The students do not work well and neither does the experiment. Today's students are less prepared but face the same old experiments which are not relevant and from this they are supposed to get some feeling for a laboratory science.

There have been various suggestions or proposals about how we can go about correcting this problem in chemistry. There are some proposals such as abolishing chemistry laboratories. There may be something to that, although, it may not solve the problem. Students hate the laboratory and find it to be a monumental waste of time, so why shouldn't we abolish the laboratory. But

if we do this, we throw out what I consider to be the most important part of the course and the reason for studying chemistry. So I hope no one takes this suggestion seriously - but then what do we substitute?

Someone has suggested that the laboratory will be completely replaced by the computer and that there will be some interface where the student would make contact with computer. I think we have to be careful at this stage so that we do not loose the real essence of our subject by finding short cut ways to alleviate some of the problems. I feel that the essence of chemistry is working with chemicals and getting a feel for the subject which cannot be short cut. The student must do work in the lab and it cannot be replaced by a computer. It must include wet chemistry, dry chemistry and all kinds of chemistry which must be explored if the student is to get any real appreciation for the subject.

One of the things that we must do is to really study chemical reactions. This will give us some real things to do in the laboratory that is going to be very close to genuine chemistry. As far as the biology orientation of chemistry is concerned, we will be helped because we do not have to quickly introduce this into the laboratory because the students already have some interest and have some curiosity to build upon. Experiments are already somewhat familiar to them in this science area.

What is the ultimate solution to the notion that the laboratory is very important? In our Cornell catalogue, we have something called laboratory instruction, which is a misnomer if there ever was one. The student is given a book that has some blank pages in it and he is supposed to somehow do some experiments based upon his background. He is asked to fill in all the blank spaces and that is supposed to give him some feeling of chemistry. I think that it is about time that we started facing up to the fact that the hardest job is to get the students into the laboratory and to do this in a constructive way, we will have to conduct some real instruction in the laboratory. We frequently spend three hours preparing a lecture, but whoever heard of spending three hours getting ready for a laboratory session? We would ask, "what do you do with all that time?" However, once you have the student in the laboratory, why not teach him? I do not want you to get the idea that I am against computers and teaching aids and all these things, but we should work with the students and help them get used to the laboratory.

There is a problem involving the use of the word, "experiment." An experiment usually involves something that the student does not care about, but they do it and usually do not get the expected results. Then they find what the expected results were and write that down. I think we need to eliminate much of what we are doing and use those experiments which enable the students to learn from doing and find out what is actually happening.

The only experiments we do that meet my criteria are those that have to do with analysis. This includes both qualitative and quantitative analysis. These experiments are sound and the student does not know the answer beforehand. He must show some ingenuity and he must learn something before he starts completing the blanks on the experiment sheet. I am fully in agreement with the introduction of qualitative and quantitative work as early as the end of the freshman curriculum. This would require the introduction of some instruments. However, much of chemistry is instrumental in nature and as long as the student can understand some of the principles of the instrument, I think it is fine. If the instrument can malfunction, so much the better. It should be able to be fixed conveniently and it should be something that the student can use and see how the particular properties are measured.

Discussion Points

Instructional Media

1. Before undertaking a major effort toward using any of the instructional media and aids, a practical philosophy must be developed to ascertain specific goals and general paths to be used for reaching the goals.

2. The EDEX-Raytheon Student Response System can be used in the chemistry lecture room to 1) record reponse to true-false and multiple choice questions to check on student comprehension, 2) determine when a lecture or discussion is getting beyond the comprehension of students and 3) taking attendance.

3. The use of media such as films, film loops, audio tapes, single concept demonstrations and models works well if given sufficient support through self-quizzes, study guides and other self-evaluation tools.

4. Models become effective when the student is able to actually become involved in model construction. However, the student must realize that the constructed model is an attempt to visualize a conception model. Among the more popular types are the stick models (Prentice-Hall, Inc.), styrofoam kits and wooden geometric forms. A film has been produced by R.T. Sandeson of the University of Iowa on model construction. Although primarily for faculty viewing, it is also beneficial for students.

5. Audio-tutorial instruction appears to have little, if any, potential for decreasing instructional costs, particularly at small colleges. Its effectiveness must be evaluated by improving student performance, which has not been quantified.

6. Continuous revision of the audio-tutorial materials is necessary for both up-dating and improvement. This is facilitated by the "bit" philosophy used at Meramec Community College. An individual "bit" is two to five minutes in duration and is devoted to a single point or concept. This enables a student to have a stepwise progression through the programmed material.

7. The use of carrels for audio-tutorial work permits keeping records of who listens and for how long. To avoid long delays for running cartridge tapes through to their end to get to the beginning, either standard tapes can be used or equipment can be selected to give fast forward and fast reverse capabilities to cartridge tapes.

8. Making use of the audio-tutorial system optional gives the student an impression of privilege. If it is required, students lose the idea of "privilege" and interest falls to a much lower level. Final grades correlate well with the amount of time the student spends using the audio-tutorial materials.

9. At Meramec Community College, each student may expect a carrel to be available to him at least four hours per week. Laboratories are open from 8:00 a.m. to 6:00 p.m. four days per week and until 10:00 p.m. on Thursdays. Quizzes are given on Fridays at Meramec Community College. The audio-tutorial system has been used with introductory chemistry only. Audio-tutorial materials for Freshman Chemistry will be available in Fall, 1968.

10. At Meramec Community College, both staff and students have responded well to the audio-tutorial approach. Teachers have twenty-four contact hours per week and students still require time exposure to assimilate information.

11. Concept presentation must be kept short and be followed by a student response -- either note book exercises or laboratory procedures. Long tapes reduce interest and effectiveness is sacrificed.

12. Tapes must be revised on the basis of student performance and experience. Scripts are written and then taped by the instructor. Study guides are duplicated and sold in the bookstore.

13. Suggestions for making tapes: 1) vary the voice quality, 2) talk directly to students, 3) use a personal approach, 4) edit all script before recording and 5) put a personal touch into the tape.

14. Poorer students are helped most by the audio-tutorial method. Students budget time better after the first two weeks so that equipment is used more steadily with less student waiting time.

Instrumentation

1. The increase in quantitative experiments in the first year and disappearance of traditional descriptive chemistry through replacement by more fundamental concepts has resulted in an increased need for use of instruments at this level. For many chemical measurements, instrumental techniques have replaced "test-tube" techniques.

2. It was suggested that two-year colleges determine what instrumentation is being used at nearby four-year institutions for basic chemistry courses before determining the total extent of instrumentation needs.

3. Maintenance of equipment may become a major problem. A technically competent assistant who can maintain equipment and perform other services may be feasible for some colleges. The use of Work-Study programs enables some departments to employ students who are able to make some repairs. Some departments may be able to use students or laboratory assistants from an Electronics Technology program. Appropriations for maintenance as well as purchase should be considered when making equipment purchases.

4. Funds for equipment purchase may be available from several sources such as the National Science Foundation and matching funds from U.S. Office of Education. Some two year colleges could qualify through Title III of the NDEA Act. Proposals must be prepared and undergo critical review before being put in competition with similar proposals for the available funds. Gifts should not be overlooked.

5. No consensus was reached regarding the use of limited funds -- should instruments be purchased in quantity as funds become available or should one of each instrument be purchased before obtaining satisfactory quantities. Responses varied from -- "The three-ring circus technique is not recommended and permits no depth" to "On this level we should concentrate on principles and one or two instruments will suffice for a class."

6. A sampling of forty-nine two-year colleges by Ethylreda Laughlin (Cuyahoga Community College) produced the following information.

ERIC

Equipment	Number Available	Number Schools	Mean	% of schools that have Equipment
Calculator	47	28	1.6	57.1
Centrifuge	340	48	7.0	93.8
Cloud Chamber	36	22	1.6	44.8
Conductance Meter	33	16	2.0	32.6
Dishwasher with Distilled Water	5	5	1.0	10.2
Drying Oven	130	43	3.0	87.7
Electrically Heated Steam Bath	32	15	2.1	30.6
Explosion-proof Refrigerator	17	15	1.1	30.6
Fisher-Jones Melting Point Apparatus	40	24	1.6	48.9
Flame Photometry Equipment	17	16	1.0	32.6
Gas Chromatography Equipment	37	30	1.2	61.2
Grating Spectrograph	19	12	1.5	24.4
Heating Mantle	478	26	18.3	53.0
High Vacuum Pump	43	29	1.4	59.1
Hot Plate	449	43	10.4	87.7
Ice Making Machine	25	25	1.0	51.0
Lathe & Workshop	6	6	1.0	12.2
Magnetic Stirrer	330	45	7.3	91.8
Microcombustion Furnace	2	2	1.0	4.0
Microscope	72	21	3.4	42.8
Microscopes, Polarizing	13	9	1.4	18.3
Molecular Model Kit	657	39	16.8	79.5
Muffle Furnace	66	43	1.5	87.7
pH Meters, Line Operated	246	46	5.3	93.8
Polarograph	15	13	1.1	26.5
Polarimeter	23	22	1.0	44.8
Potentiometer	62	23	2.6	46.9
Rate Counters or Scaler	83	35	2.3	71.4
Recorder	58	33	1.7	67.3
Refractometer, Abbe	28	25	1.1	51.0
Refractometer, Fisher	7	6	1.1	12.2
Shakers, or Mixer (e.g. Vortex Genie)	10	7	1.4	14.2
Single-Pan, Automatic Balance, Analytical	229	46	4.9	93.8
Single-Pan, Automatic Balance, Top Loader	94	28	3.3	57.1
Spectrophotometer, IR	20	19	1.0	38.7
Spectrophotometer, UV	22	20	1.1	40.8
Spectrophotometer, Visual Range	101	38	2.6	77.5
Standard Taper Glassware for Organic	903	40	22.5	81.6
Vacuum Tube Volt Meter	80	25	3.2	51.0

Second Southern Regional Conference

Keynote - Stephen L. Razniak, East Texas State University
Co-Chairmen - Cecil Hammonds, Metropolitan Junior College
Jack Samlin, Kankakee Area Junior College
Recorder - Daniel Fisher, Metropolitan Junior College

First Eastern Regional Conference

Keynote - Robert Walter, Haverford College
Co-Chairmen - Myron Cucci, Monroe Community College
- Sister M. Bohdanna, Manor Junior College
Recorder - Renata Tysnick, University of Pennsylvania

Eighth Annual Conference

Keynote - Robert Pecsok, University of California at Los Angeles
Co-Chairmen - Jerome Holmes, Hartnell College
- Richard Lungstrom, American River College
Recorder - Darold Skerritt, Hartnell College

INSTRUMENTATION FOR SECOND YEAR CHEMISTRY COURSES

Stephen L. Razniak
East Texas State University
Commerce, Texas

(The following is a combined summary of Dr. Razniak's reworks and ensuring discussion. Ed.)

Instrumentation must be used in two-year colleges if they are to maintain acceptable transfer courses in chemistry. The instruments are used most extensively for organic chemistry and analytical chemistry, sophomore courses with low enrollments. This presents the problem of justifying purchase of expensive instruments for so few students. It should be noted that instruments can and must be used in chemical technician programs, nurses training courses, and other semi-professional programs using chemistry. Much of the quantitative analysis being done in the freshman chemistry laboratory can be designed to make significant use of instruments for the instruction of larger numbers of students.

For some colleges, a sophomore level course in instrumental analysis may be offered concurrently with organic chemistry. The instruments need not be of research quality for use as teaching tools. This enables the purchase of less expensive apparatus.

The instrumentation should permit use of infra-red spectroscopy and gas chromatography in Organic Chemistry. Electrodeposition apparatus, pH meters, a visible spectrometer, an excitation spectrometer (e.g., Duo Spectranal) and single pan balances should be available for quantitative analysis and/or the freshman laboratory course. The most inexpensive gas chromatographs that are available are certainly adequate for teaching. They can also be built from rather basic parts at a very small cost. (A recorder must still be purchased and will cost at least $300.) Most of the other instruments can be obtained at a cost below $1,000.

Most budgets are insufficient to allow purchase of all of these instruments. A possible source of additional funds is from the federal government through the following programs:

1) Title VI - Provides matching funds for equipment. Allocation is by state and enrollment pressures are helpful.

2) NSF-Similar to Title VI except that all schools in the country are eligible and competition is fierce.

3) NDEA-Matching funds, but committed for several years ahead.

4) NIH-Equipment for medical sciences. This could apply to nurses training and might be stretched to include organic chemistry.

5) Title I - Recently revised so that two-year colleges are eligible.

(These interpretations were made at the meeting and may be inaccurate or may have changed since then.)

It was emphasized that these programs entail a great deal of paperwork.

Local industries frequently have older instruments and may be willing to donate them to colleges as a tax write-off in lieu of trading them for newer instruments. It is helpful to talk with industry representatives concerning courses or topics they would like to have taught. They can be shown how instruments would help meet their needs. The instrument companies also have used and rebuilt equipment at greatly reduced prices. However, some states do not permit the purchase of used equipment.

Schools, having instruments in use, report few maintainence problems, primarily because the classes are well supervised and the use (and cost) of the instruments is thoroughly explained. The courses must be modern and the instruments must be an integral part in order for them to be effective.

BIORGANALYTICAL CHEMISTRY

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Los Angeles, California

In the fall of 1966, UCLA introduced a new unified laboratory course at the sophomore level. We are now reporting on the first year's experience.

Planning the Course - Concurrent with the change in the University calendar from the semester to the quarter system, we decided to make a complete revision of our chemistry curriculum. Although, many favored the "Hammond Plan" of eliminating the traditional division, in fact, it appeared that these same people were willing to do so only for divisions other than their own. Organic chemists still want to teach something called "organic chemistry", etc.

The problem centered around analytical chemistry which had previously occupied the second year. It was generally conceded that this course tended to be unattractive to the students; and that while the material was important, it would be advantageous to relate it more directly to other fields. The analytical chemists agreed that a new combination of topics should be considered.

ERIC

Some of the guidelines to be considered were:

1. About 400-500 students per year will be taking this course.

2. What is good for chemists is good for related majors, especially those in life sciences who make up about 70 per cent of the enrollment. We attempted to build a core of material of maximum use to both kinds of students.

3. The first two years of our program must be compatible with what local junior colleges can be expected to do. Many students transfer to UCLA after one or two years at a junior college. Nearly half of our BS graduates started at a junior college.

4. We expected to upgrade the equipment in the freshman course so that good quantitative analysis could be done during the first year.

5. It is important to introduce a significant amount of biochemistry early in the curriculum.

6. Insofar as possible, the analytical chemistry should be relevant to other courses and the kind of techniques in current use.

Outline of Second Year - Because of the transfer problem, we decided to make a flexible program with a sequence of courses that can be entered with a varied background. Two series of courses run parallel and concurrently. The average student takes the entire program in the second year.

	1st Quarter	2nd Quarter	3rd Quarter
Chem 4 -	Elementary Org.	Elementary Org.	Elementary Biochem.
Chem 6 -	Analytical Methods of Organic Chemistry and Biochemistry		

The Chem 4 courses have two lectures and one 4-hour laboratory per week (20 and 9 per quarter). Each course is given two units of credit. Course outlines follow:

4A and B

Introduction (History)
Characterization of Organic Compounds
Hydrocarbons
Reactions of Hydrocarbons
Functional Groups with Single Bonds to Carbon
Functional Groups with Multiple Bonds to Carbon
Electrons and Chemical Bonds
Stereochemistry

4C

Chemistry of amino acids and peptides
Protein structure; primary, secondary and tertiary
Kinetics of enzyme action
Chemistry of carbohydrates and of polysaccharides
Enzyme degradation of polysaccharides; hydrolytic phosphorolytic
Chemistry of nucleic acids: nucleosides, nucleotides, nucleotide coenzymes
Nucleic acid structure and enzyme degradation
Nucleic acid replication and function
Biological energy generating mechanisms
Biological oxidation: electron transport
Metabolic transformations: glycolytic pathway, tricarbozylic acid cycle
Metabolic regulation

6A

Phase Equilibria
Partition Equilibria
Molecular Structure and Spectroscopy

6B

Nuclear Magnetic Resonance
Mass Spectrometry
Electrochemistry
pH Equilibria
Acidity Concepts
Kinetics

6C

Introduction. Spectrophotometric determination of pK_a's and rate constants.
Non-enzymic catalysis (ester hydrolysis). Acid-base catalysis. Polyfunctional catalysis.
Enzymic catalysis (ester hydrolysis). Discussion of mechanism of action of chymotrypsin.
Enzymic catalysis (biological oxidations). Theory and specific examples.
Determination of kinetic parameters.
Methods of separation of biological molecules based upon size: gel filtration, ultracentrifugation
Svedberg equation. Theory and applications.
Amino acids as zwitterions. Isoelectric points. Distribution coefficients and electrophoretic mobility; dependence upon pH.
Methods of separation of biological molecules based upon charge: electrophoresis, ion exchange chromatography.

Methods for determining size of biological macromolecules. Chemical methods, including end group analysis.
Viscosity. Theory.
Viscosity. Applications.
Discussion of behavior of DNA molecules in solution.
Behavior of protein molecules in solution. Reactivity of functional groups in proteins. Masked functional groups.
Isotopes in biology. Methods.
Isotypes in biology. Application.
Frontiers in biochemistry.

Laboratory Program of Chemistry 6ABC

First Quarter

Determination of melting points.
Separation by extraction of a two-component mixture with identification by melting point.
Separation by fractional distillation with analysis of fractions by gas chromatography.
Separation by column (absorption) chromatography with analysis of fractions by thin-layer chromatography.
Study of a charge-transfer complex by spectrophotometry in the visible region.
Study of infrared spectrophotometry (by film) and the interpretation of selected infrared spectra.

Second Quarter

Study of nuclear magnetic resonance spectrometry (by film) and the interpretation of selected NMR spectra.
Study of mass spectrometry (by film) and the interpretation of selected mass spectra.
Interpretation of combined spectra (UV, IR, NMR, and MS) for selected compounds.
Study of phosphate buffers with the pH meter.
Acid-base titrations in nonaqueous solvents; the determination of nicotine in tobacco.
Kinetics of methanolysis of an ester followed by gas chromatography.

Third Quarter

Reaction kinetics of acid-catalyzed and chymotrypsin catalyzed saponification of p-nitrophenyl acetate followed by uv spectrophotometry.
Reduction of pyruvate to lactate (hydride ion transfer) catalyzed by nicotinamide adenine dinucleotide followed by spectro-photometry; determination of Michaelis constant of pyruvate.
Separation of amino acids by ion exchange followed by paper chromatography.
Determination of Geiger counter characteristics.
Isolation of ^{131}I-tagged ovalbumin by gel filtration followed by radioactive counting.
Kinetics of degradation of DNA solutions followed by viscosity to determine number of strands.
Study of phosphorylase catalyzed cleavage of glycogen followed by ^{32}P labeling.
Oxidation of glycogen with periodate to determine end groups and branching followed by pH titration.

Laboratory Equipment - Two major areas were involved. Upgrading the freshman laboratory equipment (balances and glassware) was a major expense because of the large number of students (1500 per year). However, by changing from two 3-hour laboratories to one 4-hour laboratory per week, we were able to schedule a maximum of 48 students (2 sections) in the sophomore laboratories at a given time. Thus, major equipment could be used many times per week. We have provided one pH meter per student, one Spectronic 20 per two students, and one gas chromatograph per two students. These, plus standard taper glassware and assorted biochemical pipets for each student, brought the cost of the total changeover to \$100,000. (We have succeeded in convincing at least two manufacturers that there is a market for inexpensive, durable, yet high quality instruments.)

Teaching Aids - Since it was beyond our resources to provide instrumentation for IR, NMR, and mass spectrometry, we considered the use of films to give a meaningful laboratory exposure to these important instruments. None were available for NMR, so the department has produced a 30 minute color-sound film introducing the principles, instrumentation and applications of this important technique. This film is distributed through John Wiley & Sons. Other films which are useful at this level are:

Infrared Spectroscopy - The Chem Study Film entitled, "Molecular Spectroscopy", and "Infrared Spectroscopy" by Calvin Productions.

Mass Spectroscopy - A film available from Associated Electronics, distributed by Picker in this country, entitled, "Analysis by Mass".

