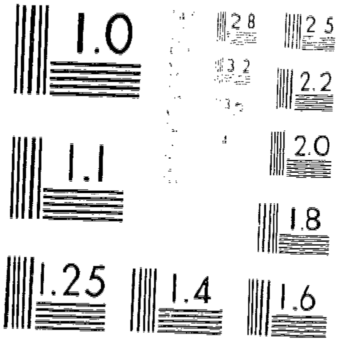


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

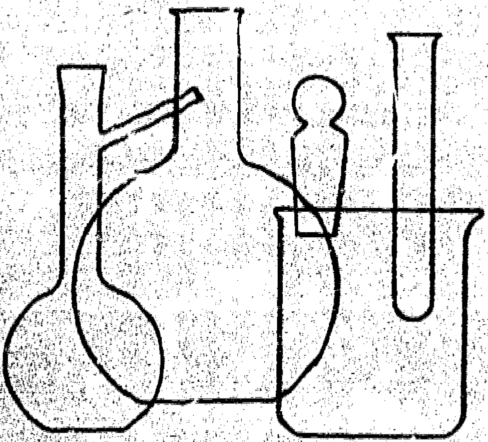
DOCUMENT RESUME

ED 128 220 SE 021 317

AUTHOR	Chapman, Kenneth, Ed.
TITLE	Chemistry in the Two-Year College, 1972 No. 2.
INSTITUTION	American Chemical Society, Easton, Pa. Div. of Chemical Education.
PUB DATE	72
NOTE	98p.; For related documents, see SE 021 314-320
EDRS PRICE	MF-$0.83 HC-$4.67 Plus Postage.
DESCRIPTORS	*Chemistry; College Science; Community Colleges; *Conference Reports; Conferences; *Curriculum; *Higher Education; *Instruction; Junior Colleges; Science Education

ABSTRACT

This publication, issued twice per year, includes proceedings from Two-Year College Chemistry Conferences and papers of special interest to the two-year college chemistry teacher. In this issue, content and curriculum of first-year courses and nonmajor courses are discussed, and special instructional methods in chemistry involving the computer are described. Other topics include health-related chemistry courses, chemical technology courses, the chemistry-biology interface, and chemical aspects of the relationship between science and society. (MH)



CHEMISTRY
IN THE
TWO-YEAR
COLLEGE

1972 NO.2

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

Industrial-Commercial Supporting Members (1972)

Academic Authors, 873 Ninth St.
Manhattan Beach, Ca 90266

Allyn & Bacon, 470 Atlantic Ave.
Boston, Ma 02210

W. A. Benjamin, Inc., 2725 Sand Hill Rd.
Menlo Park, Ca 94025

Burgess Publishing Company
426 So Sixth St., Minneapolis, Mn 55415

Canfield Press, 850 Montgomery St.
San Francisco, Ca 94133

Carle Instruments, Inc., 1141 East Ash Ave.
Fullerton, Ca 92631

Chemical Technician Curriculum Project
Lawrence Hall of Science, Berkeley, Ca 94720

Computer Based Instructional Systems
4303 Woodway Drive, Austin, Tx 78731

Computer Design Corporation, Suite 1830
One Embarcadero Center, San Francisco, Ca 94111

Thomas Y. Crowell Co., 666 Fifth Ave.
New York, NY 10019

Curtin Scientific Co., P.O. Box 1546
Houston, Tx 77001

Dickenson Publishing Company
16561 Ventura Blvd., Encino, Ca 91316

Eastman Kodak Company, 343 State St.
Rochester, NY 14650

GOW-MAC Instrument Company
100 Kings Road, Madison, NJ 07940

Hamilton Publishing Company, Suite 123
El Paseo, Santa Barbara, Ca 93101

Harcourt Brace Jovanovich
Polk & Geary Streets, San Francisco, Ca 94109

D. C. Heath and Company, 125 Spring Street
Lexington, Ma 02173

John Huley Associates, 343 Sycamore Ave.
Merion, Pa 19066

Instruction for Research & Industry
108 Franklin Ave., Cheltenham, Pa 19012

Kontes Glass Company
Vineland, NJ 08360

McGraw-Hill Book Company, 1221 Avenue of the Americas
New York, NY 10020

Chas. E. Merrill Publishing Company
1300 Alum Creek Dr., Columbus, Oh 43216

Mettler Instrument Company
Princeton-Hightstown Road, Hightstown, NJ 08520

Nagle Company, 75 Panorama Creek Drive
Rochester, NY 14625

Prentice Hall, Sylvan Avenue
Englewood Cliffs, NJ

Rinehart Press, 5643 Paradise Drive
Corte Madera, Ca 94925

Sargent-Welch Scientific Company
1617 E Ball Road, Anaheim, Ca 92803

W. B. Saunders Company, W Washington Square
Philadephia, Pa 19105

Scott Foresman & Company, 1900 E Lake Avenue
Glenview, Ill 60025

Smith and Underwood, 1023 Troy Court
Troy, Mi 48084

Spectrex Corporation, 3594 Haven Ave.
Redwood City, Ca 94063

Technicon Instruments
Benedict Avenue, Tarrytown, NY 10591

The Torsion Balance Company
35 Monhegan Street, Clifton, NJ 07013

Varian Instrument Division
611 Hansen Way, Palo Alto, Ca 94303

Wadsworth Publishing, 10 Davis Drive
Belmont, Ca 94002

John Wiley & Sons, 605 Third Avenue
New York NY 10016

Willard Grant Press, 53 State Street
Boston, Ma 02109

Xerox College Publishing
191 Spring Street, Lexington, Ma 02173

Wilmad Glass Company
US Route 40 & Oak Road, Buena, NJ 08310

Table of Contents

First Year Course Content and Curriculum

Non-Major Course Content and Curriculum

Special Instructional Methods in Chemistry — Computer

Special Topics Health Related Courses

Special Topics Chemistry Biology Interface

Special Topics Science and Society

Chemical Technology Courses Content and Curriculum

FOREWORD

This second volume of the 1972 edition of Chemistry in the Two-Year College is the fourth volume to be published under this logo and format and the first to be prepared under the complete editorial supervision of Jay and Ellen Bardole of Vincennes University Junior College. We look forward to a long run of outstanding Chemistry in the Two-Year College volumes edited by the Bardoles as they assume this position of great responsibility for improving communication within the chemical education community of the community and junior colleges and our friends.

Readers of Chemistry in the Two-Year College should realize that the publication, the Two-Year College Chemistry Conferences reported herein, and the work of the Committee on Chemistry in the Two-Year Colleges and its subcommittees are sponsored by the Division of Chemical Education, Inc. of the American Chemical Society. 1972 is the twelfth year of Division activity in the two-year college field and, to the best of our knowledge, no other subject field discipline organization can show such a long and intensive interest in our work and our colleges.

The Division of Chemical Education is involved in improving chemistry teaching, with respect to both content and the communication of this information to students. To this end, it serves as a common meeting ground for the teachers of chemistry and their students, as well as others who are also interested in the larger aspects of chemical education. In addition, the Division includes within its purview those who are preparing for careers in fields related to chemistry, as well as those who study chemistry for its broad educational and cultural values.

These interests are served, notably, by the official publication of the Division, the Journal of Chemical Education, but other activities also serve: Summer conferences, summer institutes, the visiting scientists program, the consultants service, the small grants program, the two-year college program, participation in regional ACS meetings, special regional conferences, cooperation with similar groups overseas and in other countries of North America, cooperation with the Division of Science Teaching of UNESCO, sponsorship of comprehensive conferences and symposia dealing with broad aspects of chemical education, continuous on-going re-examination of curricular programs and problems, continuous attention to the teacher and his work, and notably, the Divisional meetings which are part of the semi-annual national ACS meetings.

In no less a manner, the Division is a liaison agent between high school and college teachers, integrating and extending their individual and collective efforts. With equal emphasis, the Division is concerned about the improvement of the professional dignity and responsibilities of teaching, in general.

The individuals who carry out these activities are recognized by the Division through the sponsorship, or co-sponsorship, of awards for outstanding contributions. Professional status is also encouraged by emphasis on research and other scholarly activities, and by the purposive development of a public attitude which leads to a better understanding and appreciation of the contributions of the teacher to our society.

Members are invited to participate in the standing committees of the Division. It is by this voluntary work that chemical education has been able to show a steady growth in the past, and by such future participation that it will continue to grow. Generally the committees of the Division each meet separately twice a year during and preceding the national meetings of the American Chemical Society. Visitors are always welcome at these working sessions. Almost any new idea or valid criticism of chemical education can be carefully considered at one or the other of these committee meetings. They are indeed a forum for chemical education.

Two-year college chemists are encouraged to join the Division of Chemical Education and participate in its programs and work on its committees.

The 1972 Two-Year College Chemistry Conferences were reviewed in the Foreword of the first volume for 1972 as was our program of cooperation with the Manufacturing Chemists Association. In this volume I would like to make note of the subcommittees of the Committee on Chemistry in the Two-Year College and their work during 1972. There were seven such groups holding open subcommittee meetings and workshop sessions at the various Conferences and carrying on studies and work by mail between the sessions.

The Chemistry for the Allied Health Programs Subcommittee, chaired by Ethelreda Laughlin, Cuyahoga Community College---Western Campus, has been developing a skeletal curriculum for the paramedical chemistry course.

The Behavioral Objectives for Two-Year College Chemistry Courses Subcommittee, chaired by Wanda Sterner of Cerritos College, has been concerned with the identification and evaluation of suitable behavioral objectives for our chemistry programs.

The Chemical Instrumentation for Two-Year Colleges, led by C. G. Vlassis, Keystone College, with considerable assistance from Gordon Williams, Monterey Peninsula College; W. G. Sink, Davidson County Community College; and Anthony Trujillo, San Joaquin Delta College, completed their study of the chemical instrumentation available in the two-year colleges and was preparing it for publication in the Journal of Chemical Education as well as planning the next phase of their activity at the end of 1972.

The Media for Two-Year College Chemistry Courses Subcommittee was continuing their identification of media projects, papers, studies and programs for the committee to consider under the direction of C. Herbert Bryce of Seattle Central Community College.

The High-School Chemistry---Two-Year College Chemistry Interface Subcommittee, Curtis Dhonau of Vincennes University Junior College in charge, worked during the year to develop models for cooperation between a two-year college and its feeder high schools.

The Recruitment for Chemical Technology Porgrams Subcommittee continued to identify and study various methods which colleges with chemical technology programs use to interest and attract students into these programs. Kenneth Chapman continued to lead their efforts even though he moved from the ChemTeC project in Berkeley to San Antonio.

The Teaching Chemistry in the Urban Community College Subcommittee activities directed by Louis Kotnik of Cuyahoga Community College---Metropolitan Campus expanded their activities during the year so Dr. Kotnik moved his work over to the Curriculum Committee of the Division where they became involved with the underprepared student in chemistry in any type of collegiate institution.

Chemistry in the Two-Year Colleges features papers and discussion summaries from the Two-Year College Chemistry Conferences and other conferences of interest to the two-year college chemistry faculty member. We also include other papers, submitted and invited, which we believe will serve the interests of improving the chemical education in the community colleges, junior colleges, technical institutes, and university branch campuses which we serve.

The papers in this issue deal with the content and curriculum for the first-year chemistry course for science majors, for the non-science majors course, and for chemical technology courses. A section is also devoted to special instructional methods in chemistry concerned with the computer. Three special topics sections have been included and these are concerned with Health Related Chemistry Courses, the Chemistry-Biology Interface, and Science and Society.

All two-year college chemists are invited to attend and participate in the Two-Year College Chemistry Conferences, to subscribe to *Chemistry in the Two-Year College* and to the *2YC3 Newsletter*, and to become actively involved in the work of the subcommittees.

William T. Mooney, Jr.

Chairman

Environmental Chemistry: A Topic for Freshman Chemistry Courses

H. Stephen Stoker and Spencer L. Seager
Weber State College, Ogden, Utah 84403

Presented at the Symposium on Innovations Involving Chemistry Teaching and the Environment, 30th Two-Year College Chemistry Conference, Corvallis, Oregon, June 16, 1972.

INTRODUCTION

The cry for relevance has echoed loudly across the academic scene during the past 5 years. In an attempt to calm students, taxpayers, and legislators, higher education has started to include "relevant" topics and courses in their offerings. In many disciplines courses have been manufactured to hopefully satisfy the mounting pressures. The manufacturing of relevant topics is not necessary in chemistry since such topics are available and waiting to be included in our programs.

Among the relevant topics suitable for chemistry courses are those dealing with the pollution of the environment. The increasing popularity of these topics has caused them to be discussed frequently and widely in the mass media. Indeed, the 1970's will undoubtedly be known to many as the environmental or ecological decade because of the wide coverage given the subject.

The general public, including college students, has, as a result, been exposed to the subject. Much of the presented material--especially that appearing in print--has been given from a position firmly entrenched on one side or the other of the issues, and objectivity has often been most obvious by its absence. As a result, many college students possess inadequate or exaggerated information about pollution problems. The lack of objectivity in written material was mentioned by the author of an instructor's manual for a recent freshman chemistry text. He found it difficult to recommend "responsible current books" as references to the text chapter dealing with the environment. As he put it, "too many adopt an exaggerated position."

It is important that college students of today in all disciplines have a proper perspective of pollution problems and solutions, for their attitudes, votes, and tax dollars will determine to an appreciable extent whether these problems are solved or not. Since most of the pollutants and solutions to pollution problems are chemical in nature, chemistry courses present a logical place to attempt to influence the students' ideas about environmental pollution. This paper deals with the approaches we have used to include environmental chemistry in the freshman courses taught at Weber State College.

TOPICS COVERED

The lack of objective reading material led us to compile a syllabus for student use. This syllabus has since been published by Scott, Foresman and Company in the form of a soft-bound supplemental textbook. In this text we have attempted to take an objective look at the problems of air and water pollution. We have tried carefully to present both sides of controversial issues, resorting in some instances to a list of the pros and cons surrounding a decision. The topical coverage in our courses closely parallels that contained in the textbook.

Table 1 shows the air pollution topics that are discussed. Each of the 5 main categories of air pollutants is included as well as the two common meteorological phenomena that are often associated with air pollution.

TABLE I

Air Pollution Topics

Topic	Textbook* Reference
General	
Unpolluted versus Polluted Air --A Comparison	Chapter 1
Specific	
Carbon Monoxide	Chapter 2
Nitrogen Oxides	Chapter 3
Hydrocarbons and Photochemical Oxidants	Chapter 4
Sulfur Oxides	Chapter 5
Particulates	Chapter 6
Temperature Inversions and the Greenhouse Effect	Chapter 7

*Environmental Chemistry: Air and Water Pollution, H.S. Stoker and S.L. Seager, Scott, Foresman and Co., 1972

The approach to each of these main topics is essentially the same, and is represented by the sub-topics given in table II. In each case the main emphasis is on the chemistry and chemical compounds involved.

TABLE II

Sub-Topical Coverage

1. Basic chemical reactions--formation of the pollutant
2. Sources of the pollutant--processes, industries, etc.
3. Fate of the pollutant after getting into the environment
4. Pollutant concentrations and distribution
5. Effects of the pollutant on vegetation
6. Effects of the pollutant on humans
7. Effects of the pollutant on materials
8. Possibilities for pollutant control

Our approach to water pollution consists of three main areas:

1. A comparison of unpolluted and polluted water
2. A discussion of the basic categories of water pollutants
3. A discussion of waste water treatment

Table III illustrates the water pollution topical coverage. The topics of detergents, insecticides, oil, mercury and leadare given particular emphasis since these are the topics familiar to most students as a result of mass media exposure. The subtopical coverage is similar to that used for air pollution.

TABLE III

Water Pollution Topics

Topic	Textbook*Reference
General	
Unpolluted Versus Polluted Water --A Comparison	Chapter 8
Specific	
Basic Categories of Water Pollutants:	Chapter 8
Oxygen-demanding wastes	Chapter 8
Disease-causing agents	Chapter 8
Plant nutrients--detergents	Chapters 8 and 11
Synthetic organic chemicals --insecticides	Chapter 12
Oil	Chapter 13
Inorganic chemicals and mineral substances--mercury and lead	Chapters 9 and 10
Sediments	Chapter 8
Radioactive materials	Chapter 8
Heat--thermal pollution	Chapter 8
Waste Water Treatment	Chapter 14

*Environmental Chemistry: Air and Water Pollution, H.S. Stoker and S.L. Seager, Scott, Foresman and Co., 1972.

PRESENTATION OF TOPICS

We have used two different methods to present environmental topics in the chemistry courses taught at Weber State College. In what we call the integrated approach, the environmental topics are integrated into the course throughout its entirety. They are inserted where they best fit in with the regular course topics. In our block approach, a specific block of class time is devoted to lectures dealing with environmental chemistry.

The integrated approach has been used in our three-quarter freshman sequence designed for those who plan to take further chemistry courses. This includes chemistry and other science majors, pre-medical and pre-dental students, and other health occupation majors. The block approach has been used in our terminal, one-quarter, general education course.

Tables IV and V show how the various air and water pollution topics fit into the normal topical coverage during the application of the integrated approach.

TABLE IV

The Use of Air Pollution Topics in the Integrated Approach

Air Pollution Topics	Regular Course Topics
Overview: Unpolluted versus polluted air--a comparison	Gases, Chemical composition of the atmosphere, Nitrogen chemistry
Carbon monoxide	Inorganic carbon-oxygen compounds
Nitrogen oxides	Nitrogen oxides
Hydrocarbons and photochemical oxidants	Hydrocarbons, Ozone
Sulfur oxides	Chemistry of sulfur
Particulates	Solids
Temperature Inversion	Gases: temperature-density relationship
Greenhouse Effect	Carbon dioxide

TABLE V

The Use of Water Pollution Topics in the Integrated Approach

Water Pollution Topics	Regular Course Topics
Overview: Unpolluted versus polluted water	Purification of water, Hard and soft water
Oxygen-demanding wastes	Chemical properties of oxygen, Solubility of gases in water
Disease-causing agents	Purification of water for health purposes, Chlorine chemistry
Plant nutrients	Phosphorus chemistry, Detergents, Fertilizers
Synthetic organic chemicals	Hydrocarbon derivatives, Chlorine Chemistry(organochlorine compounds)

Oil	Hydrocarbons
Inorganic chemicals	pH (acidity), Osmosis salinity, Heavy metals (Pb and Hg)
Sediments	Water purification
Radioactive Materials	Radiochemistry, Nuclear fission
Heat	Temperature and solubility, Density, Rates of reactions
Waste water treatment	Water purification

The sequence of the regular course topics varies from one textbook to another as shown in table VI. The supplementary environmental textbook is written so that the chapters are essentially independent and may be presented in any order. This allows it to be used in an integrated way with many of the freshman chemistry textbooks now available.

TABLE VI

Correlation Between Pollution Topics and Textbook Contents

Pollution Topics	Textbook Chapter in Which Pollution Topics Could be Used		
	Murphy-Rousseau	Mortimer	Sienko-Plane
Air Pollution			
General Considerations	Chapter 3	Chp. 6	Chp. 5
Carbon monoxide	16	12	24
Nitrogen oxides	18	12	25
Hydrocarbons and photochemical oxidants	17	20	24
Sulfur oxides	18	11	26
Particulates	9	7	6
Temperature Inversions	3	6	5
Greenhouse Effect	16	12	24
Water Pollution			
General considerations	16	---	18
Oxygen-demanding wastes	10, 18	8, 9	16
Disease-causing agents	18	11	27
Plant nutrients	18	12	25
Synthetic organic chemicals	17	20	24
Oil	17	20	24
Inorganic--acidity	13	15	9, 12
Inorganic--salinity	10	9	8
Inorganic--mercury	15,	18	22
Inorganic--lead	15	18	24
Sediments	---	---	---
Radioactive wastes	20	21	29
Heat	10, 12	9, 14	8, 10
Waste water treatment	---	---	---

We have found that a block of 10 lectures evenly divided between air and water pollution provides time for sufficient coverage in the general education course. More time could easily be spent, and when student interest or local issues prompted us, as many as 15-20 lecture periods have been used.

MOTIVATION OF STUDENTS

Many of the students in our courses were already highly motivated to learn more about pollution problems. We have found, however, that even their motivation can be enhanced during either the integrated or block approach by the use of newspaper articles. We have used newspaper articles in three different ways:

1. Each student is required to keep a notebook of applicable articles that appear in the local newspaper. These articles are then tied into the lecture when it is appropriate.
2. Useful articles are pre-collected by the instructor, placed in folders, and made assigned reading throughout the term--even prior to the discussion of pollution topics. In this approach the student builds up a store of information which is then brought together during the lectures on pollution.
3. Useful articles are pre-collected by the instructor, placed in folders, and made assigned reading during the time the pollution topics are covered in lecture.

In addition to newspapers, news magazines and other magazines often contain stimulating materials. We have also found that current local issues can be used to increase student interest. In our immediate locality, for example, we have a water treatment plant and a garbage incinerator that have both been topics of lively debate. A little further away but close enough to affect us are a copper smelter, a steel mill, and thermal electrical generators that have at various times been implicated in serious sins against the environment.

SUMMARY

We have found the topic of environmental chemistry to be well accepted by the students as a legitimate and relevant subject for inclusion in the freshman courses. We have also found that the topic can be easily included in such courses by using either the integrated or block approach. We have gained a great deal of enjoyment and satisfaction from teaching environmental chemistry because of the extremely good response and acceptance shown by the students. We recommend the program with no reservations.

Chemistry-Biology Interface in General Chemistry

William Masterton
University of Connecticut
Storrs, Connecticut 06268

Presented as the General Chemistry for Science Majors Keynote Speech, 31st Two-Year College Chemistry Conference, Brooklyn, New York, August 26, 1972.

In a typical class in general chemistry, no more than 5-10 per cent of the students go on to major in chemistry. Given this situation, it seems obvious that we should make chemical principles "relevant" to the other 90-95 per cent of our students by pointing out the application of these principles to other disciplines. These include not only biology, with which this symposium is concerned, but also the other natural sciences, engineering, pharmacy, and the social sciences. Indeed, the most important "interface" in the general course is probably that between chemistry and the environment, with which all of our students are concerned.

There are many different ways in which these interfaces may be explored in general chemistry. One approach is to design experiments which bridge disciplines. An example is the separation of amino acids by paper chromatography. Another approach, and one that I find particularly appealing, is to assign problems with a biological or environmental flavor. Consider, for example, the elementary treatment of chemical equilibrium. Many of us, in introducing the equilibrium constant, choose to keep the mathematics simple by starting with reactions in which the sums of the coefficients on the two sides of the equation are equal. One such reaction commonly used is:

$$CO_{(g)} + H_2O_{(g)} \rightleftarrows CO_{2(g)} + H_{2(g)}$$

A more interesting example is the equilibrium involving carbon monoxide, oxygen, and hemoglobin of the blood.

$$CO_{(aq)} + Hem.O_{2(aq)} \rightleftarrows O_{2(aq)} + Hem \cdot CO_{(aq)}$$

Taking the equilibrium constant to be about 200 at body temperature, students can calculate the ratio of concentrations of CO and O_2 in the blood stream which would convert various fractions of hemoglobin to the carbon monoxide complex. The assignment can be made more practical (and more challenging) by going a step further and considering the equilibrium with gaseous CO and O_2. If the Henry's Law constants for carbon monoxide and oxygen in water are given, the student can predict $Hem \cdot CO/Hem \cdot O_2$ ratios from concentrations or partial pressures of carbon monoxide and oxygen in the atmosphere.

In lecture, there are many opportunities to point out the application of chemical principles to biology. The few examples listed below will, I am sure, suggest others equally pertinent.

1). Structure determination. In discussing the use of X-ray diffraction to determine crystal structures, we should mention the widespread use of this approach in determining the structure of proteins. Again, when we show how colligative properties are used to determine molecular weights, we should point out the advantages of osmotic pressure measurements with solutes of very high molecular weight (starch, simple proteins, and so on).

2). Properties of water. The unusual physical properties of water can be directly related to life processes. The high specific heat and heat of vaporization of water are essential to the maintenance of constant body temperature. One can calculate that if these properties were comparable to those of a normal liquid, we would have to drink about five times as much water (soda, iced tea, beer, etc.) to keep cool on a hot day.

3). Coordination chemistry. It might behoove us, in discussing the chelating ability of EDTA, to say more about its use in the treatment of metal poisoning and less about its applications in analytical chemistry.

4). Kinetics. Here, enzyme-catalyzed reactions are an obvious example of the chemistry-biology interface. They serve to illustrate all of the features of catalysis, including the effects on mechanism and activation energy.

5). Thermodynamics. The principles of thermochemistry are readily illustrated by considering the oxidation of foods in the body. The process by which the chemical energy of foods is converted to mechanical energy offers an excellent opportunity to introduce the Second Law, the concept of thermal efficiency, and the distinction between heat and work. If the body were a heat engine, one can calculate from the basic Second Law equation

$$\text{Efficiency} = \frac{T_2 - T_1}{T_2}$$

where T_2 is body temperature (approx. 310°K) and T_1 is room temperature (approx. 298°K), that only about 4 percent of the potential energy of foods would be converted into useful work (e.g., muscular activity). Indeed, on a day that is hot, the efficiency would approach 0 per cent; we might spend more energy eating than we would obtain from metabolism. The fallacy, of course, is that the body is not a heat engine. Instead, coupled reactions, including the synthesis and later hydrolysis of ATP, yield a much higher conversion of chemical to mechanical energy.

