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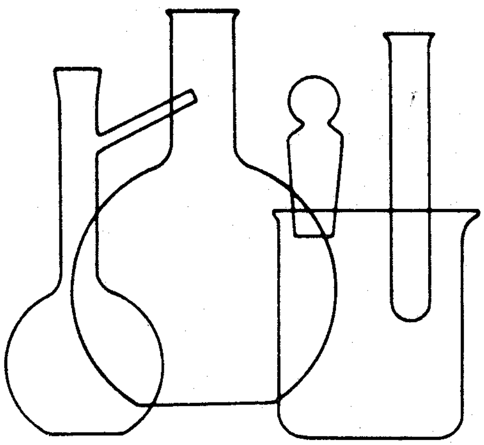

CHEMISTRY IN THE TWO-YEAR COLLEGE

VOLUME XXV SPRING 1983

2YC3
COMMITTEE ON CHEMISTRY IN THE TWO-YEAR COLLEGE
DIVISION OF CHEMICAL EDUCATION • AMERICAN CHEMICAL SOCIETY

FOREWORD

As I write this foreword, I realize that it might be more appropriately called an epilogue. This issue, Volume XXV of "Chemistry in the Two-Year College" represents, in all likelihood, the last of the $2YC_3$ proceedings. As I look back on former issues, I realize how invaluable this publication has been to $2YC_3$ members. Not only has it served a permanent reminder of pleasant times and information exchanged at regional conferences; but for those unable to attend, it became an important sourcebook--the next best thing to being there.

Over the years the Committee on Chemistry in the Two Year Colleges has continued to develop, change, and expand as any vital organization should. Needless to say, the pressure for changes in our publication coincided with Jay Bardole's desire to be released from his long term involvement as editor. Jay and Ellen Bardole have dedicated their efforts to this journal for over 10 years; we offer them heartfelt thanks.

What can two-year college chemistry teachers look forward to in the way of publications? Fortunately, between the Society Committee of Chemical Education (SOCED) and the Division of Chemical Education (DivCHED), there is a sum or $6000 to explore an ACS staff program in two-year college chemistry. Janet Boese, who works in the newly established Office of College Chemistry headed by Robert Ridgway, will spend approximately 20% of her time on the two-year college program. In 1983, this office plans to produce and distribute a publication aimed at all two-year college chemistry teachers. Ethelreda Laughlin, our recently appointed editor, will be the $2YC_3$ spokesperson and together we look forward to a successful enterprise.

Additionally, $2YC_3$ looks forward to creating and giving a "new face" to a column in the Journal of Chemical Education in which we can address problems, issues and outlooks that are unique to two-year college teaching. Joe Lagowski, editor of the Journal of Chemical Education, has agreed to such a column four times a year and has invited us to collaborate with them in this area.

Articles included in this issue "Chemistry in the Two-Year College" are form $2YC_3$ Conferences held in 1981 and 1982, concluding with the meeting at New York City Technical College. Our conferences are the products of many individual efforts. We wish to thank the people who provided the coordination of these conferences; Bill Cheek (Central Piedmont, NC), Teddy Edwards (Las Vegas meeting), Warren Eidsness (Normandale Community College, MN), David Klein and Cecil Hammonds (Kansas City), and Dick Gaglione and Henry Zimmerman for the New York City meeting. We are deeply indebted to the host institutions for the use of their facilities.

I look forward to 1983 as a year characterized by a spirit of teamwork--a year in which we can face the future with optimism in spite of the depressed times.

Tamar Y. Susskind
Chairwoman, COCTYC

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CHEMISTRY IN THE FUTURE

SPECIAL TOPICS

COMPUTERS IN CHEMICAL EDUCATION

The Computer and Chemistry Instruction

James D. Beck
Virginia State University
Petersburg, Virginia 23803

Presented as a paper and workshop to the Seventy-Third Two Year College Chemistry Conference, Central Piedmont Community College, Charlotte, North Carolina December 4 and 5, 1981.

The widespread availability of inexpensive microcomputers has made it possible for us as chemistry teachers to utilize the computer as an effective instructional tool. In this presentation I will try to give you a little of the how, why, and where of computer use--how you can use the computer, why you should use the computer, and where you can get information on the use of the computer. I will show you some of the ways in which I have used the computer with my students at Virginia State University and will offer some general suggestions and advice to the instructor who plans to make use of the computer in the teaching of chemistry.

Let me begin by presenting a brief overview of some of the many ways in which computers are being used in the teaching of chemistry:

1. Calculations. This is the use which one normally associates with the computer. Students can now routinely access programs to do all sorts of calculations, from curve-fitting to matrix operations. The portability of the microcomputer makes it possible for one to do on-line calculations in classes and laboratories. Instructors can demonstrate complex calculations and students can obtain immediate results from their laboratory work.

2. Collection and Treatment of Data. Many instruments now have microprocessors built-in and many can be interfaced directly to a computer so that the data which is generated during an experiment is fed to the computer for analysis and display. Graphical representation of results, statistical analysis, curve-fitting, etc. are possible.

3. Computer-Assisted Instruction. This term is used to refer to a variety of different modes of computer use. I am using it here in a limited way to include programs that are designed to teach a specific topic or to provide drill-and-practice. Programs for teaching are often called tutorial programs, although there is no real dividing line between these and other programs which are primarily for drill. In either case, the purpose is directly related to teaching and the need for a student to master a topic.

4. Generation of Exams, Problem Sets, etc. The computer can be used to generate large numbers of individualized sets of questions on prescribed topics. These can be used

as practice sets for students or to provide individualized examinations.

5. Simulations and Games. A laboratory experiment, the operation of an instrument, or the management of chemical plant can be simulated by a computer program. Chemical concepts can be cast in game format to make learning more enjoyable.

6. Graphics. This is not really a separate area of use but rather a computer technique that can be employed in many ways. I have already mentioned graphical representation of data and results. Graphics can be very effective for on-line calculations and illustrations in lecture classes. Diagrams and drawings can enhance simulations, games, and computer-assisted instruction programs. The availability of graphics is a strong selling point for most microcomputers.

7. Grading and Record-Keeping. Scoring examinations and analyzing results are routine uses for computers. Many instructors keep their grades on the computer.

8. Searching Data Files. This is an incidental use for chemistry instruction. The availability of data bases for the chemical literature has made computer searching an important element of chemical research. Undergraduate chemistry students need to be exposed to these new means of information storage and retrieval.

9. Computer-Managed Instruction. This term is used to describe a system in which the computer does record-keeping and also provides feedback to the student and instructor. Certain activities may be suggested to the student based on the computer's analysis of work completed and student performance. The instructor can obtain complete information on individual student work or for the class as a whole.

My discussion here will emphasize three of these areas of application--computer-assisted instruction, simulations, and computer-generated problem sets. These are the primary areas of computer use in chemistry at Virginia State University; the applications overlap some of the other areas which have been described.

Before I go into more detail on these uses, I would like to cite some of the advantages of computer use, especially in the area of computer-assisted instruction:

1. Individualization--each student accesses the computer individually and receives responses based on input.

2. Repeatibility--the computer can repeat the same operation or sequence, for the same student or for many different students.

3. Infinite Patience--the student can practice extensively.

4. Immediate Feedback and Reinforcement--the computer responds immediately and can offer the positive reinforcement needed by many students.

5. Variety of Instruction--some students find the computer to be an effective alternative to traditional learning modes.

6. Motivation--many students find the computer interesting and motivating.

7. Automatic Grading and Record-Keeping--this may be an important consideration for the chemistry teacher.

8. Reduction in Test Anxiety--the non-threatening environment of the computer may help to reduce test anxiety for students who use it extensively.

Now let me give you a few examples of programs that my students use. Virginia State University is a relatively small, predominantly-black, four year public institution in Petersburg, Virginia. Most of our students come to us with weak backgrounds in science and mathematics. The computer applications which I will describe are from our general chemistry course, a two-semester sequence which enrolls a variety of students, including chemistry, life sciences, physics, geology, mathematics, agriculture, and some home economics majors.

Our primary use of the computer is for drill-and-practice. We have a series of single-concept programs which are designed to provide practice on specific topics. These are all similar in format. There is a brief introduction followed by a series of questions which are designed to test the student's knowledge of the topic. The student's responses are checked by the computer which administers the appropriate "pat-on-the-back" or gives additional information or the correct answer. The extent of the feedback and reinforcement varies with the subject matter. Most of the programs are open-ended, allowing the student to practice to an unlimited extent. Provisions are included for grading and record-keeping. A random number generator is used to vary questions and content.

Here is a portion of a sample run of a program involving density calculations:

```
YOU HAVE 200 G OF A SUBSTANCE WITH A DENSITY OF 1.0 G/ML.
WHAT IS ITS VOLUME IN MILLILITERS? 300

NO, IT SHOULD BE 200 MILLILITERS.  LET'S SEE HOW IT WORKS OUT:

   USING THE DENSITY AS A CONVERSION FACOTR:

            200G X __________ = ? ML

   THE CONVERSION FACTOR MUST HAVE UNITS OF ML/G IN ORDER TO
   CANCEL G AND LEAVE ML.  IF WE USE THE INVERSE OF THE
   DENSITY WE WILL GET THE PROPER UNITS:

                    1.0 ML
            200G X __________ = 200 ML
                     1 G
YOU HAD BETTER TRY ANOTHER ONE LIKE THIS:
```

YOU HAVE 2100 G OF A SUBSTANCE WITH A DENSITY OF 3.0 G/ML.
WHAT IS ITS VOLUME IN MILLILITERS? 700

EXCELLENT! YOU SEEM TO BE ABLE TO HANDLE THAT TYPE OF PROBLEM.

One of the significant advantages of this type of program is the potential for feedback to the student. More extensive feedback obviously requires more extensive programming.

We also have a few simulations available for student use. One allows the student to perform a titration on the computer. Another simulates a qualitative analysis scheme. One of the best is a program which simulates the production of ammonia using the Haber process. These programs and the much more extensive list of drill-and-practice programs are available for students to use individually throughout the course.

There are certain topics and types of problems which are not suitable for on-line interactive computing of the type that I have just described. These may require extensive calculations or multiple steps, or require the use of special tables, graphs, or other data which cannot readily be supplied at the computer. Limitations of computer hardware and time will usually not permit a student to spend a lengthy time period at the computer. For these reasons we also use computer-generated problem sets. The computer is used to generate an individualized set of questions for each student. The questions are printed as a problem set of questions for each student. The questions are printed as a problem set which is distributed to the student. Here is a portion of such a problem set:

1. HOW MANY GRAMS IN 7 MOLES OF CO_2?
2. WHAT WILL BE THE VOLUME AT STP OF 380 G OF N_2 GAS?
3. CALCULATE THE DENSITY, IN G/L, OF NO GAS AT STP.
4. HOW MANY ATOMS OF OXYGEN WILL THERE BE IN 0.060 MOLES OF N_2O_4?

Each set of problems is generated by a BASIC program. A companion program is used to check student answers. This program requests the answers to the questions and checks them; feedback and reinforcement are possible since this is an interactive program. The problem sets also have the potential for diagnosis and prescription. The computer can examine the responses provided by the student and suggest additional activities to remedy weak areas. These activities might include additional pages to read, drill-and-practice programs, slide/tape programs, or extra problems to work.

Before leaving this brief description of our computer use at Virginia State, I would like to emphasize that the computer has a specific role in our teaching. It is one instructional tool among many. It does not replace any other mode of learning, but is used as supplement. Students also have available the lectures, laboratory, textbook, practice sessions, slide/tape programs, recitation classes, lecture notes, copies of old examinations, a study guide, and some audio tapes.

They select among these the best way to learn chemistry. Our experience has shown that the computer programs and problem sets are widely-used and are perceived by our students as being very worthwhile.

Now let's consider the where--where can you get information and programs. Here are a few sources of general information:

1. INDEX TO COMPUTER BASED LEARNING. The 1981 edition by Anastasia C. Wang, provides descriptions of over 4800 programs, several hundred of which are in chemistry. Available from Educational Communications Division, University of Wisconsin-Milwaukee, P.O. Box 413, Milwaukee, WI 53201.

2. CHEMISTRY WITH A COMPUTER. This book by Paul Cauchon provides listings, sample runs, and descriptions of 28 BASIC programs. Available from Programs for Learning, Inc., P.O. Box 954, New Milford, CT 06776.

3. SELECTED BIBLIOGRAPHY OF COMPUTER PROGRAMS IN CHEMICAL EDUCATION. Compiled by Warren T. Zemke, this covers the period 1967-79. Available from CONDUIT, P.O. Box 388, Iowa City, IA 52244.

4. COMPUTERS IN CHEMICAL EDUCATION NEWSLETTER. Published by the Task Force on Computers in Chemical Education of the ACS Division of Chemical Education. Available from Donald Rosenthal, Editor, Department of Chemistry, Clarkson College of Technology, Potsdam, NY 13676.

5. COMPUTER SERIES, JOURNAL OF CHEMICAL EDUCATION. This series, edited by John Moore, has been running since 1979. A compilation of the articles published during the first two years is available as a book entitled ITERATIONS. Available from J. Chem. Ed., 20th and Northampton Streets, Easton, PA 18042.

What about programs? You can write your own, of course. Most of us do not have time, interest, or ability to do that. You can get some from organizations and individuals cited in the general references given above. If you wish to purchase programs, here is an incomplete list of vendors with brief descriptions of their wares:

SOME SOURCES OF CHEMISTRY PROGRAMS

1.	CONDUIT P.O. Box 388 Iowa City, IA 52244	variety of tested programs in many disciplines, some in chemistry, some in BASIC, some for microcomputers (APPLE, PET, TRS-80)
2.	PROGRAMS FOR LEARNING, INC. P.O. Box 954 New Milford, CT 06776	large selection of BASIC programs in chemistry, available for many different types of computers, including microcomputers
3.	COMPress P.O. Box 102 Wentworth, NH 03282	43 programs on 7 discs for APPLE II covering variety of topics in organic chemistry, written by Stan Smith at Univ. of Illinois

4. J & S SOFTWARE
140 Reid Avenue
Port Washington, NY 11050

15 drill-and-practice programs in chemistry, for APPLE and TRS-80

5. University of Michigan
c/o Paul G. Rasmussen
Ann Arbor, MI 48109

several programs, mostly for PET computers, written by William Butler, James Beatty, and H.C. Griffin; most are laboratory simulations

6. HIGH TECHNOLOGY, INC.
P.O. Box 14665
Oklahoma City, OK 73113

for sets of chemistry lab simulations in BASIC for APPLE II and ATARI 800 computers

7. THE MILNE PRESS
P.O. Box 1246
Carmel Valley, CA 93924

selection of programs in physical chemistry, written by Gordon Barro programs for general chemistry are under development(?)