No suitable text was available. To meet this necessity, we have been using a preliminary version of a text to be generally available March 1968 -- Pecsok and Shields, "Modern Methods of Chemical Analysis", Wiley (1968). A companion volume containing laboratory directions is already available: "Experiments in Modern Methods of Chemical Analysis", edited by R.L. Pecsok, Wiley, 1967.

Evaluation - Perhaps the most important accomplishment is the enthusiasm of the teaching staff -- both instructors and teaching assistants. Likewise, the students have been stimulated to do an unusually good job. Another measure of success is the fact that about 50% more students take this course than we had expected, largely because it is required for many more other majors in the life sciences.

Impact - Our upper division courses have been upgraded to take advantage of this background. At least six other institutions (junior colleges as well as universities) have indicated their intention of following our curriculum. If nothing else, we have certainly created widespread interest in our program.

Discussion Points

1. Physical chemistry has been given high priority as a requirement for health-related sciences. Some units of the University of California have suggested that two-year colleges offer a one quarter course comparable to the Chem 14, Introductory Thermodynamics, given at these institutions. For the health-related sciences, the physical chemistry content of General Chemistry, might prove sufficient. Most two-year colleges would expect from three to eight students to enroll in a regular thermodynamics course. What some colleges call Physical Chemistry constitutes a major portion of General Chemistry in another college. Thus, real care must be exercised when discussing whether or not "physical chemistry" should be given in the two-year college.

2. Many two-year colleges provide a one-year organic chemistry course. Some two-year colleges offer two one-semester organic chemistry courses -- one for biologically related majors, and one, for chemistry and chemical engineering majors. It appears very important that students seeking to transfer credits for an organic chemistry course should complete the full course at the two-year college. If only one-semester of a two-semester course is transferred, the student will usually find a different course organization and the likelihood of success will decrease considerably. Most two-year colleges should consider giving a full one-year course in organic chemistry. It was suggested that traditional topics of physical chemistry could frequently be incorporated into both first and second-year chemistry offerings.

3. The increased emphasis on quantitative experiments in first-year chemistry was discussed. It was suggested that quantitative analysis could be expected to disappear into the first-year course and that it would be formally replaced with a course in instrumental analysis. Since, some professional schools continue to have a quantitative analysis prerequisite, catalog course descriptions of the first-year course should clearly indicate the extent of quantitative analysis in it. It was felt that every effort whould be made to meet the needs of the student, but that unnecessary proliferation of chemistry course should be avoided.

4. Through group consensus, the following list of instrumentation was developed. Where a quantity of instruments per laboratory is indicated, a twenty-four station

laboratory is assumed. It was emphasized that use of equipment should be coordinated between different laboratories where possible.

ANALYTICAL

Item	Quantity	Notes
Single pan balance	6 per lab	Suitable support for balances is important
Top-loading balance	1 per lab	
pH meter	1 per 2-student station	
Muffle furnace	2-4 per lab - depending upon furnace size	
Drying oven	2-4 per lab - depending upon oven size	
Rate Counter	2 per lab	Most colleges represented do not use
Spectrophotometer	1 per student	Spectronic 20 or equivalent
Magnetic stirrer	1 per student	
Ice-making machine	1 per department	
Grating spectrograph	1 per department	Desirable
Calculator	2 per lab	In lab or available from some other department
Electrically-heated steam bath	1 per lab	
Gas Chromatograph	1 or 2 per lab	UCLA has 1 Carle Basic Chromatograph per 2-student station
Recorder	1 per chromatograph	
Flame photometer	Not essential	

ORGANIC

Item	Quantity	Notes
Molecular Model kit	1 per student	Issued by stockroom or purchased by student
Heating mantle	1 set of 3 per student station	Instruction important to prevent burnout
Spectrophotometer:		
U.V. - Vis, dual beam	1 per department	
I.R.	1 per department	
Explosion-proof refrigerator	1 per lab	
Polarimeter	1 per lab	
Melting-point apparatus	1 per 3 students	Low priority
Refractometer	1 per laboratory	
Microcombustion furnace	1 per laboratory for 1-year organic course	
Standard taper glassware	1 set per student	

CHEMISTRY NEEDS FOR HEALTH-RELATED SCIENCES

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The content and organization of college chemistry programs for students majoring in chemistry or other physical science, biological science, health science or engineering has undergone considerable change in recent years. At the same time, these changes have been introduced primarily to meet the needs of the chemists, biochemists and chemical engineers. However, an increasing proportion of the students enrolled in general and organic chemistry in two-year colleges are looking forward to careers in one of the biological or health related sciences. These developments have come at the same time that the content and organization of biological science courses for biology or health-science majors have also undergone considerable change. Important changes in the requirements for additional knowledge of chemical, physical and mathematical concepts and techniques have occurred

Two-year college chemistry faculty members are seeking answers to the following questions:

1. What chemical concepts and techniques do students studying for careers in one of the health-related sciences need to acquire to have a reasonable chance of achieving their goal?

2. What modifications in the present chemistry programs of two-year colleges should be made to meet the needs of these students?

3. How do the needs of these students compare with those of students majoring in chemistry, physics, or engineering?

This symposium on chemistry for the health related sciences has been scheduled as one way of helping chemistry faculty members in two-year colleges obtain answers to these and related questions. Representatives of a school of medicine, a school of dentistry, a school of pharmacy and of the medical or clinical laboratory technology field have been invited to answer these questions as they relate to their fields. Specifically, they have been asked to answer these three questions:

1. What chemical concepts and techniques generally associated with general chemistry, analytical chemistry, and organic-chemistry should a student know and understand to have a reasonable chance of success in his particular field?

2. What topics and techniques not generally associated with these courses should be added to improve the student's background for advanced studies or professional work?

3. What are some specific examples and applications of the use of these concepts and techniques in advanced studies or professional work that the chemistry instructor might use in the teaching of his general, organic, or analytical chemistry course to make that chemistry course more relevant to his students?

CHEMISTRY NEEDS FOR MEDICAL SCHOOL

Richard Fineberg
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The members of medical school faculties differ quite widely in their opinions

concerning the needs for the chemical background of a physician. One issue is the importance of fundamental biochemistry and its direct applications to medicine. All agree that the applications of chemistry in medicine are increasing enormously. One example is the recent discoveries of more and more genetic enzyme defects that lead to disturbances of the metabolism. For example, a doctor has to know that an infant with phenylpyruvic acid in the urine and increased phenylalanine levels in the blood has a defect in hydroxylation of phenylalanine and must be fed a low phenylalanine diet or the child will be an idiot.

It should be clear that basic molecular and cellular biologies are primary teaching goals in medical biochemistry. This is true, even from the practical point of view of ultimate application to medicine because understanding is more reliable than just rule-of-thumb knowledge. Also, many of the recent applications to medicine are already obsolete and will soon be replaced by applications which will be based upon presently unknown aspects of fundamental biochemistry. It is only this basic knowledge which can help the student understand future applications.

This same philosophy suggests that the chemist is the best judge of what to teach in chemistry. However, some aspects of chemistry may be suggested that seem to be pertinent to medical biochemistry, and there are no doubts that illustrative applications will serve to stimulate ideas, interest and incentives for the student. This is certainly true in the case of medical students that come to the medical school wanting to be doctors and expect to face a patient on the first day. Instead, they have a couple of years of academic study that is just like college and this becomes depressing. It is necessary to emphasize some applications even though the primary purpose is to teach fundamental biochemistry.

For many students, it is unfortunately true that there is often a two year time span between the last chemistry course and the first biochemistry course. They take all the chemistry during the first two years, go to a four-year institution and take a couple of years of biology or history or something else and they forget all their chemistry. There is little that can be done about this situation.

There are several examples of topics that should not be neglected in inorganic and analytical chemistry. There should be no neglect of the elements that are characteristic of biological compounds -- carbon, hydrogen, oxygen, nitrogen, sulfur and phosphorus. Isotopes should be included because of their broad applicability in reaearch, biochemistry, physiology, diagnosis, therapy and medicine. Students should know something about the nature of isotope sources, the types of radioactive decay, methods of detection and measurement and tracer methods. They should know the meaning of a tracer dose, how tracers are used to measure the turn-over of a substance in a steady state pool and there are many applications in biochemistry, physiology and medicine. One example in medicine is the common procedure of measuring the turn-over rate of the serum iron to help differentiate between types of anemia such as hemolytic anemia (very rapid turn-over) and aplastic anemia (very little turn-over) where both are characterized by very high concentration of inorganic iron in the serum.

Another general subject that is of great importance in biology is pH and buffers. Of course, it is a common topic but an example to illustrate the application to medicine might include the carbonic acid-carbonate buffer system which is the principal buffer system in the body that protects against acidosis and alkalosis. Students should learn some things about hydration and CO_2 and sollubility of gases in liquids as a function of the partial pressure of the gas. Analysis of the state of the carbonic acid-carbonate buffer system in the body gives an indication of a diagnostic aid in differentiating one kind of acidosis from another. In diabetes for example, there is an increase in non-volatile acids in the body, primarily acetoacetic acid, whereas in certain lung diseases there is an increase of carbonic acid caused by failure to excrete CO_2 by way of the lungs.

When teaching about applications to biological systems it is useful to emphasize pK_a instead of the basic pK to avoid confusion so that all the acids are seen as acids. (For example, ammonium ion appears as an acid which dissociates to free ammonia). A medical application is the observation that ammonia poisoning is much more pronounced if the body is a little alkaline, since the equilibrium is displaced toward free ammonia. This uncharged form of the molecule readily penetrates certain cell membranes which contain a lipid barrier and specifically will penetrate and exert a toxic effect on metabolism of the neurons in the brain. This corresponds very dramatically to the pH of the blood even with the very small variations in the degree of blood acidity.

Analytical chemistry is probably quite different from what it was twenty years ago. If today's quantitative analysis is the same course it was then, it contains a large quantity of extraneous material. In the old days everything was gravimetric, but I presume other methods are emphasized today. Emphasis should be placed upon separation methods of chromatography, countercurrent distribution, electrophoresis and ion exchange. An example of the application of electrophoretic separation of closely related substances in diagnosis would be the separation of abnormal hemoglobins. This is a commonly utilized diagnostic procedure. Also, abnormalities of the quantities of the different plasma proteins are commonly analyzed electrophoretically.

Other aspects of simple electrochemistry are extremely important in biology. An example is the diffusion of ions through a membrane which has differential permeability to cations and anions which can lead to separation of charge and produce a potential across the membrane. If students could be encouraged to think about problems like these in advance, they will be better prepared to understand the potentials in cell-membranes which are important for maintaining the excitability of nerves and muscles which are involved in action potentials.

Instead of students spending many hours on gravimetric analysis, they should spend part of that time on photometric methods. Photometry is used extensively in biology. For example, enzyme assays depend upon UV absorption of the reduced form enzyme.

In organic chemistry, students should be introduced to other physical methods of analysis that are also based on the interaction of electro magnetic radiation with matter (electron paramagnetic radiation, nuclear magnetic radiation, etc.). Many of the students are deficient in their knowledge of simple organic chemistry. They do not remember structures, names and such things. In their elementary courses, many of them did not really get around to the biological compounds. This is not so crucial, but it is desirable that they study these as well as simple molecules. Their study would include some of the principle metabolites like perhaps the monomeric compenents of macro molecules, the structures of several amino acids, structures of one or two sugars and some of the reactions of these compounds. It is also desirable that they know something of the structure and properties of some of the vitamins. Besides the covalent bond being studied in organic chemistry, it is desirable that they learn more about intermolecular bonds including hydrophobic bonds. This should include various attractions, ionic and ion-dipole bonds, hydrogen bonds and van der Walls forces. These play an extremely important role in biology and determine the three dimensional structure of macromolecules, proteins, nucleic acids and also determine the specific interactions between enzymes and substrates, antigens and antibodies and between components of subcellular organelles. Another subject that some students do not study is the chemistry of coordination complexes, organic molecules with metallic ions, which are important in many contexts in biology. They need to know more about the nature of these complexes and understand the change in color and magnetic susceptibility in electron spin resonance of hemoglobin when oxygen combines with it. They should understand the many applications of chelating agents to medicine; chelators are used to remove metals and metal poisoning and many biological active compounds are known to be chelating agents. Some of the antibiotics are even specific chelators for sodium and potassium ions.

Another general subject to which pre-med students should be introduced is the general principle of thermodynamics. The concept of free energy and entropy could be introduced in relation to biological energy exchanges or energy transductions. Photochemical reactions are exemplified by photosynthesis, the action of light on the retina, release of chemical energy through oxidation or hydrolysis, the utilization of chemical energy driving the synthetic reactions for muscle contraction and other mechanical events and for conducting osmotic work like transport of ions and other nutrients across cell membranes.

An understanding of the so-called energy-rich compounds and several types of bonds is needed for the study of metabolism. It will be very useful for them to know something about the mechanisms of organic reactions because knowledge from organic chemistry of reaction mechanisms is being directly applied to the mechanisms of enzymes which catalyze just about everything important that occurs in the body. Millions of examples could be cited to demonstrate biological reactions as examples of standard reaction mechanisms.

Many of the topics mentioned may belong in the course of physical chemistry, but at present, many of the medical schools do not include a formal course in physical chemistry as a prerequisite for admission to medical school. Yet much of the content of the physical chemistry course is important for understanding biology, so the question must be raised relative to whether or not more physical chemistry should be placed in the elementary chemistry courses. The other alternative is for the medical schools to require a separate physical chemistry course. In general, when discussion of scientific prerequisites for medical school has occurred, many of the medical school faculty offer stiff resistance to the prescribing of every course. They fear the exclusion of a goodly number of talented students who might want to be psychiatrists or something else and do not need to be as talented in chemistry as the rest.

The importance of chemical technique must be raised to explore the question of laboratory teaching. There is disagreement among the medical school faculty and even the basic science faculty in the medical schools regarding the need for laboratory training in basic sciences in the medical school. One thing seems clear as far as physicians are concerned; the efficient use of chemical techniques is no longer necessary for most physicians. Doctors do not do their own lab work. However, it is true that the learning of any experimental science is enhanced by dealing first-hand with the experimental techniques involved in obtaining the knowledge in those fields.

CHEMISTRY REQUIREMENTS FOR THE DENTAL SCHOOL

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The formal requirements for applicants to dental schools were set a number of years ago by the Council on Dental Education of the American Dental Association, and they have been essentially the same for all dental schools ever since. The chemistry requirements are one year of inorganic and one-half year of organic chemistry, including both lecture and laboratory work in each course. These requirements were designed to prepare the successful applicant for a specific course in biochemistry in the dental school, as well as for the courses in physiology, microbiology, and pharmacology which he also must take.

At the time these requirements were instituted, the courses in inorganic and organic chemistry were more or less standardized in the various colleges, as was the course in biochemistry. Now, a deeper understanding of biochemistry requires a

a deeper knowledge of the other branches of chemistry. It is my impression that courses in the preparing institutions vary rather widely in what they offer under the name of inorganic or organic chemistry.

At the present time, the chief need of the dental schools is for a fairly complete grounding in at least elementary physical chemistry. Emphasis on kinetic theory, mass action, and a good understanding of the concept of energy in its various forms is essential. If the student is not going to have any chemistry beyond the formal requirements, he should get at least that much physical chemistry in his inorganic course. In organic chemistry, emphasis should still be placed on the type reactions of the various classes of organic compounds. A course in quantitative analysis would be of great value in teaching laboratory techniques, where many first year dental students are definitely weak.

It should be noted that, while the formal requirements for admissions to a dental school are still set at two years of preliminary college work, there is an increasing tendency to accept only those students who have had at least three years of preparation, and many applicants now have the A.B. degree. The additional time is often employed in taking various courses in zoology or other biological sciences. Recently, there has been some discussion among the various dental schools concerning the possibility of having applicants take an introductory course in biochemistry so that the dental school course could be conducted on a deeper level. It is the feeling in our school that a course in physical chemistry would be of greater value to the student and would permit greater depth of coverage in biochemistry. The biochemistry course in a dental school is in all essentials, except the laboratory work, the same as that given medical students, but there is usually somewhat more emphasis on such topics as calcium metabolism. Thus, a firm grounding in basic chemical principles is required.

The major difficulty in presenting physical chemistry to dental school applicants is that the physical chemistry courses offered in most universities are designed for chemistry majors and involve more physics and mathematics than most applicants have time to acquire. Thus, there is great need for further instruction in the branches of physical chemistry mentioned above at a lower mathematical level than is available. Such a course could be developed better if separated from the general introductory inorganic course in which there is so much else to be learned. It is here that the two year college could be most helpful. Such a physical chemistry course could be given in the second half of the second year, after the organic chemistry had been completed. Obviously this would crowd the student with chemistry courses, but if he is going to take further college work before entering dental school he will have time for such a course and he would be more likely to obtain it in a two year college than in a large university. The other biological sciences in the dental school would also profit by such a course and the student would be better prepared than if he took additional courses in zoology.

CLINICAL LABORATORY TECHNOLOGY CHEMISTRY NEEDS

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Today, chemistry is the most significant and widely employed science in the clinical laboratory. Over the past thirty years, there has been more progress and improvement in the diagnostic laboratory procedures involving chemistry than any other major laboratory science. Having begun with no more than enough available chemistry tests for urine and blood, the physician in 1900 would feel alienated in a modern laboratory of the present where as many as 300 different tests may be performed using principles and techniques developed out of the science of chemistry. The state of

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world health, and certainly the quality of medical care enjoyed by those of us in this country, is clearly based upon the availability of knowledge and skills in chemistry applied by individuals that have carefully learned this subject beginning with opportunities to do so in the first two years of college.

Since my first and major allegiance has been to microbiology, you may wonder why I speak so enthusiastically about chemistry. If you wish, you may interpret this as a repayment of honor to the father of microbiology, Louis Pasteur, who was a chemist.

To more clearly visualize and appreciate appropriate changes that might be considered in chemistry courses, it will be helpful to look at the physician and his laboratory and what has happened to this laboratory since the beginning of our century.

At about 1900, we find that the physician has already given up extensive preparation of the medications needed for his patients. Pharmacy had long become an established science and now commanded that professional specialists train beyond the basic knowledge acquired by a physician in the course of his medical training. The laboratory still remained as a part of the armament of his practice, personally controlled and usually personally operated by the physician himself. As new tests were developed, and as confidence in them developed, the physician began to train individuals to help in laboratory work. Eventually, more knowledge and skills were being demanded of laboratory personnel than the physician had time to impart. By 1940, colleges were beginning to play an active part in preparing individuals for the practical training the physician would still provide to equip individuals for his laboratory. During and immediately following World War II there was a marked increase in medical laboratory discoveries within the area of chemistry. This was accompanied by a high degree of sophistication in techniques to detect and measure human pathology. At this point, the clinician began to give up his laboratory for the same reasons he gave up his pharmacy 50 years or more before.

Just what the clinical laboratory is today may also need to be appreciated to more effectively design appropriate academic preparation for the people working there. California law defines the clinical laboratory as "any place, establishment, or institution organized and operated for the practical application of one or more of the fundamental sciences by the use of specialized apparatus, equipment, and methods for the purpose of obtaining scientific data which may be used as an aid to ascertain the presence, progress, and source of disease in human beings."

The sciences traditionally applied in this laboratory are chemistry, hematology, immunohematology, and microbiology (which includes bacteriology, serology, parasitology, virology, and mycology). At the present time, there are approximately 13,000 clinical laboratories in the United States with 6,000 of these being non-hospital or independent laboratories. In California, we have 1,500 of these clinical laboratories or about 12% of all laboratories in the nation. This is perhaps a little more than our share since we have about 10% of the nation's population. Of some significance has been a recent observation by the California State Department of Public Health that the 600 independent laboratories in this state which have been certified to participate in the Medicare program represents 24% of the nation's total number of non-hospital laboratories in Medicare. Some of these figures are explained by this state's share of the nation's population as has been mentioned. Others, however, can only be explained by the ambitious and progressive programs of medical care created by co-operative and organized medical effort and made continually possible by strong support from highly qualified individuals, such as clinical chemists, in the various allied health professions.