In conclusion, I should "make one point perfectly clear". I am not suggesting that we teach biology to students in general chemistry. Our colleagues in the biological sciences would be properly appalled were we to attempt to do this. Neither, I think, should we be overly concerned that our students learn all the chemistry that they need for later courses in biology. One can imagine how impossible that task would become if it were expanded to include all the other disciplines represented by our students. Rather, I am advocating that we take a little time to point out some of the applications of chemical principles to the world around us in the hope that we can stimulate interest among all our students, regardless of their major fields.

Summary of Discussion Following Professor Masterton's Address

Summarized by E.H. Vickner, Jr.
Gloucester County College
Sewell, New Jersey 08080

The meeting opened with a discussion of an earlier talk given by Professor William Masterton. The discussion centered around the problem of identifying special students with special needs (e.g. nursing students, engineering students, etc.). The question: "Should we gragment our present chemistry courses to fulfill these special needs?" was discussed. It was decided by the group that chemistry is a service course in most institutions and only the larger institutions can specialize their chemistry offerings. Members of the group pointed out that smaller institutions should offer a general chemistry course which the student can adapt to his needs. It was further pointed out that at most two-year colleges there are two distinct groups of students taking general chemistry - those who should be taking a remedial course and those who have well defined goals and can handle the regular general chemistry course. Members of the discussion group said that most students having difficulty in general chemistry need more help in the area of chemical calculations.

The next section of the meeting was devoted to a discussion of the chemistry-biology interface. Some of the comments raised by the group were:

1. Many students in general chemistry are not chemistry majors, and therefore, we should offer more interface.
2. Other members pointed out that maybe too much biochemistry would be given in general chemistry if there was a heavy biological interface.
3. This lead to a discussion of teaching organic chemistry in general chemistry, and the group decided that not too much time should be spent on organic chemistry.
4. In some general biology courses there is a great deal of emphasis on biochemistry - a topic which many biology students cannot handle.
5. The group decided that rather than just use examples from biology in teaching general chemistry, topics from all sciences should be used to make the course material more relevant.
6. Most community college students go into biology courses rather than physical science courses because the majority of community college students are poor in math and writing ability. To improve the student's writing ability the members stressed that students should be given more discussion and essay questions on exams.
7. Toward the end of the meeting the topic of behavioral objectives was briefly discussed. Members pointed out that the use of behavioral objectives improve student study as well as sharpen teaching ability.

A Place for Topics that Generally Carry a Biochemical Label in General Chemistry

Gordon Barrow
Carmel Valley, California 93924

Presented at the Symposium on the Chemistry Needs of the Biological and Health Science Majors, 32nd Two-Year College Chemistry Conference, Oakland, California, October 20, 1972

It is hard to deny that we ought to pay attention to the biological oriented student; they now number about 50% of the students taking general chemistry. There are several ways in which we may attack the problem. We may (1) concoct a special course for them, (2) we could stick a little bit of biochemistry in at the end of the regular general chemistry course, (3) we could make little references to biological systems as we teach our usual courses, and (4) we could ask the biologists what they need and then teach only that. None of these, however, attacks the biological problem directly. This based probably on the tendency of the average teacher to draw back from the bigger issues whether it is biological or industrial and teach a very aseptic course.

We should concern ourselves with the chemistry-life interface rather than with the chemistry-biology interface. When we do this the cell becomes a holder of chemicals that are interacting. The chemist doesn't need to worry too much about the differentiation of the various cells.

When talking about living systems it is important to point out that there is a lack of equilibrium and use this lack to point out that force is necessary to keep things out of equilibrium. If we, as chemists, try to take a new view of chemistry and try to get at the essence of life processes we might learn more chemistry in the process. For example; we talk about proton transfer in acid-base reactions and we talk about electron transfer in redox reactions, so why don't we talk about phosphate transfer in biological energy transfer reactions?

The chemist today is too much interested in getting a set of tools to be used in later courses. We should use the real world to teach chemistry using the interests that the teacher and the students have and bring in the tools only when they are to be used.

Future Trends in the Organic Chemistry Course for Non-Majors

Summary of Presentation by Ralph Fessenden,
University of Montana, Missoula, Montana, 59801
and Discussion following

Summarized by Joseph Asire, Cuesta College,
San Luis Obispa, California 93401

Dr. Ralph Fessenden led the discussion concerning what he considered the future trends in organic chemistry for the non-science major. His main thesis was to get away from the traditional functional group approach and synthesis reactions to, as he called it,"bond type approach". A typical outline course could be:

1. Ionic Bonds
2. Covalent Bonds
3. Isomers - All types
4. Nomenclature of all groups
5. Chemistry of the bond mechanistic approach
6. Sigma bond - Acid and Base
7. Inductive effects
8. Resonance
9. Substitution Reaction, S_N1, S_N2, E1, E2
10. Pi Bonds
11. Addition
12. Carbonyl
13. Aromatic Bonds

With this type of approach, coverage could be accomplished in a semester or two-quarter course. This would be limited to the lecture portion of the course.

The laboratory trend seems to be dealing more with the techniques, particularly separations, rather than trying to correlate the lecture with the lab.

If this material was to be used in a one quarter course, then some modification of the outline would have to be made to fit a quarter course. With this type of an approach to teaching organic chemistry to non-science majors, more meaningful aspects of chemistry could be presented. The student would be able to relate chemistry to his particular needs.

The present method of memorizing functional group and reactions for the sake of doing organic chemistry is much too artificial and leaves the student cold and without a real understanding of chemistry. A non-science student in chemistry should be able to interrelate some of the major concepts of organic. It is not important that he know a particular reaction or synthesis. These were the major parts of discussion by this group.

Chemical Investigations for Changing Times: An Out-In-This World Laboratory for Nonscience Students

John W. Hill
University of Wisconsin-River Falls
River Falls, Wisconsin 54022

Presented as the Keynote Address for the Chemistry for the Non-Science Majors Section, 32nd Two-Year College Chemistry Conference, Oakland, California, October 21, 1972.

Last April at the 29th Two-Year College Chemistry Conference in Boston, I gave a paper about a nontraditional chemistry course that I had developed at University of Wisconsin-River Falls. At the conclusion of that talk, several questions were asked including, "What do you do about lab?" I answered in a tentative, sketch way, for we were still in the midst of developing our laboratory program.

I would now like to report on that laboratory, for we have now been through the program four times. We still believe, now more firmly than ever, that nonscience students should have laboratory experience. We must as firmly believe that the experience should not be the traditional one in which students test laws that are already well-proven, redetermine physical constants which are more easily found in a handbook, and analyze "made-up" unknowns. The main goal of our course is to get the students involved in investigating the real world. We use made-up samples only to show what a positive test looks like or to calibrate our apparatus.

Students obviously cannot reverify all the chemical principles in one term. Nor can they necessarily understand all the chemical reactions and principles involved in the investigations undertaken in our course. We have found, however, that students are quite willing to accept our standardized solutions, comparative samples, etc. They also recognize and respect our expertise as chemists. We feel that is as it should be. We all depend upon the work of others and build upon it without repeating every experiment or calculation.

We feel that the role of chemists is changing. Indeed, it must change if chemistry is to survive as a profession. In the past, most chemists have concentrated on making new <u>products</u> -- "better <u>things</u> for better living." While we will continue to need new and improved materials, more and more chemists will have to become involved in designing "better <u>processes</u> for a more livable world." Chemists will also become more involved in monitoring air and water quality and other aspects of our chemical environment. It is these changing roles that we emphasize in our laboratory.

Before going further, let me outline the program as we present it. Let me also acknowledge the creative contributions of my colleagues, Lawrence W. Scott, Leon Zaborowski, and Peter Muto, to whom much credit for the success of the laboratory is due.

Our course is presented in fourteen units. We run three laboratory sections of 24 each. All meet at the same time (8:00-9:50, Friday) in different rooms. Our goal is to provide three different options each week. A student may choose (within the limits of laboratory capacity) which of three different investigations he wishes to do. These we vary considerably in complexity and sophistication, as we shall see.

INTRODUCTORY UNIT -- WONDERING ABOUT THINGS
i. Blue Bottle
ii. The Fountain
iii. Hot Water Really Rises

UNIT I MEASUREMENTS
1. Length, Volume, and Weight--Could You Eat a 30 cm. Pizza?
2. Density -- Why Oil Floats When the Tanker Sinks
3. Temperature Conversions on the Computer--The Hot-Cold Printout

UNIT II CHEMICALS AND ELECTRICITY
4. Conductivity -- Getting a Glow On
5. Electroplating -- A Chrome-Plated World
6. Cathode Ray Tubes -- The Jolly Green Electrons
7. Some Molecules are Polar Bearers
8. An Electrochemical Titration -- Till the Lights Go Out

UNIT III ATOMS, MOLECULES AND CHEMICAL REACTIONS
9. Model Building
10. The Conservation of Matter -- What Goes in Must Come Out

UNIT IV MOLECULAR ARCHITECTURE -- GAMES ORGANIC CHEMISTS PLAY
11. Aspirin and Oil of Wintergreen -- Headache or Bodyache
12. Esters -- Perfumes and Flavors
13. Space Chemistry -- Sugars from Formaldehyde

UNIT V MOLECULAR ARCHITECTURE -- A TICKY-TACKY PLASTIC WORLD
14. Polyurethane -- Foaming
15. Polystyrene -- Casting
16. Epoxy Resins -- Potting or Gluing
17. Forty Feet from 30 mls - The Nylon Rope Trick

UNIT VI PLASTIC POLLUTERS
18. Hydrogen Chloride -- How to Lose your Marble
19. Cyanide -- The Case Against the Sweater Burners
20. Polystyrene -- Soot and the Single Egg Carton

UNIT VII FOODS

21. Vitamin C and the Common Chemistry Student
22. Ground Meats -- Fat or Lean
23. Additives -- Bane or Blessing
24. Your Diet -- Good or Bad?
25. Alcohol in Beer or Wine

UNIT VIII WHICH "CIDE" ARE YOU ON?

26. Pesticide-Herbicide-Fungicide-Insecticide

UNIT IX ENVIRONMENTAL EVALUATION: WATER

27. Phosphates
28. Nitrogen Compounds
29. The Ins and Outs of Water
30. Oil in Soil

UNIT X THE BIG SUDS STORY -- SOAP VS. DETERGENTS

31. In Soft and Hard Water
32. In Hot and Cold Water
33. Float Your Own Soap -- It's No Lie!
34. Water Softeners

UNIT XI CHEMICALS IN YOU

35. Mercury in Hair? Only Your Chemist Knows For Sure
36. Urine: What's in Your'n?

UNIT XII ELEMENTS AND YOU

37. Mercury
38. Potassium
39. Chlorine
40. Lead
41. Aluminum

UNIT XIII DRUGS -- THE MEDICINE CABINET

42. Before All Else Fails, Read the Label
43. Screening Over-The-Counter Drugs for Caffeine by TLC

UNIT XIV RADIOISOTOPES -- WHAT MAKES THE COUNTER CLICK

44. Beta or Gamma

Our students have made a number of interesting discoveries. The cyanide-from-Orlon experiment was based on an extension of the hydrogen chloride from polyvinyl chloride experiment. This discovery has been accepted for publication in Environmental Letters. The oil-in-soil experiment developed out of a student project designed to get evidence against a local gas station suspected of polluting the Kinnickinnic River. The mercury-in-hair experiment has turned up some surprisingly high levels. One whole family was advised to seek medical treatment. Dangerous (to infants) levels of nitrates have been found in water from nearby farm wells. Incompatible food additives have been found in a well-known brand of wieners. Screening of pottery has uncovered a number of pieces used for cooking or serving food that had dangerous levels of lead.

These students, with little training -- with little prior interest in chemistry -- have made these and other exciting discoveries. This enthusiasm extends beyong the confines of the course. Students join departmental projects, bring in samples, help conduct routine analyses. Some even take further chemistry courses. It is a lot of hard work, but very rewarding for a teacher to see students turning on with chemistry -- not chemicals.

Summary of Discussion Following Professor Hill's Address

Summarized by Kieth Biever
Bellevue Community College
Bellevue, Washington 98004

Discussion centered around various details as to how Dr. Hill's course was taught at Wisconsin.

There are three lecture sections of 72 students, each divided up into 3 lab sections. This course meets the general education requirement for science. The grading is optional, graded or non-graded, but most students demand grades.

The laboratory uses no lockers. The students check out boxes of equipment that are labeled by unit. If there are several options in a particular experiment, the students sign up ahead of time for the option that they want.

After the course is about one-third over the students vote on the topics that they want to cover during the remainder of the course. The course uses both films and outside speakers and there is little drop-out.

The lecture is really a discussion-demonstration meeting. The students do the assigned reading, the exams are primarily based on the textual reading. In addition the students do some outside reading.

The Mathematical Aspects of Computers in Chemistry

T.R. Dickson
Cabrillo College, Aptos, California 95003

Presented at the Symposium on Computers and Chemistry, 32nd Two-Year College Chemistry Conference, Oakland, California, October 20, 1972.

The three ways in which computers can be used in chemistry are in computations, simulations and tutorials. Computations involve using the computer for a numerical calculation or for data reduction and manipulation. Simulations involve the use of mathematical models of some physical or chemical phenomena to allow students to investigate the phenomena. Tutorials are methods by which students can interact with the computer to learn certain kinds of topics.

These three kinds of computer applications in chemistry require the use of certain computer and numerical methods. A summary of some important methods is given below.

Graphics and Plotting:

The graphing of a function or the display of a figure or model is possible on a computer with auxiliary equipment. Prewritten plotting or display programs are available. Digital plotting is the simplest form of display but can be accomplished with typewriter or printer output. X-Y plotters allow for more precise plotting and figure making. Cathode ray tube (CRT) and plasma display units are more sophisticated tools for plotting and graphics. In some cases slide projectors or microfiche projectors can be operated by computers.

Function Evaluation:

Mathematical functions representing some physical relationship can be used to generate digital tables of variables. For example, pressure and volume data can be generated from an equation of state of a gas.

Root Evaluation:

An empirical or theoretical function may have to be solved for one or more roots. An analytical method is available for quadratics. Other functions can often be handled by iterative approximation methods such as the Newton-Raphson or Bairstow methods. As an example consider the case of the determination of a root of a polynomial generated in a competing equilibria problem.

Numerical Integration:

The approximation of definite integrals can be accomplished by numerical methods called quadrature. Simpson's rule, Gaussian quadrature and the Rhomberg method are commonly used. An application arises with the evaluation of some thermodynamic quantities such as heat capacity and entropy.

Simultaneous Equations:

A system of linear simultaneous equations can be solved by matrix inversion methods. An example would be the solution of a set of equations obtained in multicomponent spectrophotometric analysis. A nonlinear system of equations can sometimes be solved by iterative approximation methods. Some competing equilibria cases involve such equations.

Matrix Manipulations:

A variety of matrix manipulations are possible with a computer. One useful method is the determination of eigenvalues and eigenvectors. Such a determination can be used in some quantum mechanical and molecular orbital calculations.

Curve Fitting:

A common problem involves the determination of a functional relationship between experimentally generated data. This is called curve fitting. The method of least squares is often used to find the"best" straight line or polynomial which corresponds to experimental data. Other methods such as mapping are also used. As an example, curve fitting can be used to determine linear relationships from kinetics data.

Other Methods:

Numerous other numerical methods find application in the solution of some chemical problems. Statistics and error analysis can be accomplished with a computer. The numerical solution of some differential equations is possible. Some linear combination problems can be solved. Linear programming methods are available. Monte Carlo techniques are possible on a large computer.

Numerical Method References:

Low Level: Dickson, R.T., *The Computer and Chemistry*, Freeman and Co., San Francisco, 1968

Grove, W.E., Brief Numerical Methods, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1966

Intermediate to High Level:

Hildebrand, F.B., *Introduction to Numerical Analysis*, McGraw-Hill Book Co., New York, 1956

Kuo, S.S., *Numerical Methods for Computers*, Addison-Wesley, Reading, Mass., 1965

Ledley, R.S., *Use of Computers in Biology and Medicine*, McGraw-Hill Book Co., New York, 1965

Lee, J.A., *Numerical Analysis for Computers*, Reinhold Publishing Co., New York, 1966

Pennington, R., *Introductory Computer Methods and Numerical Analysis*, The Macmillan Co., New York, 1965

Many examples of computer use in chemistry are available. The indices of the December (1968 to 1971) issues of the J. Chem. Ed. list applications appearing in that publication. The proceedings of the Conference on Computer Use in Undergraduate Chemistry is another source. Some specific examples are discussed below.

Simulations:

A mathematical function or model which is adaptable to the computer is needed in a simulation. Simulation is most effective when the student is able to interact or converse with the computer. In some cases a graphic display is useful. As an example consider a program which simulates and displays a nuclear magnetic resonance spectrum. The student can develop spectra corresponding to various field strengths or coupling constants to observe the effect of these parameters.

Tutorial:

Tutorial programs are often termed computer aided instruction (CAI). Tutorials require an interactive or conversational computer mode with typewriter or graphic display. Examples of tutorials include nomenclatures, problem solving and numerical drills, and spectra interpretation exercises.

Computational:

The use of a computer as a computational tool is the most convenient way to apply a computer. Many prewritten programs are available so that data input is all that is needed. Furthermore, specialized programs can easily be written. Reduction of laboratory data, function evaluation and curve fitting are quite common applications. An example of computation is a program which calculates the parameters of pi molecular orbitals by the simplified Huckel linear combination of atomic orbitals approach. A student can use the program to generate the parameters for a specific molecule, then determine the energy distribution and approximate shapes of the molecular orbitals.

Calculation of Pi Molecular Orbitals

The Hückel molecular orbital approach applied to pi bonding can be very useful for the visualization of the molecular orbital structure of some molecules. The relative energies of the molecular orbitals provide a way to predict the pi electron distribution in a molecule. Furthermore the linear combination of atomic orbital (LCAO) approach provides a view of how each atomic orbital contributes to the molecular orbitals (MO) and thus, gives an indication of the shapes of the resulting molecular orbitals.

In the LCAO method a pi molecular orbital system is described in the form of a secular matrix developed from the number, type and proximity of atoms contributing p orbitals to the pi molecular orbitals. The molecular orbital problem is solved by setting up the matrix and then solving for the eigenvalues and corresponding eigenvectors related to the molecule. In general the matrix representing the pi molecular orbitals for a molecule has the form:

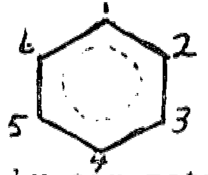
$$\begin{bmatrix} \alpha_1 - E & \beta_{12} & \cdots & \beta_{1n} \\ \beta_{21} & \alpha - E & \cdots & \beta_{2n} \\ \cdot & \cdot & & \\ \cdot & \cdot & & \\ \cdot & \cdot & & \\ \beta_{n1} & \beta_{n2} & \cdots & \alpha - E \end{bmatrix} \begin{bmatrix} C_1 \\ C_2 \\ \cdot \\ \cdot \\ \cdot \\ C_n \end{bmatrix} = 0$$

where E corresponds to the energies of the molecular orbitals and the C_i values represent the contribution of each atomic orbital to a given molecular orbital. The α_i terms are called coulomb integrals and the β_{ij} terms are called resonance integrals. The alpha terms are related to the energies of the atomic orbitals and the beta terms are related to the overlap of the atomic orbitals. When a molecular orbital problem is solved a set of E values (eigenvalues) will be obtained. These values are the relative energies of the molecular orbitals. A given molecule will have as many molecular orbitals as atomic orbitals which contribute to the formation of the molecular orbitals. That is, if six p atomic orbitals are involved in pi bonding, then six molecular orbitals will result. Each eigenvalue will have a corresponding eigenvector (C_i) which describes how each atomic orbital contributes to the molecular orbital. This can be expressed as:

$$\psi_{mole} = C_1X_1 + C_2X_2 + \ . \ . \ . + C_nX_n$$

where ψ_{mole} is the wave function of the molecular orbital and the C values are weighting factors for the atomic orbital wave functions (X_i). The sign and magnitude of a C value indicates the nature of the contribution of an atomic orbital to the molecular orbital.

To set up the matrix for a molecule the atoms contributing p orbitals to the pi molecular orbitals are first numbered for reference. For homonuclear cases the α_i values are all the same. However the β_{ij} values are given values of zero for nonadjacent (nonbonded) atoms and are represented by β for bonded or adjacent atoms. As an example consider the benzene molecule.



The matrix for benzene is a six by six matrix since six p atomic orbitals are involved in pi bonding. The matrix is:

$$\begin{bmatrix} \alpha-E & \beta & 0 & 0 & 0 & \beta \\ \beta & \alpha-E & \beta & 0 & 0 & 0 \\ 0 & \beta & \alpha-E & \beta & 0 & 0 \\ 0 & 0 & \beta & \alpha-E & \beta & 0 \\ 0 & 0 & 0 & \beta & \alpha-E & \beta \\ \beta & 0 & 0 & 0 & \beta & \alpha-E \end{bmatrix}$$

Note that the subscripts of the β terms correspond to the numbering of the atoms in the molecule. For instance since atom one and two are adjacent β_{12} is β. To provide for simplified computations each element in the matrix is divided by β. This gives a matrix of the form:

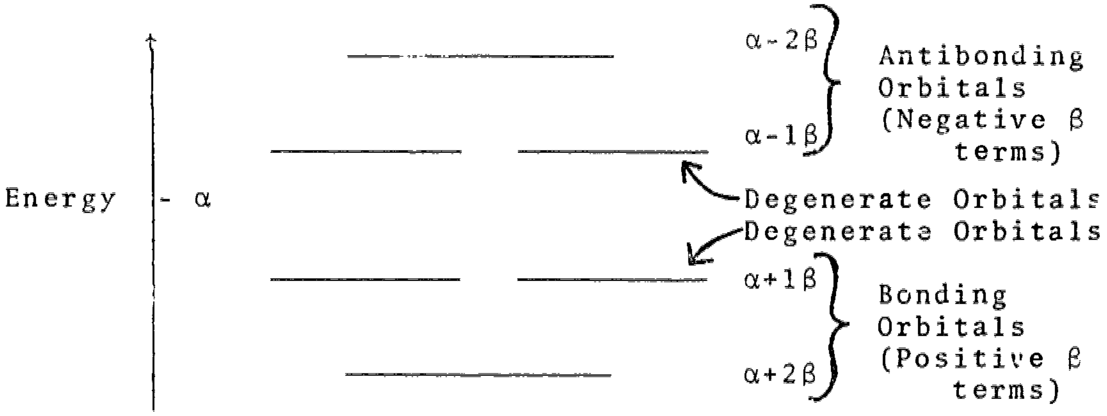
$$\begin{bmatrix} (\alpha-E)/\beta & 1 & 0 & 0 & 0 & 1 \\ 1 & (\alpha-E)/\beta & 1 & 0 & 0 & 0 \\ 0 & 1 & (\alpha-E)/\beta & 1 & 0 & 0 \\ 0 & 0 & 1 & (\alpha-E)/\beta & 1 & 0 \\ 0 & 0 & 0 & 1 & (\alpha-E)/\beta & 1 \\ 1 & 0 & 0 & 0 & 1 & (\alpha-E)/\beta \end{bmatrix}$$

The general pattern for developing a matrix is to set up a matrix of the dimensions given by the number of atoms involved in pi bonding. Use a value of one (1) for each element corresponding to β_{ij} of adjacent atoms and zero (0) for elements corresponding to β_{ij} values of nonadjacent atoms. The elements of the major diagonal are $(\alpha-E)/\beta$.

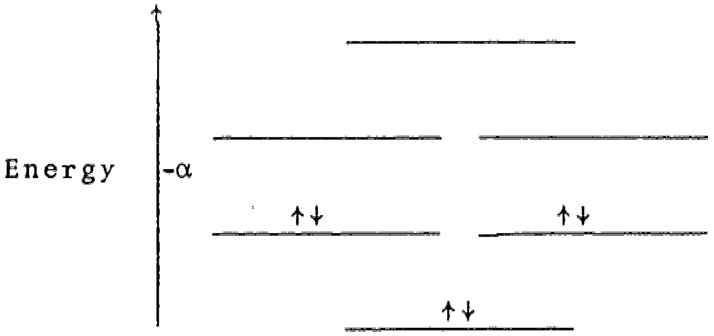
For heteronuclear organic compounds involving nitrogen or oxygen approximations of the coulomb integrals and resonance integrals in terms of α and β for carbon are available. The coulomb integral for oxygen is $\alpha + 2\beta$: the coulomb integral for nitrogen is $\alpha + \beta$. The resonance integral is $\sqrt{2}\beta$ and β

for oxygen and nitrogen respectively.