8. QUEUE
5 Chapel Hill Drive
Fairfield, CT 06432

general software vendor; sells chemistry programs produced by CONDUIT, Programs for Learning, Instant Software, Redcomp, J & S Software, and Microphys

9. MARCK
280 Linden Avenue
Branford, CT 06405

general software vendor; sells chemistry programs produced by CONDUIT, Programs for Learning, J & S Software, MicroLearning-Ware Microphys

10. Educational Materials and Equipment Company (E.M.E.)
P.O. Box 17
Pelham. N.Y. 10803

seven drill-and-practice programs in basic chemistry for APPLE II

11. Opportunities for Learning
8950 Lurline Avenue, Dept. E
Chatsworth, CA 91311

general software vendor; sells chemistry programs produced by Programs for Learning, others

12. DIGITAL EQUIPMENT CORPORATION
Education System Group
129 Parker Street
Maynard, MA 10754

listings of some BASIC programs--Tutorial Exercises for Chemistry, Huntington Simulation Programs, BASIC Application Programs for Chemistry

13. Gary L. Breneman
Department of Chemistry
Eastern Washington University
Cheney, WA 99004

variety of BASIC programs for chemistry, including some in quantitative analysis and organic chemistry, arailable for APPLE II or in listing form

Before I close, I would like to offer some advice in the form of a list of don'ts:

--don't use the computer in a vacuum

--don't use computer-assisted instruction when another method will do a better job

--don't write a program before you organize your material and define your objectives

--don't try to do too much in one program (or at one computer session)

--don't short-change the student feedback

--don't require lengthy and complicated calculations at the computer

--don't include extensive text without breaks

--don't frustrate the student

--don't wait until you are an expert programmer

Computer-based learning has come of age. DO try it with your students.

Microcomputer Applications in Analytical Chemistry

Joseph W. Long
Broome Community College
Binghamtion, New York 13902

Presented as a part of An Innovation In Teaching Symposium as the Seventy-Second Two Year College Chemistry Conference Monroe Community College, Rochester, New York, October 16, 1981.

In the first half of this paper, I would like to deal with microcomputers in a general way by making comments on the following questions.

1. Why bother with microcomputers at all?
2. What applications are there for microcomputers in analytical chemistry?
3. How much does a usable microcomputer system cost?
4. What are the major systems and subsystems in a microcomputer?
5. Which microcomputer to buy?
6. Where can one get further information on microcomputers?

In the second half of the paper, I would like to briefly describe a microcomputer-controlled automatic titrator which I have assembled, and which is currently being used by students at Broome Community College.

PART I

WHY BOTHER WITH MICROCOMPUTERS?

Microcomputers are not toys. Many of today's microcomputers are more powerful and usable than large-system computers from twenty years ago. Over the past few years, the cost of small-system computers has fallen to the point where it is below the cost of much of the instrumentation within even a very modestly equipped analytical laboratory. Computers are finally affordable within many community college chemistry departments. Further, industrial laboratories are making heavy use of microcomputers and our students need some familiarity with this sort of equipment if their education is to remain current. Finally, many of the applications which can be made within an anlytical lab can not be done on a large-system computer because of problems related to time-sharing on large systems.

WHAT APPLICATIONS ARE THERE FOR MICROCOMPUTERS IN ANALYTICAL CHEMISTRY?

1. They can be used for "off line" data processing. A large-system computer would often (but not always) be a better choice for this application.
2. They can be used for "on line" data processing. Here, data are transferred directly from an instrument to a computer and the data can be processed as the experiment is under way.
3. They can be used for process control. In this case, the computer functions as an executive which, on the basis of a program and perhaps real time data, controls an experiment. The automatic titrator constructed at Broome Community College is an example of this application.
4. They can be used to substitute software (i.e., computer programs) for hardware---electronic components, gears, etc. Examples of this are use of a computer program to generate voltage ramps for use in polarography or to generate pulses to drive a strip chart recorder at different speeds.
5. They can be used for storage of data. The scintillation spectrometer system described later can put 65 spectra on a single minifloppy disk.

HOW MUCH DOES A USABLE MICROCOMPUTER SYSTEM COST?

Complete microcomputers may be purchased for as little as two hundred dollars or for as much money as one might care to spend. Investing around four thousand dollars is required for a truly high quality, usable system. This investment would include about two thousand dollars for a video terminal, and a good printing terminal. Careful shopping, and deletion of some desirable but not mandatory features, would permit a system to be implemented for about two thousand dollars.

WHAT ARE THE MAJOR SYSTEMS AND SUBSYSTEMS IN A MICROCOMPUTER?

A microcomputer, like any computer, must have the following systems: a control processor (CPU), memory, some sort of input/output (I/O) and mass storage. In order to be usable for real time processing and control, two additional systems are required. These are a "Controller" and an Analog-to-Digital——Digital-to-Analog converter (AD/DA). The Controller allows relays to be opened or closed in the external world under computer control, and the AD/DA provides a path for analog voltages into and out of the computer.

WHICH MICROCOMPUTER TO BUY?

An important decision which must be made very early is on which of two approaches to take in setting up a microcomputer. This decision is on whether to buy a complete "one-box" computer or to buy a more modular system. This is analogous to the decision facing the purchaser of high fidelity equipment who must decide on whether to opt for a "components" system, or for a console system. Each has its advantages; but, because of the versatility and expandability it allows, a modular approach seems to be the best approach where process control and real time computing are involved. We have used this approach at Broome Community College with great success. Our microcomputers are all based on the so-called S-100 Bus. S-100 based computers are available from numerous manufacturers, and dozens of other manufacturers produce scores of different boards which will plug right in. The resulting versatility is almost limitless.

PART II

In this section, I will briefly describe three applications for microcomputers I have developed at Broome Community College. They are:

A. an automatic titrator

B. a gamma scintillation spectrometer

C. A chromatographic data analyser.

A. Microcomputer Controlled Automatic Titrator

The automatic titrator I will describe here illustrates most of the ways in which microcomputers can be applied within the field of analytical chemistry. For that reason, it is a good, concrete example of many of the principles expressed in Part I of this paper. I will discuss the automatic titrator from the following viewpoints:

1. operation of the titrator

2. it's capabilities and applications

3. special (non-computer) hardware required

4. titrator software

OPERATION OF THE TITRATOR

The titrator consists of a titrant pump and motor (digital burette), a pH meter and a strip chart recorder interconnected through the microcomputer. It functions, briefly, in the following way: the computer monitors the pH of the solution being titrated. When the pH reaches a constant value, it is output to the teletype and to the chart recorder. Under computer control, the chart recorder paper is advanced, a titrant increment is added and the cycle begins again as the computer monitors the pH of the solution once more.

TITRATOR CAPABILITIES AND APPLICATIONS

(a) It can perform any potentiometric titration which could be done manually using a standard pH/millivolt meter, including acid-base, redox precipitation titrations, etc.

(b) As each increment of titrant is added by the computer-controlled pump, the pH (or voltage) can be printed on a teletype. At the same time, the data can be plotted under computer control on a strip chart recorder.

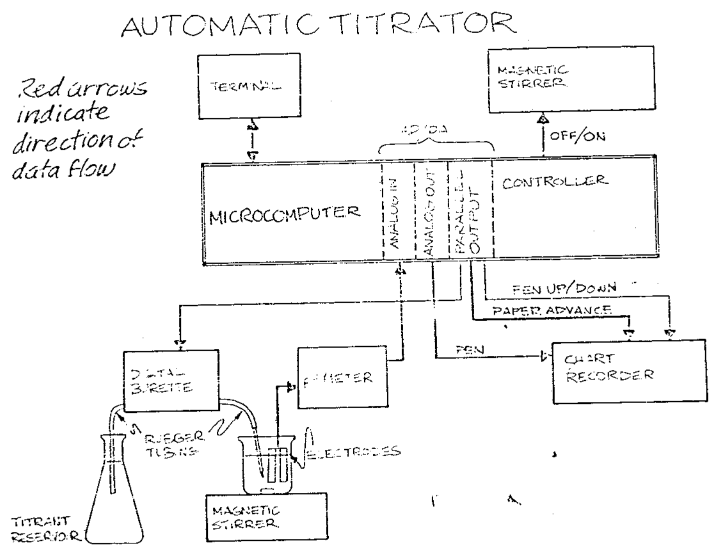
(c) Titrating variables, such as the amount of titrant to be delivered, chart recorder format, criteria for stopping the titration, etc. are set by the operator in response to prompts from the titrator program.

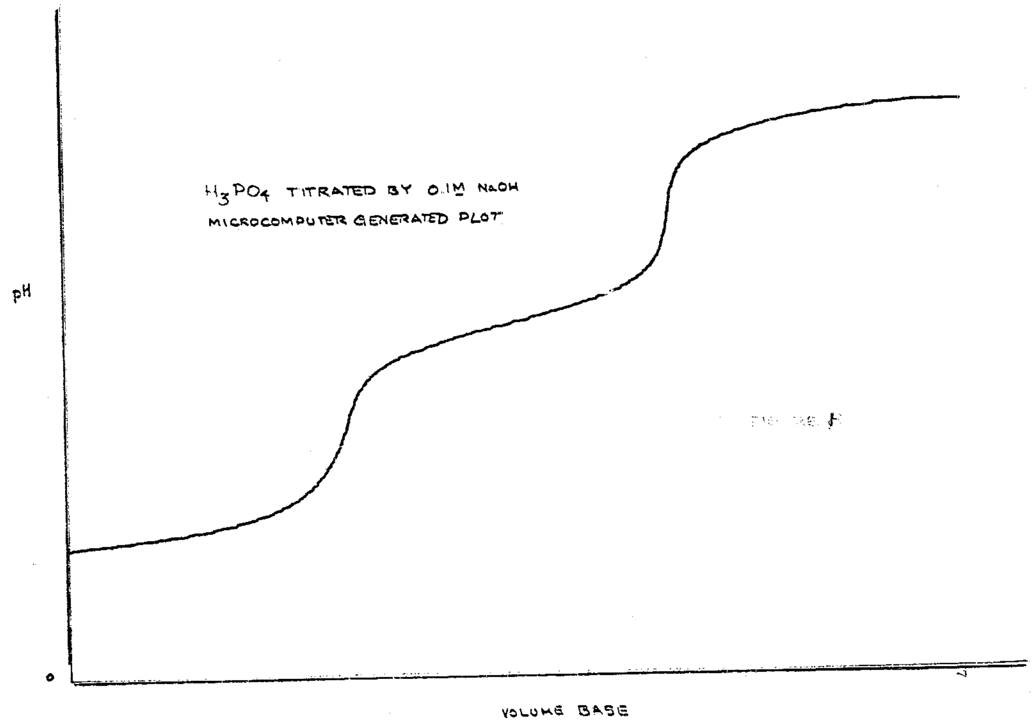
(d) Changes in the software allow limitless modification and adaptation of the titrator's capabilities. For example, first or second derivative plots can be done, or routines to perform stoichiometric calculations based on the endpoint of the titration could be added. This can be done by changing the titrator <u>programs</u>. The hardware need not be touched. Here is an excellent example of replacement of hardware. Operational amplifiers would be required for derivative plots if the programming power of the computer were not available. This makes the titrator very versatile and in many ways, "intelligent."

TITRATOR SOFTWARE

The titrator program is written in a special form of BASIC called "CONTROL BASIC" which is especially designed for process control. Figure B gives a titration curve generated by the titrator. Once the system is started, the sample is titrated and the curve plotted completely automatically.

AUTOMATIC TITRATOR





INSTRUCTIONS FOR OPERATION OF
THE PROCESSOR TECHNOLOGY GAS CHROMATOGRAPHY DATA ANALYSER

I. INTRODUCTION

A. Capabilities

This equipment will analyse the results of gas chromatographic runs and produce the following information:

1. relative area of each peak
2. retention time of each peak.

The information is automatically output to a printer if hard copy of the data is desired.

B. Limitations

The analyser makes the following assumptions about the chromatographic data:

1. The baseline is constant and close to zero
2. The data are fairly noise-free.
3. The peaks are completely resolved.
4. The peaks are symmetrical. (Affects accuracy of retention time only.)
5. The peaks are of reasonable height on a 10 mV scale recorder.

Assumptions 1-4 are based on the analyser software, which could be modified to eliminate any or all of them

Assumption 5 is based on the analyser hardware and would require modification of the "analog and digital interface" described below.

C. Hardware Description

The equipment consists of a processor technology microcomputer system, including a dual floppy disk, AD/DA converter, video display and printer.

The interface between the computer and chromatograph is another piece of hardware called an "analog and digital interface". This box connects the chromatograph to the computer. Its purpose is to convert the output voltage level of the GC into a level and range usable by the computer.

Figure 1 is a diagram of the hardware.

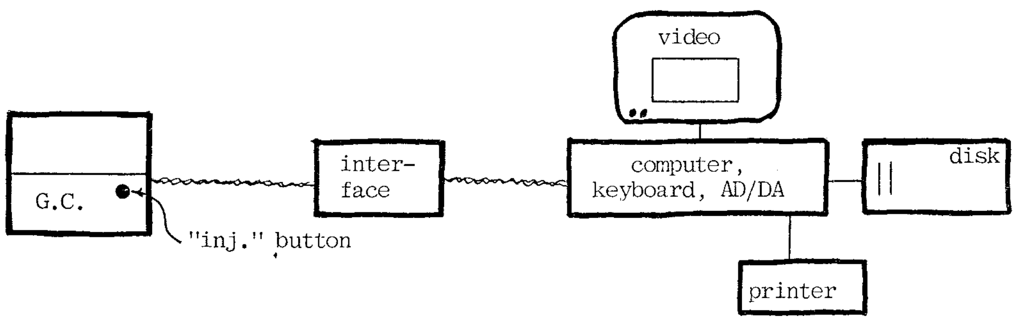


FIGURE 1

II. START-UP AND OPERATION

A. GC Start-Up

1. Start up GC in normal manner.
2. Adjust sample size to give good peaks when recorder is set to 10 mV scale.
3. Carefully zero recorder, using recorder zero adjust and zero button.
4. Adjust GC filament current to exactly zero on recorder.
5. Turn on "analog and digital computer interface."

B. Computer (cold) Start-Up

1. Turn on computer (key on disk). You should see a > prompt on video display.
2. Carefully insert disk into L.H. drive. Be sure disk is oriented correctly.
3. Type: boot <ret> . You should get a "PTDOS" message, followed by a star (*) prompt.
4. In response to *, type: DO INTEG <ret> .
5. The analyser software will load and automatically execute.
6. You should see the following prompt: "Number of peaks expected?"
7. If you got this far, all is well. If not, remove disk, turn off computer and go to B-1.