Those considering a new position of chemistry in college curricula should know that the best estimates indicate that one billion clinical laboratory procedures were completed in the United States last year. This represents approximately five tests

performed for every person in the nation. Current studies also predict this number will triple within three years. Since approximately 20 to 25% of these tests are chemistry procedures, the growing need for quality training, both academic and practical, becomes immediately apparent.

To fashion chemistry courses that are relevant to the needs of those individuals that are to be performing clinical laboratory tests, the academic architects of college curricula need to be aware of what type of person is now wanted for the clinical laboratory. The clinical laboratory technologist is now an established professional category among the health professions and is defined by licensing laws in many states, including California. In this state, this person must essentially have a bachelor's degree with a major in one of the biological sciences. A prerequisite for this degree must include at least general inorganic chemistry and either organic or quantitative analysis. This person must also have completed one year of specialized practical training in a laboratory approved for this purpose by the State Health Department and, finally, must have successfully passed an examination covering all sciences applied in the fields of medical laboratory technology. The federal government has recently enacted regulations to implement the Medicare program which similarly define the qualifications for the clinical laboratory technologist.

At the present time there are approximately 70,000 technologists in the United States, 10,000 of whom (or 13%) are in California. A clinical laboratory manpower assessment conducted by the California State Department of Public Health two years ago indicated an 8% vacancy in California laboratories. This is not considered significant when compared to vacancies existing in other professional fields. However, since 65% of the individuals writing the California technologist licensing examination last year obtained their college education outside of this state, and since improved standards and salaries are beginning to be offered in other states, it is expected that competition will increase California's vacancy rate. The medical and laboratory communities will then call much more heavily than before upon the California colleges to produce the needed trained laboratory scientists which have been previously provided by colleges elsewhere in the country.

An observation that should represent a challenge to colleges teaching chemistry to clinical laboratory technologists is the experience chemistry majors have with the California licensing examination for technologists. Of the 800-1000 examinees for this license considered every year, about 5% of them have completed a chemistry major in college. However, more chemistry majors (31%) fail this examination than do individuals in any major category. These chemistry majors show consistently higher scores in the chemistry section of the examination but low scores in the other laboratory sciences. This suggests one point that speaks to the objective of this conference and deserves some emphasis: chemistry, to be useful to the person entering medical laboratory careers, must be very closely correlated and perhaps backgrounded upon the basic biological sciences. Since analytical geometry, algebra, and even basic calculus are now being taught in some of the elementary grades in our public schools, it may now be time for two year colleges to include biochemistry or elementary clinical chemistry as a part of the chemistry curricula, or at least more directly relate principles of chemistry to the measurement of biological activity. If a conscientious and coordinated effort could be made to upgrade both the quality and scope of chemistry being taught in high schools, the two year colleges could then make effective use of their resources to provide a much stronger program in basic chemistry for students planning to enter medical practice or the medical laboratory.

A coordinated and conscientious effort also needs to be made by colleges to reassess what has been traditionally accepted as the "basic" chemistry in the freshman and sophomore years. In addition to teaching the practical application of chemistry in measuring biological activity (as has been mentioned), there should be added some knowledge or at least an awareness of the chemical principles and techniques involved in the use of isotopes to measure this biological activity.

Authorities in medicine and in medical laboratory technology are unanimous in their conviction that all the knowledge and skills that may be acquired in chemistry (especially clinical chemistry or biochemistry) is of little value if the individual so endowed lacks the ability to be fully aware of the variables that surround a chemical procedure. To be effective as a chemist, this person must be able to interpret his observations of these variables in such a way and in sufficient time to keep his tests under control. In order for any laboratory test to be clinically useful to the physician, the chemist in the laboratory must know how to employ very elementary statistical techniques to measure the precision and accuracy of what he is doing. These techniques of reliability (or quality) control should be introduced to the student either within or adjacent to his chemistry courses - and as early as possible. Progress will be made if nothing better than an appreciation can be communicated to the student to the effect that a chemist, particularly one who is dealing with a host of biological variables, must continually employ methods to evaluate his chemistry test results to assure himself that his performance is precise and to assure his physician that his results are accurate.

Technical excellence in the clinical laboratory can be achieved if those performing the tests there are trained in this excellence at the very beginning of what must be a challenging college career.

CHEMISTRY NEEDS FOR PHARMACY SCHOOL

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When I received this invitation to speak, I wrote down some ideas and sent them to a number of colleagues across the country. Thus, what I am going to say will be a composite of what I sent to them and the feedback I received.

Schools of pharmacy may be in a similar situation to that of the schools of dentistry several years ago. We are changing or trying to change the role or function of the pharmacist in an effort to reorient the profession toward a more meaningful role within the health sciences and moving away from the present technician role. The schools of pharmacy have been going from three to four to five and now some to six year programs. At the present, there is no accredited school of pharmacy in the country offering less than a five year program leading to a BS in pharmacy. There are a few schools offering a six year program leading to a doctorate in pharmacy. These schools are: the University of California at San Francisco, the University of Pacific (which has both programs) and outside of California only the University of Michigan and the Philadelphia College of Pharmacy have instituted the Pharm. D. as an optional program, although a number of others are considering it.

In both of these programs, we require two years of pre-pharmacy. This puts pharmacy in a slightly different context than either medicine or dentistry in the sense that students come to the School of Pharmacy directly from the two-year or junior college or from a regular four-year college. We have a small number, possibly five to ten percent of the students, who come with a four-year BS.

There is one other very fundamental difference in our requirements and those of medical and dental schools. In pharmacy, chemistry is a much more central and a much more significant part of the curriculum. In dentistry and medicine, chemistry is a complement and it is a background for materials that are to be covered later. However, chemistry and chemical science will continue to be emphasized very heavily during the whole pharmacy curriculum. Some of the people in pharmacy will tell you that pharmacy is getting more biologically oriented. That means that it

is getting more health sciences oriented and less merchandizing oriented but under this basis, the chemical sciences will be very heavily emphasized.

Medicinal or pharmaceutical chemistry requires a clear understanding of the synthesis and the chemical and physical properties of organic and inorganic compounds.

It also requires knowledge of the methods of determining and measuring chemical substances in very small amounts, biochemistry and the biochemistry of the normal system and the biochemistry of drugs. These are needed to understand the nature of the drug-recepticide interaction and finally the relationship between structural features, physico-chemical parameters and biological activities. Such knowledge, which we encompass with the term of medicinal chemistry or pharmaceutical chemistry, requires a very strong background in basic chemistry given through general chemistry, inorganic chemistry, organic and physical chemistry.

I would like to emphasize that when thinking in terms of necessary chemical background, I like to think not in terms of organic chemistry, inorganic chemistry, and general chemistry, but I like to think more in terms of the Hammond type of curriculum where courses have been integrated and where more team teaching is used. As a matter of fact, in our own school we are now going toward what the medical school calls the "Western Reserve" type of curriculum where we try to integrate courses along a whole year unit.

Let us now discuss some of the background we would like to see the student bring into pharmacy from junior college. The general chemistry that is traditionally offered appears quite adequate. There are rumblings that some people still like to have more descriptive inorganic chemistry but this is not a very valid point. The emphasis on the physical and chemical concepts of bonding, aspects of physical chemistry and chemistry concept that were discussed by Dr. Leicester discussed before are absolutely significant and I feel should be incorporated into the general chemistry material. In medicinal chemistry, we cover physical chemistry ourselves so our students know a rather substantial amount of physical chemistry. Some students call it physical pharmacy because it is more palatable. (We were able to include calculus that we could not include under that name by calling it pharmaceutical calculations.) The knowledge of chemistry that we want for our students is at least as intense as that for chemistry majors in either organic or quantitative chemistry.

Organic chemistry poses the big problems. Until now, we have offered chemistry in the traditional way at the third-year level, that is the same as the first-year pharmacy level. We have just decided, effective in one or two years, that we are going to require organic chemistry as part of their pre-pharmacy reference. This should be of great interest to junior colleges because students will have to have the organic chemistry in junior college before they come to pharmacy.

What we do want in organic chemistry? We want everything; we want the same kind of course with the same intensity that a chemistry major would need. This includes nomenclature, structural organic chemistry, sterochemistry, reactivity and nature of mechanisms of organic reactions. There should be discussion of some of the methods and tools employed in modern organic chemistry for the study of such compounds such as infrared, NMR, mass spectroscopy, ESR and the related tools. We also feel that because our students will still be chemically oriented, I personally feel that they should have a good laboratory course. They should be able to synthesize compounds and understand the procedures and manipulations in organic chemistry with a laboratory. I suspect that some parts of isotopes will be discussed in general chemistry, but I feel that many reaction mechanisms of organic chemistry can only be appropriately discussed if the results from labeled compound experiments are included.

The course, quantitative analysis now presents the greatest difficulty and promotes the greatest discussion. My personal feeling was, and is, that quantitative analysis should also be taught in the junior college level, and I would like the students coming to us with a full-year course. It should be a course that is heavily instrumental and with a modern orientation. However, I seem to be a somewhat alone in that position. The vote on the appropriate faculty committee was eight to one and other responses have an absolute unanimity that quantitative analysis should be offered in the school of pharmacy rather than at the pre-pharmacy level. Nevertheless, I feel that if junior colleges offer an adequate course, this may be acceptable.

The reason why we argue about whether quantitative analysis should be in the school of pharmacy rather than at the pre-pharmacy level is the time limitation. We require our students to have completed 60 units which includes physics, calculus, a number of the humanities and social sciences. Having been told time and again that there would be no time for a good course in quantitative analysis at the junior college level, I would like to ask you, "Is it possible or is it not possible to do it?" So what do we want in terms of modern quantitative analysis when gravimetric and volumetric methods of analysis should and could be very well taught at the general chemistry level. As a matter of fact, I received a rather detailed analysis from a friend at Columbia who said, "I would hope that junior colleges would present a course in general chemistry much like the one we are developing here at Columbia; that is, a first semester of general chemistry and qualitative analysis follow by a second semester of general chemistry and quantitative analysis. The quantitative aspects of the course would a solid introduction to quantitative methodology dealing almost exclusively with classical and the gravimetric and volumetric principles. This is followed in our institution by a second semester of quantitative analysis which is highly instrumentally oriented and into which the concepts learned in the general chemistry course are elaborated upon." Therefore, I feel that volumetric and gravimetric work should be conducted at the general chemistry level and that the course in quantitative analysis should be what we call modern quantitative analysis--mainly instrumental and measurement.

The comment that junior colleges are getting better equipped is certainly most encouraging. I would like to know how generalized this situation is and if this is an exception rather than a rule because we do get students coming from junior colleges, from four-year colleges and from a number of places so we would like to use a curricula that is applicable to students coming from most of the states rather than just a few.

I want to conclude by making a comment about our attempt at trying to cram more and more material into less and less time. I am still a bit baffled by our system, but I do want to recall how I got initiated into teaching at an American university. I got my education abroad and I came here to do a post-doctoral. As a result of somebody getting killed two days before classes started, I was asked to teach a course in organic chemistry. So I started teaching a course in organic chemistry as I thought it had to be taught. After the third week of the course, I was in the middle of discussing a certain reaction, someone in the back raised his timid little hand said, "What is an alcohol?" It took me some time to realize that the student had had no exposure whatsoever to organic chemistry and I was laboring under the delusion that they had had a full year of elementary introductory organic chemistry at the high school level. We are trying to cram too much into too little time, but perhaps we should insist on some of that material being included in the high school course.

MODERN TEACHING AIDS FOR COLLEGE CHEMISTRY

In recent years, many changes have occurred in the chemistry courses offered at the high school and beginning college level. Lecturing is frequently used exclusively to teach scientific concepts to students who were reared with television and high-fidelity stereo. Although media systems can help the teacher present more concepts in greater depth to the (potential) learner, he may also be forced to use the media systems to get the student's attention before or while the concepts are presented.

With the emphasis placed upon teaching by the two-year colleges, chemistry faculty in these institutions can and are making the media hardware items into genuine servants by developing new software programs or altering old programs to fit local needs. The papers presented in this section should encourage faculty members to accept the various media systems as additional components of their arsenal for creating a learning atmosphere for both science and non-science students. (Ed.)

THE TUTORIAL SYSTEM OF INSTRUCTION

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Students learn as individuals, but we teach them in groups.

This may be true for a number of reasons - tradition; we teach as we were taught; or economy of operation.

In recent years, fresh approaches have been made in college chemistry instruction which center attention on learning by individual students. Some of these developments have been outlined in the August, 1967 Newsletter of the Advisory Council on College Chemistry. Developments at Meramec Community College, Oakland Community College, Oral Roberts University, and Simon Fraser University are among those described. Much of the trend toward tutorial systems of instruction stems from Postlethwait's work in botany at Purdue.

The conviction on which this paper is based is two-fold: 1) that the tutorial systems approach offers hope for a major breakthrough in introductory chemistry instruction; and, 2) two-year college chemistry teachers can lead the way.

The aim of the tutorial systems approach is the facilitation of student learning by means of a systematic approach which couples the best of one-to-one teaching with advances in instructional technology. A system may be viewed as a process having an input and output and a feedback-control loop from the output back to the input.

In more traditional instruction, the teacher and student are associated in an "open loop" system. Frequently the teacher's role in communicating to the student is a one-way approach. The student is a passive receiver and has little opportunity to make the process a two-way one.

The tutorial system strives for the ideal of frequent student responses to the teacher, producing a "closed loop" system. The instructional system is designed on the premise that students learn best when they are motivated, active and have frequent feedback about their progress. They should be able to go at their own pace. They should know exactly what they will be expected to do and how well they are progressing toward that performance specification. A variety of communication techniques should be used as appropriate to the learning steps -- tape recordings, laboratory observations, slides, film loops, models, programmed booklets, self-tests and videotapes. The system should encourage a maximum amount of personal contact and permit learning at a faster rate.

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The rate of learning depends on pacing. If a student is held back by the pace of the group, he becomes bored or apathetic. When the pace picks up he becomes interested and challenged. When the pace gets too fast for him, he becomes anxious, confused, and frustrated. Dr. William Platt of Stanford Research Institute suggests that the rapid covering of material gives some students the feeling of getting "the fire-hose treatment." The student should at least be given a chance to close the valve if the flow is too rapid or turn it on if it is too slow. The tutorial system attempts to place the student in control of the learning pace so that he can adjust it, within limits, according to his needs.

The tutorial system design can be applied to any level -- the two-year program, the one-term course, the one- or two-week unit, or the hour or less learning step. Four basic questions form the basis of the system analysis and synthesis:

1) What should this system enable the student to do?
2) How will he know he can do it?
3) What can he do at the start?
4) How can we help him get from where he is now to the performance level required for the system output?

The system is designed with a series of decision points. These yes-no points route the student to the next learning step or recycle him through a branch of the system for tutoring, review, or even a decision that he should leave the system, that is, withdraw from the course.

The decision points are essentially these:

1) Does the student meet the entry pre-requisites?
2) Has the student mastered this learning step?
3) Is the student ready for the examination?
4) Did the student meet the terminal performance standards for the system?

At Oakland Community College all this is designed within an instructional model which consists of four components, reflecting the pattern established by Postlethwait at Purdue:

1) tutorial learning laboratory
2) general assembly
3) small assembly
4) home study

The tutorial laboratory is the heart of the model. Students schedule themselves into the study carrels and wet laboratories several hours a week. The general assembly meets only once a week and is the only required meeting. The optional small assembly sessions provide discussion time for groups of ten to twenty students. An instructor is in the tutorial laboratory during each hour it is open, typically 8:00 am to 10:00 pm on weekdays.

Each student receives a detailed outline of the course which indicates the general objective of a unit, the intermediate objectives, the learning steps he is expected to follow, the tapes, filmstrips, slides, film loops, programmed booklets, text book reading, calculations, reference books, laboratory observations and experiments and the self-tests. He knows what he will be expected to do upon completion of the unit. He is given devices for assessing his progress. He is given responsibility to seek help from an instructor when he needs it.

Let's take an example of a learning step within a unit on stoichiometry. The learning objective is:

> Given a balanced chemical equation, periodic chart, slide rule, paper and pencil, the student will calculate to three significant

figures the weight of a substance related to the weight of another by using the three steps of the mole method, and complete this within five minutes.

The student has met the pre-requisites for entry to this unit of instruction. These included the concepts of chemical system, chemical species, chemical bond, chemical formula, chemical equation, mole, cancellation of units and the distinction between observation and interpretation.

The student is directed through a taped tutorial, slides or a study guide to observe in the laboratory the burning of magnesium ribbon and the differences between a used and unused photographic flash bulb. He is led to describe the chemical system of magnesium metal and oxygen gas forming solid magnesium oxide. He indicates the submicroscopic species as Mg atoms and O_2 molecules forming a solid containing Mg ions and O ions. He expresses the mole ratios of these species from the balanced chemical equation. He is led through the three steps in solving a weight-weight problem: converting the amount of A to moles of A, converting the moles of A to the moles of B, and converting the moles of B to the amount of B. He works some similar problems, checking his progress by means of a self-rating device or comparing his answers with those in his study guide. He then takes the self-test if he feels he has mastered the learning steps. If he answered 9 of the 10 items correctly, he goes on to the next learning sequence. If he finds he needs help, he goes to the instructor individually or in a small assembly session.

The primary potential of the tutorial system is improved quality of chemistry instruction through the facilitation of student learning. The instructor gains from the discipline of analyzing the relationship of chemical concepts in the course to each other and to student performance, synthesizing an instructional design to accomplish specific objectives, and validating the system to insure its effectiveness. Students gain by knowing exactly what is expected of them and by assuming more responsibility for their own learning.

Other possible benefits can be summarized in four categories: 1) feedback, 2) self-pacing, 3) validation, and 4) flexibility.

Feedback information is valuable both to the student and the instructor. When a student frequently learns about his progress in a "non-exam" way, he becomes more highly motivated. When an instructor learns regularly about student performance, he is able to recommend modifications in the system design, increasing or decreasing the size of the learning steps and changing the mediation of the instruction where necessary.

Self-pacing permits serving the growing diversity in student backgrounds, capacities and interests in two-year colleges. Branches in the system can be designed for students who can jump ahead or those who need additional instruction to meet the terminal performance standard.

Validation is possible because specific student outcomes are stated initially and the examination established to assess student outcomes. The task was specified along with the conditions and criteria for evaluation. During the development of tutorial learning sequences, they can be tested with small numbers of students like those who will be using the materials in the total system. What works you use; what doesn't you revise.

Flexibility in application is a big asset. The system frees the student schedule. It permits the instructor to spend less time on repetitious or drill material and more time on instructional design, and personal contact with students. The system can be used with less experienced teachers and still assure more uniformity in minimum results. The sequences can be developed as modules of varying length and the sequence

of the modules can be altered as desired. Alternate modules can be assigned for students interested in life and health-related sciences and those interested in engineering-related fields. And most importantly, the tutorial systems approach can be applied to group instruction as well as to individual instruction, thus permitting more gradual changes in traditional modes of instruction.

The problems center in the worn phrase, "There is never enough time or money or personnel."

Finding the right personnel is a key to developing an effective tutorial system. The faculty who design and produce the materials must be both experienced in teaching these chemical concepts at the college level and committed to the innovation. Experienced faculty may become too set in their ways, and younger faculty with bright ideas may lack the control of the concepts or the maturity to judge what students need to facilitate their learning. Another key to success is strong support by administrative personnel who permit a great deal of operational latitude. Students may find they are not yet able to handle very much freedom in scheduling their own time.

The time factor is critical. Clear distinction in time should be made between time for invention and design, time for development and validation, and the time for production, implementation, and minor operating revisions. If too little time is allocated to design or to developmental testing, much more time will be required before the system becomes satisfactorily operable. Experience with such curriculum developments as CHEM study or CBA suggest about three years' time from start to published materials in use. If a one-year course is involved, at least one year of released time should be allotted for development before the pilot course is first taught. During this year, time should be allocated for consultation with chemistry teachers outside the college as well as within. Contact with the larger chemistry community is vital. Finally, time should be allowed for modification of the system based on feedback gained during use before the system is "frozen" or judged to be essentially complete.