Once the matrix for a molecule has been set up the APL program called MOLORB* can be used to solve for the eigenvalues (Molecular orbital energies as a function of α and β) and the eigenvectors (the weighting coefficients for the atomic orbital contributions to the molecular orbitals). The program utilizes a general eigenvalue-eigenvector program which uses the Jacobi method of solution. These programs are contained in Workspace MOLORB, user number 15009. Note that the matrix is input row by row and that the major diagonal elements are input as zeros. For the homonuclear case other elements will be either 0 or 1 as discussed previously. Alternatively the matrix elements may be input as selected elements. Once the calculations have been carried out the results are interpreted as follows.* The atomic orbital energies correspond to α, thus the relative energies of the molecular orbitals are compared to α. For benzene the relative energies are



Since there are 6 pi electrons (one from each of the six p atomic orbitals) the electron distribution in the pi molecular orbitals is found by filling the molecular orbitals with two electrons each starting at the lowest energy orbital.



As for interpreting the eigenvectors the sign of the weighting coefficient indicates which lobes of the atomic p orbitals are overlapping. The magnitude of the coefficient indicates the extent to which the atomic orbital contributes to the molecular orbital. Two adjacent atomic orbitals with weighting coefficients of opposite sign will cancel electron density between them. On the other hand, two adjacent atomic orbitals with weighting coefficients of the same sign will enhance electron density. The molecular orbitals (top view) of benzene are shown in Figure 1.

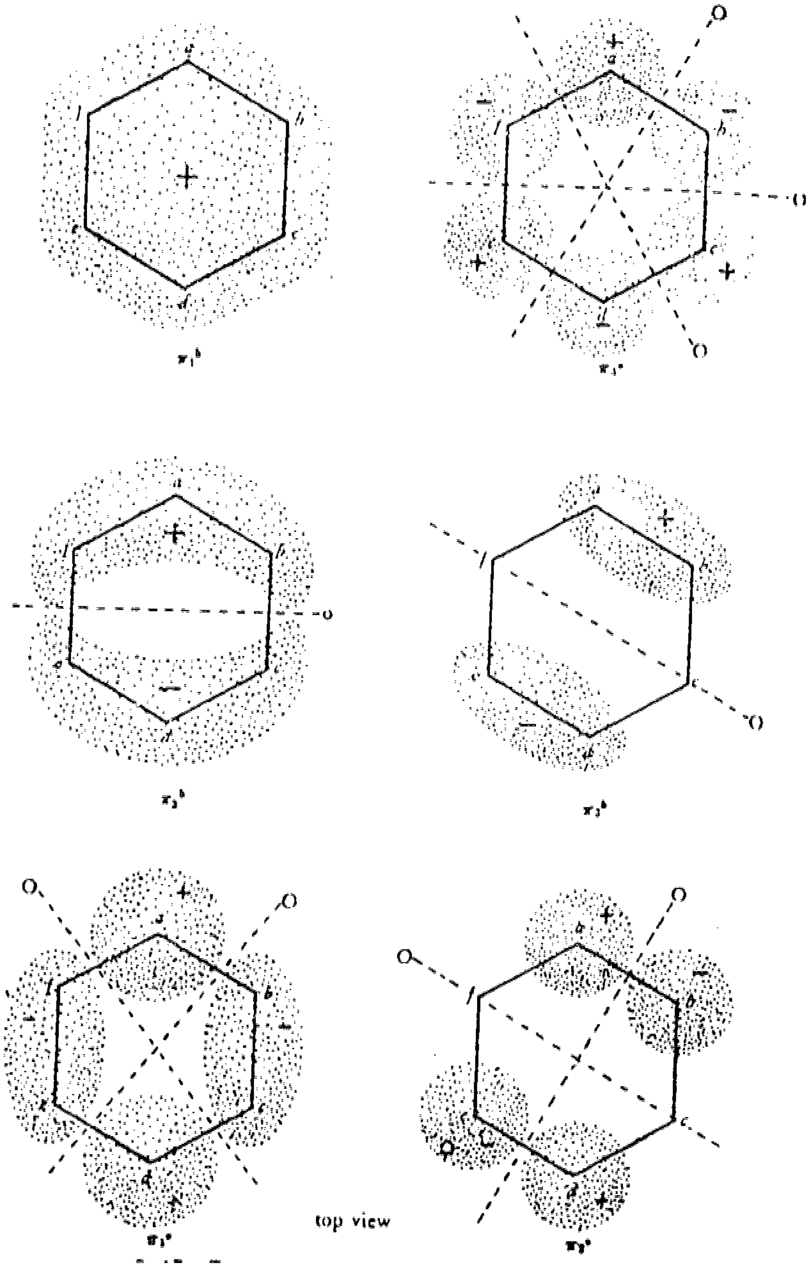
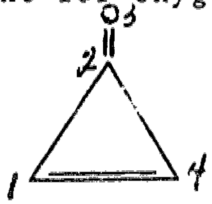


Figure 1. The Benzene Molecular Orbitals

For a heteronuclear molecule such as cyclopropenone the diagonal element for oxygen must be input as 2 and for nitrogen as 1.



The off diagonal elements for oxygen-carbon overlap must be input as $\sqrt{2}$ and the nitrogen-carbon overlap must be input as 1. Note that the elements of the four by four matrix for cyclopropenone are input as selected elements.* Furthermore, note the results of the calculations. The interpretation of these results are left to the reader

---

*Programs and examples are available from the Editors upon request.

How to Use a Computer in Chemistry

Ron Code
N.C.R.C.N. Project
Stanford University
Stanford, California 94305

Presented at the Symposium on Computers and Chemistry, 32nd Two-Year College Chemistry Conference, Oakland, California, October 20, 1972.

It has been anywhere from 10 to 20 years, depending on your perspective since chemists began to seriously consider the computer as a valuable tool for their profession. Despite what appears to be ample time to incorporate computer knowledge into the teaching of chemistry, precious little has been done. Advocates of various approaches (elaborate computerized teaching systems, laboratory devices, simple programming assignments, etc.) have vocalized their positions and have attracted many admirers but few disciples. The various positions are often separated by vast chasms of disagreement. The actual accomplishments remain small and scattered. It is quite understandable that most attending this conference have taken a "wait and see" attitude.

This procrastination is enhanced to some extent by the improvements which are being made in computers, terminals, and programming languages. What with this year's machines being faster, smaller, cheaper, and easier to use than last year's, the advantage is on the side of the instructor who puts off 'til tomorrow what he could do with more difficulty today. Implicit in this observation is the optimistic viewpoint that things are getting better, and one only need wait for the world to solve its problems. But, this ignores just one important thing - the student. Educational institutions have a mandate to provide the most complete and modern education possible, and I find it hard to believe that the lower division chemistry education could be complete without some exposure to electronic computers. I have a particular bias for taking this viewpoint. For the past several years, I have been attempting to encourage new applications of the computer in every possible discipline. This activity, funded by an NSF grant to the Stanford Computation Center, has included finding computer applications in astronomy, philosophy, marketing, political science, even religion! If I am not on firm ground when I call for use of computers in chemistry education, I might as well pick up my marbles and go home. Whereas most other disciplines can find a place for the computer, chemistry would be hard pressed to find an area where the computer does not belong.

If you are already convinced of the value of educational computing, please excuse any repetition which I am about to put you through. In preparation for this paper, I was looking through some issues of the Journal of Chemical Education of recent vintage. I was impressed that every issue has some article which pertained to computers. Working backward, it goes something like this - August '72, "Interactive Program for Teaching pH and Logarithms"; July '72, "Computer Calculation of Polynomial Product Terms" (used in isomer counting); June '72, "A Computer Program for Counting the Magnetic Moment of Ions" and "Computer Program for Calculating Pore Volume and Area Distribution from Gas Adsorbtion-Desorbtion and Mercury Intrusion Data"; May '72, "A Computer Program for Calculating van der Waal's Volume" and "A Computer Program for Plotting NMR Spectra". In addition, there are six other computer articles in earlier issues of 1972. Many entire texts have been devoted to the applications of the computer to chemistry and to even very specific branches of chemistry. At a meeting of the Interuniversity Communications Council this month, Dr. Peter Lykos of the National Science Foundation described the advantages of establishing a national center for computational chemistry.

Now, to say that chemistry is only beginning to flex its computer muscles would be somewhat misleading. Some of the present work is both elaborate and sophisticated. Some individuals are doing more than their share (if there is such a measure) to advance the state of the art. But, if we were to measure our collective activity on a thermometer scale, we would be somewhere around 2^o - Kelvin! Some vibrations, but not much action.

Before saying what should be done, I want to turn back to the promised topic of this paper; Uses of the Computer in Chemistry. These uses can be conveniently grouped under several broad categories. I have no quarrel with those who would combine or further fragment this list.

1. Information Retrieval
2. Instrument Control and Monitor
3. Simulation
4. Data Analysis
5. CAI, Drill & Practice, etc.

Information retrieval can be divided into two segments for chemistry; document retrieval and data retrieval. A general document retrieval system for the computer is designed to replace the manual aids (card catalog, indices, poking around dusty shelves, etc.) which have become unwieldy in the information explosion. In 1973 alone the number of Chemistry Abstracts will grow to 360,000. Obviously, the task of finding the "right" information is something which needs to be handled at electronic speeds. We should expect to see these large data file systems available for anyone's use within a few years. Actually, several are now operational and can provide the researcher with the latest information for a fee (I understand about $100 per search). The second type of information retrieval which you may be interested in is more unique to chemistry. Chemistry is an experimental science and, as such, has built a huge volume of data on such things as chemical compounds. This information resides in unwieldy tomes which are dusted on occasion. Once this data is computerized, however, it can be indexed in a variety of ways, and, in general, made to come to life.

The Dow-ASTM file contains infrared spectra for 92,000 compounds (5,000 inorganic, 87,000 organic) and is available for computer searches by several commercial firms. Each record of the file also contains a large amount of information on the structure and physical properties of the compound. This file, which is growing at the rate of 10,000 compounds a year, is being used at the Triangle Universities Computer Center and provides a search for less than one dollar to educational users. A system such as this can have a profound effect on the type and depth of the laboratory work which students can perform. I am not sticking my neck out very far to predict that the use of large chemical data base systems will be commonplace in even small laboratories within the decade.

The laboratory use of computers is really nothing new, it's just that a general purpose computer is likely to be used today, where specially designed electronics were used in the past. It is very reasonable to use a small computer to control laboratory equipment since the cost of such machines has dropped dramatically in the past 10 years, especially in relation to the cost of other laboratory materials. These machines are flexible, taking on different functions as their programs are changed. If the laboratory is so arranged, the same machine can time and control an experiment, collect the data, and analyze it at the same time. Later it may serve as an "ordinary" little programming computer or be tied to a larger computer on campus which handles the heavy work. The price of these clever machines continues to drop toward the point where every laboratory (including your junior college's) will have one. People with some feel for these prices have predicted that such machines, at least the central processing circuits, will be produced on a single "chip" at a cost of only a couple of dollars within 20 years. The implications of this much computing power for such little money staggers the imagination. One thing for sure, we are going in a direction which will not reverse itself. Part of the design of a chemical experiment will routinely involve writing the accompanying computer programs for the control and monitor of the experiment and analysis of the results. We should expect that these skills will be part of the background and education of experimental chemists.

The third category of computer usage is the most ready for immediate exploitation; simulation. There is even some chance that the use of computers to simulate laboratory events will reduce costs, but I wouldn't bet on it. Students usually do more when they have computers rather than doing the same things cheaply. This isn't all bad is it? The computer can simulate costly or dangerous experiments. It can change a time frame from microseconds to minutes or from months to seconds. It can even allow the simulation (if simulation is the proper term) of impossible or theoretical conditions - no friction, perfect elasticity, a hypothetical atomic structure. The student can vary the parameters and observe the results with perfect repeatability.

There are some who would argue that the actual experience of the laboratory is in and of itself an important part of chemistry education, but I can speak from own experience that the understanding of the experiment being performed was always of less importance than getting the right answers without breaking any equipment. At last resport, we would always turn to the trusted "pony". Of course, the laboratory is important. I leave it to you to formulate your own happy medium between the real and simulated worlds.

Data analysis includes such traditional calculations as integration, curve fitting, solution of simultaneous equations, correlation factors as well as evaluations of empirical formulas. The data obtained from experiment or other observation must usually be processed in some way before it is fit for human consumption. When the calculations are simple enough, say a simple pressure-volume-temperature relationship, a slide rule or sharp pencil suffices. But, when compressibility of liquids, and all the other little factors which are usually omitted are put into the problem, the student would never be able to wade through the calculations. These complications are not difficult for most students to appreciate - only to compute. The computer likes (statements like this would worry a psychiatrist) to compute - let it handle these messy tasks. Let the students calculate results from the idealized case, compare those with the full-blown mathematical model and with laboratory observations.

There are times when computers make an otherwise impossible task easy. On the other hand, I am reminded of one of my first assignments as a scientific programmer at a large research laboratory. A certain formula was to be evaluated at 1000 different values of an independent variable x. In those days computer work took a little longer, but the point is the same. Several hours were spent setting up the program and waiting for my turn on the computer. When the results came back, I was sure that I had made a programming error. For every value of x the same value for the formula was printed. The program was rechecked - with everything OK. I turned back to the original problem, did a little mathematics, dividing, etc. and what do you know - it reduced to $f(x) = x$. I quickly destroyed the program, making sure no one saw me, and wrote a short reply to the person who needed the evaluations that no program was needed since that would be a waste of time.

There are times when computers can be a waste of time and occasions when blind acceptance of an answer on computer paper would be a serious error. The sooner a student learns to make these judgments, the sooner he will become a mature scientist.

The last category of computer use is the one in which junior college teachers have shown a great deal of interest. Many are ready to jump on the Computer Aided Instruction bandwagon, if only it would get rolling. The kinds of CAI or drill and practice programs which are in general use at hundreds of schools are only primitive attempts when compared with the expensive, elaborate CAI research projects. There seems to be a great deal of disillusionment about CAI, caused perhaps by too much sensationalism. Actually, some of the practical little programs are pretty good and students seem to enjoy the experience. Many teachers have found them successful in motivating some of the poorer students. Unfortunately, this use of computers does not replace teachers or lower costs as would be the goal of a comprehensive CAI project.

Well, those are the major application areas of computers in chemistry, but where does that leave the uninitiated teacher? Before coming here, I asked one of the conference committee members what message I should bring to this meeting. He said it would be nice if I could assure the teachers who have not yet used the computer that it really isn't so difficult a after all.

I'm not sure whether you can give that assurance to your freshman students about chemistry. I was rather surprised to see how much more difficult chemical theory is today as opposed to a decade ago. If it's been several years since you attempted to use computers, you will be surprised that the operation of computers has not become more difficult but much easier. The demonstration which the Stanford Computation Center is providing is designed to convince you of this. Everyone is invited to try one of the two computer terminals and some of the chemistry programs which are provided.

It's possible to use the computer without knowing how to program it. Some people say it's like driving a car without knowing how the mechanical parts function. While there is some truth to this viewpoint, I would agree that a language such as BASIC is so easy to learn that it is foolish not to do so. Dozens of texts are available which will teach you the language with or without a computer terminal. The understanding of computer techniques gained by learning a simple programming language will be valuable even if you never intend to write a computer program yourself.

Science students should also know something of computer programming, although it should not be necessary to take a computer science class. Dartmouth College provides a few hours of instruction in BASIC programming to its incoming freshmen and finds that they are able to proceed on their own from there. This relieves teachers from the burden of instructing the students in the use of computers. Dartmouth's experiment has been so successful that it is surprising that it has not been copied more often.

In conclusion, there are three ingredients which will ensure that computers will be used in the educational process.

First, a commitment on the part of the administration and computer center management to serve educational computing needs. Second, a computer which can support sophisticated time sharing work. And last, an in-service program to encourage the faculty to learn about and use computers. If you are not able to collect all of these ingredients, feel free to make substitutions of your own.

SPECIAL TOPICS HEALTH RELATED COURSES

The Two Year College — Four Year College Interface for Allied Health Programs at Brookdale Community College

Thomas Berke
Brookdale Community College
Lincroft, New Jersey o7738

Presented to the Two Year College-Four Year College Interface in the Allied Health Fields Section, 31st Two-Year college Chemistry Conference, Brooklyn, New York, August 26, 1972.

I am Thomas Berke, representing Brookdale Community College, the County College of Monmouth. We are a student and community oriented college.

We have attempted to make our educational environment an inviting and useful one. We decided to leave the two barns and several farm houses on a 221 acre race horse breeding farm. The insides of the barns were open-space classrooms (teaching stations), two formal lecture halls (forums) and Science labs. The second floor was dedicated to our Learning Resource Center (LRC) in which we have books, films, tapes, journals, learning packages and various displays.

We have provided meeting areas for students as well as small classes. In various teaching stations and areas within the LRC lounging chairs are set up. We have sunken into parts of our walkways and arcades sitting areas. There are terraces which extend into our woods. Our lawns are extensively used by students and classes. Out pub is a favorite meeting place. Our nursing students have rooms where they can meet with each other.

Additional work areas are provided by our carrels and wherever audio-visual equipment can be installed. Our campus extends to all parts of the county and several courses have been conducted throughout the world.

Our concept of the building environment has carried over to our new buildings. One such building is at Sandy Hook State Park, our center for oceanography and marine biology. Our newest building on our main campus has the entire, enormous second floor dedicated to the LRC with classrooms and teachers desks and open office space on the ground floor.

Brookdale is divided into 4 institutes under the theory that students in different major areas need their own turf. Each student in a particular area has a counselor from that institute. He meets regularly with the counselor.

The Natural Sciences institute is divided into four areas: 1) Allied Health 2) Engineering Technology 3) Logic Systems and 4) Sciences.

This is where Brookdale really begins for our students. Every student has a guidance counselor.

The counselor in addition to helping the student with personal and financial problems, tries to determine with the student through conversation and aptitude testing a program best suited to the student's needs. Some 30-40% of our graduates are involved in career programs; the majority, 60-70% are involved in transfer programs.

One of the services performed by our counselors for students in transfer programs is to help the student narrow down his choice of a four-year college. This is handled through several channels: (1) during orientation students have an opportunity to meet with faculty members in their field, or fields of interest to discuss their needs in terms of present programs as well as future interests and colleges which might best meet those needs, (2) students can meet at their convenience with our transfer counselor who in our Career Services Center has (in addition to our LRC holdings) college catalogues, reference guides and Chronicle Guidance View Deck (lists jobs and colleges which meet these job and geographic requirements). Our counselor has been involved with a group of transfer counselors and in addition to maintaining contact with other colleges has helped to establish the Single Application Method whereby a student can apply to five N.J. colleges and pay only one fee. This would help insure each student a spot in a 4-year college. The application is sent to the college of first choice and then to college of second choice, etc.

We have, in addition, had representatives from at least 100 colleges visit BCC this year. Next year we plan on having a "College Day" during which interested high school students who will either be entering Brookdale or another college and present Brookdale students can meet with representatives from many four year colleges plus our counselors and transfer counselor to get a view of what is available to them in advanced studies.

Once these decisions are made the student then sits down with his counselor and a course of study is bid out with the Student's study interest and the program required for the transfer institution in mind. College catalogues from these colleges are used during the planning stage. Students are encouraged to obtain their own catalogues from the schools of their choice. They are also encouraged to make contact with someone in the department they wish to enter to discuss the transferability of the program set up at Brookdale and to get any recommendations from the school as to recommended background for a transfer student.

In addition to students going on their own to visit other colleges, our Student Activities program sponsors, or finances, trips to New Jersey's colleges for groups to give them a first hand view of these institutions.

In our Nursing program we have made special arrangements with Trenton State whereby our nursing students have priority on getting into their B.Sc. nursing program. All courses except nursing can be transferred and one-year of general chemistry in place of the 1 semester inorganic, organic and biochemistry must be taken. Nurses who decide early that they are going to transfer take the one year general chemistry with up to 64 credits at Brookdale all of which are chosen so that they will be accepted and all nursing courses are taken at Trenton State. Nursing students can complete the nursing courses offered at Brookdale and challenge three of the four semesters of the nursing courses they must take at Trenton State. This means that nurses who successfully challenge the Trenton State nursing courses and who have in addition the maximum number of transfer credits allowed can complete the B.Sc. program in about 1 year.

Rutgers will accept our R.N. degrees except for the nursing courses which must be challenged. Many of the other institutions within the state are too extensive for many of our students.

Our Inhalation Therapy program just developed in 1971 has not yet graduated its first class. But they and the Med Lab Tech students who wish to transfer are given programs which omit the clinical course. These in general are nontransferrable and must be taken at the 4-year colleges.

For special schools such as medical school or veterinary schools which are difficult to get into, we recommend that students make immediate contact and maintain with the ones of their choice to set up prescribed programs and to help with their being accepted.

The Chemistry Needs of the Pharmacy Major

Grafton D. Chase
Philadelphia College of Pharmacy and Science
Philadelphia, Pennsylvania 19104

Presented to the Symposium on the Chemistry Needs of the Biological and Health Science Majors, elst Two-Year College Chemistry Conference, Brooklyn, New York, August 25, 1972.

Pharmacy is one of the oldest health professions. Together with physicians, dentists and nurses, the pharmacist serves on the public health team in the prevention and treatment of disease. His specific role is to serve as the expert on medicinal agents. He is concerned with their collection, manufacture, analysis, storage, use, and pharmacological activities as well as with placing them in suitable and effective dosage forms for prescription by physicians and dentists.

If one is to determine the chemistry needs of the pharmacist, one must first examine in some detail the many topics with which the pharmacist is concerned since his role is very broad, leading to a variety of specialty areas. One possible classification of pharmacists is given in the following table. Included are the typical academic degrees earned by pharmacists.

Types of Pharmacists
(Including typical academic degrees earned)

1. Community pharmacist (B.S. or M.S.)
2. Hospital pharmacist (Pharm.D.)
3. Manufacturing pharmacist (B.S., M.S., or Ph.D.)
4. Pharmaceutical educators (Pharm. D. or Ph.D.)
5. Research pharmacist (Ph.D.)
    a. Pharmaceutics
    b. Pharmacology
    c. Pharmacognosy
    d. Pharmaceutical chemistry

The Community pharmacist is no doubt best known to the layman for it is the community pharmacist who he most readily recognizes as a pharmacist. Each year community pharmacists fill about one billion prescriptions and the number continues to increase. The community pharmacist is not only trained to fill prescriptions but to give professional guidance as well in the purchase of home remedies, sickroom supplies and other health needs.

Hospital pharmacists are in ever greater demand as the sophistication and complexity of medical care increases. Hospital Pharmacists have been trained specifically for clinical practice in an environment of patient care. While all pharmacists are becoming more patient oriented, those practicing in hospitals, clinics, nursing homes and similar institutions must work in close cooperation with physicians and nurses if the best of patient care is to be achieved.

Manufacturing pharmacy has also become more and more important with the greater diversity and complexity of modern drugs. Special training in large scale production techniques is now important since the manufacturing pharmacist prepares hundreds of thousands of tablets per batch rather than the quantity needed to fill a single prescription. Special problems such as those associated with mixing and heat transfer are often encountered with large batch methods, problems not normally encountered by the community pharmacist.

Pharmaceutical educators and research pharmacists need very broad scientific backgrounds while at the same time requiring a high level of training in relatively narrow fields of interest. Typical areas of concentration include pharmaceutics, pharmacology, pharmacognosy and pharmaceutical chemistry. Perhaps a brief word of explanation is in order to describe these rather technical fields of pharmacy.

Pharmaceutics is concerned not only with the practical aspects but also with the theory involved in the design of dosage forms including physical, chemical and physiological properties. Will the product pour from the bottle? Does it have a pleasant texture? What about its shelf life? Does it do the job for which intended? Drug absorption, rheology, complexation, protein binding, preservation and stabilization, solubilization, enzyme kinetics and pH are but a few of the topics encountered in pharmaceutics.

Pharmacology is the study of drug action. What is the function of a drug? Where does it go in the body? How does it work? How is it metabolized? In what form and how is it excreted? Does it have side effects? A Pharmacologist must answer these questions and many others as well.

Pharmacognosy is that area of specialization dealing with drugs of natural origin. It includes not only a consideration of the crude drugs obtained from plants, but also substances such as hormones, antibiotics, enzymes and vitamins. Plant biochemistry is likewise important as well as histochemistry and chemical microscopy as used in defining the processes and constituents of plant drugs.