C. Operation of Analyser Program

1. Touching the "mode select" key will stop the pro- Type: RUN to start it again.
2. Advice on response to various prompts in program.
   a. "Number of peaks expected?" Enter the number if you know; otherwise enter a large number (say, 100).
   b. "Do you want hard copy?" Enter yes or no, as it pleases you.
   c. "Turn on TTY." Be sure local light (on keyboard) is off.
      (1) Turn TTY to line, not local.
      (2) Local light is on lower left of keyboard. Try pushing the key a few times.

D. "Type 'GO' as you inject sample."
At this point, your sample should be in syringe, ready to inject. As you inject, push inject button (on lower GC box).

E. "Touch escape key to interrupt and print results early."

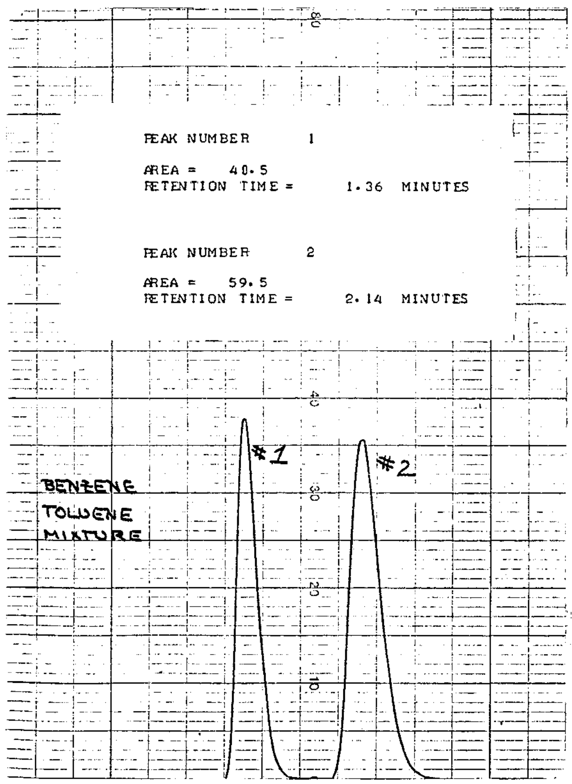
1. Escape key is in upper L.H. corner of keyboard.
2. Use escape key if you see all the peaks you want analyzed. Useful when you don't know in advance how many peaks to expect.

F. "Integrating....."
This is not a prompt. It merely indicates that integration is currently under way.

G. "Touch space bar to continue, or mode select to stop"
If you have more samples to be analyzed, do space bar.

H. "Same conditions as last run?" (yes or no) Type no if you want to change any options, such as peak number estimate.

Example of Output from analyser



EXAMPLE OF OUTPUT FROM ANALYSER

INSTRUCTIONS ON OPERATION OF THE NUCLEUS/NORTHSTAR COMPUTER CONTROLLED SCANNING SCINTILLATION COUNTER

I. INTRODUCTION

A. Capabilities

This equipment will generate accurate, reproducable gamma scintillation spectra. The spectra may be saved on a minifloppy diskette (one diskette will hold 65 spectra) for subsequent playback. The playback can be either to a strip chart recorder, graphics video terminal, or both.

After manual calibration of the Nuclear Analyser, the operator has control via video terminal of maximum and minimum scan energies, scan direction and chart recorder output width.

The software has been prepared in such a way as to be nearly self-teaching. A student can be taught to operate the equipment in just a few minutes.

Three switches located on the scintillation equipment can be set to give complete computer control or to give the "normal" original operation, completely independent of the computer. This is helpful in case of computer breakdown, which while rare, has been known to occur.

B. Limitations
   1. The "nuclear" equipment must still be calibrated manually.
   2. Both ordinates (energy and amplitude) of chart recorder plotted spectra are limited to 256 points, due to the use of an 8 bit AD/DA converter to interface the computer with the "nuclear" equipment.
   3. Amplitude and energy ordinates of video plots are limited to 24 to 80 points respectively.

C. Hardware Description
   This equipment can be visualized in three sections.
   1. The scintillation equipment, consisting of: (Figure 1)
      a. detector
      b. pulse height analyser
      c. GM counter/scaler
      d. chart recorder
   2. The computer equipment, consisting of: (Figure 2)
      a. Horizon II microcomputer
      b. Cromenco 8 bit AD/DA
      c. Lear Siegler video terminal
   3. The interface hardware (Figure 3)
      The interface hardware consists of several operational amplifier circuits. The function of these circuits is to match the voltage levels of the scintillation equipment with the AD/DA converter in the computer.

II. START-UP OPERATION OF SYSTEM
   A. Scintillation Equipment
      1. Set the three extra toggle switches (SW 1-3) to their up positions. This gives total computer independence (Figure 4).
      2. Tune up scintillation equipment in normal way.
      3. Reset extra toggle switches as desired.

SWITCH	SETTING	EFFECT
SW 1	up	Internal chart adv
	down	Computer chart adv
SW 2	up	Direct GM to recorder pen
	down	GM signal routed thru computer to recorder pen
SW 3	up	Pulse height analyser scan ramp generated internally
	down	Pulse height analyser scan ramp generated by computer

   B. Computer Equipment
      1. Turn on computer and terminal.
      2. Insert program (L.H. drive) and spectrum data (R.H. drive) disks.

3. Push reset switch on computer. You should see a message followed by a *.
4. Loading and execution of program
   a. Respond to * by typing: GO BASIC <cr>
   b. Respond to READY by typing: Memset 48000 <cr>
   c. Respond to READY by typing: load gamscn <cr>
   d. Respond to READY by typing: run <cr>
   e. If you have any trouble, <u>remove</u> <u>disks</u>, go to B1 and try again.

C. Operation of Program
   1. Study "help" file within program.
   2. Attend instructors' lectures on operation.

FIGURE 1

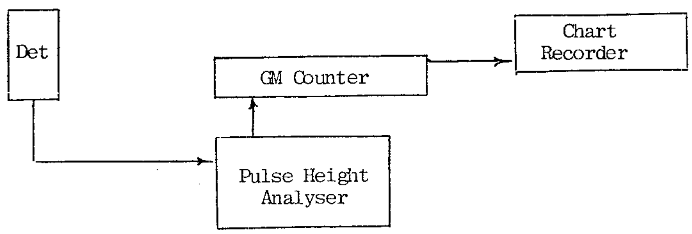


FIGURE 2

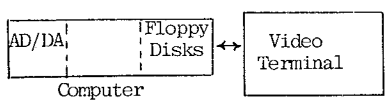


FIGURE 4

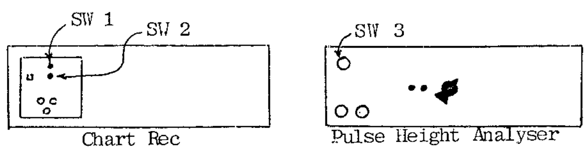
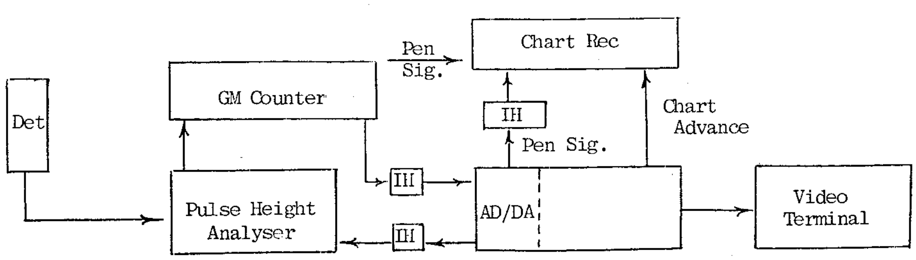
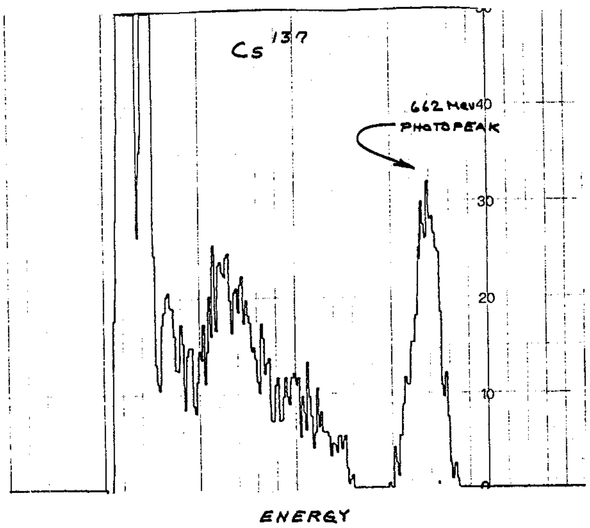


FIGURE 3

Boxes labeled IH are the interface hardware

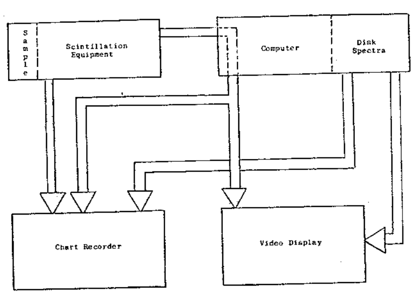


Example of scan on Scintillation Spectrometer



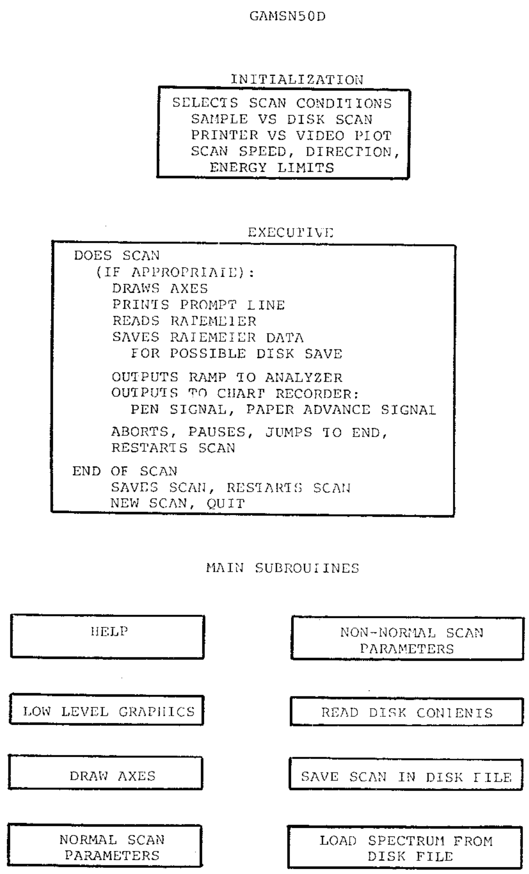
EXAMPLE OF SCAN ON SCINTILLATION SPECTROMETER

Information Paths Available in Computer Controlled Spectrophotometer



INFORMATION PATHS AVAILABLE IN COMPUTER CONTROLLED SPECTROPHOTOMETER

Spectrometer Software



Chemistry Labs on the Computer

Norma McKenzie
Charlotte Country Day School
Charlotte, North Carolina 28200

Presented to the Seventy-third Two Year College Chemistry Conference, Central Piedmont Community College, Charlotte, North Carolina, December 4, 1981.

High School students are fascinated by the computer. When they first learn some of the miraculous things that the computer will do, they want to start programming Star Trak games, hangman, tic tac toe, etc. After several months of playing, I have heard several of them say "What can I do on the computer that is constructive?" Operating chemistry labs on the computer is very exciting to them. Those who know nothing about the computer are generally in awe and disbelief that anything so "neat" could be devised to help them with their work. Most of these students then want to learn how to program and many do. Those students who do know how to program are pleased to realize that this expensive piece of equipment that the school owns has another use for them other than playing games.

An example of how a program would run is on attachment #1. Students are asked for data by means of input statements.

The data was collected in the lab. They then put the data in and when asked for an answer that requires calculations they do the calculations. If they have correctly tabulated their results the computer will tell them. See attachment #1. The grade for this question is stored and later used to compute the lab grade. When students are through with the lab the computer will tell them so and the grade for the entire lab is given (See attachment #1.)

Sometimes, as we well know, the student will make a mistake (see attachment #2). When this happens, again the computer will tell him in the print out and the student will immediately be given the correct answer. The computer then tabulates (the student does not see this step) the per cent accuracy which is stored to be used when calculating the grade for the lab. The student then goes on with the lab using the corrected answer so that his final results will be logical. The final lab grade is then displayed to the student. This grade is based on the per cent accuracy for all of the calculations in the lab report.

At the end of each lab further assignments will often be given for the student to turn in. These assignments are found in the students lab manual. These assigned questions are generally non-mathmatical questions which can not be handled by a computer. Often times these questions are opinion questions, lab analysis questions or graphing questions.

Many times in a chemistry lab a student is given an unknown. Any calculations on the unknown are evaluated by the computer, using the students input data. At the end of the lab the computer then takes the previously inputted unknown number and tells the student how close his identity of the unknown came to the actual (See attachment #2).

Many times a student may not wish to complete his lab in one sitting. He may input data, make some calculations then wait a day or two to complete the lab. Once a student has attempted a question and received an answer to the question, he may not go back and write over his first mistake. The computer will immediately let him know that he has already answered the question and he will not be given a second chance. (See attachemnt #3).

As any teacher can see the protection and security of each student file is very important. I have taken a great deal of precaution to see that no student can utilize another students file to get the information and then put the correct imformation into his file. In order to get into any file the student must have a code number, a code name, and his own name. All of these must match in the record or the student will be unable to enter the file (See attachment #4).

After a class has finished a lab I am then able to go into each file and with the aid of a grading program, I am then able to get grades for the entire class for that class instantly. Another added advantage that the grading program will do is that it lets the teacher know the date that the lab was put onto the computer. The computer will write the date into the students file automatically without the student being aware of this. On the grading program you can see (attachment #5) the students name, code name, date and grade for the lab.

Having chemistry labs on the computer has many advantages for the student.

1) They see the use of the computer in a constructive way

2) In a lab in which subsequent calculations are based on current calculations the student gets instant feedback as to whether that calculation is correct. If it is not correct he will be told what the correct answer is so he can base all future calculations on the correct answer. This avoids bizarre final results being reported which often result in the student missing the entire point of the lab.

3) Another very positive point on having labs put on the computer is that the student gets instant feedback as to whether the calculated answers in his lab are correct. He also immediately finds out what he has made on the lab based on the percent accuracy of each calculated result. In the days on my manual grading it might take a student a week to a month to find out if he is correct and by then he has forgotten what the lab was about and really does not care about anything but the grade.

As I see it there is only one major disadvantage for the students putting labs on the computer. The student does not routinely do a formal lab write up. Some labs with graphs and explanations that can not be put on the computer may be written up formally. Students need practice in writing science experiments and using their English, sentence structure etc. Lab on the computer reduce the importance of English in the minds of the science student.

Computerized chemistry labs for the teacher offers many advantages to the teacher.

1) There is no grading time. Grading is done instantly and accurately

2) Students grades on the lab may be kept on the file as long as the teacher wants to leave them.