We always encounter the expense problem -- not just the cost of tape recorders or projectors but the cost of developing the program. IBM specialists in this area budget $2000 to $2500 per hour of self-instructional materials to be developed. One hundred hours of tutorial systems sequences for introductory chemistry at this rate exceeds what any community college could allocate. But with the flexibility of this approach, even an hour or two of material could be developed with profit to the student, especially when the results can be assured by validating the sequence. And considerably lower budget projects are possible. In the last analysis, money may not be the third major problem along with people and time; it may well be ideas. If the ideas are sufficiently imaginative and timely, funding from outside the college is a distinct possibility.

The problems are real but not insurmountable. They are challenges to be met in pursuing the potential of the tutorial systems approach in chemistry instruction.

Two-year college chemistry teachers have an opportunity to make a significant contribution to chemical education through this approach. The need is to broaden the base of operation and combine the talents and resources of a larger number of chemistry teachers.

These four steps could be taken now:

1) identify interested chemistry teachers
2) identify possible self-instruction modules to be developed for introductory chemistry

3) initiate information exchange about current explorations in this field and developments at two-year colleges
4) develop the guidelines for a cooperative venture.

The tutorial systems approach offers great potential for significant advances in chemistry instruction at the introductory level. Two-year college chemistry teachers can lead the way in this advance.

A MULTI-MEDIA APPROACH TO THE TEACHING OF GENERAL CHEMISTRY

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In the past, the chemistry teacher has had the "teaching aids" of the laboratory experiment and the classroom demonstration to supplement his spoken "gospel" and the necessary textbook. In recent years, an arsenal of audio visual teaching aids have been developed and vary from quickly prepared overhead transparencies to elaborate teacher-prepared films, and videotapes. Effective techniques and materials for mass instruction, individual self study, review and remedial purposes are available to the teacher of chemistry. Unfortunately for the teacher who prepares his own materials, much time is spent in that endeavor. However, his results usually reward his prejudice that teaching aids can make chemistry learning more exciting and effective. The following is a short summary of teaching aids used (and mostly prepared) by the author in teaching a general college chemistry course. Each description will touch on equipment and its cost, the applications of specific media, examples and cost of commercially available media, the cost of materials for teacher-prepared media and examples of the author's preparations.

1. Overhead transparencies (projecturals)

Using portable overhead projectors (under $200) the teacher can project in fully lighted classrooms convenient tables of data, graphical representations, equipment diagrams, outlines and schematic procedures, and short quiz questions. Indeed the projector can serve as a black board but suffers from "localization" of the instructor. Commercially available projecturals are expensive (about $5.00 each and up for elaborate overlays). Individually teacher-prepared projecturals are conveniently and inexpensively (about 20¢ each) made by the thermofax process from a carbon base single sheet original. Printed originals in chemistry are commercially available from the 3M Company. Other processes include 3M models 70 and 107, diazo-ammonia process, and other wet chemical methods.

The projectural is almost a must for best classroom discussion of large quantities of experimental data, the analysis of graphical data and the logical development of outline and schematic procedures. The projectural suffers in attempting to depict three dimensional geometry of structures and solid plastic models are more effective for this purpose.

2. Sound film rental-16 mm

Some excellent 16 mm sound movie films are commercially available in elementary chemistry. They may show difficult-to-run experiments, elaborate instrumentation, effective animation or hazardous experiments. Modern Learning Aids (Ionization Energy, Electrochemical Cells, Crystals and their Structures) and Association Films (Bomb Calorimeter, Vapor Pressure, Solubility Product) have several useful films. Rental fees range from $3 to $6 per film.

The publication, "Modern Teaching Aids for College Chemistry", prepared by the Advisory Council on College Chemistry lists sources of films. Also this publication deals with 8 mm films, Video Tapes and Computer Assisted Instruction.

3. Film-8 mm and Super 8 mm

Whether purchased or teacher prepared these films are especially effective in short presentations (as film loops) of laboratory demonstrations and techniques. A \$300-\$500 investment buys necessary camera, lighting and projection equipment for teacher prepared films. Materials cost \$1 to \$3 per minute of prepared film (compare to the price of \$3 to \$10 per minute for commercially available films). The film loop is particularly suited to student self-study in carrels where loop projectors and small box screens are available.

"Teacher-Produced Instructional Films in Chemistry", also by the Advisory Council on College Chemistry, thoroughly discusses the topic from philosophy to techniques, equipment and sources.

The author is preparing three 4-minute films on the following topics: 1) Rate and Mechanism of Chemical Change; 2) Criteria for Chemical Equilibrium; 3) Oxidation Potentials and Chemical Change.

4. Programmed instruction texts

Programmed instruction covers a broad category of media from the more common linear programmed texts and topics on chemistry to detailed technique and equipment procedures on slide-tapes and concept development through computer instruction. These texts provide for varied rates of individual student learning. Programmed texts are also useful for review and remedial purposes. Examples include mathematical techniques of graphing, slide rule; powers of ten, significant figures and chemistry problems in stoichiometry and equilibria. A small supply of selected programmed texts can be loaned to students for review and remedial work. Caution must be exercised in using available program texts since the logical development of presentation in the texts should match the instructor's approach to the topic. A bright student will welcome a new approach but an average student will probably be confused if his instructor develops chemical equilibrium through thermodynamics and the program text uses a rate approach.

Two linear programmed texts used by the author are Barrow, et al, Understanding Chemistry, published by the W. A. Benjamin Company and Harris, Numbers and Units in Science, published by the Addison-Wesley Publishing Company.

5. Slide-tapes

This audio-visual aid is probably one of the least expensive in terms of materials cost per minute of presentation (25¢ to 40¢ per minute for a 20 minute and 20 slide presentation). Equipment needs would include a 35 mm camera (an SLR for close-up work), automatic slide projector, audio-tape recorder and slide tape synchronizer (records and plays back slide advancing signal). Total cost of this equipment may be held to about \$500. As noted above, this media is well suited for programmed instruction and general self-study applications.

A major limitation of this method is its necessarily static subject matter. Thus, rates of reactions, and chemical changes in process, are best reproduced by film or video tape.

The filmstrip-record combination is a similar medium though this does not allow for convenient stopping of the presentation as does a pause button on a tape recorder. Many filmstrips are available commercially and chemistry teachers can prepare their own audio commentary.

The author has prepared a slide-tape lecture on "Electrochemical Equilibrium".

6. Video tapes

Portable video tape recorders have become relatively inexpensive (about $1000 for camera, recorder and monitor for a one-half inch system) and provide a most versatile A-V medium for individual and mass instruction both in live and "canned" productions. When the cost of color TV units descends from its currently high level, TV may become the prime educational medium.

The cost of 1/2" tape is about 75¢ per minute but this cost is approximately a maximum since there is no waste footage. Spoiled footage can be reused, a feature not possible with film. Of course much of the beauty of chemistry is in the color of its changes and for these displays color slide and movie films are best suited.

Other VTR applications to chemistry would include taping of actual student practice of using single pan balances and other instruments and playback for their self improvement. The inexpensive videotape recorders also allow for limited close circuit broadcasting within a building by the use of long recorder monitor cables. The brave chemistry teacher might use the media for his own teaching improvement by having some of his lectures videotaped and then objectively scrutinizing the playback to evaulate his classroom effectiveness.

The author has prepared a videotape, "Bonding in Solids and Freezing Point Depressions in Acetamide."

Each of the above media makes considerable demands on the time of the chemistry teacher if he prepares his own materials. However, he reaps some tangible rewards in the form of stimulating presentations which he can use again. He also can create exciting and effective teaching aids which can increase the interest and learning "yield" of the chemistry student.

DO IT YOURSELF WITH 8mm FILMS

Rod O'Connor
Advisory Council on College Chemistry, Palo Alto, California

Instructional films in chemistry are really nothing new. Their value for presenting ideas and techniques has been recognized for many years, yet they are not widely used at the college and university level. Frequently films are difficult to obtain for desired schedules, too expensive to be permanent items in most departments, and not really tailor-made for use in the specific local teaching situation.

The author has been exploring the feasibility of making instructional films in 8mm or super 8 on the basis of being a professional chemist, but an amateur cameraman. The philosophy of this approach is that this medium may afford another teaching technique which permits the instructor to develop and construct the material according to his own needs and interests. The 8mm film makes it possible for the individual instructor (who is a photographic amateur) to produce films that illustrate topics of his choice according to his own ideas and thus preserve an intimate intellectual contact with his students. The 8mm film is thus an instructional medium which falls into the category of the blackboard, the overhead projector, or the classroom demonstration.

Many of the available commercial films have the psychological disadvantage of assuming control of the class by a "master" instructor. Chemists are generally resistant to such a delegation of authority. When no specific person appears in a teacher-produced film which has been made locally, the instructor retains control of the teaching situation by controlling the content of the film and the narration which accompanies it. Many inexpensive 8mm silent films with only a "pair of hands" being

shown are now available commercially. Such films can and should be used in lieu of a locally-produced film if the content is satisfactory and the teacher can still be his own "master" by supplying the narration.

Teacher-produced films have been used in many areas with considerable success.

1. Technique Instruction: Techniques ranging from the handling of solids and liquids to the operation of an infrared spectrophotometer have been presented on simple films. Complete pre-laboratory instructions have been given using sound super 8 films projected into rear-projection screens in the fully lighted laboratories at Kent State University; instruction in specific techniques has been presented on silent, cartridge-loaded film loops accompanied by instructor narration at Oregon State University; and, at Ohio State, filmed techniques have been shown via closed-circuit TV to many laboratory sections simultaneously. Cartridge-loaded or "auto-loading" reel-to-reel projectors have been provided in individual study carrels or undergraduate reading rooms for review of techniques or study of techniques prior to laboratory time as described in AC_3 Newsletter No. 10.

2. Filmed Laboratories: In some cases entire laboratory investigations or problem situations have been placed on film so that students observe the laboratory situation, obtain data, and make calculations and correlations without physically being in the laboratory. Such uses are especially appropriate where "exotic" equipment or hazardous operations are involved or where special effects such as stop-motion of time-lapse photography are important.

3. Instrument Familiarization: So much of modern chemistry depends on the use of instruments that the importance of a student's intimate and early acquaintance with the "gadgets" can hardly be exaggerated. Frequently, important instruments are inaccessible to lower division students and films of their theory and operation provide valuable aids to lecture courses when discussion of instrumental data is underway. Schools not owning major equipment items may be able to obtain films from their more prosperous neighbors or, indeed, instructors from smaller schools might profitably spend a few days of summer or Christmas vacation on larger campuses making their own "instrument familiarization" movies.

4. Lecture Aids: Any good lecture-aids program should include a variety of materials so that the best can be selected for each particular purpose. Frequently, commercial 16mm films contain excellent sections on such things as amination and complex reactions but do not warrant the time required to show the entire film in class. In such cases, it is advantageous to run the film up to the proper point prior to class and show just the brief segment desired without sound except for the instructor's narration.

Film animation of such topics as molecular vibrations, reaction mechanisms and electrochemical processes can be prepared quite easily with 8mm cameras using conventional models. Special effects such as time-lapse photography, stop-action, or extreme closeups may also be of use in lecture film situations. The use of rear-projection screens allows such films to be shown in lighted lecture rooms and special projectors are available for their use with conventional screens in larger auditoriums.

5. Auto-Tutorial Uses: Individual booths (carrels) can be set up in libraries or special rooms for student study or in or near laboratories for individual review of technique films.

Films may range from introduction to or review of a laboratory technique or the use of a slide rule to a problem situation for student analysis. The films may be silent, with appropriate titles or instructional booklet, or may be shown with sound on synchronized tape or on the film itself. A very useful procedure which avoids the problems of synchronizing audio tapes with films, which still gives more detailed information than is feasible with film titles alone, is the use of a type of pro-

gramed viewing in which the student reads some instructional material and views parts of the films in alternating sequences. The written material is arranged in separate numbered sections or pages. A section is read and then film projection is begun. At the appropriate point a film title sequence states "Stop Projector and Read Section 2". At the end of that section the student is instructed to start the projector again, and this process is continued until the entire instruction is completed. Individual carrels may also be equipped with audio tapes, programmed materials, and other study aids for placing a major emphasis on "individualized" instruction.

A properly prepared instructional film can be used in many different ways. By keeping individuals out of the picture the "master" teacher problem is avoided. Silent 8mm or super 8 movies can then be used by many instructors in multi-sectional courses, each providing his own narration live, on synchronized audio tape or on magnetic sound stripe on the film itself. The use of a number of common films in multi-sectioned courses can do much to coordinate the content of the sections.

Films prepared in the same basic way can be used at many levels by varying the accompanying narration. For example, a film on determination of an infrared spectrum could be used for physical chemistry, analytical chemistry, organic chemistry, general chemistry, physical science and, perhaps, high school chemistry. Although showing the same pictures, "level" of the presentation is determined by the accompanying narration (live, taped, or on the film), which can range from highly theoretical to elementary introduction.

Suggested methods for preparing 8mm instructional motion pictures are contained in "Teacher-Produced Instructional Films in Chemistry", available free from the Advisory Council on College Chemistry and in "Production and Use of Single Concept Films in Physics Teaching", from the Commission on College Physics.

DO IT YOURSELF WITH 8mm FILMS AND FILM LOOPS

Edward Eagan

Quinsigamond Community College, Worcester, Massachusetts

Note: Mr. Eagan presented several films and film loops which he had made. He used this opportunity to demonstrate faults in the films, reasons for the faults and ways to avoid them. A number of suggestions and questions that the potential film-maker must answer were posed. It was made clear that making instructional films is time-consuming and demanding but that results enable the teacher to better plan his instructional program as well as make good use of films that are of less than Hollywood quality.

Mr. Eagan's type of presentation is impossible to reproduce on paper but the following outline highlights the points made. (Ed.)

Thorough planning and storyboard preparation must precede the film making. Considerable experience will be obtained as the first two or three films are made and will emphasize the points where careful craftsmanship must be employed. Special techniques may be employed from time-to-time and the film maker should feel free to exercise his imagination.

The films and film loops exhibited included the following topics:

(a) Weighing Operations on the Mettler Balance
(b) Your Desk Equipment and How to Use It
(c) Items of Equipment in the Chemistry Laboratory

ERIC

(d) Chemical Names and Symbols
(e) Determination of Oxidation Numbers and Balancing of Equations
(f) Operation of the Infra-Red Instrument

In preparing the material, it was found that several factors had an important bearing on the results. Causes of faults in the finished product may include the following:

(a) Lack of attention to light exposure of material being photographed. (For example, it is difficult to get the proper light in photographing the dim readout of the Mettler Balance.) Successful shots can be made with daylight, but photoflood lights should become a part of the equipment supply at an early point.
(b) Failure to use close-up lenses. (These lenses are inexpensive and are highly recommended.)
(c) Lack of attention to the time allowed for each shot. (Will the person seeing the scene for the first time be allowed enough film time to get the message?)
(d) Lack of a written script. (Unless the film is composed of a few simple shots, lack of a written plan for filmed sequences will cause inconsistencies, errors and result in excessive splicing of film.)

A film maker should investigate the following advantages and disadvantages:

(a) A movie title set. How much time can be allowed for setups? What care should be taken? Are there reflections from the glass? Letters set on a cellophane roll will eliminate glass cleanup. Shoot a few feet of a main title and clip the developed film, thus providing titles for later film work.
(b) Blackboard and chalk. Printing is preferable to script. An equation written on the blackboard may be photographed in several shots taken successively.
(c) A closeup lens. College catalogs, typed material, or material printed with a felt-tipped marker on 8 1/2 x 11 paper may be photographed effectively with a closeup lens.
(d) An assistant. A photographer would free one to operate instruments in the process of being filmed, as well as allow one to direct camera angles.
(e) The tripod or other steady base is most helpful in some film operations.

Super 8mm will soon replace the regular 8mm. It is advantageous to become acquainted with and use this equipment.

COMPUTER ASSISTED INSTRUCTION IN COMMUNITY COLLEGE CHEMISTRY PROGRAM

John Holleran
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I would like to say that I am not used to talking to such large groups since I come from a junior college where we pride ourselves in small size classes. Unfortunately, I cannot really say that.

My subject is Computer Assisted Instruction and I hope that CAI can do some-

thing about reducing the size of our classes. I would like for you to imagine a student walking into a room in which he sees several other students and some little tables spread around the room. At each table is a thing that looks like a typewriter and next to it is a screen. Then the student sits down at the typewriter and pushes a little button and the computer says, "Type your student number please."

The student types his number and the computer comes back with, "Hello, Jim! How are you. Good to talk with you again. It seems to me that the last time we talked together you were about ready to discuss the laws of gases and some of their properties. Do you think you would like to do that now?" This is all typed out on the typewriter.

The student says," Yes, I think so."

The typewriter comes back and says, "Alright, let us consider a gas in a container." At that moment on the screen next to the typewriter, a picture of a gas in the container flashes and the typewriter says, "Let us consider this gas in this container to be at a certain temperature and a certain pressure and it has a certain volume. Would you like to choose them? If so, type in the temperature, pressure and volume."

The student then proceeds to do so and the typewriter sits back and says something like, "Let us change the pressure on this gas and see what happens. Change the pressure."

The student suggests another pressure, a new picture flashes on the screen and a change in volume of the gas is given. This can be done several times as the student makes changes in pressure and the procedure is repeated.

Having used the computer-typewriter, the student knows that he is able to request certain things from the computer. If he is real sharp, he would say, "I would like to see that graphed. I would like to see the relationship between the pressure and the volume that you have just been showing. He can get that just by punching a few keys and saying graph P vs. V for instance. At that time, the typewriter would type out a nice, neat graph for him.

The computer might then say something to this effect, "You see this curve and this is the relationship between the pressure and the volume. It is quite obvious that there is a direct relationship - as the pressure changes there is a direct proportion between the pressure and the volume. Isn't that right?"

The student says, "yes".

The computer snaps back saying, "You have been mislead." You are just too sure of yourself. Okay, Jim, consider it seriously. What is the relationship between the pressure and the volume.

Jim would now probably say, "It is an inverse relationship." If Jim does not ask, the computer would probably suggest, "Would you like to see the product of P and V?" If he gives a positive answer, this is tabulated for him to also see.

This is just one instance of computer assisted instruction. It demonstrates the ability to link a computer with a terminal, as it is called, and perhaps a screen which can project motion pictures or slides and perhaps even a tape recorder. It is meant to give the student the feeling that he is communicating and that he is being talked to by a teacher.

I think we can very nicely split the functions of computer assisted instruction into three categories. The first one would be drilling and diagnosis. The

typewriter could be used for very simple drills to take away some of the drudgery from our classes by perhaps drilling on nomenclature, on symbols and symbol calculations and also testing to see if the student is getting the sort of thing that we want him to get.

Secondly, computer assisted instruction can be used for the tutorial purpose, where the computer acts as a tutor for the student and not just for the routine things but for the whole business of the course.

The third aspect can be used for simulation and gaming. I do not see that gaming is too appropriate to the field of chemistry, but the computers have been used for gaming in social science and so on. Simulation, it seems to me, is the real forte of the computer as far as chemistry teaching is concerned.

It is possible for the computer, tied to a typewriter and perhaps to a cathode ray tube, to provide the student with a situation which is very much like one that he would have in the laboratory. It is possible to go through an experiment by giving the student the feeling of being right there and doing it by using a motion picture projector, perhaps a tape recorder and a cathode ray tube to graph any results that he might get. This can be used in cases where the actual equipment is much too expensive for a junior college to acquire or where it is too time consuming to have the student do a particular type of experiment over and over.

It also can be used for the purpose of providing a way for the student to get out of the monotonous aspects of the chemistry laboratory. There are times when we have a student perform a certain thing or manipulation in the laboratory after he has proven to us that he is capable of performing it. We have had the students making solutions, doing titrations and so on when the actual manipulative skills were learned long ago and when he really does not have to go through that part to get to the principal that the experiment is trying to convey to him. After some experience, the student and teacher realizes that he has the technique mastered; nevertheless, there are many principles the student should learn which involve making solutions and titration. Why not have the computer make the solution for him? Have the computer present to him a solution of the strength which he desires, or close to the desired strength, and standardize it for him while he watches it and stops a motion picture projected image of the titration. Simultaneously, he watches a simulation of the pH meter during the course of the titration, stops it at will, watches color changes on the screen and so on. You can see how this would reduce much of the tedious work and still convey the principles you really want to get across in the chemical laboratory. This presumes he has learned the skill and that you are convinced that he does not have to do any more of this since he already knows how to make up solutions of approximately 0.2M, etc.