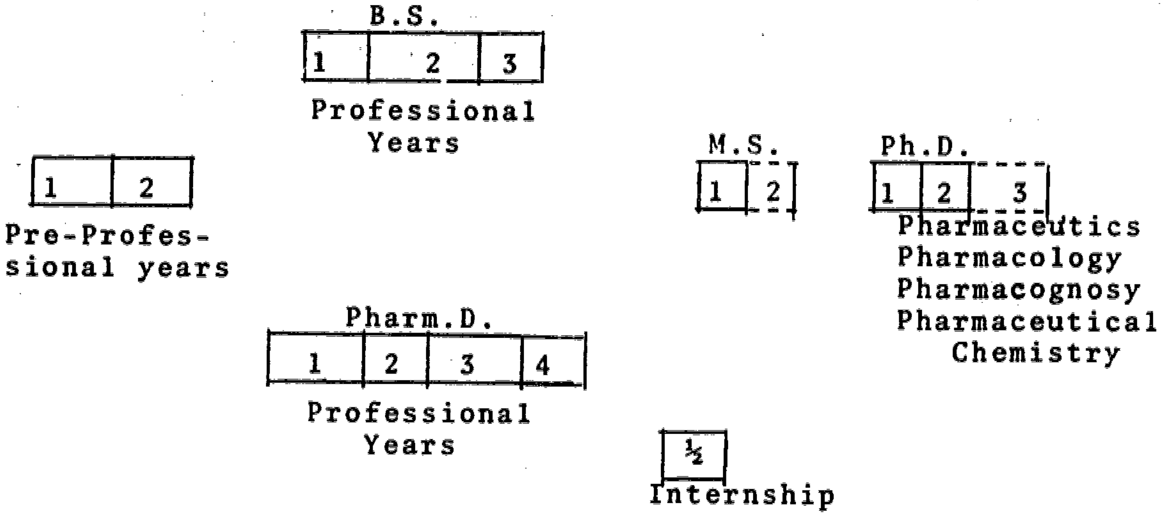
Pharmaceutical chemistry encompasses a broad spectrum of topics -- the synthesis of potentially useful medicinal agents, the isolation and characterization of plant principles, the investigation of the physico-chemical characteristics of highly purified substances, the analysis of complex systems and the utilization of radioisotopes in a variety of applications ranging from the investigation of the kinetics of a reaction to the determination of the metabolic fate of a medicinal substance.

To train such a diversity of individuals, all of whom may claim the title of pharmacist, it is necessary that the curriculum be sufficiently rigid to provide all pharmacists with the necessary fundamental technical training, yet at the same time sufficiently flexible to allow more specialized training in certain areas. Indeed different degree programs are offered to fulfill the variety of needs.

Typical degrees earned by each type of pharmacist are indicated in the table on page 1. Thus it can be seen that the bachelor or masters degree is most frequently earned by the community pharmacist, the doctor of pharmacy degree by those entering hospital pharmacy, the B.S., M.S. or Phd.D. by the manufacturing pharmacist, the Pharm.D. or Ph.D. by those in education and a Ph.D. by research oriented pharmacists.

The several degree programs are illustrated in Figure 1. The basic pharmacy curriculum consists of two years of pre-professional training plus three years of professional training and leads to the bachelor's degree in a total of five years. While the structure of this curriculum sometimes differs from one college of pharmacy to the other - some specify a curriculum consisting of one pre-professional year plus four professional years - all curricula require five years to earn the B.S. degree. Graduate work leading to a masters in one or two additional years and to the Ph.D. in from three to seven years beyond the bachelor's provides advanced training in one of the special fields mentioned earlier, that is, pharmaceutics, pharmacology, pharmacognosy, or pharmaceutical chemistry.

PROGRAMS OF PHARMACEUTICAL EDUCATION



The Doctor of Pharmacy degree program does not replace the present five year program leading to the Bachelor of Science degree, but is coordinated with it so that students wishing to continue toward the professional doctorate degree may do so at the end of the second pre-professional year since the two years of pre-professional work are identical to those required of students working for the Bachelor of Science in Pharmacy degree. To be accepted in the Pharm.D. program, students must meet certain additional academic and professional criteria established by the Doctor of Pharmacy Admissions Committee. A minimum of six months of internship is also required following graduation.

Now that an overview of pharmacy has been presented, we can pursue the basic objective of this discussion - to define the chemistry needs of the pharmacy major.

Perhaps it is already evident that the chemistry needs are variable and indeed change from year to year and are therefore in need of constant review with the objective of noting necessary or desired changes in the curriculum or course content.

Pre-Professional Years

Chemistry offerings in the two pre-professional years seems to be clearly defined, at least with respect to course offering. The following summary shows the courses and semester hours of credit given at each of ten colleges of pharmacy selected at random.

CHEMISTRY IN THE PHARMACY CURRICULUM
PRE-PROFESSIONAL YEARS

	A	B	C	D	E	F	G	H	I	J
FIRST YEAR										
GENERAL CHEMISTRY	4	8	10	4	10	10	10	8	8	9
INORGANIC & QUAL. ANAL.	5									
QUALITATIVE ANALYSIS				4						
SECOND YEAR										
ORGANIC	8		8	8	8	8	8	3	8	8
ORGANIC MEDICINAL		15								
QUANTITATIVE ANALYSIS								5		

In the first pre-professional year every college offers between eight and ten credits of inorganic or general chemistry. Here the trend has been to de-emphasize qualitative analysis. Over the past ten years many colleges have discontinued separate courses in qualitative analysis but have included some qualitative analysis as a part of the general chemistry program. I personally think qualitative analysis serves a purpose in organizing many inorganic reactions. I would not want to see it eliminated entirely from the curriculum.

In an introductory chemistry course emphasis should be placed on the basic principles of modern chemistry with the goal of unifying and clarifying the descriptive aspects of the science. A significant segment of the course should be devoted to qualitative analysis, chemical equilibria and reaction rate. Theoretical chemistry is important and has its place in such a course but practical applications must not be overlooked. By the end of the year the average student should know that copper sulfate is blue. If, in addition, he can also describe the structure of copper sulfate in terms of molecular orbital theory, that is fine too.

The curricula are very consistent in the second year with most colleges offering eight credits in organic chemistry. Those which do not make up a total of eight credits by offering organic chemistry the following year or by offering it as part of another course such as "Organic Medicinal Chemistry". Because most new drugs are organic, the need for a strong background in organic chemistry cannot be overemphasized. It should be a comprehensive course, strong on nomenclature and illustrating typical reactions of various classes of compounds and functional groups.

Here we see how introductory or general chemistry and organic chemistry have been integrated into the curriculum at the Philadelphia College of Pharmacy and Science.

Curriculum in PHARMACY
FIRST PRE-PROFESSIONAL YEAR

English	6 cr.
Mathematics	6 cr.
Introductory Chemistry	10 cr.
Vertebrate Zoology	4 cr.
Botany	4 cr.
Pharmacy Orientation	N.C.
Physical Education	1 cr.
Electives	

SECOND PRE-PROFESSIONAL YEAR

English	6 cr.
Economics	6 cr.
Organic Chemistry	8 cr.
Physics	8 cr.
Electives	

Notice, in the first year that introductory chemistry is supported scientifically by mathematics and general biology which are taken concurrently. The course in mathematics is devoted largely to algebra and trigonometry. Students who plan to take graduate work must also take analytic geometry and calculus and frequently do so as an elective in the second year.

Professional Years

Now we come to the three professional years leading to the B.S. degree. Again let us examine the chemistry offerings at the ten randomly selected colleges of pharmacy. We can see immediately some degree of agreement among these curricula, especially in the case of biochemistry. It is logical that this important course following organic chemistry, which it uses as a base.

PROFESSIONAL YEARS

	A	B	C	D	E	F	G	H	I	J
FIRST YEAR										
ORGANIC								5		
ORGANIC MEDICINAL							3			
HETEROCYCLIC	2									
QUANTITATIVE ANALYSIS		5		4	4	4			4	
PHYSICAL PHARMACY		4					3			4
BIOLOGICAL (BIOCHEMISTRY)		5	6	5	6	6	5	4	4	6
SECOND YEAR										
ORGANIC PHARMACEUTICALS										
CHEMISTRY OF MEDICINALS		4							5	
ORGANIC MEDICINALS					6			8		
MEDICINAL CHEMISTRY & PHARMACOGNOSY				9						
ADVANCED ANALYSIS						4		4		
RADIOPHARMACEUTICALS					1					
THIRD YEAR										
PHARMACY & CHEMISTRY OR MEDICINALS										

It is equally important that it be given as early in the training of the pharmacist as is possible to assist in his understanding of the physiological processes which occur in the body and subsequently to understand the pharmacological action of drugs.

We also note an importance attached to quantitative analysis. When asked how this course fits into the training of a pharmacist the answers frequently given are "It teaches accuracy and helps the student develop good laboratory technique, especially important when handling drugs", or "It is important that a pharmacist know something about quality control, even if he himself does not expect to be active in that particular area". In part years quantitative analysis was a part of almost every curriculum but it has been squeezed out of many as technological advances create more and more demands on already tightly packed curricula.

At some colleges of pharmacy, physical pharmacy or physical chemistry is taught at the undergraduate level. When it is, it usually appears in the first professional year. The inclusion of such courses which teach fundamental sciences help the pharmacist understand the principles of pharmacy thereby making pharmacy less of an art and more of a science.

THe Curriculum in Pharmacy given at the Philadelphia College of Pharmacy and Science is typical of that given at most colleges of pharmacy. Note the inclusion of biochemistry and quantitative analysis in the first Professional year. Pharmacy and Chemistry of Medicinals, not taught until the second professional year at most colleges, commences here in the first year but is restricted in scope to pharmaceutical substances not used for their therapeutic activity but in formulation, that is, solvents, preservatives, anti-oxidants, surfactants, etc. Physiology is taught concurrently with biochemistry.

By the second professional year, chemistry is no longer basic but has become blended almost completely into pharmacy. "Organic Pharmaceuticals","Chemistry of Medicinals", and "Pharmacy and Chemistry of Medicinals" cover essentially similar material. Official and unofficial drugs are discussed, classified chemically and by their therapeutic activity. The properties and uses are stressed as are certain structure-activity relationships. Generic and proprietary names are correlated and available dosage forms discussed.

Note that chemistry no longer appears as a basic course in the second Professional year, but only in applications courses. The importance of chemistry in pharmacology, pathology, pharmacy and chemistry of medicinals, manufacturing and dispensing, pharmacy and pharmacognosy need hardly be mentioned.

The third professional year follows in like manner with chemistry appearing in the form of pharmacology and the pharmacy and chemistry of medicinals.

CURRICULUM IN PHARMACY

(at the Philadelphia College of Pharmacy & Science)

FIRST PROFESSIONAL YEAR

Physiology	7 cr.
Human Anatomy	3 cr.
Biochemistry	4 cr.
Quantitative Analysis	4 cr.
Pharmaceutics	8 cr.
Health Care and Drug Distribution	2 cr.
Pharmacy and Chemistry of Medicinals	3 cr.
Orientation to Institutional Practice	2 cr.

SECOND PROFESSIONAL YEAR

Pharmacognosy	4 cr.
Microbiology	5 cr.
Pharmacology	8 cr.
Pharmacy and Chemistry of Medicinals	6 cr.
General Pathology	4 cr.
or	
Advanced Analysis	4 cr.
Manufacturing and Dispensing	3 cr.
Orientation in Medicine	2 cr.
Electives	

THIRD PROFESSIONAL YEAR

Pharmacology	4 cr.
Pharmacy and Chemistry of Medicinals	4 cr.
Professional Pharmacy	4 cr.
Public Health	4 cr.
Dispensing	4 cr.
Pharmaceutical Jurisprudence	2 cr.
Clinical Pharmacy	5 cr.
Electives	3 cr.

DOCTOR OF PHARMACY PROGRAM
(at Philadelphia College of Pharmacy & Science)
PROFESSIONAL YEARS

First Year

Physiology - Human Anatomy	9 cr.
Biochemistry	6 cr.
Quantitative Analysis	4 cr.
Pharmaceutics	8 cr.
Pharmacy and Chemistry of Medicinals	3 cr.
Orientation fo Pharmacy Practice	2 cr.
Health Care and Drug Distribution	2 cr.

Second Year

Pharmacology	8 cr.
Pathology	6 cr.
Pharmacy and Chemistry of Medicinals	6 cr.
Orientation in Medicine	2 cr.
Manufacturing and Dispensing Pharmacy	3 cr.
Pharmacognosy	4 cr.
Microbiology	5 cr.

Third Year

Pharmacology	4 cr.
Pharmacy and Chemistry of Medicinals	4 cr.
Dispensing Pharmacy	4 cr.
Professional Pharmacy	4 cr.
Public Health	4 cr.
Pharmaceutical Jurisprudence	2 cr.
Clinical Pharmacy	5 cr.
Principles of Biostatistics	2 cr.

Fourth Year

Advanced Clinical Pharmacy and Toxicology	8 cr.
Sterile Techniques	3 cr.
Electronic Data Processing	2 cr.
Administrative Principles	3 cr.
Seminar	2 cr.
Clinical Clerkship	1 unit
Professional Electives	12 cr.

Doctor of Pharmacy Program

Earlier it was stated that the two pro-professional years for the doctor of pharmacy program are identical to those for the five year pharmacy program. Let us move quickly through the four years of the curriculum noting similarities and differences with the five year program.

In the first professional year, we see that biochemistry, quantitative analysis and the pharamcy and chemistry of medicinals are the same as for the five year course. Only minor differences in certain professional courses will be noted.

Examination of the second professional years show them to be essentially identical also.

And the third years, too, are similar from the standpoint of their chemistry content.

Finally, the fourth professional year of the doctor of pharmacy program is seen to consist largely of non-chemical subjects but they are subjects in which chemistry is applied to the practice of pharmacy.

Clinical pharmacy is concerned with drug therapy as it relates to laboratory findings, diagnosis course and prognosis of disease. Matters such as dosage regimens and reactions, individual patient response and potential drug-drug interactions are stressed. During the period of the clinical clerkship the student is required to take drug histories, monitor drug therapy, provide drug information and participate in drug selection at one of the participating hospitals. Students from the Philadelphia College of Pharmacy and Science serve their clerkships at the Hospital of the University of Pennsylvania or Thomas Jefferson University Hospital.

Graduate Program

Students participating in the graduate program generally anticipate continuing through to the doctorate level. The purpose of the graduate program is to prepare them for a career oriented toward research. By the time a pharmacy major has completed the necessary course work for a graduate degree he has accumulated more credits in chemistry than the average chemistry graduate with a bachelor's degree. I point this out to emphasize the great amount of chemistry required of the Ph.D. in a pharmaceutical science.

The list of courses illustrated here is typical of those offered at most colleges of pharmacy offering graduate degrees. Course selection depends upon the student's area of concentration. However credit in physical chemistry and radiochemistry (radioisotope technology) is currently required of all graduate students at P.C.P. & S. That this should be suggests that these courses offer knowledge especially important to their careers.

TYPICAL GRADUATE COURSES IN CHEMISTRY

Title	Semester Hours
Qualitative Organic Analysis.	4
Heterocyclic Chemistry.	3
Advanced Organic Chemistry Laboratory . . .	2 or 4
Physical Chemistry	8
Chemical Kinetics	3
Thermodynamics	3
Advanced Physical Chemistry Laboratory. . .	2 or 4
Colloid Chemistry	2
Advanced Analysis II	4
Electronic Instrumentation in Chemistry . .	2
Radiochemistry	3
Techniques in Biochemistry	2
Modern Theories of Organic Chemistry. . . .	3
Advanced Inorganic Chemistry.	3
Special Topics in Physical Chemistry. . . .	2
Special Topics in Analytical Chemistry. . .	2
Advanced Biochemistry	4
Analysis of Medicinals	3
Special Topics in Organic Chemistry	2
Chemistry of Medicinals I	3
Chemistry of Medicinals II	3
Graduate Seminar in Chemistry	2
Experimental Medicinal Chemistry.	2
Structure-Activity Correlation.	2
Research	4
Doctoral Research	Variable

A Chemistry Curriculum for Medical Technologists: A Two Year Training Program

John Kiyasu
Roosevelt Hospital
New York City, New York

Presented to the Symposium on the Chemistry Needs of the Biological and Health Science Majors, 31st Two-Year College Chemistry Conference, Brooklyn, New York, August 25, 1972.

The medical technologist in the field of Clinical Chemistry or Biochemistry differs from other modes of chemical training or employment, in that lives and state of health of others are involved, is daily demanding, ad hoc demanding, and is completely service oriented to fulfillment of needs for others. Very seldom can a medical technologist employed in a hospital Biochemistry Service, actually experiment with new principles, dwell patiently on thorough investigational pursuits, leave things off until tomorrow or a point in future time until he or she is in the mood for pursuing or expediting a determination. Each test performed is for real. It is not to satisfy one's curiosity or to accumulate data to be compiled to ascertain new projected goals. Everything is for now - and any quantitative analysis performed is a datum which potentially has medical - legal meaning and is a datum reportable to somebody with reasonable surety. A chemist or a chemistry technologist cannot say - oh by the way- the determination (amylase for example) performed several days ago is actually this or that.

It is fair to state that chemical values obtained from patients are of more imminent nature than other areas of medical technology, since the chemical parameters such as pCO_2/pO_2/blood pH, etc. are fluctuating moment to moment and can turn medical management toward life or death. Although other areas of laboratory science such as serology, hematology, etc., are not unimportant, the biological basis of these latter parameters are more insidious or chronic in nature and therefore do not require immediate management (i.e. a matter or minutes or hours). The only other area of planned or unplanned crisis is the area blood banking, in which poor laboratory practices will be reflected in a catastrophic manner.

Since human physiology is such an important framework of the care and management of the patient, and really the matter of human biology in the medical or post-medical classroom, and are described or understood via metabolic pathways, enzymatic defects, acid-base balances, etc., it is not remarkable that heavy duties of STAT nature will rest upon the chemical technologist. This is because the medical training emphasizes the importance of chemical parameters in biological fluids. A very important requirement for a trainee in clinical biochemistry will therefore, by necessity include a quality or stability from such a candidate. The service nature requires such a candidate to be of cooperative nature, friendly but firm, methodical, most responsible, completely cool under pressure and mechanically adept. Yes, these are a lot to ask in a person or candidate, but these do appear prime requisites even before we consider the chemistry curriculum and/or training program. Testing for manual dexterity, psychometrics, aptitude are entirely appropriate before a training program is committed to a candidate.

CURRICULUM

Dr. Bethune has listed four areas of discipline which are:

1. Mathematics - mostly algebra
2. Chemistry - general, organic, quantitative and analytical
3. Physics - instrumentation, theory, optics and some electronics
4. Biology - biochemistry and physiology

These of course, can easily expand to a four year university setting. In my opinion, I would de-emphasize theory, although the understanding of principles might be difficult without the theory.

I would emphasize the addition of one more area:

5. Data processing, statistics and typing instruction. (The last may sound trivial, but is not).

Since a two year program is really a short period of time, especially since one half year is usually reserved for practical experience, a streamlined version of a curriculum might be:

1. One semester intense for math, physics and chemistry combined with emphasis to problem solving.
2. One semester intense for biochemistry and physiology with continuation of problem solving relative to biological parameters.
3. One semester intense data processing, statistics and typing instruction. Here, typing could be made a prerequisite at the high school level. Statistics would involve establishment of norms, quality control and reinforce biological parameters such as electrolytes, etc.

EXPANSION OF CURRICULUM

I. Math, Physics and Chemistry - without going into the matter of semester hours and the allocation of time respective to fields, I shall point out areas of practical needs in a Biochemistry Service Laboratory.

A. Concentration and Amounts - Surprisingly enough, technicians have a tendency of saying 15 mg. % of total protein per T.V. (Total Volume) of 1500 ml of urine/24 hrs. When the question is asked: "What is the total output of urinary protein per 24 hours?", the technician often refers to a pat formula, the derivation of which she or he does not understand, of if lucky, comes out with the right numerics but the wrong expression. She might answer: 225 mg. % protein per T.V. instead of 225 mg. In a nutshell, technicians have to know the metric system, the correct point of decimal places, calculation ability when no formulas are present, ability to derive equations when formulas are present, and the ability to conceive the concept of concentration. There are the usual problems confronted in freshman chemistry - the need for problem solving is paramount in a Biochemistry Service. Another case in point is: If you have 420 cc of 70% ethanol in a beaker, how many cc of 95% ethanol must be added to obtain a final ethanol concentration of 78%.

B. Instrumentation Most of the female gender, in my experience, are relatively weak in matters of mechanics, or having the need to take apart machines, no matter how simple. Furthermore, the principle and concept of how the instrument works seems a little nebulous to many laboraboty workers. It would be my recommendation that any physics course with a laboratory counterpart would include as part of a requirement, the complete disassembly and the reassembly of a Klett colorimeter (or some facsimile therof), explaining verbally to the instructor in charge, the function of each component. A written examination of this sort usually involves memorization with little if any of residual understanding.

C. Chemical Analysis This requires some fundamental appreciation of valences, reactivity and functional groups. Since most of the analysis in the laboratory involves measuring organic compounds, the tools of organic chemistry must be made available to the technology trainee. The basic elements of base catalysis or acid catalysis requires some understanding or reaction mechanisms. Examples of nucleophilic displacements versus electrophilic substitution should be reviewed so that a few arrow could be flipped around. To what extent you will succeed here is problematical in that, not many undergraduates manage to reach this level of chemical understanding. However, every possible attempt must be made to strive for biochemical technicians not to be afraid of chemical reaction mechanisms.

No curriculum is worth much unless it can be expedited and enforced. Obviously some attrition of students must proceed if course requirements are to be met. If the three semesters outlined above are kept in their respective sequence or some facsimile thereof, and in principle accepted as plausible, the implementation of a teaching curriculum may be met by the following schedule.

1. Twenty percent of the students at the end of the 1st. semester should be called out to either repeat the first semester or to drop out of the program. Certainly they might be encouraged to shift toward blood banking or other areas. This is because the robot nature of Clinical Chemistry in a hospital service laboratory, in fact, often attracts the robot type of person, which as I will develop later, is UNDESIRABLE .

2. Ten percent of the students at the end of the 2nd. semester should be called out to either repeat the wnd. semester or be encouraged to work for industry in some area not requiring biological interpretation.

3. At the end of the 3rd. semester, on the basis of completion of the two successive semesters involving the tools of quantitation and appreciation of life processes, the completion of a program geared toward statistics, data processing, and managerial aspects, the faculty of a technology program should be able to place candidates for a 4th semester in experience, into a small or large hospital, computerized or non-computerized laboratories, teaching or non-teaching hospital, etc.

In my opinion, for the fourth semester of practical experience (if such is the curriculum), the success of a medical technology program by an institution is the proper placement of the appropriate student to his or her type of laboratory. Based upon the performance of such placed candidates, the host institution will feel the rewards of suitable employment of that donor institution's protegee. Reputation is generated based upon the "success/ratio" and productivity and therefore the appreciation of the host laboratory, the potential employer.

I would like in conclusion to develop in depth, the goals of a technology program as I see it. The Clinical Chemistry Service is very routine, to the extent of intellectual sterility, at times. This is bad. On the other hand, a service laboratory cannot habitually intellectualize for work must be performed daily along the same standards day after day, week after week.

The job market, however, appears to be rather flooded, but in spite of the few laboratory openings and the excess applicants for these laboratory positions, there is still paucity of good laboratory technologists.

A good laboratory bench performance is only part of the needs of an expanding biochemistry service. Advances in the field of Clinical Biochemistry have been incredible! Quantitation of enzymatic activity in serum, for example, is being performed routinely in some service laboratories, using measurements of zero order kinetics. The differentiation of serum isoenzymes, to pin point a diseased organ requires not only some sophisticated isolation techniques, but also some appreciation of the quaternary structure of proteins. Clinical Biochemistry in a hospital setting is no longer bath-tub chemistry, but employs techniques and instrumentation that only a decade ago were considered highly specialized research tools. Thus, it is no longer adequate to just teach the trilogy of Beer's Law, Henderson-Hasselbach equation and redox potentials.

Therefore, the goals of a technology program, should be to give selected applicants in Clinical Biochemistry the hard core fundamentals of chemistry, physics, and quantitative analysis, similar to chemistry majors in a four year university. The shortness of time necessitates de-emphasis of theory, although basic principles must be understood. The attrition rate may be significant, but such nonqualified students may be encouraged to apply themselves to other areas of laboratory science. Finally, typing and data processing techniques will be useful qualifications in the area of Clinical Biochemistry because of the morass of statistics, work volume, and the current attempts to computerize hospital laboratories, especially in Clinical Biochemistry.

The curriculum I present you is general, for each teaching institution has different resources of teaching staff and student population. I have stated more the trends and need of existing laboratories for services of medical technologists in Clinical Biochemistry. The success of any teaching program is placement, a successful placement of members of each succeeding class.

I would like to close with the point that even the Biochemistry and Chemistry Departments at four year universities and colleges are wondering how their curriculum may be changed in order for their graduates to be more successfully placed. The challenges are demanding, but each institution represented here should be able to meet these trends in their own creative approaches to adapt theory to practicality.

Relevant Applications of Chemistry in the Allied Health Area

Rena Orner
Fairleigh Dickinson University
Teaneck Campus, Teaneck, New Jersey 07666

Presented at the Symposium on Innovations in Teaching
Chemistry, 31st Two-Year College Chemistry Conference
Brooklyn, New York, August 25, 1972

The solubility product principle can be related to the dissolution and deposition of bone and teeth. The mineral of these tissues consists mainly of tricalcium phosphate which precipitates from solution. Therefore, concentrations of participating ions must exceed certain values in the immediate environment in order for precipitation to take place. Even at equilibrium, surface ions from the crystal lattice structure of the mineral exchange with like ions from solution.