3) If the teacher has a deadline for the lab and the students puts the lab in the computer after the deadline the late date is automatically recorded in the students file.

The disadvantages to the teacher are

1) It is difficult to remember how each student is doing with lab work since you spend no time grading their work.

2) You always run the risk of some little "mastermind" being able to crack the system.

Having operated the system for one year I would say that considering the advantages and disadvantages, the advantages for both teachers and students far outweigh the disadvantages.

Designing the programs to fit the teachers purpose is time consuming but interesting work. The type of programs that I have used is possible to put on any disc computer but the language and software will vary from computer to computer. This is an age of computers, students are as aware of this as is the faculty. I feel that any type of exposure we are able to give them with these machines will be of tremendous value to them later on. It is with commitment and enthusiasm that I strongly believe in this program.

ATTACHMENT #1

```
#FIVE
YOUR CHEM # MAKE SURE YOU USE CONTROL E :
NAME PLEASE? BIG MACK
YOUR CODE # MAKE SURE YOU USE CONTROL E :

AS ALL LABS YOU ARE ON YOUR HONOR NOT TO HAVE COPIED DATA

EXPERIMENT #5:FINDING THE SIZE OF A MOLECULE AND A VALUE FOR
AVAGADRO'S NUMBER

THE FOLLOWING QUESTIONS REFER TO THE DIAMETER OF ONE DROP
ALL DIAMETER MEASUREMENTS TO NEAREST .1

DIAMETER OF ONE DROP IN CM 4.5
ANOTHER DIAMETER IN CM(SAME DROP) 5.0
SAME DROP FINAL DIAMETER IN CM 5.0
WHAT IS YOUR AVERAGE FOR THE DIAMETER OF THIS DROP (TO .1) 4.8
RIGHT

NOW DO THE SAME FOR 2 DROPS ALL MEASUREMENTS IN CM
DIAMETER 1 6.0
DIAMETER 2 7.0
DIAMETER 3 8.0
WHAT IS YOUR AVERAGE TO THE NEAREST .1 7.0

RIGHT

NOW DO THE SAME FOR 3 DROPS ALL MEASUREMENTS IN CM
DIAMETER 1 8.5
DIAMETER 2 9.0
DIAMETER 3 8.0
WHAT IS YOUR AVERAGE DIAMETER FOR 3 DROPS (TO .1) 8.5
RIGHT

FOR THE FOLLOWING AREAS USE THE AVERAGE DIAMETER IN YOUR CALCULATIONS
WHAT IS THE AREA FOR ONE DROP TO .01 18
RIGHT
WHAT IS THE AREA MADE BY TWO DROPS TO .01 57

NOPE ITS 38.47
USE 38.47 IN ALL FUTURE CALCULATIONSUSE 38.47 IN ALL FUTURE CALCULATIONS

WHAT IS THE AREA MADE BY THREE DROPS57
RIGHT

WHAT IS THE AREA OCCUPIED BY ONE DROP CALCULATED FROM THE CIRCLE
FORMED BY 1 DROP TO NEAREST .01 18
RIGHT

WHAT IS THE AREA OCCUPIED BY ONE DROP CALCULATED FROM THE CIRCLE
FROMED BY 2 DROPS TO NEAREST .01 19
RIGHT

WHAT IS THE AREA OCCUPIED BY ONE DROP CALCULATED FROM THE CIRCLE
FORMED BY 3 DROPS TO .01 19
RIGHT

WHAT IS THE AVERAGE AREA OF ONE DROP FIGURED FROM ALL CALCULATIONS
ABOVE TO .01 18.66
RIGHT
```

```
HOW MANY DROPS FROM YOUR PIPETTE MAKE ONE ML46
WHAT IS THE VOLUME OF ONE DROP FROM YOUR PIPETTE TO .001 .022
RIGHT

WHAT IS THE MASS OF STEARIC ACID IN ONE DROP TO THREE SIG FIGS 3.3E-6
RIGHT

WHAT IS THE VOLUME OF STEARIC ACID IN ONE DROP TO THREE SIG FIGS 3.9E-6
RIGHT

WHAT IS THE THICKNESS OF ONE DROP TO THREE SIG FIGS 2.1E-7
RIGHT

WHAT IS THE VOLUME OF ONE MOLECULE TO THREE SIG FIGS 9.3E-21
NOPE ITS 8.74E-21
USE 8.74E-21 IN ALL FUTURE CALCULATIONSBIG MACK
USE 8.74E-21 IN ALL FUTURE CALCULATIONS

HOW MANY MOLECULES ARE IN ONE DROP OF SOLN TO THREE SIG FIGS 4.2E14
NOPE ITS 4.44E+14
USE 4.44E+14 IN ALL FUTURE CALCULATIONSBIG MACK
USE 4.44E+14 IN ALL FUTURE CALCULATIONS

HOW MANY MOLES OF STEARIC ARE IN ONE DROP OF SOLN TO THREE SIG FIG1.2E-
RIGHT

ACCORDING TO YOUR CALCULATIONS WHAT IS THE VALUE FOR
AVOGADRO'S NUMBER TO THREE SIG FIGS 3.5E22
NOPE ITS 3.83E+22
USE 3.83E+22 IN ALL FUTURE CALCULATIONS
USE 3.83E+22 IN ALL FUTURE CALCULATIONS

EXTENSIONS FOR LAB5

IT TURNS OUT THAT THE WIDTH(W) IS ABOUT 1/5 OF THE LENGTH.
CALCULATE THE VOLUME OF A STEARIC ACID MOLECULE ON
BASIS OF THIS BETTER APPROXIMATION OF ITS GEOMETRY
WHAT IS THE VOLUME TO THREE SIG FIGS 3.7E-22
NOPE ITS 3.5E-22
USE 3.5E-22 IN ALL FUTURE CALCULATIONS
USE 3.5E-22 IN ALL FUTURE CALCULATIONS

BASED ON THE NEW MOLECULAR VOLUME FIND THE NUMBER OF MOLECULES
IN ONE DROP ON SOLN9.2E23

NOPE ITS 9.55663E+23
USE 9.55663E+23 IN ALL FUTURE CALCULATIONS BIG MACK
USE 9.55663E+23 IN ALL FUTURE CALCULATIONS

WHAT IS THE NEW VOLUME FOR AVOGADRO'S NUMBER TO THREE SIG FIGS 6E23
NOPE ITS 8.23847E+31
USE 8.23847E+31 IN ALL FUTURE CALCULATIONS
USE 8.23847E+31 IN ALL FUTURE CALCULATIONS

WHAT IS THE ANSWER TO QUESTION #3 UNDER EXTENSIONS6.055E23
NOPE ITS 1.21156E+24
USE 1.21156E+24 IN ALL FUTURE CALCULATIONS
USE 1.21156E+24 IN ALL FUTURE CALCULATIONS

THIS IS THE END OF LAB #5

ASSUMING THAT YOU LAB IS NOT LATE YOUR AVERAGE FOR THIS LAB
IS 88.2
```

ATTACHMENT #2

```
YOUR CHEM # MAKE SURE YOU USE CONTROL E :
NAME PLEASE? BIG MACK
YOUR CODE # MAKE SURE YOU USE CONTROL E :

AS ALL LABS YOU ARE ON YOUR HONOR NOT TO HAVE COPIED DATA

SPECIFIC HEAT OF UNKNOWN LIQUID

UNKNOWN # 1
DENSITY OF UNKNOWN IN G/CM 1.11
VOLUME OF 100 G OF UNKNOWN TO .001 90.1

RIGHT

TEMP OF WATER (INITIAL) TO .1 32.6
TEMP OF WATER (FINAL) TO .1 53.4
CHANGE IN TEMP OF WATER TO .1 20.8

RIGHT

TEMP OF UNKNOWN (INITIAL) 26.2
TEMP OF UNKNOWN (FINAL) 59.5
CHANGE IN TEMP OF UNKNOWN 33.3

RIGHT

WHAT IS THE SPECIFIC HEAT OF LIQUID TO .001 .625

RIGHT

SPECIFIC HEAT OF METALS

WHAT IS THE UNKNOWN # OF METAL 1
MASS OF TEST TUBE TO .01 20.00
MASS OF TEST TUBE + METAL 30.90
MASS OF METAL TO .01 10.90

RIGHT

MASS OF WATER (CALORIMETER) TO .01 60.0
TEMP OF WATER (BATH) 99.5
INITIAL TEMP OF WATER (CALORIMETER) TO .1 26.2
FINAL TEMP OF WATER (CALORIMETER) TO .1 29.5
CHANGE OF TEMP IN WATER (CALORIMETER) TO .1 3.3

RIGHT

CHANGE IN TEMP OF METAL TO .1 70.0

RIGHT

SPECIFIC HEAT OF METAL TO .001 .26

RIGHT

FOR A POINTS SEE IF YOU CAN DO #2 UNDER EXTENSIONS
HAND IT IN NEXT LAB PERIOD

YOUR UNKNOWN IS LEAD.SPECIFIC HEAT IS .0310.WEIGHT IS 207

ASSUMING THAT YOU LAB IS NOT LATE YOUR AVERAGE FOR THIS LAB
IS 98.9
```

ATTACHMENT #3

```
#SIX
YOUR CHEM # MAKE SURE YOU USE CONTROL E :
NAME PLEASE? BIG MACK
YOUR CODE # MAKE SURE YOU USE CONTROL E :

AS ALL LABS YOU ARE ON YOUR HONOR NOT TO HAVE COPIED DATA

DETERMINING THE SIMPLEST FORMULA OF A COMPOUND

RECORD ALL MASSES TO THE NEAREST .01

WHAT IS THE MASS OF CRUCIBLE + LID 16.21
MASS OF CRUCIBLE + LID + MG 16.56
MASS OF CRUCIBLE + LID + PRODUCT 16.80
WHAT IS THE MASS OF MG USED IN THE REACTION .35
BIG MACK, YOU HAVE ALREADY ANSWERED THIS QUESTION
WHAT IS THE MASS OF MAGNESIUM OXIDE .59
BIG MACK, YOU HAVE ALREADY ANSWERED THIS QUESTION
WHAT MASS OF OXYGEN REACTED WITH MAGNESIUM .24
BIG MACK, YOU HAVE ALREADY ANSWERED THIS QUESTION
HOW MANY MOLES OF MG ATOMS TO THE NEAREST .001 .014

NOPE ITS 1.5E-02
USE 1.5E-02 IN ALL FUTURE CALCULATIONS
```

ATTACHMENT #4

```
YOUR CHEM # MAKE SURE YOU USE CONTROL E :
THERE IS SOMETHING ABOUT THAT NUMBER THAT DOES NOT COMPUTE
PLEASE TRY AGAIN
YOUR CHEM # MAKE SURE YOU USE CONTROL E :
YOU ARE IN THE WRONG ACCOUNT.ARE YOU AWARE THAT THIS IS AN HONOR OFFE
YOUR CHEM # MAKE SURE YOU USE CONTROL E :
NAME PLEASE? BIG MACK
YOUR CODE # MAKE SURE YOU USE CONTROL E :

AS ALL LABS YOU ARE ON YOUR HONOR NOT TO HAVE COPIED DATA

SPECIFIC HEAT OF UNKNOWN LIQUID

UNKNOWN #
```

ATTACHMENT #5

```
FROM CHANNEL 1 TO CHANNEL 1 FROM RECORD 00TO RECORD 18
FROM ITEM 3TO ITEM 11
WHICH ITEM HAD DATE 2
FISH
 4

AVERAGE FOR LAB IS 87.8888

FLYNN
 4

AVERAGE FOR LAB IS 80.5555

CACKIE
 4

AVERAGE FOR LAB IS 83.5555
```

```
GORDON
 5
AVERAGE FOR LAB IS 95.3333
JOHN
 6
AVERAGE FOR LAB IS 30.7777
WYNN
 5
AVERAGE FOR LAB IS 33
ROBERT
 5
AVERAGE FOR LAB IS 80.5555
AMI
 22
AVERAGE FOR LAB IS 0
MUFFIN
 5
AVERAGE FOR LAB IS 88.1111
```

SE

The Use of Computers in Science Teaching

AAron McAlexander
Central Piedmont Community College
Charlotte North Carolina 28211

Presented to the Seventy-Third Two Year College Chemistry Conference, Central Piedmont Community College, Charlotte, North Carolina, December 4, 1981.

First of all, allow me to define the vantage point from which I am viewing computer use in science teaching. My job is teaching physics and although I feel that it is a necessary part of my job that I become "Computer Competent," I have neither the time nor the inclination to become a computer programmer. And since I have neither the skills nor the time to develop the requisite skills for becoming a computer programmer, my use of the computer in teaching physics is going to be greatly affected by the availability of appropriate software.

So far the availibility of appropriate software has posed a rather serious restriction on the educational use of computers in our department; highly advertised programs have frequently either turned out to be "not yet fully developed" or not as applicable as we had hoped. I am convinced that it is of considerable importance, on several counts, that we place an increasing emphasis on computer use in our science instruction; but I am not particularly encouraged by the instructional software which I find to be currently available. I do know a number of college teachers who are frustrated by pressure to increase the use of computers in their courses, while they are not released from any teaching time to (or locate) suitable software.

One of the many reasons why the use of computers as a part of our science instruction is desirable has to do with the state of technical education in this country in general. Probably everyone in this room is more or less aware of the relatively dismal status of science and mathematics as a part of general education in the secondary school graduates in the Soviet Union (97% of the school age population) have five years of physics and four years of chemistry. Compare this with the situation in the United States, where only about 9% of the students graduate from highschool with even one year of physics and only 16% with a single year of chemistry (Rigden, 1980). Although the contrast with many other of the developed countries may be less startling, it appears that we are rapidly becoming the least technically literate of the developed countries.

There is a tendency to view the increased use of computers by the general population as an indicator of a corresponding advance in the technical sophistication of the general population. I do not think that this is necessarily the case. Robert Cowan (1981), for example, characterizes a large percentage of current applications of microcomputers as "glorifying the trivial." Merely using the computer to do the sort of thing which we have easily been doing using an electronic calculator may not provide sufficient justification for the effort and expense involved. Without bothering to even discuss the use of microcomputers to develop hand-eye coordination or to repel imaginary space invaders, I consider the use of a computer for such purposes as balancing the household budget or averaging grades or filing recipes to at least be cases of overhill, if not being downright counterproductive. Yet these are precisely the sort of computer uses which many manufactures and dealers have been promoting. An article in a recent issue of a computer magazine touts one mother's placement of the shcool's soccer club mailing list on her handy home computer (The, 1981). Fine, I guess, but not the sort of thing one has in mind for the student when one encourages him or her to learn to use the computer.