It seems to me that this simulation is really the forte of computer system instruction. This can also be done by ordinary programmed instruction. One of the rules that most people in the field of CAI will tell you is that if it can be done with programmed instruction, then do it that way for reasons of the time of preparation.

How does a program such as the one that I described get on a computer? Various languages can be used to talk to a computer in CAI. I have worked with two--one was Course Writer and the other one was APL which stands for A Program in Language. There is a third one with which I have not worked but have heard about called LYRIC, which combines some of the advantages of both of the two previous methods. These languages operate in two modes. They are called author-mode and student-mode. In author-mode, the teacher or coder can sit down at a terminal and prepare a "course." A "course" is jargon in this particular field for just an aspect of the course--a very short aspect of what we already normally call a course in chemistry. A "course" might be solubility product calculations. The teacher, or the coder under

the teacher's guidance, can code into the computer the questions, the dialogue and the answer that he wants. The answer is needed so that the computer can check with the student to see whether or not the student came up with the right answer. All that is then necessary is to change the mode to student-mode and the student can sit down at the same terminal and go through that particular "course."

I will now draw a diagram for you the way a teacher or an author goes about this. First of all, he has his notebook or his workbook in which he writes down his ideas about the "course" that he would like to put on the computer. Then he gives the information on the "course," if he is not particularly adept to writing in any of the languages, to some encoders, who put it in the actual language of the computer. These languages are not difficult to learn, or at least course writing is not difficult to learn. It has a built-in logic of its own which only takes a couple of days to assimilate. At the same time and if he has facilities for slide projection or movie projection or tape, then he also gives the audio-visual people and artists the information that he wants put on slides, photographs or art work. This is all put together into a program which the author then reviews. He then tells the encoders what changes should be made, examines the branches and then looks back at the notebook and goes through the whole process again and changes some of it. The next step, which is a very important and essential one, is testing it with students. It is necessary to get a small group of students to determine if the program is working very well and how well the students are learning what the author hopes they will learn. The author then has to take the results of those tests and change the program by adding branches providing for unexpected contingencies deleting parts of the program and changing anything that is necessary and then go through the whole process, or a part of it if it is necessary to do so.

One time I was writing a program on solubility product constant, where I know from experience that students have a lot of trouble with that simple aspect of solubility product problems--when do you multiply by two before you square and when don't you multiply by two. I prepared a computer program on this point. I gave a test to the students after they went through this program and they failed miserably.

I went back to my work and again reviewed the program, changed some of the branches and added some branches where the students had some trouble in understanding what happened when a substance ionized. I decided the program was perfect and would work so I tested it again on some students and the impossible happened--they failed miserably.

So finally, I went back, threw the whole thing out, started the whole program all over again and worked on the thing until I thought I had thought of every single possible contingency. At that point an amazing thing happened - I understood how to work that kind of problem. I now realized that I had not really known how to work that problem before because I could not intelligibly explain it.

Some of you may know Jay Young, a former mentor of mine. His thesis, when he was working with programmed instruction, was that the value of programmed instruction was for the teacher. One can go through life and teaching by using pet ways of introducing a subject that seems beautifully logical but without knowing anything about it. Students did not understand the beautiful logic I presented and I found out a little about the way their minds work. Therefore, you plan for every possible contingency by making many branches for the many different ways students will be thinking about the problem.

We can now make a comparison between CAI and programmed instruction. CAI and PI gives an active student response to a question. This is an advantage over just ordinary reading. CAI gives immediate feedback with the student realizing immediately that he is right or wrong. This is also true with PI but is more limited than with CAI. With CAI, emphasis is on criterion performance rather than on normative performance. This is also possible with PI, but with greater limitations.

With CAI, independent trait measures can be input for programs for individual branching. PI does not have this unless you have different books for different people. This allows making contact with the student on a real personality basis. The computer can be programmed to distinguish between individuals and permit responding to them in different ways. This can be done, although it is involved, and when it has been done, it is permanent and can be reused indefinitely. There is no particular reason why the computer must be told that Joe so and so is a particular kind of individual and certain branches should be used. It can receive the results of psychological testing and determine the kind of response needed without input from the chemistry teacher. It can select the right branching. The computer can look back at preceding responses and branches and on the basis of any answer or group of answers branch in certain desired ways. The computer permits rapid retrieval of information from a data file and PI obviously does not have this advantage. The terminal is backed by speed and power and nothing of this nature exists with a PI book. CAI presents an interface that can utilize all sorts of audio-visual impacts while PI presents no similar interface.

The diagnoses of progress with CAI can be based upon any answer or any subset of answers. With PI you can only branch on the answer to the last question. If the computer notices that a student has been hanging up in a certain aspect of every question, then it can branch accordingly for review.

These are the great advantages of CAI but I must also tell you that people have been tested who used CAI and compared with those using PI, with both groups covering exactly the same material. Unfortunately, test scores showed that students performed exactly the same whether they used CAI or PI. As a matter of fact, it took the students a little longer to learn the material from the computer than from the book. I am not sure that those results would be true with all the advances that have been made in the audio-visual aspect of the CAI terminal.

The greatest potential of CAI is for the student, not for the teacher. The real potential enables us to get the best chemistry teacher, put him into the computer and let any student have access. The computer actually takes on the personality of the programmer. It frees the teacher of the routine portions of his work and permits closer relationships with students instead of the big depersonalized classes. It gives the teacher more time to do the kind of teaching he wants to do.

Potential also lies in the simulation aspect of CAI. This is where most of the potential lies. It not only frees the teacher, but it also frees the student to do more creative experimentation.

There is considerable potential in the use of audio-visual interfaces next to the terminal. There is potential to not only use the typewriter for communications, but to also use the voice to say what the typewriter would have printed. However, it is hard to get the computer to understand the talking student.

Although it has been shown that first graders can learn to use the terminals, it does take a little while to learn it and it does get rather boring waiting for the typewriter to print out its message because a person can read much faster than a terminal can type.

Analog and hybrid computers also have potential. A digital computer takes much time to solve any problem involving a differential equation whereas an analog computer can solve it very rapidly. One demonstration of a hybrid computer tried to optimize an industrial chemical system. It was given seven differential equations and twenty-two parameters in all. In ten seconds it provided graphs which showed the optimum conditions at which this industrial process could be run. However, a hybrid computer was needed to accept the input data in digital form and arrive at an answer by solving differential equations. This offers considerable potential for CAI.

The problems of CAI start with MONEY and the cost of the terminals. The terminals may be rented from IBM for $200 each per month. For a good chemistry program in CAI, you need tens or even a hundred of these terminals, depending upon the size of your classes and how frequently the terminals are used.

The other major problem is finding the programming time. To handle local needs and local situations, you need to do your own programming or someone in your school does the programming. Companies are not sure how they will handle programs which are developed for more general use in CAI systems.

A computer smaller than the IBM 1401 with a 12K storage capacity cannot be used for CAI. For this machine, the complete computer would be tied up for all of the time that CAI is being used.

The last problem is the psychological problems with the computer. The computer does exactly what it is told to do, not what you think you told it to do. This can be frustrating as demonstrated by the attempt to translate English into Russian and back to English. Programs were written to do this and the phrase fed into the computer for translation was, "This spirit is willing, but the flesh is weak." After being translated to Russian, the Russian version was fed back through a conversion program to English with the phrase being produced, "The vodka is good, but the meat is rotten."

MOLECULE-A-GO-GO

Donald G. Hicks
Georgia State College, Atlanta, Ga.

Apparently, there are at least some people in the country who would like to relegate scientists to the role of <u>second class citizens</u>! If you think not, consider this quote from a five-page article by Mr. William H. Ferry in a widely read magazine, "the regulation of (science and) technology is the most important intellectual and political task on the American agenda!" [1] The author went on to suggest rewriting the Constitution of the United States to control technology. While this attitude may not be effective, and there may not be very many as totally outspoken as Mr. Ferry, it is my feeling that he is not entirely alone. Scientists must not allow this sort of attitude to develop extensively among the "great scientifically-unwashed herd" in our society. I wonder if these sorts of feelings might not stem from a <u>fear of the unknown</u> by our "<u>scientifically illiterate</u>" society? This segment of Society includes, unfortunately, many of the so-called "intellectuals" who are well-trained in the arts, humanities, theology, and laws but are hardly cognizant of the difference between atoms and molecules. Apparently, these are the people qualified (?) to control science and technology. Having made a few small efforts myself during the past 1-1/2 years toward alleviating the popularization of science problem, it is with special interest that I note the constantly growing chorus of prominent voices who have expressed a concern over our "scientifically-illiterate" society. Dr. Gordon Harris (Schoellkopf Medal winner and chairman of the Chemistry Department at New York State University at Buffalo) and Dr. Donald Hornig (Special Science Advisor to President Johnson) have both made major speeches this year emphasizing the need for popularization of science. It seems to me that the problem of teaching the non-science oriented student is directly related to the general problem of "scientific illiteracy" of society - <u>particularly in the area of physical science</u>. Dr. Hornig has suggested two needs to maintain the pace of progress in science; (1) learn to <u>talk to</u> laymen, and (2) our educational system must include an understanding of science, <u>along with</u> literature and history, as part of our culture. The time has certainly come to teach

1. Ferry, William H, "Must We Rewrite the Constitution to Control Technology," Saturday Review, March 2, 1968, page 50.

chemistry as one of the humanities since it is the basic science underlying so many of our natural sciences; such as medical science, geology, life sciences, agricultural chemistry and pharmaceutical science.

Some of the ways a chemist or chemist-educator might help decrease scientific illiteracy are as follows:

1. Develop (or encourage those who are trying to develop) for the upper elementary science curriculum some "new chemistry" teaching units which would introduce concepts in a palatable way and systematically build toward later courses in high school and college. This might get at parents in the current general public as well as the public of the future.
2. Two-year colleges and other colleges could make a great effort to educate, scientifically, the non-science oriented student. The two-year colleges have a unique opportunity to make a great contribution in this area.
3. Chemists and chemistry teachers should get out and talk to laymen.
4. Develop some unusual interest motivating devices to aid in the above three points.

How do you talk to laymen? How do you talk to non-science oriented students (at any level)? How do you get "new chemistry" units quickly accepted?

I really am not qualified to speak about all the ways, but I do know that you certainly need their attention. Perhaps we could somehow relate our topic to current activities of the life and times - such as the popular music and dance of the 1960's. It has certainly been used by the radio-TV (and even written) media to successfully advertise everything from medicine and toothpaste to automobiles, hair lotion and even bulk chemicals.

You may remember one brand of cornflakes advertised by music and dance called "Doin' the Flake", and, of course, "Things go better with Coke". With such success, one might wonder why this has not been used in teaching.

I asked myself that same question about 1-1/2 years ago, and with your indulgence, let us briefly consider an approach to teaching molecular vibration concepts using popular music and dance as interest motivating devices. It is my feeling that this topic should be taught in all kinds of courses for at least four very important reasons:

1. Qualitative identification of unknown molecular species (use of the singularly powerful tool known as the infrared spectrophotometer).
2. Quantitative determination of the number of molecules in a sample (Beer's Law).
3. Evaluation of such fundamental physical constants as distance between atoms in molecules (bond lengths and bond angles).
4. Helps explain theoretical heat capacities.

You might begin by suggesting that if higher forms of life are found in outer space, they will probably resemble us in at least the aspect of having some form of dance. You could point out that all lost tribes on earth have had at least the common trait of some simple form of music and dance, even if nothing more than beating on a log and stamping their feet. Because of this similar trait, some observers have suggested there is a mystic rhythm which permeates the universe, and that man subconsciously seeks to imitate this rhythm in his forms of dance. It

could then be further suggested, tongue-in-cheek, that chemists have finally explained this "mystic" rhythm as being the ceaseless vibrations of the invisible molecules. If your audience does not believe you, prove it to them by showing them how easy it is to choreograph a dance based on the way molecules vibrate. I have prepared a movie to demonstrate this.*

The title of this movie is "How to do the Molecule." It is a silent, super 8 mm, color film of eight minutes duration. One could add a magentic strip and dub in his own comments and music by using the proper type of projector.

It shows how to do some steps as to a new popular style dance called "The Molecule." It illustrates 8 vibrational motions of such common molecules as water carbon dioxide, methane, ethylene and ammonia. It then shows how these motions are simulated by hand and arm movements which are the "steps" of the dance. It also includes several points to remember about molecular vibrations and four reasons why molecular vibrations and other motions are so important. After getting the attention of the student, these last four reasons serve as "lead in" material for another hour and fifteen minutes of lecture.

The dance steps are summarized in Table 1. The points and reasons for importance are as follows:

<u>Points to Rember</u> (in the film)

1. Molecules vibrate ceaselessly.
2. One molecule may vibrate several different ways.
3. Each mode of vibration in a molecule has its own "speed" or frequency: For example: CO_2 molecules "bend" about 20,000 billion times in one second and H_2O molecules scissor at about 48,000 billion times in one second and symmetric stretching of H_2O molecules occurs about 110,000 billion times per second.
4. Each molecule has its own <u>set</u> of several modes of vibration. Example: H_2O molecules have a different set of vibrations than CO_2 vibrations.
5. Molecules vibrate in the gas, liquid, or solid state.
6. Molecules of a gas may vibrate <u>and</u> rotate while moving through space.

<u>Why are Molecular Vibrations Important</u>

1. Qualitative identification of unknown chemical species and determining the structure of molecules.
2. Quantitative determination of the number of molecules in a sample.
3. Evaluation of distances between atoms in molecules (bond length) and bond angles.
4. Helps explain how molecules absorb heat and light energy.

A phonograph record has been made. It is a 45 RPM disc of a song called, "Molecules-A-Go-Go", written by myself and Tim McCabe (a young professional musician and Atlanta recording artist).** Tim is the vocalist, and the band is called The Swinging Electrons. Some of my students suggested such names as Dalton and The New Atomics, Infrared and The Good Vibrations, as well as Einstein and the Relatives. The seven minutes of music have lyrics which describe molecular vibrations in go-go terminology. It may be the first attempt at educational go-go. It uses the GO-CHEM RECORDS label.

* Copies of the movie are available from the author at cost. Address: Dr. Donald Hicks, 3002 E. Ramble Lane, Decatur, Georgia 30033.

** Available from the author.

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After spending ten to fifteen minutes to develop interest, one could use other more formal audiovisual aids and lecture on such ideas as:

- How fast do molecules vibrate?
- How many motions does one molecule have?
- How is this related to the infrared spectrum?
- Why is it important? Why are rotational and translational motions important?
- What are some examples from current research in inorganic, organic, analytical, and physical chemistry?

I should like to emphasize that the use of levity does not mean you do not teach a topic with some depth of content. In less than 2 hours of my own lecture time, I try to tie together a great many things including Beer's law, equipartition of energy, theoretical molar heat capacities, how to evaluate bond lengths, and all the other things mentioned above.

This material was developed as a pilot project for Project REACT (Research for Educational Aids in Chemistry Teaching), or as I sometimes call it, Project CHIC (Chemistry Is Culture). It is hoped that films under Project REACT would be developed such that each teacher could record his own, or a prescribed set of comments on a magnetic stripe. Classroom autonomy would thus be maintained. One of the aims of the project is to make it possible for a great many scientists around the country to more easily make levity-involving public relations speeches. Devices, such as the film and the record should enable even the least interesting of us to give a reasonably entertaining talk to a public audience.

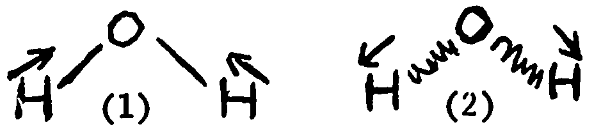
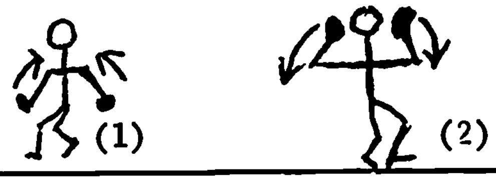
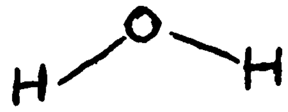
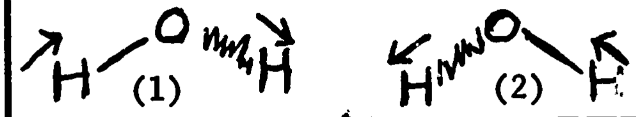
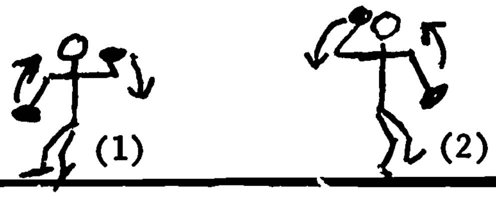
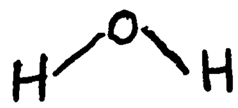
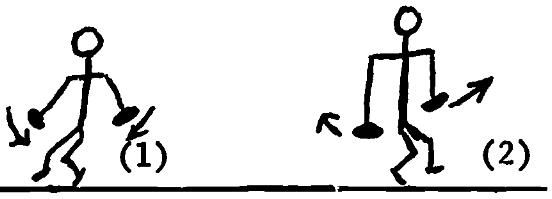
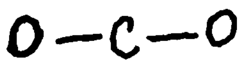
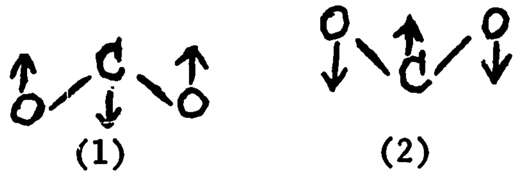
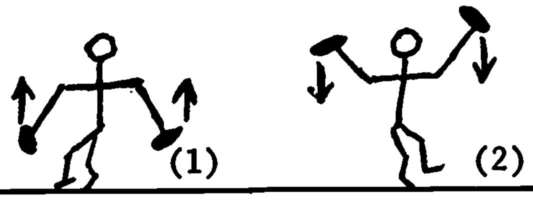
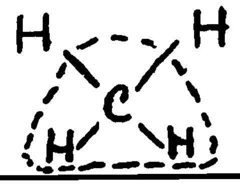
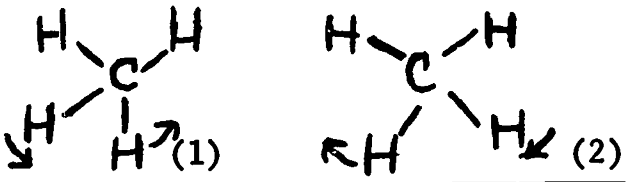
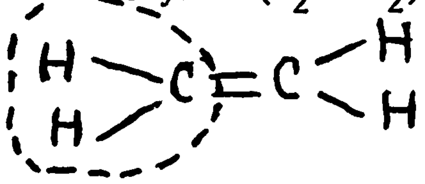
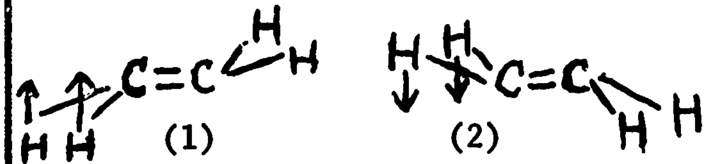
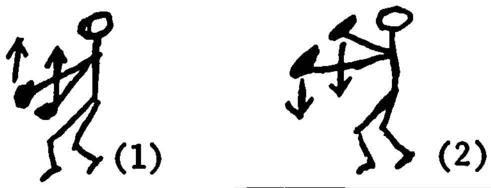
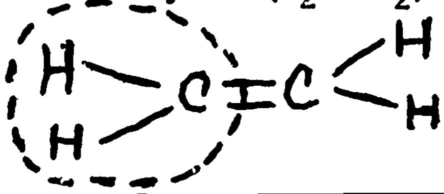
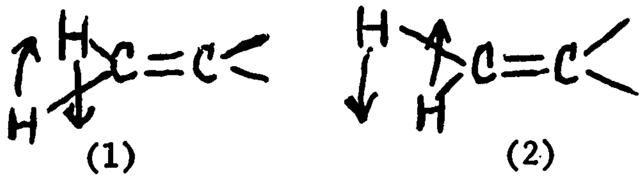
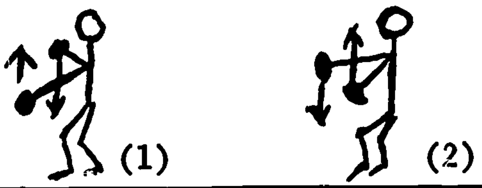
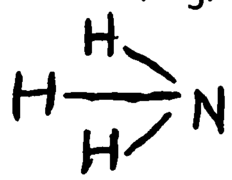
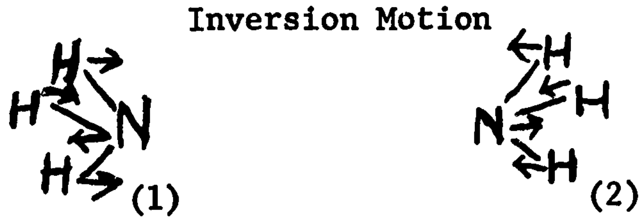
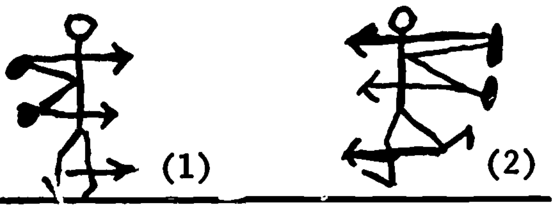
May I close by challenging you to make some of your own films like this? I am certain that you can do it if I can! Your imaginations are just as good as mine.