If we take the basic event in calcification to be the precipitation of $Ca_3(PO_4)_2$, we can write for the reaction

(equation 1) $3\ Ca^{++} + 2\ PO_4^{\equiv} \rightleftarrows Ca_3(PO_4)_2$

the solubility product expression

(equation 2) $\{Ca^{++}\}^3 \times \{PO_4^{\equiv}\}^2 = K_{sp}$

Using buffered solutions at pH 7.4 and 37°C (pH of normal blood and normal body temperature) and allowing sufficient time for equilibrium to be reached, the experimental value for the K_{sp} is $10^{-26.4}$. Are the calcium and phosphate ions in blood serum present in sufficient concentration to be just saturated with respect to crystalline $Ca_3(PO_4)_2$? The actual value for free unbound ionic calcium in blood at pH 7.4 is approximately 1.2×10^{-3}M. For tertiary phosphate ion it is about 1.6×10^{-8}M. Substituting these values in equation 2 $(1.2 \times 10^{-3})^3 \times (1.6 \times 10^{-8})^2$ we get an ion-product of 4.4×10^{-25} or $10^{-24.4}$. This value is one hundred times greater than the solubility-product constant $10^{-26.4}$ and we would expect bone precipitation to occur. However, while serum at pH 7.4 is supersaturated with respect to $Ca_3(PO_4)_2$, in the immediate vicinity of bone formation the pH is lower. This is due to metabolic reactions taking place in the bone cells. Organic anions produced by these cells in the metabolism of glucose are destroyed elsewhere in the body, and the excess hydrogen ions released lower the pH in the internal environment of the bone. The $PO_4^{\equiv}$ concentration which is strongly pH dependent is consequently reduced.

$$PO_4^{\equiv} + H^+ \rightarrow HPO_4^{=}$$
$$HPO_4^{=} + H^+ \rightarrow H_2PO_4^{-}$$

Apparently under normal conditions, when the pH of blood is 7.4 the pH in the immediate vicinity of bone formation and dissolution is sufficiently lowered to depress the $\{PO_4^{\equiv}\}$ to a point where the ion-product $\{Ca^{++}\}^3\{PO_4^{\equiv}\}^2$ falls very close to $10^{-26.4}$ and normal bone tissue maintenance exists. In the case of children suffering from chronic acidosis, the pH of blood is below normal, 7.1, and indeed bone growth is greatly impaired. In this situation the pH at the site of bone formation is below 7.1 which has the effect of depressing the $\{PO_4^{\equiv}\}$ to a value which is too low to produce an ion-product that will equal the K_{sp} for $Ca_3(PO_4)_2$. Children with this congenital defect form improper skeletons.

Another K_{sp} dependent situation exists in the mouth with respect to tooth formation and dissolution. Here, at ordinary pH values of saliva, which constantly bathes the teeth, Ca^{++} and $PO_4^{\equiv}$ are in sufficient concentration to prevent erosion of tooth tissue. In cases where salivary glands, which produce the saliva, are removed, the teeth, if not removed will deteriorate rapidly because the ion-product of Ca^{++} and $PO_4^{\equiv}$ is below the K_{sp} for $Ca_3(PO_4)_2$.

How can carie formation be explained in teeth which are constantly being bathed by saliva? A combination of carbohydrate and protein known as mucin is precipitated from saliva and forms a film or plaque on the tooth. If this is not removed by brushing and flossing it thickens as entrapped bacteria and food becomes embedded. This becomes firmly attached to the enamel or root surfaces of the tooth. It is beneath these plaques that carious lesions occur. Acid decalcification is the essential step in the process and the requisite acids are produced by the microbial fermentation of the carbohydrates entrapped in the plaque. Saliva which bathes the area cannot reach under the plaque, therefore the buffering action normally provided by the $PO_4^{\equiv}$ + $HPO_4^{=}$ ions in saliva is blocked. At the site of human carious lesions pH's have been found to be as low as 4.5-6, which is acid enough for decalcification to take place. The $PO_4^{\equiv}$ from the mineral of tooth tissue promptly neutralizes the excess acid forming a more soluble $HPO_4^{=}$.

Two units of great importance to students in the health sciences involve the study of water and solutions and the maintenance of water, electrolyte and acid-base balance of the body.

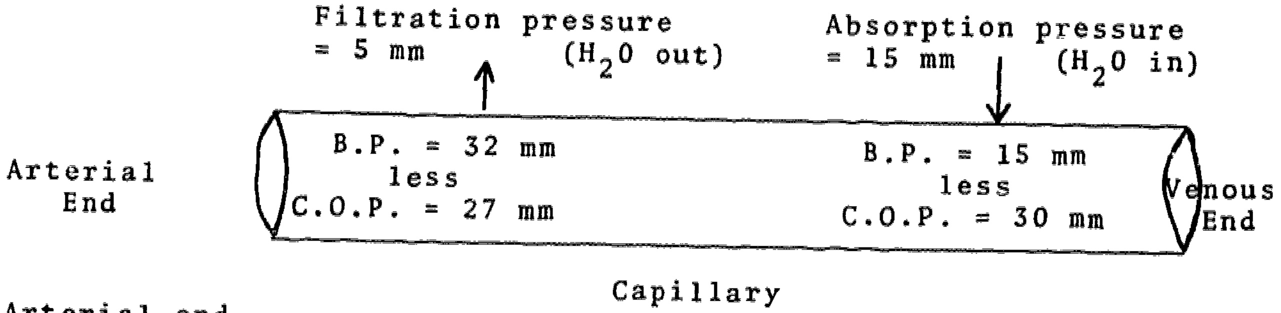
All the processes of dialysis, diffusion, osmosis and filtration can be taught as they contribute to tissue fluid formation and the movement of molecules through membranes. What are the factors that promote the exchange of food molecules from the blood to the tissues, and the waste products of metabolism from the cells to the capillaries?

Fluid passes from the capillaries and into the tissue spaces by the process of ultrafiltration. It is in this manner that water and solutes flow through the capillary wall. The chief factor promoting filtration is the blood pressure (B.P.) or hydrostatic pressure pushing fluid out of the capillaries. Opposing this is the colloid osmotic pressure (C.O.P.) or the oncotic pressure of the plasma protein pulling water in.

Filtration pressure = Capillary blood pressure minus plasma colloid osmotic pressure.

The colloid osmotic pressure will vary with the concentration of the plasma proteins. A loss of plasma protein will increase the filtration pressure and increase tissue fluid formation. An increase in blood pressure also increases the filtration pressure.

Although values for blood pressure and colloid osmotic pressure varies from time to time and from place to place the following values may be used as an example.



Arterial end

B.P. = 32 mm = (pressure forcing H_2O out)

less

C.O.P. = 27 mm = (o.p. drawing H_2O in)

Effective filtration pressure = 5 mm (H_2O goes out)

Venous end

B.P. = 15 mm = (H_2O out)

less

C.O.P. = 30 mm = (H_2O in)

Absorption pressure = 15 mm (H_2O enters)

B.P. falls at venous end due to increased resistance to flow and loss of fluid.

C.O.P. rises at venous end due to greater concentration of plasma proteins.

The kidneys in a fantastic filtration reabsorption process regulate the amount of water that will be excreted in the urine and rid the blood of waste products of metabolism such as urea, uric acid and creatine. Hormones assist the kidneys in regulating the electrolyte and acid-base balance. When the kidneys fail to function hemodialysis can be carried out with an artificial kidney machine. Without the aid of hormones the health professionals must study the blood profile of the patient and select a dialisate solution for bathing the blood (i.e. normal Na^+/K^+ or K^+ free) that will correct conditions through the simple process of dialysis.

These few examples, demonstrate a sensible approach for teaching chemistry to students in the health professions. Find applications of chemical principles as they occur in the hospital, the laboratory or in the body and teach the concept relating it to the practical situation. When teaching gas laws, draw examples from gas exchange as it occurs at the cells and at the lungs. The absolute necessity of knowing the pH, pCO_2 and pO_2 relationships in order to properly ventilate a patient furnishes numerous practical applications for the Henderson-Hasselbach equation. Nuclear medicine is a rich source of application illustrations for lecture and laboratory material. Problems can be drawn directly from hospital situations, i.e., 3 liters of 5% glucose given intravenously over a 24 hour period provides the patient with only 750 kcal.

If a self-motivated visit to one of your cooperating hospitals is not a simple matter, then a chat with a clinical staff colleague or with a physiology instructor and a look in his text book will suggest still more applications of the chemical concepts you teach. Relevence in our teaching is still a major concern for students and teachers.

Biological Chemistry and the Laboratory Technician

Stanley Cherim
Delaware County Community College
Media, Pennsylvania, 19063

Presented at the Symposium on Innovations in Teaching Chemistry, 31st Two-Year College Chemistry Conference Brooklyn, New York, August 25, 1972

The invitation to speak on the biology-chemistry interface as an innovation in teaching chemistry for future laboratory technicians raises some intriguing questions. One question, of course, is how to be innovative, and another is the nature of the interface.

In answer to the first question, I strongly submit that realism would be a critically needed innovation in many of our teaching institutions. By this I mean that the chemistry we teach for technicians must move from the theoretical-abstract-academic toward the real life practical chemistry that goes on in a biochemical research laboratory. In this situation the interface expands to include physics, electronics, mathematics, wood and machine shop work, and the important human considerations of ethics and morality.

To present my thesis I seized on the idea of narrating the story of a typical day in the life of a laboratory technician. Let's call him Steven Wolfgang (instead of plain old Bill or John) and follow his day in the realm of the biology-chemistry interface. The fictitious Steven is like any one of anumber of technicians I knew (and a few I trained) while involved in research in physical biochemistry a few years ago. The only preferatory note that needs to be made about Steve's background, although practically sine qua non, is that he has a sound preparation in basic chemistry. That is to say he can handle the most common aspects of formula writing, nomenclature (preferably the Stock system), the mole concept, basic algebra, and so on.

The first job that Steve has in the morning is the making of solutions that he will need for the preparation of pidgeon heart mitochondria. In order to do this, Steve must understand the concept of molarity. He uses his slide rule to perform the calculations which involve specific gravities, metric system units for volumetric and gravimetric measurements, and the proper labeling of reagent bottles. Steve has to be educated in terms of safety procedures. He will use the analytical balance, pipets, volumetric flasks and dilution techniques in order to prepare, for example, 50 ml of 10^{-12} M rotenone solution. He needs skill in using transfer pipets, serological pipets and micro pipets.

Next Steve uses the pH meter (after properly standardizing with buffers) to titrate a sucrose-mannitol-phosphate buffer to pH 7.2. All his tools are collected, rinsed in buffer, and set in an ice tray.

At this point Steve checks his protocol, modifying it as his experience suggests, and records all the steps in his ledger. Prior to this, it should be mentioned that Steve has skillfully performed a literature search so that his protocol for the mitochondria preparation is most efficient. He is aware of the delicacy of biological material so that he knows the danger of contamination and the importance of cold rooms and ice trays.

With all of his gear assembled, Steve rapidly sacrifices the pidgeon and dissects out the heart in a matter of seconds. Time is critical in the preparation of biologically active material. He goes through the mincing and the homogenizing steps. Then the series of differential centrifugations that separate the mitochondria from the rest of the cell debris. Steve can do this because he knows how to use a nomograph that converts the rpm units of his particular refrigerated centrifuge to the 6000 g's called for in his protocol.

Soon with a few milliliters of mitochondrial suspension in a tube on ice, Steve performs a Biuret protein assay on the spectrophotometer. He graphs his data and from the slope of the line he is able to record the number of milligrams of protein per milliliter of suspension. Now, more instrumentation. Steve moves to the oxygen electrode -- modern man's answer to the Warburg manometer -- and he determines the respiratory activity of his preparation. He can use the recorder to find and note the changes of state rates as the mitochondria are treated with microliter additions of ADP and succinate until the system is anaerobic. Steven can then perform the experiments on the mitochondria with rotenone (of varying concentrations) so that the effect of the rotenone on respiratory activity can be observed, recorded, and ultimately interpreted.

After making all the pertinent inclusions in his laboratory notebook, Steve is finally able to organize his materials and clean up. He knows the proper cleaning techniques for glassware. Steve has finished a productive and occasionally exciting day. He has been able to demonstrate the competence and good sense that earned him the respect and confidence of his superiors. It all adds up to a step forward in the cause of human dignity.

In summary, the knowledge and skills that have made Steve a laboratory technician (in the noblest sense of the title) are what we should be teaching: laboratory technique, responsibility, a knowledge of use of electronic instruments, and the extensive practical application of the fundamentals of chemistry and biology.

The Chemistry-Biology Interface in the Allied Health (Paramedical) Type Chemistry Course

John R. Holum
Augsburg College

Presented as the Allied Health Chemistry Course Keynote Speech, 31st Two-Year College Chemistry Conference, Brooklyn, New York, August 26, 1972.

There are two goals for this course that determine its content and justify its inclusion in the allied health science curriculum. The first has most to do with the chemistry-biology interface. This goal is to come to serious grips with the molecular basis of life. It is in terms of this goal that we select material, organize it for study, and decide what material from related fields (e.g., organic chemistry) to include or exclude.

The second goal has most to do with the future growth and development of the student. It is our duty both to the student and to society to provide a solid background in terms, topics and concepts by mean of which the student will more easily learn new knowledge in the allied health sciences, keep up in his or her particular field, and engage in the continual process of self-renewal that is sine quanon of the true professional.

In order to get at the molecular basis of life we recognize that the minimum requirements for biological life at even the most primitive levels are these three: materials, energy, and information.

What should we teach concerning the materials of life? First, that students become comfortably familiar with big molecules. Second, that they be able to recognize a few important functional groups and can make at least some reasonable predictions of the types of reactions such groups might undergo--particularly those reactions that involve water as reactant or product or that are redox events. Third, students should become deeply enough immersed in the "molecules of life" that as a bare minimum they can write structures that illustrate the essential structural features of molecules in the three classes of foods--carbohydrates, lipids and proteins. Depending on the time and level of the course, the basic structural features of nucleic acids might also be included. (In my short course I do not expect this.) The nature and functions of enzymes must be stressed. They not only are central to a cell's mechanisms for control and defense, as target molecules they also render the cell vulnerable to enemy agents.

If our goal were only an introduction to an understanding of the molecular basis of life, we should probably choose not to expect the students to learn many structures and definitions. However, if we intend, as I believe we ought, that they have a good, strong background for self-renewal and future growth, then we shall want them to know something.

Understanding is not the same as knowing. The difference is the difference between the Monday-morning quarterback and the Fran Tarkenton; between the amateur and the professional. One plainly must start with understanding; but then comes, equally plainly, some ordinary intellectual work--practice, drill, exercises, even memorization.

What should we teach concerning energy for life? First, the role of ATP and the central importance of the phosphorylation of ADP. Because of the great complexity of this, and because we still do not quite know how it is accomplished, we may legitimately be satisfied with a general view--certainly in the brief course. We should not let students become so mired in the intricacies of the respiratory chain, the citric acid cycle, and the ways by which this cycle is fueled--glycolysis and Knoop oxidation--that they miss the grand, overall view and the beauty of it all.

What should we teach concerning information and organization for life? We are now venturing deeply into the territory of biology, and we might well hope that no one will ask to see our passports. Here we learn humility, or ought to. There is so much difference between the inventory of a cell and its dynamic architecture that, as a minimum, we have to make this clear to the students. Yet, we do know something, and we can say much. The molecular basis of heredity learned well in this course should make the biology teacher's task much simpler. Something, at least in general terms, of the ways in which hormones might work is also a part of the molecular basis of information.

What should we teach concerning defense. We start with the major enemies and how they attack--viruses, bacteria, toxins, antigens in general, poisons, and most of the pollutants.

Finally, a question that surely has been in the forefront of our thoughts these last few years; what ought we include in our particular course from the environmental science field? So much is already expected of us that is it possible we can do anything more? This question, however, is not the leading edge of creeping despair. With only a moments thought we know that of all the freshman chemistry courses being taught our course in its entirety is directly relevant to the whole field of environmental chemistry. Precisely because we deal seriously with the molecular basis of life we are in a position to explain how the various pollutants threaten life. And we surely must not fail in doing just that. Hopefully, in the discussion period we shall be able to explore this further.

The Chemistry Needs of the Biological Science Major

Arnold Nemerofsky
State University of New York
New Paltz, New York 12561

Presented to the Symposium on the Chemistry Needs of the Biological and Health Science Majors, 31st Two Year College Chemistry Conference, Brooklyn, New York, August 25, 1972

Probably the most direct way to approach this question and at the same time gain the proper perspective, is to consider several sources that indicate the current nature of biology and the expected direction that biology will take in the future.

A 1967 report from the Commission on Undergraduate Education In The Biological Sciences states in the summary (p. 29):

> "There is a general departure from earlier curricula...(currently there is a) greater emphasis on molecular, cellular, and population biology at the expense of organismal biology..."

It goes on to state:

> "The relatively greater emphasis on molecular, cellular, and population biology necessitates increased collateral preparation in mathematics, physics, and chemistry"

and finally-

> "Within general categories of information there is much variation in specifics, but there is less variation in cellular and molecular biology than in other areas".

I think it is clear that these conclusions indicate an emphasis and general agreement on the importance of quantification in biology. In support of this trend, the institutions that took part in the study require the following: one year of General Chemistry (i.e. Qualitative and Quantitative), one year of Organic Chemistry, and, in one case, Introduction to Biochemistry. If we develop this idea a little further, namely that quantitative biology is increasing in importance and that chemistry cognates are also valuable for the major, we see that the institutions that took part in the survey devote on the average 64.0% of their total biology requirement to those biology topics that are classified as molecular or cellular. Although only four institutions took part in the 1967 study, subsequent studies reaffirm their conclusions, and this symposium is indeed additional evidence of the importance of chemistry in a modern biology program.

Furthermore, the following topics are routinely and widely presented in a beginning General Biology course: chemical equilibrium, polarity of molecules, chemical properties of the cell membrane, enzyme action, photosynthesis, the Krebs cycle, glycolysis, electron transport, glucose metabolism, protein synthesis, and D.N.A. structure and function are just a few examples. Many of the best general biology texts regularly cover such topics as atomic structure, chemical bonding, carbohydrates, lipids, proteins, nucleic acids, and energy transformation. In many institutions General Chemistry is taken before General Biology or during the freshman year concurrently with General Biology. If we consider the recent advances and efforts in biology, it is clear that the major developments are in areas requiring a chemical background. Pauling's work on the nature of a specific protein(i.e. Hemoglobin), served as a basis for further investigation into biological macromolecules: Jacob and Monod's studies of βGalactosidase regulation in bacteria, now provides a model for future studies on enzyme regulation in cells. Every grade school child is now aware of the chemical and physical nature of the genetic determinant Desoxyribosenucleic acid as Watson and Crick. Again, these examples are merely a few out of many possible choices. As a further illustration, the classical area of taxonomy (commonly known as classification) has also utilized the tools of chemistry. Relationship may now be establishes in birds by the analysis of electrophoretic albumen patterns.

With these observations serving as a background, what are the chemical needs of a biology major at a four year institution or a Liberal Arts student at a two year college who intends to transfer? I prefer to develop the chemical principles on a microscopic to macroscopic framework. This is useful to me whether I am teaching a General Biology Course or Genetics. I feel that this approach is also applicable to other areas in Biology. It should be appreciated that different courses, and areas of biology differ in the degree of rigor that each topic requires.

Atomic structure serves as a beginning from which the electronic configuration of an atom is developed; this allows for subsequent presentations of chemical bonding (i.e. ionic, covalent and hydrogen bonding.)

The next theme that is developed is the variety of molecules common to protoplasm; namely, proteins, carbohydrates, lipids, and nucleic acid. A connecting theme throughout this entire discussion is the essential and sensitive interrelationship between all biological macromolecules in the overall maintenance of cellular activities. Since proteins play a "common" role in protoplasmic events, I usually consider them first. I emphasize the primary, secondary, tertiary and quaternary nature of protein structure dwelling on the importance of amino acid sequence as a prime determinant in the final geometric shape of the macromolecule. The idea of geometric shape is reemphasized in relation to protein or enzyme denaturation and the student is cautioned to remember this point when we consider the molecular basis of mutation. The importance of geometric shape is illustrated again by reference to some fundamental aspect of enzyme action such as enzyme-substrate specificity. The importance of enzyme action in overall cellular events is presented. By this point, hopefully, the student is aware of some of the dynamic aspects of cellular activity.

The next theme to be developed is energy transformation within cells, namely, photosynthesis and cellular respiration which are appropriately considered by discussing carbohydrates. The variety of monosaccharides found in protoplasm is reviewed and their function in cellular activities is stated.

Glucose, galactose, and fructose are typical sugars present in protoplasm. The selection of these sugars provides a convenient lead into the study of isomerism. Disaccharides such as sucrose and maltose are widely distributed in nature and the reactions that they commonly undergo, that is dehydration synthesis in their formation, and hydrolysis in their breakdown are presented.

More specifically, glucose synthesis during photosynthesis and secondly, glucose degradation during cellular respiration is developed and contrasted. In both instances potential energy in the form of ATP is generated. During this topic the role of electron transfer is presented and also the importance of enzyme action is reaffirmed. Polysaccharides, such as starch, are considered in terms of "energy storage".

Briefly, lipids form a group of compounds of great importance from a cellular point of view, principally because of the part that they play along with proteins in the construction of membranes.

At this point I generally consider some aspects of active transport and some of the hypothesis regarding movement of small molecules across membranes. Cell membranes are relatively permeable to H_2O, certain simple sugars, amino acids, and lipid soluble substances. Permeability varies according to molecular size and ionic charge. Movement of material across a membrane involves the expenditure of energy. This entire process is referred to as active transport. Although the exact mechanism is not known, most theories proposed to explain this phenomenon assume that some sort of carrier molecule is involved. The carrier is presumed to react chemically with the molecule to be transported, forming a compound that is soluble in the lipid portion of the membrane.

I then consider the nature of nucleic acids. A molecular model of DNA is developed from its basic nucleotide building blocks. Chemical evidence is presented indicating the duplex nature of DNA, the mode of DNA replication, and the importance of DNA in determining protein structure. An essential point is presented, namely, that an altered nucleic acid ultimately manifests itself as a changed amino acid sequence in a protein molecule. This event is known as a mutation.

Protein synthesis brings together many of the chemical events that occur in protoplasm. Double stranded DNA separates and one of the chains serves as a template for the enzymatic synthesis of messenger RNA. Messenger RNA in turn acts as the template for the synthesis of polypeptide chains. Amino acids to be incorporated in the polypeptide chains are first activated by ATP and then picked up by a third nucleic acid, transfer RNA. Transfer RNA molecules carrying an amino acid, attach to messenger RNA at a specific association point. This ordering of the transfer RNAs along the messenger RNA molecule also orders the attached amino acids. Once the amino acids have been moved into the proper sequence, peptide linkages are formed and the resulting polypeptide separates.

With these remarks serving as an introduction, let us now consider a sepcific area of biology, chemical mutagenesis. This field concerns itself with the alterations chemical agents exert on DNA. The problem is considered in most courses in Genetics. For example, one proposed mechanism of the mutagenic effect of base analogs is that they tend to replace one of the natural occuring nucleotides in DNA. Once incorporation has taken place, tautomeric shifts result in permanent errors in nucleotide sequence.

Another active mutagen is nitrous acid. Nitrous acid acts in a highly predictable fashion, based on its chemical reactivity. Nitrous acid preferentially deaminates adenine in DNA to form a compound called hypoxanthine. Hypoxanthine has pairing qualities (based on available hydrogen bonds) that differ from adenine. Hence, alterations again occur in nucleotide pairing and sequence in DNA.

Acridines are potent chemical mutagens. Their suspected mode of action is based on their similar geometric configuration to the normally occurring nucleotide. Acridines supposedly intercalate within the DNA helix causing a permanent change in DNA structure.

Alkylating agents, such as ethyl methane sulfnate are mutagenic. These agents appear to react with DNA by ethylating the seventh position of the purine ring of guanine or adenine. This reaction is then followed by hydrolysis of the purine-deoxyribose bond and an eventual loss of the whole purine base from the polynucleotide chain. If this chemical induced gap is repaired incorrectly a mutation occurs.

The point I am trying to make with these examples is that most-if not all-chemical principles are applicable to biology. Very succintly, the contribution that chemists could make to the needs of biologists is to attempt to use those molecular examples that are familiar to biologists in their chemistry courses. The principles remain the same.

There is a second aspect related to this question of chemistry needs. I realize that this second need has been around for a long time, but I think it is just now being felt at the undergraduate level. I am referring to the importance of instrumentation and bio-chemical techniques. Techniques such as chromatography (paper, thin layer, and gas) are commonly required in bio-technology and protein research. Spectrophotometers are used routinely in enzyme studies. Manometry is a standard procedure in respiration and photosynthetic studies. These needs are employed both in teaching laboratories and research. The point of his comment is the hope that a "Bio-Instrumentation and Procedure" course could be developed at the undergraduate level and made available to biology majors. I mention the last point since I am aware that Chemistry Departments offer an instrumentation course but usually require one year of Physical Chemistry, which up until the present is not a standard requirement for biology majors.