The point of all this is, if one is going to extend himself to promote a large expenditure for computers to a school administration, to commit himself to learning how to use the computer and possibly to spending a lot of time programming the thing, then it seems advisable for one to form, in advance, some plans about just what the students are to accomplish and how microcomputers are going to help them. The effective use of any instructional tool requires that the instructor have clear objectives the tool is to help the student attain, and computers are no exception. Some examples of objectives for computer use by the science student might be:

1. To have the student become computer "literate:" This may or may not be a proper objective for a science program, but such a task will surely fall to either the science or mathematics areas. From the point of view of science instructor, the student's learning to program, learning to use, or even learning not to be intimidated by the computer is a worthwhile objective.

   One source (The, 1981) indicates that basic computer familiarity (as little as 10 hours hands-on experience) translates into about $1000.00/year in starting salary.

   The use of the computer to render students computer literate is almost incidental, as such an objective is surely the means by which some of the following objectives may be attained.

2. To have the student simulate an experiment and/or analyze experimental data using the computer: Experiments which cannot actually be run in the lab can be synthesized and data from these or actual experiments can be graphed and the proper curve fitted using the computer. Appendix A is an example of this sort of program.

3. To have the student use the computer to solve complex and/or lengthy problems: For most problem solving applications, the programmable calculator such as the HP 97 is still more powerful than the microcomputer. There are certain types of problems, such as the Wheatstone Bridge program in Appendix B, where the computer with its graphics has the definite advantage.

4. To have the student become familiar with functions and concepts which the instructor cannot effectively present using traditional lecture/demonstration methods: The example in Appendix C is a program which demonstrates the Fourier synthesis of a square wave. This is the type of demonstration which only the most skilled blackboard artisan can execute effectively. We have found that the effectiveness of this type of program is enhanced if the student is required to interact with the computer from time to time.

5. To have the student master a particular concept or block of cognitive material: In older terminology, this is referred to as CAI or computer assisted instruction. This is one of the most commonly touted applications for educational computers, and the one about which I have the most serious reservations.

   At certain educational levels, such as adult basic education, the computer can doubtlessly be used effectively. But at more advanced levels and with the typical level of programming, its use can only contribute to what is already a problem with over simplication and an over emphasis on cognitive material which lends itself to multiple choice and short answer quizzes.

   Students already get too much of this sort of thing at the expense of being required to analyze and express their idea effectively in writing, and the use of CAI can only make the problem worse. The use of the computer as an "electronic workbook" may be the poorest justification of its use of all. (In all fairness, if the students are just learning to use the computer, they might as well learn some subject matter while doing it.)

In summary, there are many good applications micro-computers in science instruction, and some which are not so good. There are too many effective and worthwhile applications to spend time "glorifying the trivial." Ask not "what clever tricks can I do with a computer, but what can the computer do for my students?"

References

Cowan, Robert, "Cottage Computing," Technology Review, November, 1981.

Rigden, John S., "Too Little Too Late, "American Journal of Physics, June 1980.

Spencer, Donald S., Using Basic In The Classroom, Ormond Beach, Fl: Camelot, 1978.

The, Lee, "What Did You Do In Computer Class?", Personal Computing, September 1981.

Appendix A **Realative Mass Increase**

```
10 CLS
12 REM *** RELATIVISTIC MASS INCREASE      A. MCALEXANDER 11/30/81
13 PRINT     THE PURPOSE OF THIS PROGRAM IS TO PRODUCE A GRAPH OF HOW MASS IN-
CREASES WITH HIGH VELOCITIES.
14 PRINT
15 PRINT     YOU WILL BE REQUIRED TO PROVIDE DIFFERENT VELOCITIES IN TERM OF THE
RATIO OF V TO C
16 PRINT     REMEMBERTHAT V/C CANNOT EXCEED 1
17 PRINT
18 PRINT     THE COMPUTER WILL PLOT THE MASS/REST MASS RATIO AS A FUNCTION OF
VELOCITY AS A FRACTION OF V.
19 PRINT
20 PRINT     ENTER 1 WHEN YOU ARE READY TO BEGIN
21 INPUT Z
22 IF Z = 1 GO TO 25
23 GO TO 21
25 CLS
26 LET X = 6
30 FOR Y = 1 to 44
40 SET (X,Y)
50 NEXT Y
60 LET Y = 43
70 FOR X = 1 to 124
80 SET (X,Y)
90 NEXT X
```

```
100  PRINT @ 768, "1"
110  PRINT @ 640, "2"
120  PRINT @ 512, "3"
130  PRINT @ 384, "4"
140  PRINT @ 256, "5"
145  PRINT @ 128, "6"
150  PRINT @ 972, "0.2"
160  PRINT @ 982, "0.4"
170  PRINT @ 992, "0.6"
180  PRINT @ 1002, "0.8"
190  PRINT @ 1012, "1.0"
200  PRINT @ 1017, "V/C"
210  PRINT @ 448, "M/MO"
220  FOR M = 1 to 6
230  LET X = 5
240  LET Y = 43 - 6xM
250  SET (X,Y)
260  NEXT M
500  PRINT @ 6, "ENTER VALUE OF V/C RATIO"
550  INPUT V
555  IF V ► .99 GO TO 700
560  LET X = 6 + (100xV)
570  LET Y = 44 - 6x(1/(1-(V[2))[0.5)
580  SET (X,Y)
600  IF V ► .99 GO TO 700
680  IF A ◄ 6, GO TO 500
700 PRINT @ 68, "THE EXTENT OF THE GRAPH WHICH CAN BE SHOWN ON THIS CRT HAS BEEN REACHED. REMEMBER THAT V CANNOT EXCEED C."
710  END
```

APPENDIX B WHEATSTONE BRIDGE SOLUTION

```
5  CLS
6  REM ***    WHEATSTONE BRIGE NETWORK    A. MCALEXANDER    11/23/81
10  PRINT    THIS PROGRAM CALCULATE THE CURRENT THROUGH EACH RESISTOR AND THE TOTAL RESISTANCE OF A WHEATSTONE BRIDGE TYPE OF ELECTRICAL NETWORK
15  PRINT
20  PRINT    YOU MUST ENTER THE RESISTANCE WHICH CORRESPOND TO THE RESISTANCES IN THE WHEATSTONE BRIDGE WHICH WILL APPEAR ON THE SCREEN
25  PRINT
30  PRINT    ENTER 1 WHEN YOU WISH TO BEGIN THE PROGRAM
35  INPUT P
40  IF P = 1 GO TO 47
45  GO TO 35
47  CLS
50  LET B = 20
60  LET X = B
110  FOR Y = 15 to 30
120  SET (X,Y)
130  NEXT Y
140  FOR X = B+1 to B+8
150  LET Y = 15
170  SET (X,Y)
180  LET Y = 30
190  SET (X,Y)
200  NEXT X
```

```
210  FOR X = B + 9 to B + 24
220  FOR Y = 14 to 16
230  SET (X,Y)
235  NEXT Y
240  FOR Y = 29 to 31
250  SET (X,Y)
260  NEXT Y
270  NEXT X
280  FOR X = B + 23 to B + 38
290  LET Y = 15
300  SET (X,Y)
310  LET Y = 30
320  SET (X,Y)
330  NEXT X
340  LET B = B + 35
350  IF B ◄ 60, GO TO 60
360  FOR Y = 15 to 30
370  SET (X,Y)
380  NEXT Y
390  FOR X = 52 to 58
400  FOR Y = 19 to 26
410  SET (X,Y)
420  NEXT Y
430  NEXT X
440  FOR X = 2 to 20
450  LET Y = 23
460  SET (X,Y)
470  NEXT X
480  FOR X = 95 to 113
490  LET Y = 23
500  Set (X,Y)
510  NEXT X
520  PRINT @ 337, "R1"
530  PRINT @ 355, "R4"
540  PRINT @ 657, "R2"
550  PRINT @ 675, "R5"
560  PRINT @ 539, "R3"
570  LET X = 2
580  FOR Y = 23 to 40
590  SET (X,Y)
600  NEXT Y
610  LET X = 113
620  FOR Y = 23 to 40
630  SET (X,Y)
640  NEXT Y
650  LET Y = 40
660  FOR X = 2 to 113
670  SET (X,Y)
680  NEXT X
690  PRINT @ 858, "E"
700  LET X = 52
710  FOR Y = 42
720  SET (X,Y)
730  NEXT Y
740  LET X = 57
750  FOR Y = 39 to 41
760  SET (X,Y)
770  NEXT Y
```

```
800  PRINT @ 64, "ENTER RESISTANCES R1,R2,R3,R4,R5"
810  INPUT R1,R2,R3,R4,R5
820  PRINT @ 128, "ENTER VALUE FOR E"
830  INPUT E
840  LET A1 = R1
850  LET B1 = -R2
860  Let C1 = R3
870  LET D1 = 0
880  LET A2 = R1 + R4
890  LET B2 = 0
900  LET C2 = -R4
910  LET D2 = E
920  LET A3 = 0
930  LET B3 = R2 + R5
940  LET C3 = R5
950  LET D3 = E
960  LET F1 = ((B1xA2)/A1)-B2
970  LET F2 = ((C1xA2)/A1)-C2
980  LET F3 = ((B1xA3)/A1)-B3
990  LET F4 = ((C1xA3)/A1)-C3
1000  LET F5 = ((F1xF4)-(F2xF3))
1010  IF F5 = 0 THEN 1200
1020  LET F6 = ((D1xA2)/A1)-D2
1030  LET F7 = ((D1xA3)/A1)-D3
1040  LET I2 = ((F6xF4)-(F2xF7))/F5
1050  LET I3 = ((F1xF6)-(F6xF3))/F5
1060  LET I1 = (D1/A1)-((B1/A1)xI2)-((C1/A1)xI3)
1070  LET I4 = I1-I3
1080  LET I5 = I2+ I3
1090  LET IT = I1+ I2
1100  LET RT = E/IT
1110  PRINT I1 = ;I1, I2 = ;I2, I3 = ;I3, I4 = ;I4, I5 = ;I5, TOTAL i = ;IT, TOTAL RESISTANCE =
;RT
1120  PRINT ENTER 1 TO CONTINUE, ENTER 0 TO STOP
1130  INPUT L
1140  IF L = 1 GO TO 47
1150  STOP
1160  PRINT
1170  GO TO 5
1300  END
```

APPENDIX C FOURIER SYNTHESIS OF A SQUARE WAVE

```
2
5  CLS
10  REM *** FOURIER SYNTHESIS OF A SQUARE WAVE        A. MCALEXANDER
20  REM *** Y = X SIN A + X/3 SIN 3X + X/5 SIN 5X +
30  PRINT FOURIER SYNTHESIS OF A SQUARE WAVE
33  PRINT
35  PRINT Y = A SIN X + A/3 SIN 3X + A/5 SIN 5X + A/7 SIN 7X +
37  PRINT
40  PRINT ENTER 1 WHEN YOU ARE READY TO BEGIN
50  INPUT Q
60  IF Q = 1 GO TO 70
70  CLS
80  FOR X = 1 to 125
90  LET Y = 24
100  SET (X,Y)
110  NEXT X
```

```
120  FOR A = 1 to 46
130  LET B = 3
140  SET (B,A)
150  NEXT A
160  LET A = 18
170  LET B = 0.05
180 FOR X = 3 to 127
190  LET Y = 24 - (AxSIN(Bx(X-3)))
200  SET (X,Y)
210  NEXT X
211  PRINT @ 0,   Y = A SIN X
212  Q = Q + 1
213  IF Q = 3 GO TO 300
214  IF Q = 4 GO TO 351
215  IF Q = 5 GO TO 400
220  PRINT @ 896, "WHEN YOU ARE READY TO DISPLAY Y = A/3 SIN 3X, ENTER 3
230  INPUT C
240  IF C = 3 GO TO 250
250  A = A/C
260  B = BxC
270  GOTO 180
300PRINT @ 896,"WHEN YOU ARE READY TO DISPLAY Y = A/5 SIN 5X, ENTER 5
31  INPUT C
320  IF C = 5 GO TO 330
330  LET A = 18
340  LET B = 0.05
350  GO TO 250
351  PRINT @ 896, "TO DISPLAY Y = A/7 SIN 7X, ENTER 7
352  INPUT C
353  IF C = 7 GO TO 354
354  LET A = 18
355  LET B = 0.05
356  GO TO 250
400  PRINT @ 896, "TO DISPLAY THE SUM OF THESE FUNCTIONS, ENTER 1
410  INPUT C
420  IF C = 1 GO TO 430
430  CLS
440  FOR X = 1 to 125
450  LET Y = 26
460  SET (X,Y)
470  NEXT X
480  FOR Y = 1 to 45
490  LET X = 3
500  GET (X,Y)
510  NEXT Y
520  LET A = 18
530  LET B = 0.05
540  FOR X = 3 to 127
550  LET Y = 26 - ((AxSIN)Bx(X-3))) + ((A/3)xSIN((3xB)x(X-3))) + ((A/5)xSIN((5xB)xX-3))) + ((A/7)xSIN((7xD
3))))
560  SET (X, Y)
570  NEXT X
580  PRINT @ 0, Y = A SIN X  + A/3 SIN 3X + A/5 SIN 5X + A/7 SIN 7X +
```

Mastery Learning in Organic Chemistry and Biochemistry With Computerized Testing

Ethelreda Laughlin
Cuyahoga Community College Western Campus
Parma, Ohio 44103

Presented to an Innovation in Teaching Symposium at the Seventy-Second Two Year College Chemistry Conference, Monroe Community College, Rochester, New York, October 16, 1981.

Chemistry teachers, particularly in two-year colleges, are constantly seeking better ways to present information to their students. I've been very concerned about the benefits of the traditional lecture presentation ever since I began teaching. I had never intended to teach and went from graduate school to medical research and industry. My first teaching assignment, in a hospital nursing school, was in chemistry anatomy, and microbiology. I had gone from graduate school in biochemistry to work in the same field yet, when I began to prepare lectures for the nursing students, I had to turn back to general chemistry texts as if I had never been exposed to the subject but I had no such trouble in recalling anatomy.

My chemistry classes, undergraduate and graduate, were all taught by lecture, Laboratory work was individual but cookbook methodology was the rule. Anatomy, however, was learned in the laboratory with four of us working on one cadaver and we constantly drilled and quizzed each other. In class, the anatomy professor would bring a small rug into the room, toss it on the floor, then point to one student and say, "I'm calling you down on the carpet". Needless to say, we burned the midnight oil in preparation. In the lab, there were many practical examinations for which one had to be constantly prepared.

Another example: I managed to get through Paris with my high school French and a Berlitz dictionary but I had a terrible struggle with German in Bavaria. The big difference was in the way in which the languages were taught. In French we acted out life situations and were drilled daily while German was taught primarily by lecture.