Special Note: A 27-page copy of the approach used in lecturing about the importance of molecular vibrations and other motions is available for 25¢ (mailing, etc.) from the author.

Table I

"THE MOLECULE"

Below is a description of the steps to a popular new dance based on imitating vibrational motions of some common molecules. The vibrational motions consist of successive changes between positions 1 and 2 below.

Molecule (General shape and average position of atoms)	Actual Molecular Motion	Dancer Motion Simulating the molecular motion.
Water (H_2O) 	Symmetric Stretching Motion 	
Water (H_2O) 	Asymmetric Stretching Motion 	
Water (H_2O) 	"Scissoring" Motion 	
Carbon Dioxide(CO_2) 	Bending Motion 	
Methane(CH_4) 	"Rocking" Motion 	
Ethylene($H_2C{=}CH_2$) 	"Wagging" Motion 	
Ethlylene($H_2C{=}CH_2$) 	"Twisting" Motion 	
Ammonia (NH_3) 	Inversion Motion 	

Second Southern Regional Conference

Discussion Chairman - Richard Gregg, Ohio College of Applied Science

First Eastern Regional Conference

Keynote	- William Porter, Temple University Technical Institute
Section Co-chairmen	- James Brown, Corning Community College
	- Howard Ayer, Franklin Institute of Boston
Discussion Chairman	- Morris Lieff, Middlesex County College
Recorders	- Gustav S. Rook, Lincoln College of Northeastern University
	- Dominic Macchia, Middlesex County College

Eighth Annual Conference

Chairman	- Peter C. Jurs, Merritt College
Recorder	- Robert J. Carr, Merritt College

A LABORATORY PROGRAM IN CHEMICAL ENGINEERING TECHNOLOGY

William Porter
Temple University Technical Institute, Philadelphia, Pa.

If we could review the history of the growth of associate degree programs in technical subjects, I think we would find that our current curricula have evolved from courses which were quite vocational. For example, mechanical engineering technology may have evolved from older drafting and design programs; electrical and electronics engineering technology may have evolved from the older electronics technician courses which were quite vocational in nature. The current courses represent an improvement in previous courses in that there has been an evolution from the "how-to-do-it" approach to a more academic curriculum which includes science and mathematics, as well as applications courses which include applications of mathematics and engineering science. The status of the engineering technician has been established in industry and the need for the graduate of an engineering technologist program is recognized.

I am not sure that this is true in the case of the chemical technologist and the chemical engineering technologist. In practice, we find that many people who have been hired in industry as laboratory technicians have been those who failed in a baccalaureate program or who for some other reason had to drop out. Thus, the chemical technician is often thought of as the person who "couldn't make it" in a standard chemistry program.

In many cases, the chemical technology program is given by a chemistry department which is also giving work towards a bachelor's degree. The chemical technology students are often enrolled in the same courses as the baccalaureate degree students. This may be necessary due to the size of the enrollment. However, care must be taken that the chemical technology students are given courses in a way that prepares them for their chosen vocation rather than be enrolled in the same courses as students who are expecting to continue for a B.S. degree. We must also beware of any trend towards regarding an associate degree in chemical technology as a "booby prize" for the person who could not complete a B.S. program.

In general, the student who is enrolled in a B.S. program is considered to be training for a career as a scientist. There is a high probability that he will go on to graduate school. On the other hand, we expect the graduate of an associate degree program to go immediately into a work situation where he will be concerned with performing various jobs in the laboratory or chemical plant. The associate degree program must be set up so that the student will receive the information he needs, will develop the appropriate work skills and will develop mental habits which will enable him to be successful in a job situation.

Laboratory work must be a significant part of the associate degree program. After all, most graduates of a chemical technology or chemical engineering technology program will at least start their work careers in the laboratory. Many of them will spend their entire working life in a laboratory or in laboratory related work.

What are the objectives of the laboratory courses in the technician's program? I would suggest the following list:

1. The development of good laboratory technique in the use of common laboratory equipment and procedures.

2. The development of good work habits in the laboratory, including the ability to organize time, maintain a neat work area, record results properly, etc.

3. The development of the ability to do laboratory calculations and to relate them to laboratory work. The student should be able to make calculations which are necessary in starting a project (amounts of materials needed, solution strengths, etc.), to perform calculations during the experiment, and to process the data obtained.

4. The technician should be able to relate chemical facts and theory to his laboratory work in order to understand what is happening in the test tube and to handle difficulties which arise in the laboratory.

5. The laboratory work should help develop an understanding of chemical theory.

There may be some who question whether or not there is a great difference between objectives four and five. I believe that the difference between the two represents the difference between the B.S. program in Chemistry and the Associate Degree program. Most people teaching chemistry look at the laboratory courses as a means of reinforcing the learning of theory. However, in the technology program we are concerned with being able to use knowledge of basic science as a tool in the laboratory to explain what is happening in the reactor.

During the past year, the staff of the Chemical Engineering Technology Department at Temple University Technical Institute has made some extensive changes in our curriculum. This has been necessary because of administrative changes in the Institute. To be truthful, it has allowed us to bring our published curriculum in line with what we have actually been doing, since we have been continually making small changes in our courses.

We have tried to develop a laboratory sequence which first enables the student to develop a sound basis of laboratory technique. Then in later courses, more time can be devoted to showing what is going on in the various experiments.

In most cases, the laboratory courses are administered separately from the lecture courses. There are several reasons for this:

1. Instructors who have a strong interest in laboratory work can be assigned to teach these courses.

2. The instructor will be less inclined to limit himself to material covered in the lectures, but rather he will draw experiments from any area which will be appropriate to the course.

3. The student who does well in the laboratory will be able to get full credit in terms of a grade for his laboratory work. There is sometimes a tendency in combined lecture and laboratory courses to discount the laboratory work somewhat in determining the grade.

In several instances we have scheduled the laboratory in a semester following the semester in which the lecture material is given. This eliminates the need for coordinating laboratory work with the lecture. It also serves to reinforce knowledge gained in the lecture.

Next fall, we will be offering a revised six semester, 92 credit hour course in Chemical Engineering Technology. This will include the following laboratory work:

> In the first semester the course in Techniques of Chemistry will introduce the student to common laboratory operations and measurements. This will include weighing, separations, temperature measurement, qualitative analysis, etc.
>
> The second semester will be devoted to non-instrumental quantitative analysis. This is the only case where the lecture and laboratory are combined. In the laboratory, the student will perform common gravimetric and volumetric analyses. In addition, he will prepare compounds which he will analyze.
>
> Two laboratory courses will be given in the third semester. One course will be devoted to chemical preparations. In this course, the student will be able to use a variety of procedures to prepare organic and inorganic compounds.
>
> The second course will be a computation and laboratory course concerned primarily with the handling of data obtained in the laboratory. This will include some elementary statistical work, graphing of data and obtaining equations from laboratory data. The experiments used are kept as simple as possible in terms of equipment and procedure, and they are designed to produce as much data as possible in a short time. For example, all the students are asked to analyze a chloride sample by the Fajans method using a laboratory supply of silver nitrate. In reality, they all have the same salt and therefore they can use statistical methods to analyze data. Simple kinetics experiments, pressure-volume relationships of gases, etc., are used to obtain data which can be used to produce data for graphing and computation of constants in equations.

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In the fourth semester, the students have laboratory work in physical chemistry. They are expected to apply the principles learned in the chemical computations laboratory to data obtained in physical chemistry experiments. Emphasis is also placed on measurement techniques. More stress is placed on proper preparation of reports.

Applications of Instrumental Analysis is given in the fifth semester. We try to avoid the "black box" approach to this subject. Emphasis is on the use of components and relatively simple instruments to assemble an instrumental system. It is important for the student to recognize what chemical properties are being measured and how they are measured.

The sixth semester laboratory course is devoted to studying chemical engineering equipment such as heat exchangers, pumps, etc.

In summary, I feel that the main emphasis in a chemical technologist program should be on developing an "applications" oriented person. This does not mean that he operates "black boxes" or is a "cook-book" chemist. He has a solid background in mathematics, science and technical subjects which he uses to help him adjust to new developments in his field. At Temple, we have tried to develop a program which will produce this individual.

A COMPARISON OF COMMUNITY COLLEGE AND TECHNICAL INSTITUTE PROGRAMS

J. L. Brown
Corning Community College, Corning, New York

I would like to stress similarities and differences between chemical technology programs as they exist in the community college and in the technical institute. In particular, attention will be given to the nature that is indigenous to the chemical technology curriculum in the community college.

There are distinct differences between education in the community college and education in the technical institute. This is true of the chemical technology curriculum as well as others.

In many instances, the chemical technology curriculum has been a '<u>Johnny Come Lately</u>' to the programs of the community college. The typical community college, at least in many areas, begins with almost 100% transfer programs. Faculty are hired and curriculum is organized with this in mind. The fundamental reasons for this are obvious: 1) it's cheaper to begin programs of this type and 2) the college is often in temporary quarters during its early years and does not have the facilities to operate the technical programs. Once this pattern of transfer orientation permeates the college, it is difficult to change. The chemistry curriculum usually includes the classic transfer courses of general chemistry, organic chemistry, and quantitative analysis and it is around these that any potential chemical technology program is built. Not only are the same courses utilized for technical as well as transfer students but in most cases, the same sections and the same laboratories. The technology curriculum, particularly in the beginning, may enroll only ten or twelve students and economics is completely against the setting up of additional courses or duplicating those already present.

The concessions to the technician training, if any, usually require the student to take more chemistry courses than his transfer oriented counterpart. In addition, he may be also required to take instrumental analysis, physics and a rather heavy dose of mathematics. In some instances, he may take technical report

writing, graphics, or unit operations. However, the core of his program is still transfer oriented. Even in those community colleges which began as technical institutes and have recently added a liberal arts curriculum, many of the so-called chemical technology courses have taken on a transfer orientation almost over night.

Even when enrollment may reach a level where the technicians can justifiably be placed in a course designed specifically for them, the rationale for allowing this to continue is easy to understand. The most often given reason is that the technical student will transfer at some future time. If he has gotten through a curriculum of this type with any degree of success, he certainly has the ability to transfer. In effect, he may be jeopardized if he does not receive the comparable courses. Other reasons for not changing to a more occupational oriented curriculum include finances, faculty opinions or even opinions of the advisory committee members who often relate to their own training when discussing what is best for the education of a technician. As a result, the technicians from the community college frequently obtains "half or more of a B.S."

Many of these factors do not exist in the technical institute and the resultant mobility and latitude which they enjoy may allow them to construct courses without regard to transferability. This is not to say that the students and the courses will not transfer. They frequently do transfer, but they are not designed with that in mind.

All other differences ultimately stem from this one basic difference in philosophy -- the community college concerns itself more with articulation with the four-year college than it does with job orientation. The technical institute takes the reverse stand.

The community college student is a distinctly heterogeneous animal. The summary surveys taken by student personnel directors or deans are frequently amusing. These invariably show the "typical" student to be carrying a certain number of credit hours, working so-many hours at a job, coming from this or that type of family with such and such educational background, etc. In fact, it is next to impossible to encounter Mr. Typical Student. It is reminiscent of the blind man describing the elephant by feeling various parts of his body. Many students work forty hours a week and many are not employed, but far fewer work twenty hours a week which might be the resultant average. It seems somewhat ludicrous for persons who are usually so concerned about individual differences to average students every year as they do.

A tremendous difference in abilities and aptitudes exist among community college students. This difference is not usually as extreme at the technical institute. For the most part, the public community college has a completely open-door policy.

Students are usually not turned away if they are high school graduates. Therefore, there may be some very bright students as well as very poor students. However, the very bright students are not usually found in great numbers in the technical programs because of pressures to pursue the transfer degree and consequent baccalaureate program. We all know what the pressures are: peers, parents, teachers, counselors, and society.

Some students enter the technical programs after being on campus for a semester or so and either become interested in chemistry through teacher or peer contacts or (and it is a second best reason) become disenchanted with another program. Many unqualified students are urged into chemical technology programs at the community college through misguidance at the high school level. High school counselors usually have an extremely fuzzy concept of what technology is. Their chief reasoning in promoting technical programs appears to be that if it only takes two

years, it must be about half as rigorous as the transfer program, which takes four years to complete. Therefore, they tend to encourage the "half-qualified student" to pursue the technical program.

As a result of these pressures and misinformation, the typical community college graduates about 25-30% of its entering freshmen.

In the technical institute, the student is usually better fitted to his program. Certain criteria have been established for admission: certain high school courses, certain levels of attainment, certain test scores, etc. If he meets admission criteria, he is accepted; if not, he does not have the opportunity to become a statistic of attrition. A much more homogeneous, better informed student body will result from this approach. Few compromises are made to enhance transfer prospects from the technical institute. The program is designed with an occupational goal. Within the college, the student is not subjected to the status or prestige factor of transfer vs. occupation. Attrition should be much lower and students should make, if not better, at least more stable technicians then those coping with the transfer syndrome. They probably stay longer on the job than the community college students do. Corning Community College has only been in business a short time in educating technicians and it is difficult to generalize. However, of the technicians that have graduated, approximately fifty per cent went directly to the four-year college from our program and all of the boys who went to industry left within a year to pursue the four-year degree. As of this time, only about twenty-five percent of the students trained as chemical technicians are actively employed and these are women. Incidentally, the boys who went to industry did not necessarily do so through their own free choice. They either could not get into a four-year college first because of poor grades or they lacked money.

The faculty of the community college is usually steeped in the liberal arts. Generally, they either come from high school teaching or four-year college teaching and do not understand technical education. The instructor in the technical institute has often worked in industry, if not as a technician he has at least been a supervisor of technicians. In general, he is more familiar with the demands of the job than is his community college counterpart.

The courses offered are much more predictable in a community college than in a technical institute. As mentioned earlier, few concessions are made by the college other than offering the usual chemistry sequence. Frequently, the chemistry or technical faculty may desire to develop innovative courses or programs to fit area industrial needs, but are strongly discouraged by the faculty curriculum committee which consider these courses as not being worthy of college credit.

In the technical institute, a broad spectrum of courses is found. In addition, the technical institute is generally much more laboratory oriented, having as many as six hours per week per course. However, many community colleges have laboratories that are very good both in types and in length.

Although the picture of technical education in the community college may appear rather glum, it is a realistic one. With it's rapid rush in all directions to be all things to all people, the comprehensive community college of today has precipitated almost as many problems as it has solved. One of those problems is technical education, particularly chemical technology. However, if the community college of today is guilty of error, we are happy that it is erring on the side of the student rather than industry. If the student's desires and abilities will take him through a four-year degree then we should prepare him to move in this direction as well as making a decent technician out of him.

Discussion Points

1. If transfer to programs in chemistry and chemical engineering is an objective, then junior chemists, not career chemical technician are being trained. Frequently low quality students are taken into chemical technology programs requiring high quality students with undesirable results such as high attrition rates.

2. The fact that poor students and dropouts are getting jobs as chemical technicians was considered by some as sufficient evidence that chemical technician training is not needed. Others emphasized that the need for personnel having some technical competence is so extreme, that practically anyone with a little technical background can obtain a job with a title of chemical technician.

3. When geographical conditions permit, colleges offering chemical technology programs should cooperate in developing their respective programs and recruiting efforts.

4. Good industrial liaison improves a college's understanding of the chemical technology program and its products. Both instructors and students should have close industrial contact.

5. Some colleges have reduced use of complex concepts and calculus to provide education more specifically for technicians and eliminate the "one-half of a B.S. program" approach. Companies looking for someone to become a manager will usually be happy with someone who can titrate.

6. Technicians should be included in groups advising the college on its chemical technology program. More emphasis should be placed on the relationships between the salaries received by good technicians and B.S. chemists. The importance of advanced degrees for chemists should also be made obvious to potential chemical technicians.

7. Student recruitment is improved by direct contact between the chemical technology staff and high school students. However, there is a great need for industrial representatives to make their needs known to the high school students as part of the recruitment program. An example was cited where three chemical companies brought over one hundred guidance counselors to a company site for dinner and discussion of chemical technician training and opportunity. Many people feel that guidance counselors are not sufficiently prepared to offer occupational guidance.

8. Some companies appear unwilling to provide adequate salaries for chemical technology graduates. Others provide a large salary gap between the high school graduate and the two-year college graduate. Most schools have no difficulty placing graduates with some being able to place ten times the number of students that graduate.

9. Some high schools may seek to provide a special type of science instruction for students that should consider technology careers. Students with low success in college chemistry and veterans may be good sources of more students.

10. Many chemical technology students have trouble with reading and mathematics. Thus, they fare poorly in most transfer oriented courses or courses that contain substantial quantities of theory. Separate courses for technicians are advisable. Generally, the theoretical level of the courses is below that of the transfer courses.

11. Technicians must be able to communicate and should be exposed to courses other than chemistry. Students are frequently motivated to considerable greater efforts by getting jobs in industry and cooperative work-education arrangements should be considered. Their course work should not be highly theoretical, but it must be up-to-date and application oriented.

12. Topics not in traditional chemistry courses should be included. Among these are first aid, laboratory safety, chemical toxicity, professional societies, notebooks, patents, library usage, seeking and choosing jobs and employe-employer relationships.

13. Entrance requirements to chemical technology programs ranges fron only high school freshman algebra to two and one-half years of college preparatory mathematics and high school chemistry.

14. The ACS suggested curriculum in chemical technology (C&EN, May 20, 1967) is difficult to evaluate since the depth of coverage is not indicated.

MULTI-CAMPUS DISTRICTS AND SYSTEMS

Second Southern Regional Conference

Chairman: J. Smith Decker, Phoenix College

First Eastern Regional Conference

Chairman: Herman Stein, Bronx Community College
Recorder: June Buckley, Bronx Community College

Eighth Annual Conference

Chairman: Ethelreda Laughlin, Cuyahoga Community College
Recorder: Celia Mae Scott, Seattle, Washington

Discussion Points

1. Operations are frequently made complex where a central administration controls all audiovisual work, all personnel, all purchasing, all curriculum, and all budget. Inter-communications become extremely important, particularly, with the purchasing department. A good working relationship should permit obtaining purchase order numbers which can be telephoned to suppliers for emergency situations.

2. Most campuses appear to have some freedom regarding the improvement of teaching chemistry. On some campuses, two percent of the budget is set aside for experimental approaches to teaching and the incorporation of new educational approaches. Industry and industrial applications should become involved in innovative efforts whenever possible.

3. Many campuses are being given great autonomy and little coordination takes place. There was a strong feeling that the department should have complete control of prerequisites and instructional problems in its discipline rather than have these matters controlled by an administration.