Chemistry From a Biologists Point of View

Charles Porter
San Jose State University
San Jose, California 95114

Presented at the Symposium on the Chemistry Needs of the Biological and Health Science Majors, 32nd Two-Year College Chemistry Conference, Oakland, California, October 20, 1972.

During the Spring Semester of the past school year I received a text to be considered for adoption and use in our Biology I. The title of this book is Life: The Conquest of Energy. This title, I believe, is wrong. For although the title captures the spirit of Biology today, it conveys the idea that life has mastered energy. This is not true. Thus the title should be Life: Our Presently Known Most Efficient Use of Energy.

No one, be that person biologist, chemist, physicist or philosopher would doubt that life is a process of complex interactions of the physical and chemical world. No one has shown as yet, that living things do not follow the laws of thermodynamics. In fact all data obtained so far indicate that living things just as machines do obey the physical laws.

This brings us to a question that has been asked many times - What is life? For this, there has been no satisfactory answer. Perhaps because the question is wrong and if one asks nature a wrong question one will get a wrong answer or no answer at all. Life can be defined only by characteristics and life is always tied to material systems. Yet when living systems of matter are analyzed the analyzer has invariably come to the consideration of life on chemical terms. Then it seems to me that all biologists, since they deal with the understanding of life, must have more than a cursory knowledge of chemistry.

Therefore I do not agree with the statement made recently in publication number 34, The Context of Biological Education August 1972 by the Commission on Undergraduate Education in the Biological Sciences. That statement is as follows and I quote: "Cognate requirements have become numerous in courses as the core curriculum in biological education. They most often consist of chemistry including organic, mathematics, including calculus and a year of physics. Theoretically, these serve to relate biology to the physical sciences and help students acquire a more comprehensive understanding of the subject. As a goal, this cannot be questioned, but the expediency of simply requiring these courses does not automatically assure its attainment." I say that the statement would hold true only if the student is passed on without his having mastered the fundamental principles in such courses. For how can such students comprehend the chemistry of carbon, which is so much involved in biology, if he does not have a basic comprehension of the chemistry of all the elements? It is simply this problem, the understanding of carbon chemistry and a bit more, that such courses are required and not a justification based on the student's needs in graduate school.

To emphasize this I shall point out for you instances where some of the fundamental concepts of life (Biology) intimately involve chemistry.

The development of living organisms today, as it probably has always been, is an orderly sequence of chemical events triggered by chemical agents.

Thus, an understanding of life calls for learning a formidable number of large molecules, some of these with architectural characteristics that are so rare as to be almost unique. Indeed some of their names usually present barriers to easy understanding. Since there is no short cut or easy way around this, the newcomer to the field of biology must, of necessity, become familiar with a new language and that language is that of the Organic Chemist. Even so, the beginning biologist need not be or become a poet in this strange language, he needs only to master along the way enough of organic architecture to develop some appreciation of the organic complexity.

It is not possible to gain even the most elementary ideas of the structure and functions of the basic units of life without some knowledge of the fundamentals of chemistry. And today all scientists agree that the laws of physics and chemistry, including thermodynamic principles, hold for biological entities and actions. No black magic nor vitalism exist whereby the living can subsist or sustain themselves. Just as thermodynamics is the most basic method of analysis for inanimate processes, it is also fundamental in the analysis of the behavior of the living world.

Let me allude to some problems that are associated with teaching biology students biology without chemistry and physics. In such teaching the main sin will be more than likely that of omission. I might say that on an introductory level, the central value lies in the elimination of details so that central concepts in both biology and chemistry may emerge. In addition to the sin of omission the second problem is one which almost always arises from an attempt to reduce complex scientific principles to simple, nonchemical and nonmathematical terms. There then lay the possibility of giving students a false sense of mastery of what turns out to be an extremely complex subject. Even so, if we say that such subjects cannot be taught on an elementary level we deny the very foundation of the education process.

In introducing students to biology, each teacher must determine for himself (herself) the level and structure of his or her course. This should be done without the omission of the importance of a knowledge or mastery of physical and chemical principles.

Some biology teachers may elect to omit topics of chemical equilibrium or reaction kinetics in introductory biology courses. Whereas discussions of carbohydrates, fats, nucleic acids and proteins would always be a central theme in teaching modern biology.

Therefore it is possible (and I attempt to do this at least in part) to introduce the biology student to an understanding of what life is in the simple terms of what life is in chemical terms. I must admit that to define all life in this way eludes me as it does all biologists. But my goal will have been attained if it has whetted the student's appetite. Not only does this apply to students whose primary interests are biological but for those who are interested in the humanities or the arts. Most of these students do not want a "watered-down" version of the existing courses designed for the majors, but what they want and need, is to have their interest in biology aroused and then to be provided with a framework on which they can continue to build this biological education long after leaving the college or university. What better way of doing this is there other than through chemistry?

I have continually made attempts to share my own enthusiasm and elation with my students of my feeling of the excitement and intellectual joy of new and significant discoveries in science, and particularly in biology. As all of you know, in the past 20 or so years the new discoveries have been made in the area of biochemistry. To list only a few: Calvin with photosynthesis, Miller with the synthesis of organic compounds under conditions thought to be those of the primitive earth, George Wald and his contribution in nerve impulse transmission, Jacob and Monod and their elucidation of the chemistry of enzymes (proteins), DuVinuard and his chemical synthesis of an active hormonal principle, Cori and Cori with their analysis of the action of insulin; Sutherland and his analysis of the role of cyclic AMP in cellular metabolism. I might add the preceding list is just a small fraction of the contributions, through chemistry, which has given new insight and directions to investigations in biology.

As far as contemporary biological investigations are concerned, ask the hematologist and biochemist who are focusing on the problems of immunity of the role of chemistry in their research. What is involved in air pollution which is threatening all of terrestial life? Chemicals! What confronts the ecologist as he tries to determine the best way to de-pollute our lakes, rivers and coastal waters? Chemicals! What has bothered us most with respect to the control of insect pests and our agriculture crop yields? Chemicals! The physician and men whose job it is to see to it that we have a healthy existence free from harmful ingredients in our foods are concerned with chemicals. Even when we biologists attempt to control insect pests by natural enemies of these pests we are confronted with chemistry - the chemistry of mating attractants, the chemistry involved in the development of both the pests and their natural enemies - such things as controls of diapause or molting.

With all due respect to my fellow biologists who are morphaligists, anatomists, taxonomist, ecologists, microbiologists, embryologists or developmental anatomists for the tremendous contributions these biologists have made to our understanding of life, modern biology requires something more than just training in identification and classification and memorization of structure. For wherever the biologist turns he runs into chemistry. Thus, yours and our young science of Biological Chemistry occupies a special place in our profession. Biological

Chemistry embraces not only chemistry, but also biology and physics. The biochemist have found that nature has been extremely ingenious in designing molecular types that possess the special ability to perform many unusual tasks. To the modern biologist, just as death and taxes, the biochemist or rather chemist is always there. Therefore to unravel the mystery of the complex construction patterns of life and yield even more wondrous information, we biologists are obliged to turn to chemistry.

The Chemical Needs of Biological Science Students

Clyde Willson
Laney College
Oakland, California 94607

Presented at the Symposium on the Chemistry Needs of the Biological and Health Science Majors, 32nd Two-Year College Chemistry Conference, Oakland, California, October 20, 1972.

The students at Laney College Perform better in Biology 1A-1B which is taken in their sophomore year if they have had some college level chemistry. Chemistry 1A (first semester general chemistry) is now a pre-requisite.

Students who have had chemistry 1A are usually not prepared in, or poorly prepared in, the following topics:

a. Organic (they should know about simple one and two-carbon compounds). It would even be desirable to have organic chemistry as a co-prerequisite, as is required at many of the 4 year colleges to which these students transfer.
b. Acid-base equilibria is often weak; they should be able to follow a derivation of the Henderson-Hasselback equation, and employ it.
c. Redox principles are usually weak or non-existant.

Discussion centered around the problem of whether it might be easier to reorder the chemistry topics or to reorder the biology topics. Neither the chemists nor the biologists seemed to think that it would be easy or desirable to change the present order. Most of the audience present approved of the idea of having chemistry 1A as a biology prerequisite, some were also in favor of the suggestion that chemistry 8 (introductory organic) be a pre-requisite, although most felt this to be impractical.

Environmental Concepts for Undergraduates

Robert W. Lamb and Joseph J. Delfino
United States Air Force Academy, Colorado 80840

Presented at the Symposium on Innovations Involving Chemistry Teaching and the Environment, 30th Two-Year College Chemistry Conference, Corvallis, Oregon, June 16, 1972.

Widespread interest in the nature of man's environment, generated by the national enthusiasm over Earth Day in 1970, led to the development of a new course for undergraduates. This course has been offered as "Pollution of Man's Environment" at the United States Air Force Academy and "Science, Society and Environment" at the University of Colorado, Colorado Springs.

The new course was designed to incorporate material which was originally taught in separate courses dealing with ecology, limnology, oceanography, water chemistry, water and waste treatment and analytical chemistry. The course was initially designed to meet the needs of liberal arts students who are not particularly interested in the sciences. As the course progressed, it eventually evolved into one aimed primarily at students in the basic and physical sciences and engineering.

Course 1. The initial offering had the advantage of a psychological carry-over from Earth Day. Thus, there was interest and motivation from the standpoint of a "fad-topic" as well as the intense national coverage given the environment in the popular press. One disadvantage, which was significant, was also due to the Earth Day Syndrome. Most of the happenings which took place in April 1970 were essentially superficial. The cosmetic approach toward solving pollution problems was unfortunately overemphasized. Thus, there was a lot of interest in cleaning up litter from highways and streams, returning cans and newspapers for recycling and riding bicycles in lieu of motorized transportation. Most of the speeches seemed to dwell on this.[1]

Thus, students taking a new course covering environmental issues were genuinely anticipating an extension of Earth Day. But, it was not possible to maintain this euphoria for an entire semester so some amount of disillusionment occurred. Typical of the student comments was "I didn't realize how technical some of these issues were. I thought it would be easy to stop pollution." Others commented that "If we wanted to take a science course, we would have taken a traditional one. This course was supposed to give us the nitty-gritty without being technical."

Apparently Earth Day had done its job all too well. The problem at hand now was to convince students that not only were the problems really there (fortunately this much was successfully done by Earth Day and the news media) but the solutions would come only by dedicated, long-term efforts with a sound technical foundation. There was no room for emotion once the problems were identified.

Four paperback texts were selected for the first offering. The choice was made on the basis of giving the students a diversity of opinion ranging from those of emotional conservationists to stoic but technically sound scientists. These texts are listed in Table I.

The course had set out to discuss the nature, chemistry and alteration(pollution) of the environment. It soon was obvious, however, that the depth of student interest was inversely proportional to the depth of technical difficulty. Thus, as time progressed, student participation was sustained by showing current films, holding open-ended discussions without any particular structure and finally by having students present the results of library research work which was required for their required term papers.

Large classes hindered truly effective discussions as too many individuals wanted to participate simultaneously. Ordinarily, a lot of discussion is highly desirable. However, when it is of the "off the top of the head" variety, very little actual learning occurs. When the discussions were narrowed to a specific technical detail, student response waned.

The experience of this first offering was worthwhile in its own way. It allowed expression of ideas and attitudes but also showed that nontechnically oriented students were primarily interested in the non-technical aspects of environmental issues. This should not have been unexpected, though, since the students really mirrored the attitudes of society in general.

Course 2. The second offering tried to overcome some of the failings of its predecessor. Eleven paperbacks were selected from the growing number on the market. Some were classics and others were of relatively recent vintage. Table II lists these selections.

The philosophy here was that liberal arts students, in general, are accustomed to heavy outside reading, illustrated by literature and history courses. Thus, assigning a new book for discussion, essentially one a week, was not expected to be a severe burden, especially since the enrollment for course no. 2 was predominantly liberal arts students.

TABLE I

1. Cleaning Our Environment - The Chemical Basis for Action by A.C.S. Committee on Chemistry and Public Affairs
2. Water is Everybody's Business by A.S. Behrmann
3. Our Precarious Habitat by M.A. Benarde
4. Moment in the Sun by R. and L.T. Rienow

TABLE II

1. Earth Day - The Beginning
   by the National Staff of Environment Action
2. The Web of Life
   by J.H. Storer
3. The Population Bomb
   by P. Ehrlich
4. Killer Smog
   by W. Wise
5. The Unclean Sky
   by L.J. Battan
6. Streams, Lakes and Ponds
   by R.E. Coker
7. Study and Interpretation of the Chemical Characteristics of Natural Water
   by J.D. Hem
8. Silent Spring
   by Rachel Carson
9. The Sea Around Us
   by Rachel Carson
10. The Frail Ocean
    by W. Marx
11. Man in the Web of Life
    by J.H. Storer

Basically this proved correct although some of the selections (notable numbers 5,6 and 7 in Table II) required more reading time and considerably more instructor explanation than the remainder.

The structure of course no. 2 can be deduced by analyzing the subject matter of the readings. Instead of trying to cover the environment field through "topical overkill", the decision was to cover certain topics in depth through extensive readings in the specific areas.

Thus, the ramifications of Earth Day were discussed, using the texts of speeches delivered on that day. Specific points from the speeches were highlighted and the facts were hopefully separated from the fiction.

Following this, basic concepts of ecology were covered through the reading of text no. 2. This well written classic made for easy reading and brought a good deal of ecological thought into focus. The framework of interdependence of organisms in ecosystems was now built and certain specific examples of man's disturbances could now be discussed.

The population problem was dramatically introduced by text no. 3, another classic and best seller. This reading was thoroughly enjoyed by the class and was dissected in detail. The book, written by the famous biologist Paul Ehrlich, also introduced a wide spectrum of environmental problems and thus served as a good reference point for later discussions.

Following Ehrlich's text, two books on air pollution were read, titles no. 4 and 5. William Wise's book (no. 4) touched home with many students. One older member of the class had actually been present at the 1952 air pollution episode in London and was quite vocal in support of air pollution control. Other students had experiences to relate from living in Los Angeles, Tokyo and New York City. Thus, while reading of the plights of individuals in London twenty years ago, the students were able to relate these to current experiences of their own. Some of the best discussions were generated by this reading. Text no. 5 was a primer on meteorology and its role in air pollution (particularly in the formation of thermal inversions). Also, some basic concepts of photochemistry and air pollution control were covered. The book, taken by itself, would have made for only routine reading but following on the heels of Wise's text, made the material quite relevant and interesting.

The water environment was approached first through a layman's introduction to aquatic biology as covered in reading no. 6. R.E. Coker gives a very lucid presentation of aquatic systems while not being overpowering. However, there were many pages on physical limnology and these required extensive instructor explanation. Following Coker, text no. 7 was a heavy hitter. This book was written by U.S. Geological Survey water chemist John Hem and proved to be the most difficult to use. It required a fair understanding of chemistry which was lacking on the part of many students. However, for a fundamental exposition of the chemical aspects of the aqueous environment, there is no better, easily purchased text available. Ultimately, the students realized that water pollution problems were complex and aggravated by the many possible chemical transformations occurring in natural waters. This text was supplemented by instructor lectures on the basic of sewage and industrial waste treatment processes as these were not covered by Hem to any extent.

The issue of pesticides could not be covered first without reading text no. 8, written by Rachel Carson. Perhaps critics of this book claimed it was an emotional outburst, unsubstantiated by fact. I don't fully agree, as many facts were given and mor importantly, many things discussed by her ultimately came to pass as scientists became more sophisticated in their methods of analysis. A new companion to this book is now on the market[2] but was not included in this course.

The problems of the oceans were covered with two books. One was an introduction to oceanography written by Rachel Carson (text no.9). Then, ocean pollution was discussed by using Wesley Marx's popular book (text no. 10). The problems of oil pollution and organic chemical contamination of the sea were included and also supplemented by material prepared by this author.[3]

In conclusion, an updated version of John Storer's book on ecology (text no. 11) was used to bring the problems into focus and show how man's activities have indeed created a stress on the world's ecosystem.

In sum, course no. 2 represented a lot of individual effort in reading a considerable amount of material and digesting many facts. It was almost too difficult to do in one semester. If a course were to be taught like course no. 2 in the future, it should be expanded to cover two semesters and a few more readings added. All in all, though, this was one of the most rewarding of the courses given and did elicit a favorable student response. This was especially welcome in view of the large amount of work required of each student.

Course 3. The immediate response to the fatigue of voluminous reading in course no. 2 was to find a text which covered all of the desired topics for inclusion in an environment course. Such a text was found and selected for course no. 3. This is outlined in Table III. Detwyler's reader contains over 50 separate selections covering what appears to be a wide spectrum of environmental issues. Some of the selections were very recent and reasonably technical. The readings in his section 2 covering the atmosphere were especially good and the coverage of waste treatment processes was quite adequate in section 3. However, other sections proved less useful, especially section 4 (land and soils) and sections 6,7,and 8 (vegetation and animals). It appeared Detwyler's selections were influenced by his professional affiliation with geography. Naturally, geographers have a genuine concern for the environment and have been leaders in the study of this area for some time. But the selections in the previously cited sections proved to be quite uninteresting from the student point of view and some were out-dated enough to be difficult to read due to phraseology which is no longer in use.

Also, the older articles suffered from the lack of recent references which would have helped to put the earlier work into current perspective. Also, there was a certain degree of incompatability between selections within a given section as well as a lot of overlapping coverage which made reading occasionally tedious.

The editor's attempt to conncet the various sections as well as his introductory comments prior to each selection were useful. But in sum, the text contained, simultaneously, too much and too little and its use as a basic text wouldn't be recommended. Student response to this third course offering, essentially based on this text, was relatively unfavorable. Since a lot of outside material had to be presented to make up for undesirable selections, the text itself lost much of its utility and was finally used only as a reference book rather than as a primary reading text.

TABLE III

Man's Impact on Environment, Edited by T.R. Detwyler

Text contains 52 individual selections, e.g., Reprints from Science, et.
Text is divided into 9 sections

1. Basic Causes of the Ecological Crises
2. Man's Impact on Atmosphere and Climate
3. Man's Impact on the Water
4. Man's Impact on Land and Soils
5. The Spread of Organisms by Man
6. Destruction of Vegetation by Man
7. Destruction and Extinction of Animals by Man
8. Man as a Maker of New Plants and Animals
9. Trends and Prospect

Course 4. The experiences of the first three courses led to the development of a course outline that could be used in a combined lecture-discussion format for science and engineering students and could also be supplemented with a few selected texts and library journal readings. The course outline is given in Table IV. It should be noted that this course would not be attractive to non-science oriented students.

Some of the topics listed in Table IV overlap with coverage given in earlier offerings, especially courses no. 2 and 3. Some topics are new. For example, the course opens with a discussion of recent research into the mechanism of chemical evolution. Since many ecologists are predicting that the earth will soon be unfit for human habitation, it is useful to trace the development of life on earth throughout geological time as well as the various atmospheric environments which have prevailed. The effect that hostile atmospheres had on early chemical evolution might give us a clue as to what might happen in the future if the pollution of our atmosphere continues to increase. Some knowledge of organic chemistry is needed here since the structures of early organic molecules rapidly increase in complexity as porphyrins and chlorophyll proto-types evolve.

Discussions on population and resources, the biosphere, the atmosphere, as well as water chemistry follow patterns similar to course no. 2 but are based primarily on reports from the current literature. Articles from Science, Environment and Environmental Science and Technology are used frequently.

There are some basic texts assigned in this course and they are given in Table V. Some are repeats from earlier offerings, representing the relatively technical material (texts no. 1 and 2 in Table V). The other two texts are specialized in the aquatic biology area. Also given in Table V are four reference volumes which serve as sources of technical material on water chemistry, limnology and oceanography. These texts give a wealth of information but have to be screened and used in accordance with the students backgrounds. Some of the thermodynamics given in the instructor reference text by Stumm and Morgan can only be discussed if the students have had physical chemistry. Otherwise, a less rigorous treatment can be given.

The remaining topics in Table IV are likewise covered by mixing current literature with readings in the assigned texts. Also, topics such as chemicals in food and drugs, while not being strictly environmental topics, certainly are of concern to society as a whole and thus merit consideration in a course which takes the earth as an ecosystem and then proceeds to discuss the many interactions that occur within it.

TABLE IV
TOPICS

1. Chemical Evolution
2. Population and Resources
3. Nature of the Biosphere
4. The Atmosphere: Structure, Pollutants and Photochemistry
5. Fundamentals of Water Chemistry
6. Water and Wastewater Treatment

TABLE IV (cont.)

7. Introduction to Limnology
8. Water Pollution; General Aspects, Effects on Organisms and Fish
9. Eutrophication of Natural Waters
10. Lake Sediments and Water Quality
11. Impoundments and Water Quality
12. Water Pollution: A Case Study on Mercury
13. Pesticides and Herbicides
14. Organic Compounds and Toxic Wastes
15. Introduction ro Oceanography
16. Environmental Sampling and Measurements
17. Microbiology of Natural Waters
18. Chemicals in Food
19. Chemicals and Society - Drugs
20. Selected Topics of Current Interest
    Thermal Pollution of Lake Cayuga
    Estuary Pollution
    Solid Waste Disposal
    Lead Contamination
    Legal Aspects of Pollution Control

TABLE V

1. Cleaning Our Environment - The Chemical Basis for Action
   by A.C.S. Committee on Chemistry and Public Affairs

2. Study and Interpretation of the Chemical Characteristics of Natural Water
   by J.D. Hem

3. The Practice of Water Pollution Biology
   by K.M. Mackenthum

4. Biology of Water Pollution
   Reprints of papers on aquatic biology compiled by Keup, Ingram & Mackenthum

ADDITIONAL REFERENCES FOR INSTRUCTOR USE

1. Aquatic Chemistry
   by W. Stumm and J. J. Morgan

2. Principles and Applications of Water Chemistry
   by Faust and Hunter

3. Treatise on Limnology, Vols. I and II
   by G.E. Hutchinson

4. The Oceans
   by Sverdrup, Johnson and Fleming

To summarize, this paper has discussed the genesis of a course covering environmental concepts for undergraduates. The good and not so good points have been pointed out. It appears that a course such as offering no. 2 would be an excellent approach for motivated liberal arts non-science majors whereas course no. 4 has a definite appeal for science and engineering students.

Note

The opinions and comments stated herein are solely those of the author and do not reflect the attitude of the United States Air Force Academy or the United States Air Force.

References

1. See book No. 1 in Table II, p. 3.
2. Graham, F. Since Silent Spring.
3. Delfino, J.J. "Pollution of the Oceans" Proceedings, Am.Soc. of International Law, Symposium on International Regulation of the Environment, Denver, Colorado, May 1.

Chemistry in Society: A Necessary Chemistry Course for Non-Science Majors

Robert A. Rouse, James S. Chickos, and David L. Garin
University of Missouri-St. Louis
St. Louis, Missouri 63121

Presented as the Keynote Address for the Chemistry for the Non-Science Majors Section, 30th Two Year College Chemistry Conference, Corvallis, Oregon, June 17, 1972.

Abstract

A new and necessary chemistry course which includes both the appropriate chemistry and a discussion of the chemical facets of related societal problems has been developed. The topic priorities, goals and syllabus are described. The importance of student feedback is stressed and the preparation of the instructor for controversial topics is emphasized.

Introduction

The general education requirements of many colleges and universities include several hours of science courses. The reason for this is that in our technologically oriented society the educated citizen must have some knowledge of the nature and role of science and how scientific expertise can be applied to a wide range of problems that affect all of us.

Most chemistry departments, ours included, offer a limited number of courses for this purpose ranging from a lengthy treatment of a small number of scientific principles to a dilute coverage of many. For a large number of students, most of them non-science majors, these options are insufficient. The very reasons for requiring the course, an introduction to scientific methodology and its application to scientific problems, is lost in a maze of facts and formulas that appear irrelevant to their future goals.

Three years ago, with departmental support, we volunteered to examine the possibility of developing a new course for the non-science majors with emphasis on topical issues. Our initial approach was to outline those areas in chemistry that are fundamental to basic knowledge of the science and those areas of social concern that are most urgent in this decade. After producing a list of topical issues, we decided to include only those chemical principles that bore directly on the problems. Indeed, the major task was eliminating, not formulating. Once agreed on priorities, which will be discussed later, we envisioned putting together a collection of essays, short articles and monologues on the different subjects. We shortly rejected this as a possibility. It was obvious that we would generate a pot-pourri of reading material that could not be intertwined; if sophisticated, it would contain terms that required definitions and explanations; if free of new concepts, it was reading matter that while interesting was not specific to chemistry and could be better replaced by more demanding, specifically organized and oriented material. These readings could not be the core of the course although it could serve as additional reading material.