Why not, I said to myself, teach chemistry with drills and quizzes and a hands-on approach? To investigate the technique, I spent a day in the Posthelwait laboratories at Purdue University and was very enthused. It was such a fun way to learn biology! Then I joined a workshop for allied health instructors at my college and spent three days learning how to prepare a mastery unit (a do-it-yourself procedure for learning). A small grant from Cuyahoga Community College took me to a PSI workshop in New Orleans that was conducted by a group mainly from Georgetown University. I learned about the Personalized System of Instruction one chapter at a time, passing a quiz before moving on to the next chapter. This is the technique I now use with my students. The workshop was concluded with the preparation of a unit and testing of that unit on others in the group.

I have been working with mastery units for three years. Ideally, lab and "lecture" are held in the laboratory so that one experience helps the other. The students work with molecular models with most of the units. There are also audio cassettes, reference books, and some film strips. The students are encouraged to work in groups and to drill each other. I seldom address the group as a whole for more than fifteen minutes at a time. The learning process is a do-it-yourself procedure as much as possible.

Usually, the day classes are much to large to be housed in the laboratory and, since after the third unit, students are working at different paces - some retaking tests while others are ahead of the class-it is necessary to provide retests which are different, to guard against cheating, and to have a data base. Computerized testing is used. The college provided a Caliss format and a special purpose program had to written to reformat the file for display on a color terminal (Intelligent System 8001). The program is written in basic and there are provisions for upper and lower case and the special characters necessary to illustrate benzene rings, Haworth sugar formulas, subscripts, etc.

I don't know if learning with Mastery Units is increasing retention of chemistry as I hope it will. Since the teacher is present to help the student, some fear of the subject should be eased. The students are told that the retesting is done without penalty and that everyone should be able to achieve a grade of at least a B. Students do seem to be more interested in the subject.

Presenting a subject with mastery units is a difficult way to teach. The teacher has to be available and there is much hand grading of tests as well as constatnly writing more questions for the computer. The satisfaction I have found is having the students ask why more courses aren't taught this way.

Evolving Topics in Biochemistry for Professional Health Chemistry

John Holum
Augsburg College
Minneapolis, Minnesota 55406

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Among the several difficulties that we face as teachers of chemistry to students of professional health care fields, one of the most unremitting and yet one of the most interesting is that of keeping our course up-to-date without letting it become overly complex. The center of this difficulty occurs largely in the biochemistry section of the course, not in general chemistry or in organic chemistry. The winds of change have been blowing in biochemistry at high rates, occasionally at jet stream speeds, for at least a century. To appreciate this, glance through a text in chemistry for nurses of just a quarter a century ago. I recently did this to a text available for my use when I first began teaching. It no longer is in print, but at one time it must have been very popular. It went through seven editions in 23 years.

The chapter on enzymes was three pages and devoted mostly to classes and names of enzymes. At the end there were seven questions. Nucleic acids weren't mentioned, of course, this being BCW--before Crick and Watson. The chapter on carbohydrates consisted of nine and a half pages, a third of which described the common names and occurrences of the principal members of the family. I could continue along this vein, but this is sufficient. In this text--and it was fairly representative--no effort was made to develop a coherent, overarching view, a consistent idea that deep within cells there exists a molecular level to life. By these remarks, I do not intend to "put this text down." It was a reflection of the expectations and the state of knowledge of the time.

As I thought about the contrast between then and now, the first thought that developed concerned our students. The students today are confronted with vastly more biochemical details than the students of a quarter century ago. Yet the students of today are fundamentally no more able that those of the earlier time. (And certainly no less able, either, in my judgement.) Yet, given the opportunity, some encouragement, and halfway decent illustrations and discussions, they have turned out to be perfectly capable of understanding some rather complex material-the Crick-Watson theory, to give just one example. Therefore, as I see it, the chief problem in having our courses up-to-date doesn't reside in any inability of students to handle complex material. Rather, the principal difficulty is in identifying what particular new developments we ought to allow to come into our course.

Concerning this, it is important to realize that we have far fewer real options than teachers of other courses. We really do not have the option of say "no" to new advancements. We may never forget that we teach a <u>service</u> course. It serves courses in physiology, microbiology, nutrition, drugs, emergency care, surgical nursing, inhalation therapy, respiratory care, and other fields. If professors of these courses want their incoming students to be familiar with at least the broad outlines if not every last detail of glycolysis, the citric acid cycle, the chemistry of heredity, oxidative phosphorylation, enzyme regulation, acid-base balance--the list is much longer, and of these only acid-base balance was mentioned in the older text to which I have referred--then we ought to try to find out ways to rendering these services.

Since our course has not been alloted more time, we work largely by replacing the old with the new. No longer can we nor do we spend the equivalent of one text page worth of time on the differences between wrought iron, cast iron, and steel; of a half a page on the uses of magnesium metal in photography and military flares; or sixteen pages on the physical and chemical properties of nitrogen and its inorganic compounds. Instead of spending a lot of time studying metals as elements, none of which descriptive chemistry is relevant in any way whatsoever at the molecular level of a healthy body, we use the time in studying the ions of selected elements, particles of major importance in the body. Thus the problem of keeping up-to-date isn't a question of student ability and it isn't one of constantly adding on new things. It is in identifying among the seemingly innumerable new advances those that we should now begin to ease more and more in the course.

I should like to describe five areas among relatively recent advances that merit our serious attention. I shall mention four only briefly and go into more detail with the fifth. The first area concerns the molecular basis of diabetes mellitus. From the beginning of my teaching I have used this as a prime illustrative example of the molecular basis of a disease--at least of the course of a disease if not fully its cause. Diabetes in one form or another is not only widespread in the nation, it involves many topics that have been studied in both the general and the organic chemistry sections. More advances were made on a molecular understanding of diabetes in the decade of the 1970s than in all previous history, according to one scientist in the field. These developments concerned the possible role of viruses, for example, of the involvement of the human immune system. I expect the decade of the 1980s to be just as fruitful, and this area bears close watching.

The second topic is related to diabetes because it involves the synthesis of human insulin by a new technology, recombinant DNA technology. I don't take much time with this, but I want my students to have at least heard about it from me. What they read in the newspapers is generally unclear in technical details, and they're bound to hear more and more about recombinant DNA as test continue with human insulin, human growth hormone, and human interferon made this way.

The third area concerns something more fundamentally related to the chemistry of heredity than a technology derived from this chemistry. What we have been teaching has been the chemistry of heredity as it occurs among prokaryotic organisms such as E. coli. Happily most of what we have taught still survives, but we now know that among eukaryotic organisms, those with well-defined cell nuclei, a gene is not a continuous sequence of nucleotide units. It is split up or interrupted by long nucleotide sequences that apparently have no direct bearing on directing the synthesis of a polypeptide. In the eukaryote, a gene is made up of segments of the DNA molecule called exons, segments that are separated by others called introns. The RNA made under the direction of such DNA is not messenger RNA but a longer molecule called heterogenous nuclear RNA (hnRNA)--or, in some references, primary transcript RNA. After synthesis, this RNA is "edited". Its segments that correspond to introns in the DNA are snipped out, and the segments that relate to the exon parts of the DNA are knitted back together. The result is mRNA that then leaves the nucleus and participates in polypeptide synthesis. Actually, with figures, it takes very little time to present the involvement of hnRNA, so this advancement puts virtually no strain on the course.

A fourth area where advances beg to be introduced in our course is that of neurotransmitters. The decade of the 1970s saw several advances in our understanding of how both hormones and neurotransmitters work, and what makes this advance relatively easy to introduce is that these two families of biochemicals often work in very similar ways at the molecular level. In at least some instances, the only significant initial difference between the two is in how far they travel. Most hormones have to travel about 20 cm before finding target cells, b t neurotransmitter molecules move only across the narrow synaptic gap from one neuron to the next. In some instances, both a hormone and a neurotransmitter must lock to a receptor protein, and this somehow activates adenylate cylase, an enzyme that is part of the cell membrane itself. The enzyme then catalyzes the conversion of ATP to cyclic-AMP inside the cell, and the cyclic AMP goes on to carry out the message of the hormone or neurotransmitter. What makes our knowledge about neurotransmitters exciting and interesting to students are the many connections we can describe to the actions of drugs at the molecular level. If our students are headed for nursing, they often are already working on the floor, and some have been handing out or otherwise handling drugs--tranquillizing or pain-killing drugs. Even if our study of neurotransmitters is limited to a broad overview, the students have a better sense of what is going on the they find genuine satisfaction in that.

The fifth area, the area about which I want to go into considerable detail, concerns oxidative phosphorylation. Those who teach microbiology will appreciate any of our efforts to acquaint the students with the respiratory chain and what it does, because at least some drugs used to control micro-organisms intervene in their respiratory chains.

As you know, there are two substrate-level phosphorylations in glycolysis--the transfer of a phosphate unit to ADP from 1,3-diphosphoglycerate and from phosphoenolpyruvate. These last two phosphates have higher phosphate-group-transfer potentials than ATP. They are particularly high-energy phosphate intermediates, and they have long been known. When scientists inquired into the mechanism of the phosphorylation of ADP made energetically possible by the flow of electrons in the respiratory chain, they naturally theorized that the mechanism might involve particularly high-energy phosphates. Teams of scientists looked for them, but they were never found.

In the early 1960s, one young scientist, Peter Mitchell, suggested that the reason they've not been found is that they don't exist. He proposed a different mechanism that explained many facts and raised many questions---as any good theory ought The experimental data of the time were insufficient to compel scientists to accept it and to abandon their searches for high-energy phosphate intermediates. However, in time Mitchell theory began to receive mention in junior-senior level biochemistry texts. For example, in his first edition of <u>Biochemi</u> published in 1975, Lupert Stryer described Mitchell's theory as the third possibility. Stryer probably wrote this part of the manuscript sometime in 1973, or about 11-12 years after Mitchell first outlined his theory. Events were now moving at a rapid (and controversial) pace. Mitchell's theory was sufficiently established to win him the 1978 Nobel prize. And in the second edition which came out earlier this year, Stryer closed his first paragraph of Chapter 14, "Oxidative Phosphorylation," with an italicized sentence that says, "...... oxidation and phosphorylation are coupled by a proton gradient across the inner mitochondrial membrane."

This quotation carries the fundamental concept of the chemiosmotic theory of Peter Mitchell. Later on, Stryer refers to the older theory with the words, "An alternative proposal was that the free energy of oxidation is trapped in an activate protein conformation, which then drives the synthesis of ATP. Investigators in many laboratories tried for several decades to isolate these putative energy-rich intermediates, but none were found." Stryer then goes on to describe the "wealth of evidence" that support Mitchell's theory.

The accompanying diagrams made up part of a "handout" that I used last spring in teaching the chemiosmotic theory of Mitchell to my class. These handouts paralleled the overhead projection slides that I made. The students were not asked to memorize the details of the respiratory chain. In fact, some details are still subject to controversy. The double loop involving cytochrome <u>b</u> and coenzyme Q, for example, is the way Peter Mitchell believes the chain to proceed, according to his Nobel Prize technical lecture. But Stryer, on the other hand, does not present it this way. Moreover, very little is actual know about the exact mechanism of the way in which a flow of protons through the F_o-F_1 complex helps to make ATP. What one of the accompanying diagrams shows are two of the possible ways that this could happen, again according to Peter Mitchell. Stryer says virtually nothing about this particular part of the mechanism.

Peter Mitchell's theory is certainly no more complicated that, say, the citric acid cycle; it's just less familiar to u In my experience it can be part of the course, and students' reactions were very favorable. They find in it another illustration of the general principle that it's fun to understand something at a satisfyingly deep level.

CHEMIOSMOTIC THEORY

--by Peter Mitchell

1. ATP-synthesis occurs at an enzyme on the inner side of the inner mitochondrial membrane.

2. This ATP-synthesis requires a flow of protons through the inner membrane.

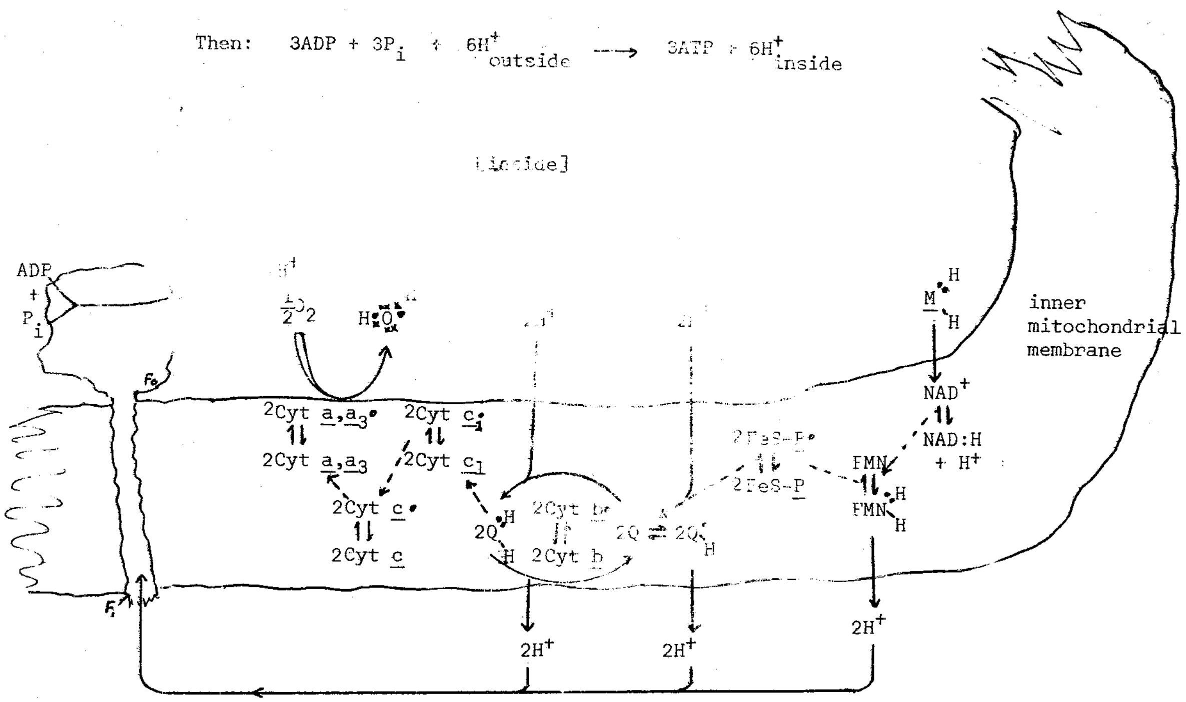
3. The flow of protons is down a proton gradient between the outside and the inside of the inner mitochondrial membrane.