4. Forty-seven two-year colleges reported budgets for supplies and equipment as follows:

Budget	Number	Percent
Up to $2,000	4	8.5
$2,000 - $4,000	13	27.7
$4,000 - $6,000	11	23.4
$6,000 - $8,000	6	12.8
$8,000 - $10,000*	13	27.7

* Range -- $8,000 to $47,000

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SMALL COLLEGES

Second Southern Regional Conference

Chairman: Lewis Barbre, Paducah Junior College
Recorder: John T. Taylor, Westark Junior College

First Eastern Regional Conference

Chairman: Edward Eagan, Quinsigamond Community College
Recorder: Richard Burke, Worcester Junior College

Eighth Annual Conference

Chairman: Harold Richwine, Jr. (on leave, Imperial Valley College)
Recorder: Reynold J. Kero, Imperial Valley College

Discussion Points

A. What Should We Do About The Low Enrollment In Sophomore Chemistry Classes? Should These Courses Be Taught? Administration Needs Education In This Area.

1. Students are concerned with maintaining a grade point average that will get them into the four-year school and often delay taking the rigorous second year courses.

2. Counseling is often a problem. The incoming freshman is told he needs English 1-A, History 1-A, Psychology 1-A, etc., and often does not start his chemistry sequence until his sophomore year. Students that may be of questionable ability may be steered clear of chemistry based on the personal experiences of the counselors while they were taking chemistry. Thus, the number of students in our first year programs is lessened.

3. Students often become bored because of the low amount of interesting work in chemistry with too much theory being taught early in the course. Thus, many of the students drop or change their major.

4. Is the work load killing off the students? Should we give less work and better grades to compete with other fields?

5. What about the text book being used? Does this have a great effect on the number of students who drop or continue on in the field? People attending these sessions had used many different text books, but had experienced the same problem with the second year courses so this does not seem to be the major cause of the problem even though it may contribute to it.

6. Does the sequence of offering the second year course start at a time of year when not all students have completed the first year requirements? This would present a more acute problem to those

teaching a full year of Organic Chemistry, as an example, than it would for a school offering only one semester where it could be scheduled for the spring semester.

7. Do the students actually have to spend three years at the two-year school to have enough time to take all of the courses they need which would then permit sufficient time to allow them to take the second year chemistry courses?

8. Is the accessibility of four-year schools a factor?

9. Has the open-door policy influenced the caliber of students and contributed a factor in the percentage of the total student body that takes chemistry? While the rate of growth in the number of students has been tremendous, the growth in the number who take chemistry has shown only a modest increase.

10. We may have to make our classes more intersting and, thus, encourage more of the students to continue even though the work load is killing them and they could get a better grade with less work in some other discipline and have a more attractive GPA for the four year schools to examine.

11. Maybe, we should offer more introductory courses in Summer Schools so that a greater percentage of the entering Freshmen would be ready to start their Chemistry 1-A, 1-B sequence, and be ready for sophomore courses when they become Sophomores.

12. What are the goals of the students and are the four-year colleges really listing what they want their students to have in the field of chemistry before they start their related, specialized field at the four-year college?

B. Correlation With The Four-Year Schools On Different Time Schedules And Articulation Of Courses

1. Many of the two-year colleges have gone or are going to the quarter system where four-year schools are working this transition.

2. Students should be told that, if, they have taken one semester of a course that is offered for three quarters at the four-year school, they should start with the second quarter course if they have hope for success.

3. The four-year colleges will allow us to teach more of the sophomore courses as they become more interested in the higher-powered courses. This seems to have been the trend in the past. We can now teach a year of organic because they want their students to have it for biochemistry.

4. We should offer whatever courses we are able to teach and the four-year schools will have to take what we give them. More and more of the first two years are being spent at the two-year schools and

studies have shown that we must be doing as good a job as the four-year schools or at least it would appear so because our transfer students are doing as well at the junior level as the students who spent the first two years at the parent institution.

5. Most of the problems we have with the four-year schools disappear when we face them on a personal basis and if we confront the members of the Chemistry Department across their desk, there no longer seem to be problems that cannot be settled. They will usually bend over backwards to help.

C. Organic Chemistry Emphasis In The Small Colleges

1. Organic Chemistry should be offered at the Junior College.

2. We should look towards teaching a full year of organic chemistry and not just one semester as most of the Junior Colleges offered in the past.

3. As the four-year schools become more interested in teaching biochemistry instead of organic chemistry, they will not only give their consent to our teaching the full year of organic chemistry, but also will encourage our doing so, in the hope, that their beginning students will be ready for biochemistry.

4. Morrison and Boyd seems to be the most popular Organic Chemistry text with Roberts and Caserio climbing rapidly. If Dr. Caserio's laboratory manual is used, instrumentation is required. Use of instrumentation at the sophomore level requires a large sacrifice of time. The trend, because of this, is toward fewer experiments done better.

D. Extent Of Use Of Instrumentation In Quantitative Analysis

1. Quantitative Analysis seems to be on the way out, but it will be over the objections of the small college chemistry instructors, MCA, and Industry.

2. It was agreed that instrumentation should be used not only in quantitative analysis, but in all courses.

3. Instrumentation is better understood with higher frequency of use, and its use become more meaningful to the student as the varied applications of the instruments is demonstrated.

4. Classical quantitative analysis should also be taught since it provides an excellent opportunity to review solubility product equilibrium, acid-base reactions, etc. It seems there are no other courses in which these are adequately covered.

5. The great care and exactness that is needed in quantitative analysis is invaluable in other laboratory courses, and is readily observable in physical chemistry classes. The opinion was expressed that wet

chemistry and chemistry techniques will be needed for development of methods of analysis, controls, and standards used by the instruments. There is a need for the knowledge of <u>why</u> , but if you have button-pushers, it is not as necessary to know <u>why</u> in the eyes of industry.

E. Do We Need A Second Organic Chemistry Course For The Non-Chemistry Major?

1. Does the student-load in chemistry warrant it?

2. Maybe, this course should be offered to enhance second-year enrollments as more students will feel they have a better chance of success in this type of course.

3. Some schools indicated they were presently offering both a short course and a full organic chemistry course.

F. How Much Physical Chemistry Should We Teach In The Freshman Courses?

1. Thermodynamics is given in Chemistry 1-A, the first quarter of chemistry at many universities.

2. We should include more thermodynamics, but less quantum theory. Kinetics, dynamics and reaction-mechanisms should be included.

3. We need more of a quantitative emphasis, but do we have to go to quantum mechanics and Schrodinger equations to do it?

4. Should we have calculus as a prerequisite? If so, where are the students to get it?

G. What Is The Status Of Quantitative Analysis At The Two-Year College?

1. This course is still a requirement at some of the four-year schools.

2. The students need quantitative analysis to gain laboratory techniques for physical chemistry.

3. Should we integrate quantitative analysis with our freshman chemistry?

4. Does quantitative analysis teach some real chemistry that is not acquired anywhere else?

5. Quantitative analysis is real chemistry and creates interest. It may develop a desire for some students to become chemistry majors.

6. The double exposure in lecture and laboratory is helpful to the students even if they do get some of it elsewhere.

7. In the instances where quantitative analysis courses are being dropped, is it in the interest of good education or is it being done for economic reasons?

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LARGE COLLEGES

Second Southern Regional Conference

Chairman: William Griffin, Hinds Junior College
Recorder: Wayne Zumwalt, Rock Valley College

First Eastern Regional Conference

Chairman: Henry Muller, Dutchess Community College
Recorder: Douglas Bauer, Mohawk Valley Community College

Eighth Annual Conference

Chairman: James Ice, College of San Mateo
Recorder: Jerome K. Holmes, Hartnell College

Discussion Points

Faculty:

1. A problem of grave concern is that many two-year colleges count laboratory time, as compared to classroom (lecture) time, on other than a 1 to 1 basis. As a result of this, the faculty members in chemistry are required to teach a larger number of contact hours than a faculty member in a non-laboratory area, such as mathematics. Those present felt that the question of liability was an important point to consider in determining the laboratory to class hour ratio. In most institutions, instructors are covered by only a small liability policy, if any at all, yet they are asked to instruct for a longer period of time than the faculty member in an area not involving any potential student accident.

   The general feeling of the group was that the laboratory to class ratio should be one to one.

   It was recommended that recruitment begin as early as possible.

2. The first concern in hiring a faculty member is that he be a good teacher. A Ph.D. may not necessarily be an indication of this. The suitability of an applicant's background for a position should be determined in the light of the courses he will be teaching.

3. What are the advantages of having faculty rank? Answers given to this question are summarized as follow:
   a) It gives the faculty member professional status.
   b) It is advantageous to have in seeking another position.
   c) It allows for a method of structuring salary levels.
   There were two schools of thought on this matter. Some people felt that this provided an excellent method for structuring a salary scale, while others felt that salary and professional rank should be completely separate so as to allow for more flexibility on the part of administration.

4. One suggested way of increasing the effective use of the faculty was to involve them in teaching large lecture sections via team teaching. It was felt that this procedure allowed the faculty member more time to prepare a meaningful lecture for the would not have to prepare each and every lecture. It was also felt that team teaching would

gather together faculty members of different backgrounds and areas of specialization and the result would hopefully be a much more rewarding learning environment for the students. It was pointed out that there still exists in many colleges the problem of how a team teaching situation is to be counted in determining faculty load.

5. It was felt that recitation sections are extremely important when a large group of instruction is used. If there is no possibility of scheduling formal recitation sections, it is suggested that the first part of the laboratory be used for this purpose.

6. A number of colleges report that they now employ full-time technical assistants who take care of pre-laboratory preparations, aid the faculty member in instruction of the laboratory, prepare for and aid in classroom demonstrations as well as in student evaluation. At least one college indicated that they employ people with bachelor's degrees to teach their laboratories while people possessing higher degrees are responsible for lecture and recitation sections.

7. Some differences in financial renumeration during the sabbatical leave year were reported. Some colleges give half pay for a full year or full pay for one semester. The percentage of faculty permitted sabbatical leave is generally in the range of two-four percent per year. Some colleges represented have no sabbaticals given.

Students:

1. At one college, prerequisites for honors course in general chemistry are: five years high school math, high school chemistry, and high school physics. The ACT English test appears to be the best indicator for success.

2. To section students in first-year chemistry, the Toledo test is used by some two-year colleges in California. A score of 45 is often used as a dividing point. Those making less than this score take a less rigorous course.

3. It was thought that instrumentation might help maintain student interest. Proper use of film helps and good demonstration techniques would also help.

PRIVATE TWO-YEAR COLLEGES

Second Southern Regional Conference

Discussion Chairman - Jack Howard, Cumberland College
Recorder - Paul Inscho, Hiwassee College

First Eastern Regional Conference

Discussion Chairman - C. G. Vlassis, Keystone Junior College
Recorder - W. L. Mills, Spring Garden Institute

Discussion Points

A. Students Lack Proper Background For Chemistry

1. The obvious answer is screening. This requires close cooperation with admissions and counseling personnel. It was suggested that the Physical Science and Engineering Aptitude Test be administered.

2. The best teaching should be in freshman chemistry. If teaching is ineffective and laboratory facilities inadequate, the students turn to something else. When the teacher is good, even students with a

poor background can be enthused and much learning can take place. Improving interest in chemistry at the high school is a responsibility someone must assume.

B. What Text Book Should Be Used?

The relative merits of four college Chemistry text books were discussed. These included: Snyder, Milton K.; CHEMISTRY STRUCTURE AND REACTIONS: Holt, Rinehart & Winston, Inc., N.Y., 1966; Quagliano, James V.; CHEMISTRY: Prentice-Hall, Inc., N.J., 1964; Hamm, Donald L.; CHEMISTRY - An Introduction to Matter and Energy: Appleton-Century-Crafts, N.Y., 1965; Mahan, Bruce H.; COLLEGE CHEMISTRY: Addison-Wesley Publishing Company, Inc. Reading, Mass., 1966.

C. What Should Be The Course Sequence For Transfer?

1. It was agreed upon by most of the participants that the two-year institutions should not attempt to specialize in chemistry. We should teach the basic chemistry courses (such as: freshman chemistry, organic chemistry, or analytical chemistry). The topics of freshman chemistry could include periodicity, gas laws, stoichiometry, structures, quantum theory, equilibrium, kinetics, and some thermodynamics.

2. Analytical chemistry should include some instrumentation, but not as a course in electronics. Students should have some physical chemistry before going deeply into instrumentation.

3. It was further agreed that by giving the best instruction possible and making students out of what we have is our most important goal. If we can teach students to use the library, think for themselves and do independent work, then, the specialization in the junior and senior years will be easier, regardless of their chemistry background.

D. How Much Instrumentation Is Necessary?

Instrumental analysis should be included in first and second years chemistry courses.

E. At What Level Should Course Be Taught When Abilities Of Students Are Stratified?

1. If one teaches for the worst students, everyone is held back. Teaching for the average students helps neither the poor nor the gifted. Therefore, by teaching to the good student and hopefully pulling up the average students more people will benefit.

2. One suggestion was to separate the good students in laboratory and work with them. The problem would be early selection for good laboratory sectioning.

3. A good English major will do well in chemistry as he probably has the ability to read and comprehend. His writing ability should also be a great asset in laboratory. It was emphasized that a good student in one subject will probably be a good student in all courses. Mathematics might be the exception.

4. An interesting question was whether or not high school chemistry helped a student do better in college chemistry. Some felt that it did not help because the student would not work as hard in college chemistry, feeling that he had had it in high school. However, it was indicated that too much depends on the type of course offered in high school for this question to be answered.

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5. Mr. William Mooney, Chairman of the Two-Year College Committee, Advisory Council on College Chemistry, interjected a comment about a questionnaire which might be sent to high schools, two-year colleges, and four-year institutions to determine what to expect of entering chemistry students. This questionnaire could help answer the question of what should be included in college chemistry. Mr. Mooney felt that if a student knew 70% of the material presented on the questionnaire, it would make college teaching more meaningful.

6. The reaction to this questionnaire was favorable. Suggestions were also made about helping students make the transition between high school chemistry and college chemistry. These were:

   a. Have a summer course of review chemistry.
   b. Give a zip course in general chemistry in first semester and start college chemistry in second semester.

   It was pointed out that many schools do one or both of these now.

7. Another question was asked about a physical science course which could be used to alleviate forcing students to take the technical courses, such as, chemistry. Dr. Vlassis discussed the course in physical science offered at Keystone Junior College. It is a two semester course of eight credits and integrates the basic principles of physics with astronomy. The course has three lectures per week and one three-hour laboratory per week. Experiments used include - determining the size of a molecule, keeping accurate accounts of the weather, and inspecting the spectra of various compounds and triangulation.

F. What Should Be The Organization Of The General Chemistry Course?

1. Should course be a survey of general, organic and biochemistry? If the course is for non-science majors and if transferrable, it might be okay for a science.

2. Should the course be equal to that of a four-year institution's course? This again seemed to reflect back to the entire theme of the $2YC_3$ meeting. We need to know how much instrumentation the four-year colleges are putting into the first two years of chemistry.

3. It was suggested that the two-year chemistry teachers buy as much equipment as possible whenever the money is available, even if the equipment is not used immediately. It was further suggested that administrators continue to cut teaching loads so that instructors have enough time to spend on incorporating the instruments into the courses.

4. Mention was made of a survey (completed at the University of Texas) reporting that two-year chemistry students transferring to four-year schools lost a fraction of a grade point the first semester.

G. Are Community Colleges A Detriment To The Private Two-Year Colleges?

Many of the people felt that they would present a problem in terms of a percentage increase of students enrollments but that the number of students in all schools would continue to increase. Some two-year institutions are rapidly changing to four-year colleges or are changing to community colleges.

Instrumentation Reported at Thirty-Four Private Two-Year Colleges

Instruments	Per Cent Colleges Reporting Use			
	1st Year Chemistry Courses	2nd Year Chemistry Courses	Other Chemistry Courses	Used for Demonstration Only
ph meter	60	46	17	11
gas chromatograph	9	14	9	3
spectrometer	17	14		9
spectroscope	17	14	6	
colorimeter	11	14	11	3
spectrophotometer	6	11	9	3
refractometer	14	14	11	
potentiometer	9	14	9	6
radio-isotope apparatus	17	9	3	9
recorder	9	14	9	
vacuum pump	40	31	20	9
polarimeter	3	20	11	
melting point apparatus	31	37	11	
hydrogenation apparatus	3	9	6	3
furnace	20	31	11	
infrared and mass spectrograph		3	6	3
conductivity bridge	9	3	11	3
fraction collector		6	3	
tensiometer		6	6	
analytical balance	86	63	17	6
electrolysis apparatus	57	17	11	17

APPENDIX A

General Chemistry at the College Level

At the 1967 ACS Middle Atlantic Regional Meeting, part of the Chemical Education program directed attention to General Chemistry. This session provoked considerable discussion. It was particularly appreciated by the two-year college chemistry faculty who were present and suggested that the papers be made more available to the two-year college community. Through the kind cooperation of the authors, it is a pleasure to present the following papers. (Ed.)

THE ROLE OF DESCRIPTIVE CHEMISTRY IN THE MODERN GENERAL CHEMISTRY COURSE

Prof. R. D. Dresdner
University of Florida
Gainesville, Florida

(Prepared in consultation with Prof. Harry Sisler)

There has been a strong trend in recent years for general chemistry curricula to bend in the direction of physical and theoretical chemistry and the attention given to descriptive chemistry, as it pertains to the physical and chemical properties of elements and their various compounds, tends to have been proportionately neglected. In some text books this type of descriptive chemistry has virtually disappeared. This is not to say that such books are poorly written or are scientifically incorrect in any way; they are frequently not what they claim to be, namely general chemistry text books. Even with the current trends in chemical education that suggest curricula which do not divide the subject matter into so-called traditional branches of chemistry as has been proposed by Professor Hammond of California Institute of Technology and more recently seconded in the Journal of Chemical Education by Professor Young of Kings College, Wilkes Barre, the place of descriptive material in the curriculum will continue to be vital.

The idea of fusing theoretical and descriptive material is not a new one. In 1943 Professors H. H. Sisler and C. A. Vanderwerf published a paper in the Journal of Chemical Education entitled Modern Theory: A Tool in Teaching Modern Chemistry. I quote from this paper,

> "We should never lose sight of the fact that a theory, as Sir Joseph Thompson was wont to say in his classes at Cambridge, is a tool and not a creed, and it certainly should not be the theoretical tail that wags the pedagogical dog. But it is the authors' contention that the use of modern concepts clearly stated and repeatedly applied greatly simplifies the study of practical chemistry, providing as it does, the continuous thread upon which otherwise isolated and incoherent facts may be strung to weave the fabric of a logical, unified and integrated course. Such treatment is probably better suited to develop the students reasoning power and to encourage his spirit of scientific inquiry than is the mere memorization of facts. A student trained in such an approach carries with him a broad picture into which new facts may be fitted, a ready tool by use of which additional knowledge may be interpreted, and a clear signpost pointing in the direction of further "truth", rather than a loose bundle of unrelated facts which slip the memory one by one. A clear cut distinction must be drawn between fact and theory, but the student must be made to realize that should a present theory be discarded for a better one, it will probably have been the present concept which has fashioned the better implement and that the latter can best be understood and utilized by those who were thoroughly familiar with the former."

Although the authors state that the ideas are not necessarily unique, they point out there is ample room for using modern theory to improve chemistry curricula offerings and procede to outline several examples of what can be done in this vein.

Surely, the revelation of the modern concepts of the structure of matter in terms of simple qualitative and more sophisticated quantitative models is one of the great contributions of the human intellect to society. Understanding these concepts and becoming a part of the education tradition that fostered them should present a stimulating challenge and give deep intellectual satisfaction to the participants in the process.

Since the above article was published, there has been a complaint that new books in general chemistry, have tended to increase the content of theoretical material at the expense of experimental facts and the description of chemical experiments. Part of this trend can probably also be ascribed to various attempts to include certain areas of classical analytical chemistry in the general chemistry programs. The consequence is that further pressure is exerted to cut out materials to accommodate this trend. If this tendency is not resisted by text book writers, general chemistry books will become elementary physical chemistry text books, as, indeed, some have been.