General Guidelines

We were suddenly left with the conclusion that we would have to write the core material ourselves. In preparing the material we kept several goals in mind. Only those chemical concepts directly needed in the course were included. Much chemical formalism, such as moles, stoichiometry, the quantitative treatment of equilibrium and balancing redox equations, was not included. Anyone who has suffered the trustration of teaching the apparently simple mole concept and seeing students wilt in those early weeks of the semester can appreciate our joy in learning that it can be done without sacrificing the aims of the course. This does not mean that sophisticated topics were avoided; optical activity, structure-reactivity relationships and detailed metabolic topics were included.

Since this was a new course, we carefully evaluated the many questionnaires we distributed to our students requesting comments on each individual chapter as well as the overall design. We were amazed! We found that it is virtually impossible to predict which concepts and ideas the students would find interesting, challenging and satisfying. We asked and they told us. For instance, we continue to include a discussion of phase diagrams because more than 95% of our students found it challenging and enjoyable and requested that it not be deleted. It is the only remaining subject that we feel is not essential but its success at leading students through predictive analysis cannot be questioned.

We also learned that our students did not like hypothetical examples so we used real examples wherever possible. For instance in discussions of chemical aspects of air pollution, specific cities were studied; specific rivers and lakes were described and effects of water pollution on each was discussed. In addition, simple cutout molecular models were handed out, allowing the student to discover for himself what is meant by conformation and mirror image isomerism. By putting together an asymmetric molecule in random fashion the student realizes that two mirror image forms are possible in a way that no written description can parallel. We have also designed the course to include several small paperback texts such as "The Double Helix", "Silent Spring", and "The Social Responsibility of the Scientist", which can be included if desired by individual instructors.

Course Outline

The course consists of six basic units which are often supplemented with one or two short topics at an instructor's discretion. The first unit involves a description of matter, energy, and nuclear, atomic and molecular structure. Nuclear power production and its relation to other power sources and the Atomic Energy Commission are briefly described. Only the major shell theory of atomic structure is used and is sufficient to determine the number of outer shell or valence electrons. This permits the student to apply the Lewis electron pair theory and the octet rule to chemical bonding and periodic properties. Molecular structures are presented to the student within an experimental framework. Electronegativity is also included.

Unit two is an introduction to organic chemistry with emphasis on structure. Conformations, isomers, optical isomers and the chemistry of important functional groups needed later in the course are presented. A survey of drug terminology and misuse, and an introduction to man-made and biopolymers is given. The atmosphere, gases and air pollution are the subjects of the third unit. The atmosphere and processes which occur there (nitrogen and carbon cycles) are described and the gas laws developed along with kinetic molecular theory. A historical introduction to the air pollution problem is followed by a description of air pollutants and their sources and effects. The automobile as a pollution source is discussed. The political and technological facets of air pollution are aired along with a description of the Environmental Protection Agency.

The fourth unit contains a discussion of the properties of liquids and solutions (including phase changes). Natural water sources (ground water and desalination) are explored, acids and bases discussed, and the chemistry of water and water purification described. Sewage and its treatment are also included. Water pollution topics such as detergents (NTA), oil spills, and biological effects of heavy metals are included. Biochemistry is the content of unit five. Proteins, lipids, carbohydrates and nucleic acids are discussed in terms of structure and function. Enzyme action, RNA, DNA, replication, and the biochemical basis for drug action are described. Unit six is concerned with some of the factors which affect our commitment to chemistry and the role it plays in daily life. Chemical contraception, fungicides, insecticides and food additives are included.

Conclusion

The course has been well received by both students and faculty. A typical class taking this course included students from the Schools of Business, Education, and Arts and Sciences; all levels from freshmen to seniors. The course has been taught by six different instructors in our department using the core text, each brings his or her own expertise and interests to it. The course contains more than enough chemistry to satisfy the original intention of requiring a science course in the college curricula and more than enough topical material to render the citizen capable of evaluating, understanding and acting upon social issues that will evolve in his or her lifetime.

The topical issues introduced are extremely controversial and often produce high levels of emotional impact. Preparation of the instruction for these topics is essential. An excellent source bibliography is "Science for Society, A Bibliography" by Moore published by the American Association for the Advancement of Science. In general we try to emphasize that well informed specialists do not always agree on these controversial topics and that there are no simple universally applicable answers but instead a trade-off of problems where the essential ingredients are a working knowledge of all of the factors involved and an objective attitude for we are truly "all in this together".

Living Chemistry

Warren C. Westgarth
Environmental Quality Laboratories
Corvallis, Oregon 97330

Presented at the Symposium on Environmental Chemistry, 30th Two-Year College Chemistry Conference, Corvallis, Oregon, June 16, 1972

The purpose of this talk is to emphasize how chemistry fits in with environmental control especially as it relates to the two year college levels. I chose the title "Living Chemistry" to camouflage my own ineptitude in the field. I am not a chemist and do not pose as an expert in the field. I have however been exposed in this room in 1945 to a college teacher, Dr. Leon Friedman, who made chemistry live in my mind. Many teachers make the language of chemistry like the old Roman language, of which it has been said, "Latin is a language as dead as it can be. It killed off all the Romans and now it's killing me."

Living chemistry is identified in various ways today. It is sometimes identified with love. Other times it is defined with the alchemy, which from the 1st century AD they tried to transform cheap metals of iron and lead to gold or silver, and then to find the elixie of life. We might note that to a degree we still practice alchemy -- the manufacture of high molecular weight elements in the 1940's and today our use of vitamins, hormones and antibiotics as elixirs of life.

Just what is Living Chemistry? Gustav Eckstein in " The Body has a Head" wrote: "To the chemist-what is life? The chemist gives us our clothes of:rayon or dacron, our artificial arteries of the same materials, cleanses our skin with detergent and manufactures foods without soil, rain, or sun. He accounts for our immunity part way, accounts for our heredity, part way. Sometimes his success leads him into extravagance, like the nightmare thought that he will alter our chromosomes, manipulate them as old Gregor Mendel his peas, pick out a bad gene, replace it with a good one, but then gets alarmed at a Meet-the-Press; if he has provided us a new society will our moral stature be equal to it? On the occasion of a late chemical synthesis the New York Times noted that experts "feel it conceivable that man will be able to make an exact duplicate of a genius, such as an Einstein, with DNA." No doubt, keep sperm and egg cells on ice until the propitious moment for bringing them together. One shrugs. One shudders."

"Long back the chemist plunged into the fight against disease. Viruses were one cause. He studies them. He came to understand more and more about them. He discovered how sexual those trifles are. He went back into history and calculated how ancient they are."

"By usual criteria a virus does seem alive. It can exist like a parasite (live on life), multiply inside of life (its seed is in itself), infect (show aggression) mutate (change to another species). All of this with the years was worked out in sometimes strange detail. A raw virus penetrates part way into a bacterium, leaves its protein coat outside, and inside the bacterium breeds, and soon there are many, and every one of the many has a coat. One is ashamed that one gets used to the strange.

Look at from the other side, a virus is an exact molecule, a matter-of-fact chemical. It is nucleic acid plus a protein."

"It is years since a chemist first startled us by bring together chemicals abundant eons ago (methane, hydrogen, ammonia, water), flashing them with an electric arc, laboratory lightning, and producing what and how, as he fantasied, had been produced at the start, life. Molecules had cooked themselves in the direction of life. (No chemist would say cooked.) Eons earlier the inorganic presumably was cooked in the direction of the organic. And eons earlier still something else presumably was cooked in the direction of the inorganic. Earliest was hydrogen. A universe all hydrogen. Before hydrogen was the vague, The vague hydrogen other molecules the inorganic life mind."

And then it was tied to the "wee beasties" by Leuvwenhock as versified by Jonathan Swift.

"So naturalists observe, a flea
Hath smaller fleas that on him prey;
And these have smaller still to bite 'em;
And so proceed ad infinitum."

So what must we teach of living chemistry to make it useful? First let's look at the tools we have as our heritage:

1. Air
2. Water
3. Land
4. 110+ elements - Periodic chart
5. Energy

Secondly, let's look at the language of chemistry. In brief, it is a mixture of Latin, Greek, German, English, sundry dialects and idioms tied into the following smattering of chemical terms:

atoms, elements, molecules and compounds, solution, suspension, atomic wt., equivalent wt., valence, radicals, molar, normal, isotopes, solids, liquids, gases, acids, bases, salts, anion, cation, charges, proton, neutron, electron, ionization, organic colloidal, coagulation, pH, forces, resonance, spin, ppm, mg/l, mel, mg%, ppt., et al.

Did you ever listen to the language of instrumentation as it might sound to the novice? Such terms as bridge, spec 20 CU, GC, IR, UV, AA and mass spec have meaning only to the initiated.

Thirdly, look at the scope of what must be taught in the two-year program. The same as an advanced degree chemist gets in 5 to 7 years.

1. Descriptive - inorganic and organic
2. Analytical chemistry
3. Physical chemistry
4. Biochemistry
5. Instrumental chemistry
6. Industrial chemistry
7. Special chemistry - Standard Methods - International Standards

Lastly, we might conclude that chemistry by itself is not enough. It must tie to life processes and therefore be made to live.

The Chemistry of Water Pollution: Determination of Carbon in Environmental Systems

William L. Griffis
Pacific Northwest Water Laboratory, National Environmental Research Center, Environmental Protection Agency, Corvallis, Oregon 97330

Presented at the Symposium on Environmental Chemistry, 30th Two-Year College Chemistry Conference , Corvallis, Oregon, June 16, 1972

It will be the purpose of this paper to briefly discuss one phase of analytical chemistry as it applies to water pollution. In dealing with the chemistry of water pollution, the oldest test as a measure of pollution will be discussed bringing together methods, past and present, used in the determination of carbon in water samples from the environment.

Analytical chemistry can be roughly divided into three, broad analysis categories; the macro analysis, the micro analysis and the analysis at low concentration. First, let us consider the macro analysis. A macro analysis involves a large sample size, usually several grams. Results are most often expressed to the nearest hundredth of a percent. A macro analysis would seldom be used in pollution determinations due to the relatively broad precision and accuracy limitations (precision at best would be ± .01%). For example, one would not attempt to measure with a macro analysis the chloride ion concentration (.4 mg/l) resulting from the solution of silver chloride. The small amount of chloride ion in solution would be beyond the limits of detection. Next let us consider the micro analysis. A micro analysis requires a small sample size, usually fractions of a gram. Results of a micro analysis are small in magnitude. The extremely small sample size involved in a micro analysis makes it unsuitable for water pollution analysis. Consider again the measurement of chloride ion from the solution of silver chloride. If a micro analysis were used, the chloride ion concentration would be far below the limits of detection because of the small sample size. Finally let us consider the analysis at low concentration. In this case we utilize a rather large sample (often a hundred milliliters or more). Results are often reported in fractions of a milligram per liter. The analysis at low concentration is ideally suited for water pollution analysis. If we wish to run a chloride analysis on a solution of silver chloride, we can do so with little difficulty utilizing a 100 milliliter sample, since the limit of detection is about .2 mg/l (1). Generally speaking, the analysis at low concentration is used much more often in water pollution analysis than either the macro analysis or the micro analysis.

The carbon content of an environmental sample provides a vital index of the level of pollution of the water supply from which the sample originated. By establishing the levels of organic carbon in a water supply (as opposed to inorganic carbon in the form of carbonates and bicarbonates), we can achieve a better understanding of the oxygen demand placed on the water supply. Organic carbon analysis is usually an analysis at low concentration, although some instrumentation (Beckman 915) requires only microliter quantities of sample.

We have at our disposal three separate techniques for the determination of organic carbon; the biochemical oxygen demand (the old classical technique), total organic carbon by combustion to CO_2 in an oxygen atmosphere (Beckman 915 system), and total organic carbon by wet chemical oxidation to CO_2 (Oceanography International Total Carbon System). Let us first consider the biochemical oxygen demand or BOD. The BOD first came into use in 1870 (2) and has been modified and improved over the years to its present form. The BOD is basically a measure of the amount of dissolved oxygen consumed by microorganisms while assimilating and oxidizing some of the organic matter which might be present. The BOD will therefore, usually provide a rough index of how much easily oxidizable carbon is present. Consider the following chemical reactions which illustrate the mechanism of the BOD:

(sucrose)

$$C_{12}H_{22}O_{11} + 12\ O_2 \xrightarrow{\text{biological medium}} 12\ CO_2 + 11\ H_2O$$

(acetic acid)

$$CH_3CO_2H + 2\ O_2 \xrightarrow{\text{biological medium}} 2\ CO_2 + 2\ H_2O$$

The BOD is somewhat limited in its application. For example, given a water sample at 20°C and 100% saturation with oxygen, the usable working range for dissolved oxygen would be from 7 mg/l to 1 mg/l since for a valid determination we need a depletion of at least 2 mg/l and a residual of at least 1 mg/l (3). Because conditions may vary greatly depending on sampling site, type of sample, and analytical procedure, precision and accuracy levels are hard to establish. The Analytical Quality Control Laboratory of the National Environmental Research Center, Environmental Protection Agency, Cincinnati, Ohio, has obtained considerable data on the BOD using specially prepared synthetic samples. Results from a large number of analysts and laboratories are shown in Tables 1 and 2. In order to have a better understanding of the data in Tables 1 and 2 (as well as the data in Tables 3 and 4 to be discussed later) we should consider a short statistical summary which appears with the data in the Analytical Quality Control Laboratory "method.Research Study.3 --- Demand Analysis"(4). First it should be noted that each statistical measurement has been carried to five decimal places. The number of significant figures, however, is only equal to the number reported for the sample increment. With the exception of accuracy, all measurements (number of values, true value, mean, median, accuracy, range, variance, standard deviation, 95% confidence limit, relative deviation (coefficient of variation), and skewness) are based on all data received, without rejection. Since the inclusion of questionable extreme values will result in unreasonable values for accuracy, the accuracy values for BOD and total organic carbon are based on retained data, that is the data remaining after the rejection of outliers using the t-test at the 99% level. The data is also arranged in ascending order and presented in a histogram. Each X in the histogram indicates in analytical determination for up to 15 values per cell. When more than 15 values occur for a given cell only 15 X's are printed and the number of values actually included is indicated by the number at the base of the cell.
The statistical measurements shown in Tables 1,2,3 and 4 are defined as follows:

Accuracy as % Relative Error (Bias). The signed difference between mean value and the true value, expressed as a percent of the true value.

$$R.E. = \frac{X_{true} - \bar{X}}{X_{true}} \times 100$$

Confidence Limit (95%). The range of values within which a single analysis will be included, 95% of the time.

$$C.L. = \bar{X} \pm t\frac{\sigma}{n}$$

where t = value from t table, σ = standard deviation and n = number of samples.

Mean ($\bar{X}$) is the arithmetic mean of reported values, the average.

Median is the middle value of all data ranked in ascending order. If there are two middle values, the mean of these values.

n is the number of sets of values of analysts reported in a study.

Range is the difference in mg/liter between lowest and highest reported values.

Relative Deviation (Coefficient of Variation). The ratio of the standard deviation, σ , of a set of number to their mean, $\bar{X}$ expressed as percent. It is an attempt to relate the deviation (precision) of a set of data to the size of n so that the deviations for differing levels of a parameter can be compared fairly

$$R.D. + 100\frac{\sigma}{\bar{X}}$$

Skewness (k). A pure number, positive or negative, which indicates the lack of symmetry in a distribution. For example, k is positive if the distribution tails to the right and negative if the distribution tails to the left.

$$\underline{k} = \frac{\Sigma(X_i - \bar{X})^3}{n^3}$$

Standard Deviation (σ). The most widely used measure of dispersion of a set of data. σ is equal to the square root of the variance and with normal distribution indicates the deviation of 68% of the values around the mean, while 1.96σ indicates the deviation of 95% of the values around the mean. The standard deviation, σ , is the measure of the deviation of the universe. However, in most experimental work with limited sampling and in this study only an estimated standard deviation, s, is measurable. The calculation differs in that n-1 rather than n is used as the denominator. In this study and in further studies, s and s^2 not σ and σ^2 will be used to estimate the deviation of the data. They will be referred to as the standard deviation and variance respectively.

$$\sigma = \frac{\Sigma X_i^2 - \frac{(\Sigma X_i)^2}{n}}{n}$$

t-test. The difference in analyzed and true value expressed as ratio over the standard deviation. The value obtained is compared with critical values in a table. If the calculated t-value exceeds the theoretical t-value, the analyzed value is probably not from the same population as the rest of the data and can be rejected.

$$t\text{-value} = \frac{X_{n} - \text{true value}}{\text{Standard Deviation (s)}}$$

True value. Those amounts actually added in sample preparation. These are not based on analyses, the latter being used only for verification.

Variance (σ^2), (s^2). The average of the squares of the deviations of a group of numbers from their average, $\overline{X}$.

$$\sigma^2 = \frac{\Sigma X_i^2 - \dfrac{(\Sigma X_i)^2}{n}}{n} \qquad s^2 = \frac{\Sigma X_i^2 - \dfrac{(\Sigma X_i)^2}{n}}{n - 1}$$

In the classical sense the BOD determination suffices in examining treatment plant performance of primary and secondary systems. When today's conditions are examined in producing effluents such as that from the plant at Tahoe, California (a tertiary plant), the limitations of the BOD determination require an alternate analysis. It is in the context of the alternatives that are available to the chemist that a choice is made to look at the carbon content.

Let us now turn our attention to the analysis of organic carbon via the combustion of the organic material to CO_2. The Beckman 915 system is in wide use by many laboratories. With the Beckman system a microliter quantity of water sample is directly injected by syringe into a furnace maintained at approximately 900°C. The carbon in the sample is immediately converted to CO_2 in an oxygen carrier stream. The water is converted to steam and is condensed and removed from the carrier stream as the sample leaves the combustion furnace.

The carrier stream moves the CO_2 and any remaining water vapor into an infrared analyzer which measures the amount of CO_2. The output from the infrared analyzed is fed into a strip chart recorder. Peak heights of standards are plotted versus concentrations to obtain a calibration curve for the determination of unknowns. The amount of CO_2 present is directly proportional to the amount of carbon present in the sample. Depending on sample treatment, several parameters may be measured with the Beckman system. If the sample is injected without any treatment, a measure of organic and inorganic carbon is obtained. If the sample is acidified and purged with nitrogen gas, a measure of all organic material in the sample which is not volatilized under conditions of acidification and purging is obtained. The Analytical Quality Control Laboratory has obtained data on two synthetic samples which reflects precision and accuracy levels one may expect during routine analysis using the Beckman 915 system. Results from a large number of analysts and laboratories are shown in Tables 3 and 4(5).

Let us now consider the determination of carbon by wet chemical oxidation to CO_2. For the measurement of carbon by this method we use an instrument called the Oceanography International Corporation Total Carbon System hereafter referred to as the OIC TC system. To make a determination using the OIC TC system we put a small amount of potassium persulfate ($K_2S_2O_8$) and a small amount of dilute sulfuric acid into a 10 milliliter glass ampoule. We then add up to 10 milliliters of sample to the ampoule and seal the ampoule on a device especially designed for this purpose. Inorganic carbon is removed during the sealing process by purging with oxygen gas. We then autoclave the ampoule for 4 hours which results in quantitative oxidation of all organic carbon to CO_2. After cooling to room temperature, the ampoule is placed in the instrument analyzer. The top of the ampoule is cut off and the CO_2 is purged out of the solution in the ampoule by a nitrogen carrier stream. The sample is carried through a system of drying columns to remove all water vapor and then into an infrared analyzer which measures the amount of CO_2 present. The amount of CO_2 present is directly proportional to the amount of carbon present in the sample. The output from the infrared analyzer is fed into a strip chart recorder equipped with a disc-type integrator for determining areas under CO_2 peaks. A calibration curve for the determination of unknowns is made by plotting peak area versus concentration of several standards. A typical calibration curve is shown in Figure 1. It should be noted that the concentration scale is in micrograms per 5 ml. The OIC TC system will allow the analyst to determine all forms of organic carbon depending on the treatment given the sample. If the sample is untreated, total organic carbon is measured. If the sample is filtered, the dissolved organic carbon is measured. If a portion of the sample is filtered through a glass fiber filter and the filter containing the trapped solids is placed in the ampoule for analysis, a measure of the particulate organic carbon is obtained. The sum of the dissolved organic carbon and the particulate organic carbon should equal the total organic carbon (see Table 11). Inorganic carbon is determined by direct injection with a syringe of a small portion of the sample into a special injection ampoule equipped with a septum and containing a small amount of acid. Limited data establishing precision and accuracy is available for samples run on the OIC TC system. Some of the data that is available for the OIC TC system is presented below. This data was collected by a single analyst at the National Environmental Research Center, Environmental Protection Agency, Corvallis, and shows precision obtained on several environmental samples and one synthetic sample (see Tables 5,6,7,8, and 9). As with tables 1-4, it may prove helpful to consider a short summary of statistical parameters included in Tables 5-9. The variance, mean and standard deviation have been previously discussed. The standard error of the mean is a statistical parameter which gives a measure of the reliability of the mean. For example, in Table 5, if N was a very large number we could say that 67 percent of the time the mean would be 49.9556 ± .5905. A comparison of data obtained from both the Beckman 915 system and the OIC TC system on the same set of samples is shown in Table 10. It should be emphasized that the Beckman 915 system and the OIC TC system are radically different. We have seen that the methods of converting carbon to CO_2 in the two systems differ greatly. Several other points of difference should be noted: Sample size utilized in the two systems varies greatly. The Beckman 915 system uses a microliter quantity of sample which the OIC TC system uses up to 10 milliliters. The OIC TC system appears to have much more detector sensitivity than does the Beckman 915 system. The OIC TC system will allow the direct determination of particulate organic carbon which would be very difficult if not impossible with the Beckman 915 system. The Beckman 915 system has a much shorter overall analysis time than does the OIC TC system. This time difference is mainly due to the extra time involved in preparing the sample for analysis on the OIC TC system. It has been found that on some samples the Beckman 915 system will not convert carbon to CO_2 efficiently. The OIC TC system may not measure volatile organic materials efficiently, because of the chance of loss during filt , purging and sealing operations.

In conclusion, we may say that the determination of carbon by any of the methods mentioned can help toward a better understanding of the causes, effects, and solutions of both existing and future water problems. It remains for those directly involved in water pollution control programs to decide which methods may best be applied to specific pollution problems.

BIBLIOGRAPHY

1. American Public Health Association, American Water Works Association, and Water Pollution Control Federation. "Standard Methods for the Examination of Water and Waste Water." 13th Edition. American Public Health Association, Washington, D.C., p. 376. 1971

2. O'Brien, W.J. and Clark, J.W. "The Historical Development of the Biochemical Oxygen Demand Test." Engineering Experiment Station, New Mexico State University, Bulletin No. 20, p. 2. 1962

3. APHA, AWWA, and WPCF. "Standard Methods for the Examination of Water and Waste Water." 13th Edition. American Public Health Association, Washington, D.C., p. 492. 1971

4. Environmental Pr ction Agency. "Meth Research Study 3--Demand sis." Cincinnati, io, pp. 13-14. 197

5. *Ibid.* pp. 18-19.