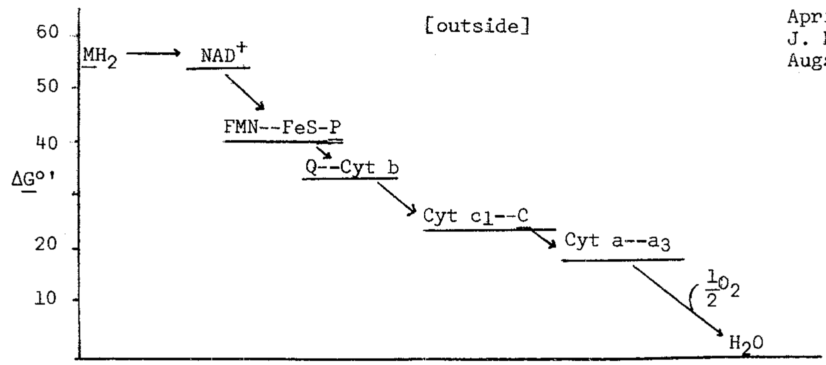
4. The proton gradient is created by electron-flow down the respiratory chain the inner mitochondrial membrane.

5. The proton gradient requires that the inner mitochondrial membrane be closed to the diffusion of all ions except at certain "portals."

$$M{:}H_2 + \frac{1}{2}O_2 + 6H^+_{inside} \longrightarrow M + H{:}O{:}H + 5H^+_{outside}$$

Then: $3ADP + 3P_i + 6H^+_{outside} \longrightarrow 3ATP + 6H^+_{inside}$





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Augsburg College

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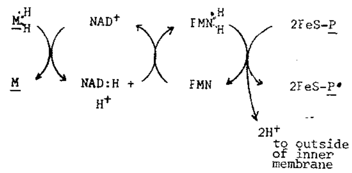
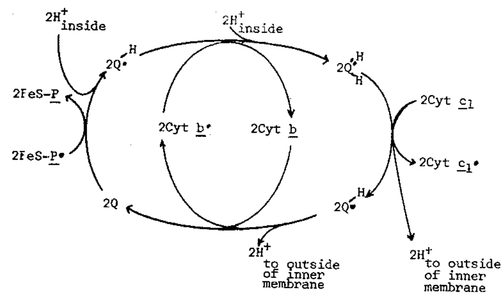
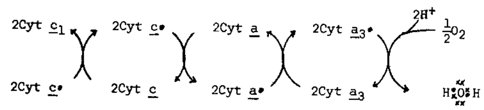
$M{:}H_2 + NAD^+ \longrightarrow \underline{M} + NAD{:}H + H^+$

$NAD{:}H + H^+ + FMN \longrightarrow NAD^+ + FMN{:}H_2$

$FMN{:}H_2 + 2FeS\text{-}\underline{P} \longrightarrow FMN + 2FeS\text{-}\underline{P}\bullet + 2H^+$ to outside of inner membrane







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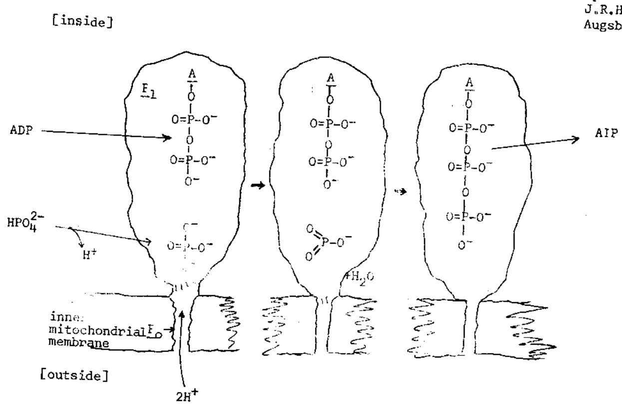

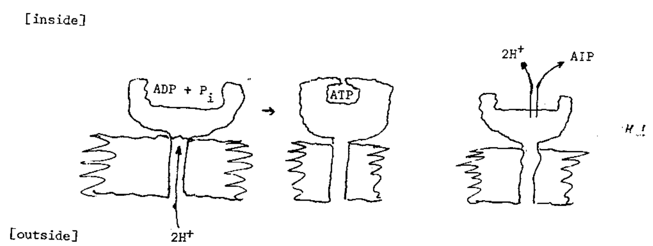

Biological Thermodynamics

Neal Langerman
Utah State University
Department of Chemistry & Biochemistry
Logan, Utah 84322

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Everyone who has tried to teach the fundamental concepts of thermodynamics has experienced the frustration of failure. Everyone who has tried to learn these concepts has experienced frustration. Certainly, the bumper sticker, "Honk if you passed P. Chem" attests to this frustration. While the content of thermodynamics is based on experience, the conceptual material is abstract. Gases are real, but the Ideal Gas and PV = nRT are very abstract. During this hour, I will try to present practical approaches to teaching the abstract concepts of thermodynamics using the experiences of the students, in their day to day lives, to help make the abstract real.

We can begin with the difficulty of "math". First, the very word "mathematics" intimidates many students. Simply by refering to arithmatic will relieve many students of a major psychological impediment to learning. Next, equations must be verbalized. Anyone who can read, can state the Ideal Gas Law, but how many of your students can explain it to their parents or siblings in terms those individuals can understand? Let me illustrate this process with the equation for the heat balance of a warm blooded animal.

$$S = M - E \pm R \pm C \pm D - K - F$$

S is heat excess or deficiency
M is heat produced by metabolism
E is heat lost by evaporation
R is heat lost or gained by radiation
C is heat lost or gained by conduction
D is heat lost or gained by convection
K is heat lost by physical exertion
F is heat lost by respiration, urination, etc.

The number of terms and the presence of the +/- associated with several act to make this relation terrifying to many students. Yet, it can be thought of as a good example of the First Law and can be used to teach both the concept of energy transformation and a method of verbalization of an equation. It is useful to assign the student the task of "teaching" this heat balance relation to their roommate or a friend, as an exercise in verbalization

Associated with the students arithmatic problems are the problems of the jargon/language of thermodynamics. Most people have an intuitive grasp of heat and temperature, yet the thermodynamic definitions of each are abstract and difficult (1). Definitions must be operable, that is they must define the series of steps needed to constract the concept being defined. This can be illustrated by defining a circle. Most people will try to define a circle by saying "it is round" or "it is a line without an end". Both of these statements are inadequate. The definition, " a circle is the locus of all points in a plane equidistant from a common point called the center" serves to describe how to construct a circle. Thi illustration of how to state a definition serves to prepare students to cope with more abstract definitions. "Heat is the exchange of energy resulting from two bodies at different temperatures being in thermal contact." Ask a student to explain that; describing heat as the energy that burns you when touch a hot frying pan, however, leads directly to the above general statement, and provides the student with the necessary frame of reference based on his/her own experience.

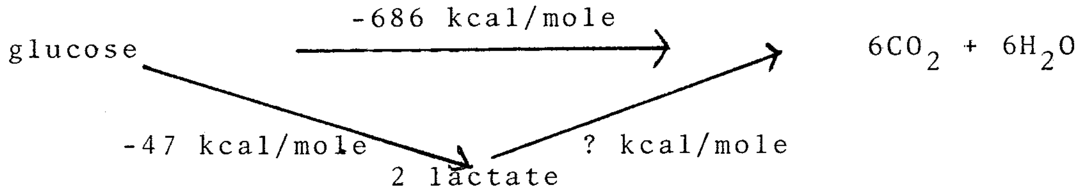
State functions are another area of dismay to many studen Each of you will be comfortable knowing that a function is a state function if its cyclic integral is zero. Can you, howev cast this into the common experience of your students? Each of us continuously experiences gravity. If you run around a level block and wind up at your starting point, you have done work, but have not changed your potential energy with respect to earth's gravity well. If you now run around the block, including going over an 800m hill, again winding up at your starting place, you have now done a different amount of work, your potential energy changed during the process, but your final potential energy is the same as your initial. This simple example serves to drive home the distinction between state and non-state functions in a succinct manner readil related to students day to day experience.

How much energy do you get from that "Twinkie" you are eating? If we treat it as glucose, then we could get energy based on

$$C_6H_{12}O_6 + 6\ O_2 \longrightarrow 6\ CO_2 + 6\ H_2O$$

$$\Delta G^o = -\ 686\ \text{kcal/mole glucose}$$

which tells us that almost 700 kcal of energy are available for every 180 g sugar consumed, if it is converted according to the chemistry given. However, much of the conversion will result in the formation of lactate rather than carbon dioxide and water. Using the state function nature of free energy changes, and some additional information, we can deduce how much energy we are being cheated of by the inefficient utilization of foodstuffs:



The result is that the C_3 conversion only provides 47 kcal per mole of glucose and that all of the remainder is made available during the conversion of lactate to CO_2 and water.

Your students could rightfully ask if it is possible to get all of the available (free) energy out of that Twinkie. The experiment shown in figure 1 substantiates that possibility. It shows the total energy released as heat during the growth of Streptococcus lactis. The amount of heat released corresponds quite will with that calculated from the conversion of lactate to CO_2 and water. (2)

You may be convinced that each of your students is unstable, but it is a thermodynamic fact that every one of us is unstable. Indeed, only the absence of an appropriate catalyst keeps us from spontaneously falling apart. The distinction between thermodynamic spontaneity, ie. a negative free energy change associated with a specific process, and reaction rate is a frequent problem. The simple fact that a reaction has a negative free energy change associated with it is insufficient to decide if it will occur in some finite time. A mixture of hydrogen and oxygen is unstable with respect to the formation of water, yet such a mixture will remain in an appropriate container for some infinitely long time in the absence of a metal surface or a spark. Similarly, the peptide bond is thermodynamically unstable with respect to the individual amino acids, yet, in the absence of proteolytic enzymes, proteins are very stable chemicals.

Most people who have read Time Magazine realize that ATP is the energy currency of life. Anyone who has had an elementary biochemistry course knows that the free energy change for hydrolysis of ATP is on the order of -7.7 kcal/mole. Yet, the standard free energy change for this process is +2.06 kcal/mole. What is the distinction? For the process

$$ATP^{-4} + H_2O\ (liq) = ADP^{-3} + HPO_4^{-2} + H^+$$

$$\Delta G^o = +2.06\ kcal/mole$$

$$\Delta G^{o'} = -7.61\ kcal/mole$$

we have a marked pH dependence. Indeed, the value normally quoted of -7.7 kcal/mole refers to the particular state of all reactants and products at unit activity (actually 1 molar concentration for ATP, ADP, and inorganic phosphate) except the hydrogen ion which is at pH 7.0 (3). The "mere" change of pH from 7 to 0 is sufficient to totally reverse the direction of this fundamental process of living systems. It is now accepted practice to indicate this special "biochemical standard state" with the imposition of a " ' " on the symbol.

A major portion of teaching thermodynamics involves teaching how to measure thermodynamic parameters. Our current concern with our environment provides many examples to motivate and make real these methods. First, I have summarized some of the laws relating to the protection of our environment on figure 2. These can be very useful for discussing such

necessary thermodynamic topics as pK. For example, titrati
methods are normally employed to determine a pK. Yet, only
a food technician cares about vinegar. Worse, none of us c
about that terrible species "HA". Useful examples for teac
everything you need to know about titrations are available
in the methods of environmental water analysis. Some of th
are shown on figure 3. Titration to the phenolpthalein endpoint measures "alkalinity" while titration to the methy
orange endpoint measures "total alkalinity". (4) In a simi
way, absorption spectroscopy and many other physical tools
be illustrated by appealing to the students inherent concer
for the world in which we live.

Most teachers agree that the ability to correctly solv
numerical problems associated with thermodynamics is essent
to mastery of the subject. Yet, the very nature of the pro
selected serves to intimidate and turn off all but the most
motivated students. Good examples of complex concepts abou
in the biochemical literature. (5) We can examine several
and discover the type concepts readily illustrated by these
systems.

If we continue to examine glucose metabolism, we can ask "what is the energy expenditure for the first committed step, the phosphorylation of glucose"? This is shown below:

$$\text{Glucose-6-phosphate} \longrightarrow \text{glucose} + P_i$$

at pH 7.0 and 25^{o}

initial conditions: 0.1 M G6P

final conditions: 0.05% G6P remained

<u>Calculate K_{eq}</u>

$$K_{eq} = [\text{glucose}][P_i]/[\text{G6P}]$$

where $[P_i]$ and [G6P] represent the formal concentration of a
such species

$$[\text{G6P}] = (0.05\%)(0.1M) = 5.0 \times 10^{-5}$$

$$\text{glucose} = 0.1 - 0.05 \times 10^{-3} = 9.995 \times 10^{-2}$$

$$= [P_i]$$

$$K_{eq} = (9.995 \times 10^{-2})(9.995 \times 10^{-2})/(5.0 \times 10^{-5})$$

$$K_{eq} = 199.8$$

What is $\Delta G^{o'}$ for hydrolysis and how is it interpreted?

$$\Delta G^{o'} = -RT\ln K_{eq}$$

$$= -1.98 \times 298 \times 2.303 \times \log(199.8)$$

$$= -13{,}64 \log(199.8)$$

$$= -3138 \text{ cal/mol G6P}$$

Using this example, we can help our students work through the concepts of equilibrium constant and free energy, as well as how the sign of the process is related to its direction. Clearly, the formation of G6P requires the excess of 3 kcal of energy, and this energy must come from somewhere. We can now utilize some energy currency and investigate the concepts of standard state free energy changes ($\Delta G^{o'}$) versus actual free energy changes (ΔG) and coupled reactions.

Calculate ΔG for the hydrolysis of ATP at pH 7 and 25^o under physiological steady-state conditions.

Physiological Conditions:

$$[ATP] = 1 \text{ mM}$$
$$[ADP] = 0.1 \text{ mM}$$
$$[P_i] = 10 \text{ mM}$$

$$\Delta G = \Delta G^{o'} + 1364 \log [ADP][P_i]/[ATP]$$
$$= -7700 + 1364 \log (10^{-4})(10^{-2})/(10^{-3})$$
$$= -7700 + 1362(-3)$$
$$= -11{,}792 \text{ cal/mole ATP}$$

Use the data from the previous two examples to calculate ΔG and K_{eq} for the reaction

$$\text{glucose} + \text{ATP} = \text{G6P}$$

$$\text{glucose} + P_i = \text{G6P} \qquad \Delta G^{o'} = +3138 \text{ cal/mole}$$

$$\text{ATP} + H_2O = \text{ADP} + P_i \qquad \Delta G^{o'} = -7700 \text{ cal/mole}$$

$$\Delta G^{o'} = +3138 - 7700 = -4562 \text{ cal/mole}$$

$$K_{eq} = 10^{4562/1364}$$
$$= 2.2 \times 10^{3}$$

Now, lest my own students accuse me of abandoning them and not discussing their work, let me finish with the story of the chicken and the egg.(6,7) The work I will discuss involves a thermodynamic study of the binding of flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD) to the riboflavin binding proteins from hen egg white (WRBP) and hen egg yolk (YRBP). The details of this work are published elsewhere.