In October 1967, there was an editorial in the Journal of Chemical Education which carried the initials WTL (which I attribute to Professor Lippincott of Ohio State University). This editorial called for a new look at what we, as chemistry teachers, have been doing that is causing so many good students to change from science to non-science careers. He states that "while this migration is not restricted to chemistry and undoubtedly has causes other than those related to course content and quality, it is difficult to believe that students would abandon an initial interest if the course offered the opportunity and challenges they expected. In the light of apparent inadequacies in modern undergraduate courses, and reflecting back to some of the more successful features of <u>traditional</u> course, we wonder if the blend of rigorous theory and factual chemistry in modern courses has not become just a little too rich in the former to be compatible with the maturity and experience of the undergraduates."

As a means of finding some solution to the dilemma of moving too far in the direction of theoretical chemistry or too far in the direction of encyclopedic recall of chemical facts, a set of principles and assumptions can be stressed to guide us in finding some compromise.

1. Chemistry is an experimental science.
2. Theories arise from observations not <u>vice versa</u>.
3. Students in elementary chemistry should gain an understanding of how chemists solve scientific problems.
4. Some descriptive chemical knowledge is intrinsically valuable even though there may be considerable choice of this material. Perhaps the choice should include the familiar enviromental and life processes.
5. Students should gain not only a knowledge of the value of scientific activity but also be assessed of its limitations.
6. Chemical information and knowledge is increasing exponentially
7. Bold and new approaches to the problems of both teaching and learning in science are emerging.
8. The background of entering college freshmen in chemistry and allied areas appears to be continually improving.

Thus the teacher and the writer working together have the tools, motivation, and students to deepen and broaden the general chemistry course. The key to success then is balance, balance between the undergirding principles and concepts and the descriptive chemistry upon which the principles and concepts are based. Our aim then should be to exploit every advantage of modern principles and concepts and to utilize the student's improved background in developing a balanced treatment of chemistry. Familiar material to the chemist such as atomic and molecular structure, and bonding, can provide the basis for a discussion of the structure and properties of various types of solid materials which have been scientifically categorized. Although we stress a valance bond treatment of the description of molecules, introduction of simple molecular orbital theory allows for an explanation of the properties of the oxygen molecule and those of certain simple odd molecules such as NO. The quantitative treatment of chemical reactions, of reaction kinetics, of simple thermodynamics and of chemical equilibrium can be taught as the basis for understanding the way in which contemporary chemists think and work.

Chemistry is an experimental discipline. Theory takes on meaning and value for the student only as it is applied in the explanation, correlations and systematization and hopefully in the prediction of descriptive facts in chemistry. The materials relating to a systematic study of the elements and their more important and more interesting compounds should be presented in a systematic manner based on the modern forms of the periodic table. The properties and reactions of the elements and their important compounds should be consistently related to the position of the element in the periodic table and recorrelated with the theories and concepts and structural relationships previously described. In these cases repetition is to be regarded as helpful rather than redundant.

Emphasis could be given to the halogens, the nitrogen-phosphorous family, and carbon and silicon among the nonmetals. The alkali, alkaline earth and aluminum family metals can be considered and studied as one comparative unit. The transition metals, the chemistry of the complex ions, noble gas chemistry and boron hydride chemistry can be treated with respect to description, nomenclature, structure and bonding within the limitations of time. The choice rests mainly with the teacher.

Selections of material and mode of presentation should be consistently geared to the students' needs in subsequent courses in chemistry and to some extent to his current professional area of interest. Accordingly, within the framework of any given general chemistry course, organic and biological chemistry may be offered not only for their vital relations to everyday life and for their vocational value to large numbers of students but also because these fields provide superb examples of the relationships between structure and other properties. For the more motivated student, the descriptions of acid-base chemistry in non-aqueous media could be useful in a course in analytical and certain areas of organic chemistry.

Care must be exercised not to cover a great deal of new advanced material for the sheer sake of covering material. This can leave the student with no genuine command of the subject but merely the attitude that "he has had all that". Accordingly some selectivity is essential.

Writing a book which emphasizes fundamental principles and which builds on supposed previous experience presents a great problem. There is no one block of material which the majority of freshmen may have had which can rightly be neglected in a general chemistry course.

Examples of the successful merging or balancing of theoretical materials with descriptive chemistry can be found in two chapters in the third edition of Sisler, Vanderwerf and Davidson. These deal with the topics, The Relationships of Properties to Structure and Bond Type; the Metallic State; the Chemistry of Oxygen and Its Compounds; Water and Hydrogen Peroxide. In the former chapter, types of crystaline solids, namely, ionic, nonpolar molecular, polar molecular, covalent network crystals, C and SiC, and metallic crystals are discussed using models and concepts to account for their various properties such as melting points, boiling point, density, conductivity and hardness. It also introduces or reintroduces the ideas behind bond polarity, dipole moment, dielectric constant and the effect of electronic and geometric structure on the polarity of covalent molecules introduced in earlier chapters. The chapter on Oxygen reintroduces the previously discussed concepts of ionization energies and electron affinity to help account for the properties of oxygen. The text points out that the valence bond description of the oxygen molecule is inadequate to account for the high bond energy and paramagnetism of the oxygen molecule. A simple molecular orbital description is used to help account for these properties in a more meaningful model, in terms of the concepts of antibonding orbitals, Hund's rule and bond order. The descriptive areas in this chapter include the preparation of oxygen from a variety of sources including electrotrolysis and the rectification of air and the chemical character of oxygen in its reactions with many metals and nonmetals. The oxides are categorized as being basic, acidic or amphoteric which leads to the elementary definition of acids and bases and their behaviour. The concepts relating acidity, structure and neutralization are also introduced.

Allotropy is presented in terms of the ozone modification. The concepts of thermochemistry, structure and reasonance which appear in earlier chapters are invoked to explain the nature and behavior of ozone.

Along with a description of the structures of water and ice and the anomalous properties of the hydrogen compounds of oxygen, nitrogen and fluorine, the concepts of hydrogen bonding is explored to help clarify the anomalies. Some bonding concepts are reintroduced in the description of solid hydrates. The ion-dipole interaction and coordinate covalent bond are reconsidered and hydrogen bonding to sulfate and nitrate ions as well as ammonia is mentioned. The properties of heavy water are given some consideration. The chemistry of hydrogen peroxide is discussed, particularly its preparation, its structure, and the structure of the peroxide ion as contrasted to the dioxide system and the acidic natures of this hydride.

The chapter on Oxygen covers an array of important subjects of a descriptive and theoretical nature. Nevertheless, it can be covered thoroughly in two 55 minute lectures. Many of the other chapters in the book dealing with the chemistry of the elements and their compounds are treated in the same complete manner giving balance to experimental and theoretical material. We feel, then, that descriptive chemistry has a real and significant role to play in the teaching of modern general chemistry and should not be neglected or overemphasized.

SOME OBSERVATIONS AND OPINIONS ON THE CONTENT OF THE ONE-YEAR COURSE IN GENERAL CHEMISTRY AT THE COLLEGE LEVEL

Prof. William L. Masterton
The University of Connecticut
Storrs, Connecticut

There is continuing controversy concerning the emphasis to be placed on descriptive chemistry in the general chemistry course. The various points of view in this area are too well known to deserve repetition here. I should, however, like to make three points which perhaps have not been emphasized in previous discussions.

1. Those of us who teach general chemistry are primarily responsible for the trend toward a reduction in the coverage of descriptive material. We should be frank enough to admit that most of us prefer to teach principles rather than facts. There is nothing unethical or immoral about this; we do our best teaching when we present material which is most interesting to us and in which we are most competent.

2. Many of us have been teaching long enough to remember the days when the introductory chemistry course consisted mainly of descriptive inorganic chemistry. If we are honest, we will admit that our students absorbed very little of what we presented. I recall a comment by one of my better students to the effect that, if he remembered correctly, the gas dissolved in pressurized cream containers was "NaOH". It is my opinion that the amount of inorganic chemistry which the student learned in the "good old days" was not greater than it is today.

3. We are unlikely to teach descriptive chemistry effectively so long as we bore students by wading through the Periodic Table, group by group. I do not want to minimize the use of the Periodic Table as a correlating concept, but I do object to its use as a framework around which descriptive chemistry is organized. It makes little sense to me to discuss in sequence the chemical properties of elementary nitrogen, ammonia, and nitric acid, three quite dissimilar substances. I prefer to organize descriptive chemistry around types of reactions (precipitation, complex-ion formation, acid-base reactions, redox reactions). With such a framework, it is easier for the student to integrate chemical principles with their applications. Clearly, there are other ways in which this purpose could be achieved. We must continue to explore ways of presenting descriptive chemistry more effectively.

There is one trend which has accelerated in the past few years which I find somewhat disturbing. This is the increased emphasis on structure in the general chemistry course. I wonder if we should spend time discussing the hydrides of boron and the halides of sulfur with students who are unable to derive Lewis structures for species as simple as ClO^- or N_2H_4. It seems strange to find text books devoting more than half of a chapter on coordination chemistry and ligand field theory with little or no material about the properties of coordination compounds, the methods by which they are prepared, and the reactions they undergo in water solution.

Another area of increasing emphasis in general chemistry is that of thermodynamics. I am optimistic enough to believe that beginning students can grasp the meaning of such concepts as entropy and free energy change and can see how important they are to an understanding of chemical reactions. However, I think that if we are to present thermodynamics to freshmen, we have to do it in a more imaginative way than the classical approach involving heat engines and Carnot cycles. I get the impression that many of the chapters on themodynamics in general chemistry texts have been abstracted from more advanced texts without any attempt to make the material pertinent to chemistry. We must realize that we do not have sufficient time to present thermodynamics in the traditional manner, no matter how logical that may be. We must address ourselves to such questions as

How can we predict, from first principles, the signs and magnitudes of ΔH, ΔS, and therefore ΔG, for a particular reaction?
How do we use free energy data to predict the spontaneity and extent of a reaction?
How can we use thermodynamic principles to predict quantitatively the effect of a change in external conditions (temperature and pressure) on the feasibility of a reaction?

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Finally, I would urge that we devote more time in general chemistry to a comparatively neglected area, that of chemical kinetics. This topic is too important to dismiss with the excuse that our students have not had calculus. If we can teach thermodynamics to students who have never heard of a partial differential equation, we can teach elementary kinetics to our students, most of whom are taking calculus concurrently. The concepts of rate and mechanism are so important in the areas of coordination chemistry, nuclear chemistry, and organic chemistry that they deserve far more emphasis than we now give them.

FRESHMAN CHEMISTRY TODAY AND TOMORROW

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During the past decade or so, introductory college chemistry has undergone great change. There is abundant evidence that this period of change is not over and that the most drastic reforms are yet to come. Among the causes of this complex phenomenon, we may identify the following continuing trends.

1. Because of the current expansion of higher education in the United States, there are now many more college students exhibiting wider ranges of abilities, preparations, interests, and needs. This expansion, together with its attendant educational problems, has also inspired the development of new educational techniques and devices.

2. The level of secondary-school instruction in the sciences has been raised, and is being raised, to an impressive degree. The future will probably bring far more widespread and thoroughgoing change in high-school chemistry programs.

3. Chemistry itself is rapidly growing and appears to be undergoing changes in organization.

The first-year college chemistry course is caught between pressures from below, stemming from the large number and diverse nature of entering freshmen, and from above, originating from the demands of higher chemistry courses as well as the growth and changing character of the subject itself. Few would propose that standard and uniform curricula be established for every rung of the educational ladder -- diversity is one of the strong points of the American educational system -- but there is an urgent need for closer articulation between high school, college, and graduate school.

At a given college, seldom can one single freshman chemistry course meet the needs of all of the students. Introductory college courses must be designed for the particular college under consideration; the design must take into account such factors as the type of students enrolled, their vocational objectives, the educational aims of the institution, the facilities available, and the structure of the advanced work in the sciences.

Without going into all of the subclassifications that may exist at a large institution, four general types of student may be identified:

1. The well prepared and highly motivated. Such students are usually either placed in an advanced, or honors, course in which an enriched program is offered or are awarded advanced placement.

2. The science student with average preparation. This group is usually the largest.

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3. The relatively poorly prepared student who has scientific interests. Types 2 and 3 are frequently placed together in a single course, although some large institutions may divide this group into sections according to preparation.

4. The nonscience student for whom a terminal course is required. Few colleges have so homogeneous a student body that they need offer only one freshman course, and the future is likely to bring more diversity rather than more unity.

The pressures on freshman chemistry from above stem from newer developments in advanced subject fields. At times, material must be added to the first-year course to serve as preparation for the later coverage of these newer topics. At other times, simple aspects of advanced work trickle down to the freshman level to make room higher up. Thus, the so-called "information explosion" influences freshman chemistry; this influence, however, is not exerted to the degree nor in the manner that many people think that it is.

The editors of Chemical Abstracts estimate that the total amount of published chemical information approximately doubles every 8.3 years. In the minds of some, this phenomenon constitutes a "wisdom explosion;" at the other end of the scale, it is thought of merely as a "word explosion." As is usually the case, the truth probably lies somewhere between the two extremes; "information explosion" seems to be the most apt label.

Undoubtedly, this condition prevails in all of the sciences. Physics is experiencing the same problem. On January 27, 1968, the American Institute of Physics announced the start of a million-dollar project to explore information storage and retrieval systems designed to handle and assimilate the growing mass of physics information. This AIP study follows the pioneering work of the ACS.

George Gammow in his book Thirty Years that Shook Physics (published in 1966) says:

> But, after thirty fat years in the beginning of the present century, we are now dragging through the lean and infertile years, and looking for better luck in the years to come . . . . Let us hope that in a decade or two, or, at least, just before the beginning of the twenty-first century, the present meager years of theoretical physics will come to an end in a burst of entirely new revolutionary ideas similar to those which heralded the beginning of the twentieth century.

How ironic a description of an age in which the AIP expresses great concern about the burgeoning growth of physics information! To historians of science, important new ideas or really fundamental discoveries are not appearing today at a greatly increased rate; the rate of change in basic scientific theory is nowhere near that of the logarithmic expansion of published scientific information.

In recent years, few of the concepts traditionally taught in freshman chemistry have been abandoned or radically changed; few directions of chemical thought have been significantly altered. Rather, the impact of the "information explosion" on the first-year course comes about through the trickling-down process.

Once it is recognized that the problems that the "information explosion" exerts on the freshman chemistry course are, in large measure, ones of organization, certain things fall into place. The freshman chemistry teacher must avoid rushing to revise his course so as to incorporate every dramatic new discovery as it is announced. The impact of new discovery on the subject is rarely that direct. Instead, the teacher should ask: "does my course prepare the student to appreciate this topic fully when it is presented to him in its rightful place in later work?"

Some of the glamorous new work should indeed be included; such topics can do much to catch student interest and show where chemistry can lead. However, such work cannot be covered at the expense of a thorough grounding in fundamental principles. The "information explosion" has made it mandatory that the composition, organization, and presentation of the course be geared to efficiency and optimum use of time.

What are the functions of introductory chemistry? The need to supply a sound basis for subsequent work has already been mentioned. This need, however, does not preclude covering certain topics at a level, and to a depth, such that these topics need not again be exhaustively presented at a later time.

A secondary function, but an important one, is that of providing an introduction, an aerial survey, or a large and constantly expanding field. A survey can help to show what chemistry is all about, how its parts fit together, where it is going, why it is significant, and where within it an individual student can find a place that suits him. The nature of chemistry is such that there is almost something for everyone within its domain, and the first-year course should attempt to interest a significant proportion of its students to continue in the discipline.

Studies show that a very small amount of the material taught in a course is assimilated and retained by the student unless he makes constant use of the material after the conclusion of his course. On this basis, therefore, it would seem to be much more important that freshman chemistry emphasize the appreciation of the methods and reasoning of chemistry rather the memorization of its descriptive facts. Nevertheless, these facts, which should be taught in a conceptual framework, are necessary; they provide a student with a basis for sound chemical reasoning.

Futhermore, most chemists have a type of intuition which springs from a knowledge of descriptive facts. When the average chemist hears the work "carbonate", a host of impressions automatically subfuse his mind. He may not realize it, but he is instantly attuned to the idea "carbonate" -- their reactions with acids, the alkalinity of their solutions, their solubilities, etc. This chemical intuition is indispensable for advanced, independent study and is not acquired by ignoring descriptive chemistry.

The freshman course also has a responsibility to present chemistry in its relation to other fields of human endeavor. Max Lerner says:

> "Scientific research seems most understandable to Americans as an ascetic endurance contest or a criminal manhunt or a success story -- as anything, in fact, except the penetrating simplicity of intellectual insight . . . . The common man wants a universe which is closed and comfortable, compact and finished. The universe of the scientist is still an expanding one, discontinuous and open."

The typical entering student wants to know the answers and wants to skip the preliminaries. But truth is only approached, and science consists of the successive refinement of mental constructs about nature. Chemistry is a dynamic discipline, not a deal accumulation. The rift between the two cultures is too important to be completely ignored; the sciences, as well as the nonsciences, have an obligation to show how their disciplines fit into the totality of man's knowledge, experience, and culture.

What about the future of freshman chemistry? Freshman chemistry will probably continue to become more quantitative, and more classical quantitative analysis will become incorporated into the laboratory programs. Qualitative analysis has virtually disappeared as a separate course. Despite cries for its complete demise, it will probably remain, in the near future, a part of introductory instruction. One would hope that new fire can be breathed into the laboratory instruction so that the relevance of qualitative analysis to modern chemistry is more clearly demonstrated.

The mathematical preparation of entering freshmen will continue to improve; however, in the immediate future, it is not likely that a rigorous calculus approach can be used for the rank and file of students. That select group that enters college with preparation in the calculus will probably continue to be handled by advanced placement or honors courses. Introductory chemistry could be far more sophisticated if the level of the mathematical preparation of the entering students was raised, and the trend is in this direction; however, significant change appears to be at least a few years away.

At the present time, far less than 50% of the high-school students in the United States are enrolled in honors programs or special programs in chemistry. The recent dramatic high-school curriculum reforms have been far from universal; the majority of high-schools have scarcely been touched. In the immediate future, it seems likely that the freshman chemistry programs of most colleges will have to continue to be designed to accommodate a student body that is highly diversified in regard to preparation.

The greatest impact of the changes in the nature of the subject and its students is probably still in the future. It is not too difficult to imagine that at some time in the future the functions of traditional freshman chemistry can be taken over by the high school completely. The first-year college course could, at that time, emerge as a physical chemistry course, for that is the direction in which freshman chemistry is headed, or an inorganic, instrumental, or organic course. Let us hope that the increase in the level of mathematical preparation in the high schools keeps pace with the increase in the level of chemical preparation, and that some acceptable level of preparation in both mathematics and chemistry becomes the norm for most students.

In the distant future, another prospect may loom. All scientific fields are expanding and probably at much the same rate. One is hard put to identify the boundaries of chemistry, physics, and biology, all of which face similar educational problems as they merge. In the future, it may be that there is no Chemistry I, Physics I, or Biology I but rather a Structure of Matter I taught not by a Chemistry, Physics, or Biology department -- for such may not exist -- but rather taught by a Structure of Matter department.

DIVISION OF CHEMICAL EDUCATION

AMERICAN CHEMICAL SOCIETY

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The JOURNAL OF CHEMICAL EDUCATION occupies a highly respected position in the world's chemical literature. Its role as the "Living Textbook of Chemistry" is fulfilled by presenting review articles on new developments, innovations in classroom and laboratory instruction, book reviews, and information about new apparatus and instruments.

The EXAMINATION COMMITTEE of the Division maintains and continually modernizes a battery of carefully constructed tests for high schools, colleges and universities. College and university tests cover the various fields of chemistry at both the graduate and the undergraduate level.

The TWO-YEAR COLLEGE CHEMISTRY CONFERENCES (2YC$_3$) have been initiated and supported by the Division. These conferences have brought together teachers of the two-year colleges to discuss their common problems. Through the Division this rapidly growing segment of chemical education is represented in planning and directing the course of chemical education at the national level.

A SMALL GRANTS PROGRAM was started in 1967. Through this program chemistry teachers may apply for several hundreds of dollars for testing, developing, or evaluating novel ideas for chemical education. A grant recently received from the DuPont Company assures its continuation as the Division of Chemical Education-DuPont Grants Program.

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