FIGURE 1

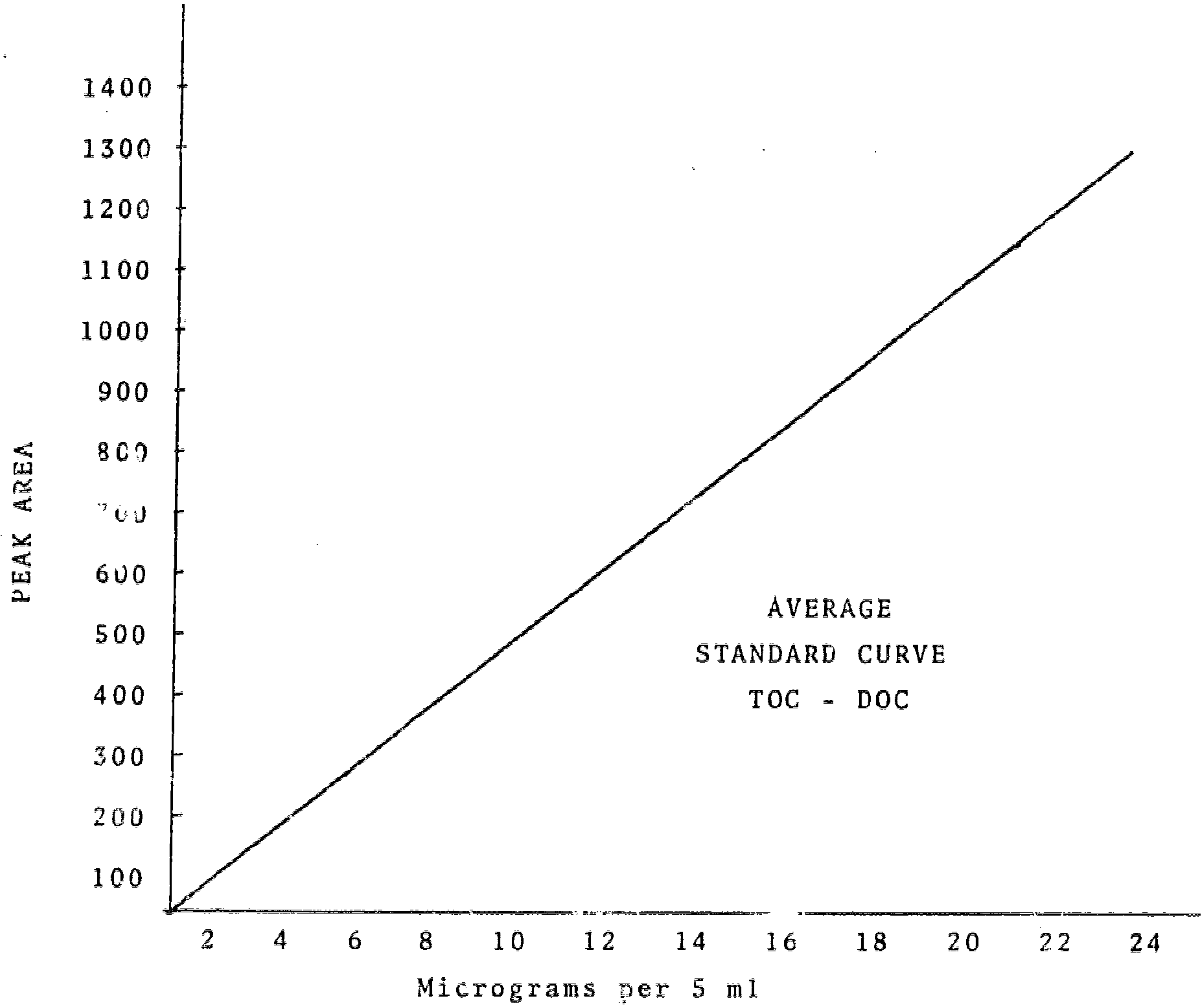

1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
PEAK AREA
AVERAGE
STANDARD CURVE
TOC - DOC
2
4
6
8
10
12
14
16
18
20
22
24
Micrograms per 5 ml

TABLE 1

Method and Performance Evaluation, AOCL
Method Study 3, Demand Analyses

BOD, Sample 1
Statistics, All Data, All Laboratories
Manual Procedure
Recovery of Increment from Seeded Water

Increment = 2.2

N	74	Range	5.50000	Coef. Var.	0.33193
True Value	2.2	Variance	0.49406	Skewness	1.80488
Mean	2.11756	Std. Dev.	0.70290	No.of Cells	8
Median	2.10000	Conf. Lim.	1.37768 (95pct)		
Accuracy	-3.74713				

Pct. Relative Error, Retained Data

Data in Ascending Order

0.3R
1.0
1.0
1.0
1.1
1.2
1.3
1.4
1.5
1.5
1.6
1.6
1.6
1.6
1.6
1.7
1.8
1.8
1.8
1.8
1.8
1.9
1.9
2.0
2.0
2.0
2.0
2.0
2.0
2.0
2.0
2.0
2.0
2.0
2.1
2.1
2.1
2.1
2.1
2.2
2.2
2.2
2.2
2.2
2.2
2.2
2.3
2.3
2.3
2.3
2.3
2.3
2.3
2.3
2.4
2.4
2.4
2.4
2.5
2.5
2.5
2.5
2.6
2.6
2.6
2.6
2.7
2.8
3.0
3.2
3.5
3.7
5.8R

R = Rejected Data

Midpoint	Freq.	Histogram
0.30000	1	X
1.0857	7	XXXXXXX
1.8714	39	XXXXXXXXXXXXX
2.6751	23	XXXXXXXXXXXXX
3.4428	3	XXX
4.2285	0	
5.0142	0	
5.7999	1	X

TABLE 2

Method and Performance Evaluation, AOCL
Method Study 3, Demand Analyses

BOD. Sample 2
Statistics, All Data, All Laboratories
Manual Procedure
Recovery of Increment from Seeded Water

```
                    Increment = 194

N            73            Range       118.00001   Coef. Var.   0.14975
True Val.    194           Variance    68[illegible].80566   Skewness    -0.49208
Mean         175.00003     Std. Dev.   26.20697    No. of Cells   8
Median       179.00003     Conf. Lim.  51.36566 (95 pct)
Accuracy     -9.79381      Pct. Relative Error, Retained Data

Data in Ascending Order                  Midpoint   Freq.  Histogram
   107.R        17[illegible]       193.     107.0000     1    X
   118.R        17[illegible].      194.     123.8571     6    XXXXXX
   120.R        172.       197.     140.7142     4    XXXX
   121.R        172.       197.     157.5714    11    XXXXXXXXXXX
   123.R        173.       198.     174.4285    20    XXXXXXXXXXXXXXX
   130.         174.       200.     191.2856    18    XXXXXXXXXXXXXXX
   132.         174.       200.     208.1427     9    XXXXXXXXX
   135.         175.       201.     224.9998     4    XXXX
   142.         175.       203.
   145.         179.       205.
   146.         180.       205.
   150.         180.       205.
   152.         181.       205.
   154.         182.       207.
   155.         183.       218.
   155.         183.       223.
   159.         183.       224.
   159.         185.       225.
   160.         185.
   164.         185.
   165.         188.
   165.         189.
   167.         190.
   168.         191.
   169.         191.
   169.         192.
   170.         192.

     R = Rejected Data
```

TABLE 3

Method and Performance Evaluation, AOCL
Method Study 3, Demand Analyses

TOC, Sample 1
Statistics, All Data, All Laboratories
Manual Procedure
Recovery of Increment from Distilled Water

```
                      Increment = 4.9

      N           27       Range      10.20000 Coef. Var.    0.33522
      True Val. 4.9        Variance    3.58489 Skewness      3.28807
      Mean       5.64814   Std. Dev.   1.89338 No. of Cells 5
      Median     5.00000   Conf. Lim. 3.71102 (95 Pct)
      Accuracy 15.26828    Pct. Relative Error, Retained Data
Data in Ascending Order    Midpoint      Freq     Histogram
  3.8        5.4            3.8000        16      XXXXXXXXXXXXXXX
  4.0        5.7            6.3500        10      XXXXXXXXXX
  4.2        6.0            8.8999         0
  4.3        6.0           11.4499         0
  4.5        6.3           13.9999         1      X
  4.7        6.4
  5.0        6.5
  5.0        6.5
  5.0        7.0
  5.0        7.2
  5.0       14.0R
  5.0
  5.0
  5.0
  5.0
  5.0
  R = Rejected Data
```

TABLE 4
Method and Performance Evaluation, AOCL
Method Study 3, Demand Analyses

TOC, Sample 2

Statistics, All Data, All Laboratories
Manual Procedure
Recovery of Increment from Distilled Water

Increment = 107

```
N           26          Range     33.00000   Coef. Var.     0.05551
True Val.107            Variance 35.99380   Skewness       0.74660
Mean        108.07693   Std. Dev. 5.99948   No. of Cells 5
Median      107.50001   Conf. Lim.11.75898
Accuracy      1.00646   Pct. Relative Error, Retained Data

Data in Ascending Order    Midpoint  Freq.    Histogram

  94.                      94.0000    1       X
 100.                     102.2500    8       XXXXXXXX
 102.                     110.5000   15       XXXXXXXXXXXXXXX
 103.                     118.7500    1       X
 104.                     127.0000    1       X
 104.
 105.
 106.
 106.

 107.
 107.
 107.
 107.
 108.
 110.
 110.
 110.
 110.
 110.
 110.
 110.
 110.
 112.
 114.
 117.
 127.R

R = Rejected Data
```

TABLE 5

```
                                        Sample #349086
                                        Raw Sewage
                                        24 Hour Composite
                                        Total Organic Carbon
                                        Data in mg/l

Imput
= 48.8, 52.8, 49.2, 47.6, 51.2, 47.6, 51.2, 50.8, 50.4
List
(1,    1) = 48.9
(1,    2) = 52.8
(1,    3) = 49.2
(1,    4) = 47.6
(1,    5) = 51.2
(1,    6) = 47.6
(1,    7) = 51.2
(1,    8) = 50.8
(1,    9)   50.4
Vardes, 1
                         Variable Description
Var      Variance        Mean             S.D.       N

 1       3.137778E 00    49.9556          1.7714     9

Var   S.E. of Mean       Maximum          Minimum    Range

 1        .5905          52.8000          47.6000    5.2000
```

TABLE 6

```
                                           Sample 0349086
                                           Raw Sewage
                                           24 Hour Composite
                                           Dissolved Organic Carbon
                                           Data in mg/l

Input
= 20.8, 21.2, 22.4, 23.0, 21.2, 21.8, 21.8, 22.2, 20.4,
  22.6
List, 1
(1,    1) = 20.8
(1,    2) = 21.2
(1,    3) = 22.4
(1,    4) = 23.0
(1,    5) = 21.2
(1,    6) = 21.8
(1,    7) = 21.8
(1,    8) = 22.2
(1,    9) = 20.4
(1,   10) = 22.6
Vardes, 1
                        Variable Description
Var      Variance        Mean      S.D.       N

 1    6.937778E-01      21.7400    .8329      10

Var      S.E. of Mean       Maximum     Mimimum    Range
 1        .2634             23.0000     20.4000    2.6000
```

TABLE 7

```
                                       Sample #1807122
                                       Freeze Dried Bottom Sediment
                                       Dissolved in Distilled Water
                                       Total Organic Carbon
                                       Data in mg/l
Input
= .3, .2, .3, .2, .2, .2, .2, .3, .3,

List, 1
(1,   1) = 0.30
(1,   2) = 0.20
(1,   3) = 0.30
(1,   4) = 0.20
(1,   5) = 0.20
(1,   6) = 0.20
(1,   7) = 0.20
(1,   8) = 0.30
(1,   9) = 0.30

Vardes, 1
                    Variable Description

Var      Variance            Mean         S.D.       N
 1     2.777778E-03          .2444        .0527      9

Var    S.E. of Mean        Maximum       Minimum      Range
 1        .0716             .3000         .2000       .1000
```

TABLE 8

```
                                    Sample #1807152
                                    Freeze Dried Bottom Sediment
                                    Dissolved in Distilled Water
                                    Total Organic Carbon
                                    Data in mg/l
Input

 = .3, .3, .3, .2, .3, .3, .3, .2, .3, .2

List, 1
(1,   1) = .30
(1,   2) = .30
(1,   3) = .30
(1,   4) = .20
(1,   5) = .30
(1,   6) = .30
(1,   7) = .30
(1,   8) = .20
(1,   9) = .30
(1,  10) = .20

Vardes, 1
                   Variable Description

Var      Variance        Mean      S.D.      N
 1     2.333333-03       .2700     .0483     10

Var   S.E. of Mean      Maximum       Minimum      Range
 1      .0153            .3000         .2000        .1000
```

TABLE 9

```
                                            Sucrose Solution
                                            Data in mg/l

Input
= 3.2, 3.2, 3.3, 3.3, 3.3, 3.3, 3.3, 3.3

List, 1
(1,    1) = 3.2
(1,    2) = 3.2
(1,    3) = 3.3
(1,    4) = 3.3
(1,    5) = 3.3
(1,    6) = 3.3
(1,    7) = 3.3
(1,    8) = 3.3
Vardes, 1
                    Variable Description
Var       Variance        Mean      S.D.       N
 1      2.142857E-03     3.2750    .0463      8
Var       S.E. of Mean        Maximum          Minimum
 1         .0164              3.3000           3.2000
```

TABLE 10

COMPARISON DATA

Beckman 915 System and OIC TC System

SAMPLE	BECKMAN* DOC	OIC* DOC	DIFFERENCE**
0349020	19	16.8	2.2
1	18	14.4	3.6
2	14	10.0	4.0
41	16	16.0	0
2	17	16.0	1.0
3	15	13.6	1.4
62	14	12.8	1.2
3	18	17.6	.4
4	17	16.8	.2
83	13	10.4	2.6
4	14	11.2	2.8
5	17	11.2	5.8
107	29	25.6	3.4
8	20	18.4	1.6
9	13	12.8	.2
128	17	17.6	.6
9	23	21.6	1.4
30	15	14.4	.6
149	14	13.6	.4
50	18	17.6	.4
1	17	16.0	1.0
170	11	9.6	1.4
1	13	12.0	1.0
2	14	14.4	.4

*Values are mg/l

**Average Difference is 1.6 mg/l

DOC = Dissolved Organic Carbon

TABLE 11

RECOVERY DATA FOR OIC TC SYSTEM

Values are in mg/1

Lab No.	POC	DOC	TOC	POC + DOC	Percent Recovery
0349020	40.4	16.8	54.6	57.2	105
021	27.2	14.4	49.4	41.6	84
022	18.0	10.0	33.0	28.0	85
041	24.0	16.0	40.2	40.0	100
042	24.0	16.0	41.2	40.0	97
043	16.4	13.6	30.8	30.0	97
1902001	171.	43.2	276.	214.	78*
002	54.8	27.2	86.4	82.0	95
003	11.8	15.6	29.6	27.4	93
0349086	30.0	21.8	48.8	51.8	106
087	26.4	20.6	44.4	47.0	106
088	13.4	16.4	27.6	29.8	108
173	21.4	22.8	47.2	44.2	94
174	19.8	21.2	44.4	41.0	92
175	13.8	16.6	33.2	30.4	92

*Volatile organic material suspected

POC = Particulate Organic Carbon
DOC = Dissolved Organic Carbon
TOC = Total Organic Carbon
Percent Recovery = $\frac{\text{POC} + \text{DOC}}{\text{TOC}} \times 100$

Science and Society

George C. Pimental
University of California
Berkeley, California 94720

Presented to the Timely Topics General Session,
32nd Two-Year College Chemistry Conference,
Oakland, California, October 21, 1972.

As an introduction to the film "Wondering About Things," distributed by Modern Talking Pictures, Inc., several examples were mentioned of the need for better scientific literacy in the public at large.

1. After recent laws were passed regarding flame retardent in children's clothing, a particular company manufactured a flame retardant that was completely acceptable. This same company also placed a phosphate-free detergent on the market, again in response to governmental restraints and encouragement Unfortunately, the phosphate-free detergents remove the flame-retardant agent in the clothing, an example of how hasty legislation to solve one problem can generate others.

2. There is increased concern about the lead content of gasoline, a legitimate concern that has awakened alarm about leas poisoning in children. To evaluate the relative importance of the various possible sources of lead poisoning, it is important to realize that 100 grams of potatoes contains 28 micrograms of lead, about the same amount inhaled by an average adult in 24 hours in an urban area. Studies of severe lead poisoning of amall children indicate that the most likely cause is the eating of paint chips and that air pollution has nothing to do with it.

The two examples show that a panicky response to a technological problem is unlikely to be fruitful but that systematic study points the way to solutions. The public must underatand this and scientific literacy will help them do so. We as teachers must reach out to a larger fraction of our students to convey this scientific literacy. These students are tomorrow's citizens and they must retain control of the uses of technology, since the uses we select affect the quality of life for all of us.

The Chemical Technology Medical Laboratory Interface

Summary of a Panel Presentation at the Chemical Technology-Medical Laboratory Interface Section, 31st Two-Year College Chemistry Conference, Brooklyn, New York, August 26, 1972

Panel Members:
Sylvia Blatt, Department of Health, Bureau of Laboratories, Division of Field Services, New York City, New York
Leonard Druding, Rutgers University, Newark, New Jersey 07102
Thomas Whitfield, Rhode Island Junior College, Warwick, Rhode Island 02886

Summarized by Frank B. Slezak, Mercer County Community College, Trenton, New Jersey 08608

Sylvia Blatt's opening comments dealt with the licensure situation for medical laboratory technicians and technologists; aspects of training programs; and some comments on current job opportunities.

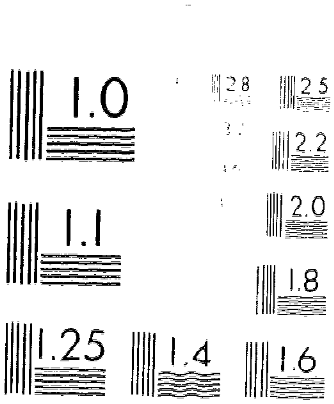
Licensure requirements exist in Arizona, California, Florida, Tennessee, and New York City. New York state does not require licensure below the level of laboratory director. Requirements vary with New York City requiring,for the technician level, a two year medical technology course of study plus one year of experience in a clinical laboratory or 6 months training in a laboratory approved for training. The requirement for a technologist rating is a bachelors degree with a major in chemistry or biological sciences including relevant medical technology courses and one year of satisfactory experience.

No licensure examination is required in New York City if the approved education and experience requirements are met. If only one or the other is satisfied a person may take an examination and qualify for one or another of the medical technology specialities. A written multiple choice answer examination must be passed and this is then followed by an oral practical examination. Higher requirements need to be met for supervisor or director level licensure.

It was recommended that the community colleges have joint programs with some of the better hospital laboratories in their areas; that some provision be made for internship training; and that an attempt be made to get some kind of a stipend for the training period. This will allow a student to qualify more quickly and to be a better technician and technologist.

A limited current employment market for medical technicians exists in the New York City area and many training hospitals are requiring a bachelor's degree of people they are hiring and accepting for training. In response to a question it was noted that the number of positions is not decreasing; only that the number of applicants for the available positions is increasing.

Dr. Thomas Whitfield indicated that the original premise behind the Rhode Island Junior College one year certified laboratory


1.0
2.8
2.5
2.2
1.1
2.0
1.8
1.25
1.4
1.6

assistant (CLA) program was to train such CLA's in as short a time as possible. Therefore the one year program, which runs on a September to September basis, has two quarters of very heavily scheduled class work followed by the third quarter and summer spent in cooperative hospital work and training.

The one quarter chemistry course serving this program is directed at meeting the immediate needs of the students. Emphasis is placed on solution chemistry, stoichiometry and stoichiometric calculations, inorganic and organic chemical nomenclature and aspects of spectrophotometry. The laboratory reinforces this with emphasis on pipeting, titrations and utilization of spectrophotometers. Use is made of these skills in the second quarter in more specific clinical laboratory determinations.

Dr. Leonard Druding, Rutgers University-Newark, noted that the overwhelming majority of students in most first year general chemistry courses are not chemistry majors. It is important to recognize the academic and career aspirations of the students making up the class and to direct the course in such a way as to best meet their needs.

It has been the experience at Rutgers-Newark, and probably at other schools as well, that many students do not declare an "official " major until their third or even fourth year. Even though this may be true only a very small percentage, in the 2 to 5 percent range, will opt to become chemistry majors. Therefore it is important that the first year general chemistry course not be directed at chemistry majors, who will constitute a minute portion of that class, but at the much larger group typically made up of biology, paramedical, medical and engineering bound students most of whom have neither the need nor the interest in many of the somewhat esoteric fine points of the subject which appeal to many chemists and presumably to chemistry majors as well.

Dr. Druding felt that a chemistry program emphasizing a broad-based science education rather than a narrowly directed overspecialized general chemistry would better serve the needs of the great majority of contemporary students finding their way into the general chemistry courses.

Committee on Chemistry in the Two-Year College

Division of Chemical Education
American Chemical Society

1972 Roster of Committee Members

Chairman — William T. Mooney, Jr., El Camino College, Torrance, Ca. 90506
Secretary — Robert Burham, Grand View College, Des Moines, Ia. 50316
Editors — Kenneth Chapman, Chemical Technician Curriculum Project, Berkeley, Ca. 94720
Ellen and Jay Bardole, Vincennes University Junior College, Vincennes, In. 47591

REGION I — WESTERN STATES
Armstrong, Mabel K., Lane Community College, Eugene, Or. 97405
Buckart, Kent R., Palomar College, San Marcos, Ca. 92069
Beaver, Keith J., Bellevue Community College, Bellevue, Wa. 98004
Bryce, C. Herbert, Seattle Central Community College, Seattle, Wa. 98122
Decker, J. Smith, Phoenix College, Phoenix, Az. 85013 *
Fohn, Edward C., Green River Community College, Auburn, Wa 98002
Hubbs, Robert R., De Anza College, Cupertino, Ca. 95014
Lungstrom, Richard A., American River College, Sacramento, CA. 95841
Marcy, Eugene, Central Oregon Community College, Bend, Or. 97701
McWhinnie, Campbell H., Casper College, Casper, Wy. 82601
Sterner, Wanda, Cerritos College, Norwalk, Ca. 90650
Trujillo, Anthony, San Joaquin Delta College, Stockton, Ca. 95204
Williams, Gordon H., Monterey Peninsula College, Monterey, Ca. 93940
Wyatt, William H., El Paso Community College, Colorado Springs, Co. 80903
Westover, Ross, Canada College, Redwood City, Ca. 94061

REGION II — SOUTHERN STATES
Allison, Harrison, Marion Institute, Marion, AL 36756
Cheek, William E., Central Piedmont Community College, Charlotte, N.C. 28204
Duncan, Hoyt D., Eastern Oklahoma State College, Wilburton, OK 74578
Edgar, James H., Navarro Junior College, Corsicana, Tx 75110 *
Elkins, L. Dean, Henderson Community College, Henderson, Ky. 42420
Griffin, William W., Hinds Junior College, Raymond, Ms. 39154
Howard, Charles, San Antonio College, San Antonio, Tx. 78212 *
Hyre, William J., Middle Georgia College, Cochran, Ga. 31014
Inscho, F. Paul, Hiwassee College, Madisonville, Tn. 37354
Milton, Nina, St. Petersburg Campus, St. Petersburg Junior College, St. Petersburg, Fl. 33733
Minter, Anne P., Roane State Community College, Harriman, Tn. 37748
Mitchell, John, Tarrant County Jr. College, Northeast Campus, Hurst, Tx. 76053
Singer, Robert, Chipola Junior College, Marianna, Fl. 32446
Sink, W.G., Davidson County Community College, Lexington, N.C. 27292
Walters, Bobby, Paris Junior College, Paris, Tx. 75460
REGION III — MIDWESTERN STATES
Ballinger, Jack, Florissant Valley Community College, St. Louis, Mo. 63135
Blough, Alvin, Hesston College, Hesston, Ks. 67062
Clouser, Joseph L., Wm. Rainey Harper College, Palatine, Il. 60067
Dhonau, Curtis A., Vincennes University Junior College, Vincennes, In. 47591
Everland, Earl, Normandale State Junior College, Bloomington, Mn. 55431
Frymiller, Herman F., Madison Area Technical College, Madison, Wi. 53703
Hammonds, Carl N., Penn Valley Community College, Kansas City, MA 64111
Heider, Rudolph L., Meramec Community College, St. Louis, Mo. 63122
Hoffhine, Charles, Lorain County Community College, Elyria, Ohio 44035
Kotnik, Louis, Metropolitan Campus, Cuyahoga Community College, Cleveland, Oh. 44115
Laughlin, Ethel, Western Campus, Cuyahoga Community College, Parma, Oh. 44130
O'Leary, Vincent, Black Hawk College, Moline, Il. 61265 *
Travaglini, Catherine, Parkland College, Champaign, Il. 61820
Weissmann, Katherine, Genesee Community College, Flint, Mi. 48503

REGION IV — EASTERN STATES
Ayer, Howard A., Franklin Institute of Boston, Boston, Ma. 02116
Bauer, Douglas J., Mohawk Valley Community College, Utica, N.Y. 13501 *
[illegible], Mother [illegible], Manor Junior College, Jenkintown, Pa. 19046
[illegible], C.H., Rockville Campus, Montgomery College, Rockville, Md. 20850
Brown, James L., Corning Community College, Corning, N.Y. 14830
Cassel, Myron W., Monroe Community College, Rochester, N.Y. 14623
Fine, Leonard W., Housatonic Community College, Bridgeport, Ct. 06608
Hajian, Harry G., Rhode Island Junior College, [illegible], RI [illegible]
Jensen, Opey D., John Tyler Community College, Chester, Va. 23831
Martins, George, Newton High School, Newtonville, Ma. 02160
Santiago, Paul J., Harford Junior College, Bel Air, Md. 21014
Scheirer, Carl Jr., York College of Pennsylvania, York, Pa. 17405
Sollimo, Vincent, Burlington County College, Pemberton, N.J. 08068
Stein, Herman, Bronx Community College, Bronx, N.Y. 10468
[illegible], C.O., Keystone Junior College, La Plume, Pa. 18440
Williams, Thelma, New York City Community College, Brooklyn, N.Y. 11201
REGION V — CANADA CANADA
Bell, D.L., Selkirk College, Castlegar, British Columbia
Dunn, David, Mohawk College of Applied Arts and Technology, Hamilton, Ontario
[illegible], Camosun College, Victoria, British Columbia
Lyons, James, John Abbott College, Ste. Anne De Bellevue, Quebec
Marston, Robert, Grand Prairie Regional College, Grand Prairie, Alberta
Pilon, Jean Guy, C.E.G.E.P. de Jonquière, Jonquière, Quebec
Roberge, John M., College Ahuntsic, Montreal, Quebec
Rothenbury, Ray A., Lambton College of Applied Arts and Technology, Sarnia, Ontario
Waters, D.C., Algonquin College of Applied Arts and Technology, Ottawa, Ontario

(* No longer at listed college after 1972)