The difference between WRBP and YRBP binding energetics suggests that either the binding domains are different or the conformations (and perhaps accessibility to binding domain) are different. The following discussion centers on a single proposed method of flavin binding in the hen egg. Admittedly, much is speculation and much is yet to be determined. The model is consistent with the available data and explains many of the anomolies observed.

Figure 4 shows the proposed model. The WRBP, synthesized in the white, may be considered nascent WRBP ($WRPB_N$) in that it has not undergone any post-translational modification. The flavin on the YRBP is transferred to the WRBP according to the following reaction at pH 7.4 and $38^{o}C$:

	H	G
YRBP - RF = YRBP + RF	14.5	8.5
$WRBP_N$ + RF = $WRBP_N$ - RF	-19.3	-8.8
$WRBP_N$ + YRBP - RF = $WRBP_N$ - RF + YRBP	-4.8	-.03

The YRBP is then degraded enzymatically. This seems logical since no apo RBP is found in the yolk. Since ^{14}C-labelled RBP injected into the hen is not found in the white, but is found in the yolk, it is doubtful that YRBP crosses the vitelline membrane (8). After the formation of the $WRBP_N$-RF complex a conformation change occurs,

$$WRBP_N\text{-}RF \quad = \quad WRBP_M\text{-}RF$$

where $WRBP_N$ and $WRBP_M$ are nascent and modified egg white RBP respectively. It is proposed that this conformatinal change costs 5 kcal/mole in binding enthalpy. In other words, anomoli observed (7) in the date are actually specific buffer interactions which effected the $WRBP_N$ to $WRBP_M$ transition prior to flavin binding. In the egg, this transition might occur after day 13 of incubation upon genetic control to transport and utilize riboflavin in the yolk. All the eggs used in this study were obtained at day 1-2 of incubation and stored at $4^{o}C$ until the proteins were isolated. This would "freeze" the development of the chick at this stage and all the WRBP should be in the nascent form. An interesting test of this idea would be to obtain RBP,s from chicks older than 13 days and see if they bind with a characteristic $WRBP_M$ H. It is further propose that the $WRBP_M$ (obtained by specific buffer interactions) is essentially the same as YRBP as demonstrated by the similariti in binding enthalpies. From entropy differences $WRBP_N$ and $WRBP_M$ (YRBP), it appears that the transition occurs with a marked decrease in organization. The $WRBP_M$ may then release its riboflavin on the white side to be transported across the vitelline membrane (path 1, figure 4). It may be important that riboflavin is a lipid soluble vitamin and that there is an isolated region of hydrophobicity near the binding site of RBP,s (9,10). The immunological studies presented earlier (11,12,13) are in disagreement as to whether bound and unbound and WRBP and YRBP are crossreactive. This is probably because the antigenetic binding recognition site may or may not be affected by the proposed conformational change (9). An interesting experiment would be to obtain RBP from the liver of the laying hens and see if this LRBP is similar to $WRBP_N$.

A consequence of the AMP, ADP, and ATP binding studies outlined elsewhere (6) would be to determine if there is a specific adenine nucleotide binding site, would this be convenient for the flavokenase and FMN adenyl transferase enzymes which carry out the following reactions in the egg, (path 2, figure 4):

$$RF + ATP \xrightarrow{\text{flavokinase}} FMN + ADP \quad (14)$$

$$FMN + ATP \xrightarrow{\text{FMN adenyl transferase}} FAD + P_iP_i \quad (15)$$

It may be discovered that $WRBP_M$-RF, ATP and the kinase are present near or in the vitelline membrane and the riboflavin is released, phosphorylated, and transported across the membrane and released as FMN or FAD into the yolk and developing embryo.

This system proves to be very exciting to discuss with many students. Because it deals with concrete examples from their day to day existence, it maintains interest and aids in their learning. There are no substitutes for the work of study to master thermodynamics. Your efforts to relate the material to the experiences of the students will aid their learning and, it will be in agreement with the essential philosophical basis of this discipline.

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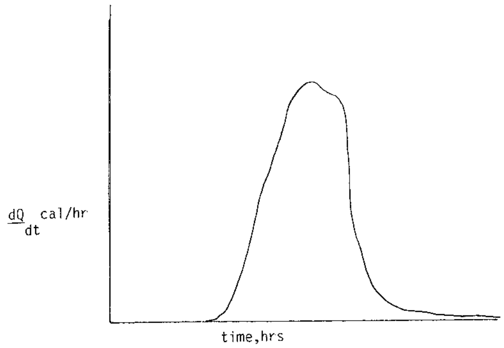

Thermogram representing the growth of Streptococcus lactis

Figure 1. Thermogram representing the growth of Streptococcus lactis on a limiting amount of lactate in defined media. Taken from (2).

US LAWS DESIGNED TO PROTECT OUR ENVIRONMENT

Federal Water Pollution Control Acts	FWPCA
Resource Recovery and Conservation Act of 1976	RCRA
Toxic Substance Control Act of 1976	TSCA
Safe Drinking Water Act of 1974	
Hazardous Materials Transportation Act of 1974	
Marine Protection, Research, and Sanctuaries Act of 1972	
Ports & Waterways Safety Act of 1972	
Federal Insecticide, Fungicide, and Rodenticide Act of 1972	

Figure 2. The laws of the United States designed to protect the environment. Each law has generated a large set of regulations for enforcement.

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TITRIMETRIC METHODS

Alkalinity:

$CO_3^{-2} + H^+ \rightleftharpoons HCO_3^-$ pH 8.3, phenolphthalein

$HCO_3^- + H^+ \rightleftharpoons H_2O + CO_2$ pH 4.5, methyl orange

Chloride ion:

$Ag^+Cl^- \longrightarrow AgCl$

Water Hardness:

$Ca^{+2} + Y^{-4} \longrightarrow CaY^{-2}$ (mg^{2+} also)

Biological Oxygen Demand - Winkler method

Sulfide

Sulfite

Figure 3. Titration methods which are routinely applied in environmental analysis of water. These methods are good for teaching titration theory.

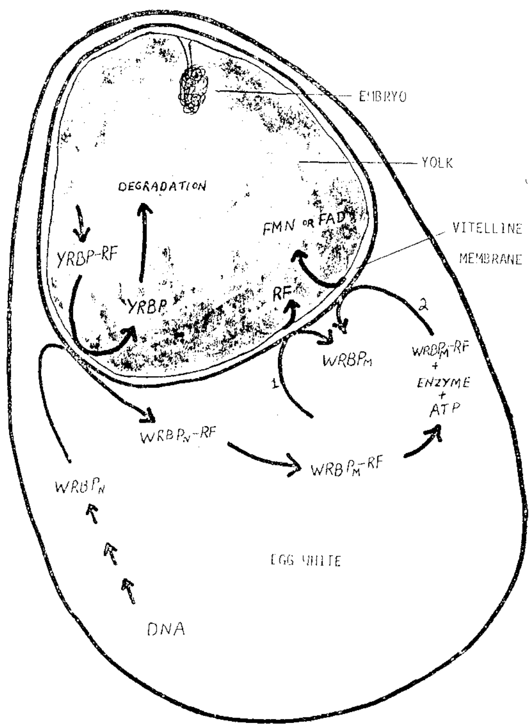


Figure 4. A schematic diagram of the movement of flavin during the development of embryonic chicks. Taken from (6).

INOVATIVE TEACHING TECHNIQUES

How to Learn Chemistry

Edward I. Peters
West Valley College
Saratoga, California 95030

Presented to a session on Inovative Teaching at the Seventy-Second Two Year College Chemistry Conference, Clark County Community College, Las Vegas, Nevada, March 26, 1982

You can lead a horse to water, but you can't make him drink Applied in our profession, that adage becomes "You can lead a student to learning, but you can't make him learn." As educators we do a lot of leading. That is our major activity. We develop our lectures and our assignments in the way we think will be most effective in promoting learning. We create "learning experiences," as the educationists might say, in our laboratories. We try to improve our skills in these endeavors by studying the learning process, as evidenced by the considerable attention given to Piaget theories in recent years, and by the day-long DivCHED symposium on "What Can Science Educators Teach Chemists about Teaching Chemistry" scheduled for Monday. And our efforts are successful. Our students do learn. Most of them, anyway. But like the shepherd who left his ninety and nine to find the one lost sheep, we, too, leave our one hundred minus x to give special help to our x -- and, alas, x is not 1 in teaching chemistry! This talk focuses on the x.

When a thirsty horse is led to water, he drinks. Nature tells him how. When a maybe-thirsty student is led to learning, he might learn, and he might not. Most students try, but still many do not learn. Could it be that, unlike the horse, nature does not tell the student how to learn? When a student confesses to having "poor study habits," he is actually saying he doesn't know how to learn, even when presented with well conceived learning opportunities that are expertly executed. The question is, then, what can we do to help the student learn how to learn.

We don't find much in the literature on this subject, but occasionally, at meetings such as this, a speaker addresses this problem. Rod O'Connor did it several years ago, which led me to getting "Toward Success in College," written by O'Connor, it's a fun book, but it's filled with excellent advice for the student who really wants to succeed at being a student. The most recent 2YC3 talk I've heard on this subject was by Leonard Grotz in Detroit a year ago. It was that talk that led to our "How to Learn Chemistry" series at West Valley College.

At the beginning of each semester we devote four laboratory periods of our general chemistry program to a "chemical skills review" that grew out of our highly successful PSI prep course. This review is designed to refresh the student in skills a general chemistry student is supposed to have from an earlier course, and counsel him into the prep course if that is where he should be. If you are interested in the CSR, it is described in the poster session immediately following this talk. This opened laboratory time for other things, one of which turned into talks on "How to LEARN Chemistry." The emphasis is on learn, not study.

The main theme of these talks is self-discipline. I don't call it that. Instead we talk about how easy it is to commit one's self totally to skiing, to a date, or to any other form of fun while engaging in that activity. We talk about how an athlete has total devotion to his sport while participating in that sport. Then we wonder about what would be the result if a student isolated that portion of his life that is spent being a student and threw himself 100% into that acitvity. Then we consider finding learning techniques that yield the maximum amount of learning in the minimum amount of time, learning at absolutely peak efficiency. The rewards for such an approach are improved learning, better grades, and more time for fun and games.

Throughout this discussion we introduce another idea that is repeated again and again in the talks: LEARN IT NOW! Take ten extra minutes to learn it now, instead of the thirty minutes it will take to learn it later. Then we talk about how to learn it now.

THE STUDY AREA

The first topic we consider is the learning environment, where a student studies, where he practices his craft of learning. This is examined in the form of a graph of learning minutes versus minutes of what a student calls "study." Ideally it has a slope of 1: one minute of learning for every one minute of study. It is not possible to reach this ideal over a study period of more than an hour or so. Fatigue sets in. So we talk about how to minimize fatigue by including study breaks, by rotating study subjects, or by splitting up study time into shorter sessions, all routine items that can be found in any "how to study" book.

Next our attention goes to those things that would flatten the learning curve over which the student exercises some control. First is radio. When you stop to analyze the minutes per hour a students's attention may be distracted from learning by his response to music, DJ chatter, commercials and perhaps news, radio is clearly the most criminal time bandit the student confronts, and the one most easily corrected. We talk about the price paid in minutes of study-without-learning because of telephone interruptions, refreshments, socializing, cigarettes, pictures, daydreaming, planning, and second only to the radio, distracting noise. "Uninteresting" radio, with headphones, is mentioned as a way to counter noise distraction. Uncontrolled, these obstacles to study introduce enough flat spots in the curve to yield a slope of less than 0.5; less than 50% of the minutes spent studying are spent learning.

HOW TO LEARN FROM A LECTURE

Next we turn to learning techniques. "How to Learn from a Lecture" explores the art of taking good lecture notes. The notebook should be divided, with half a page, or facing pages, left to revise, condense and summarize the notes taken in class, or to express them more precisely. Identifying main ideas is stressed. Examples and demonstrations are important only in the concepts they illustrate, and it is the concepts that should be recorded in the notebooks. Particular attention should be paid to graphs, which say so much in so few words.

Probably what is done before and after the lecture is as important as what is done during the lecture, and maybe more so. There is evidence that ten minutes spent looking at the textbook coverage of the lecture topic before the lecture prepares you to learn <u>during</u> the lecture. Otherwise the lecture prepares you to reach a comparable level of learning in about thirty minutes of study<u>after</u> the lecture. That thirty minutes presumes the lecture notes will be reviewed immediately after it is over. Any delay beyond the same evening easily doubles or triples that half hour. In fact, immediate review of a lecture is the best time bargain a student will find anywhere. According to a source quoted by O'Connor there is a 46% loss of lecture material if it is not reviewed until 24 hours later, whereas the student who reviews immediately has about 98% retention. Furthermore, after three weeks the 24 hour later reviewer drops to about 40% retention, while the immediate reviewer is still at the 90% level. We also talk about <u>how</u> to review a lecture, using space deliberately left for this purpose in the lecture notes.

HOW TO LEARN FROM A TEXTBOOK

Next in the area of technique we talk about "How to Learn from a Textbook." At the beginning of the term the student should get acquainted with the text. What learning aids are present? If there is a "To the Student" section at the beginning, read it. Are chapters summarized? Are new terms grouped at any place? Is there a glossary? Do the apendices contain useful information? How are the ends of chapters organized? Find out what the book has to offer, and use what is there to greatest advantage.

A quick preview of a textbook assignment is said to shorten the time required for a given amount of learning from the assignment. Zero in on section titles, boldface and italicized words, illustrations, summaries. This prepares you to learn <u>while reading</u>, rather than later, much as previewing a lecture prepares you to learn during a lecture. Then, while studying, take notes. This means pencil-and-paper notes, not highlighting the text. Grotz talked about the inadequacy of highlighting, which had never occurred to me before, but it surely is true. By taking notes, by condensing material into fewer words, the student must think through the material to the point of some understanding in order to compose those words. The student learns NOW. By highlighting, the student simply makes a date with the book to learn later. Later is usually right before a test, and by then there are so many dates it is impossible to keep them all. Learn it NOW. Never agian will it be easier than it is NOW, and never again will it take less time.

HOW TO LEARN PROBLEM SOLVING

While talking about the textbook is a good time to talk about learning How to Solve Problems. Be sure to understand the principles and relationships behind a problem, definitions that may be involved, and the mathematical operations required. Develop the ability to read a problem critically, to identify what is given or implied, and what is wanted. Select a method, algebraic, dimensional anlysis, or whatever, and then solve the problem. If working a problem from the back of a chapter, don't use a two-finger approach--one finger at the problem and another finger at an example that is like the problem, and then flip from one to another to get the answer. If stuck, go to the example and learn from it without looking at the end-of-chapter problem. Then go to the problem and solve it without looking at an example.

With both textbook study and problem solving, we emphasize that the objective is to learn. Homework is not finished when the assignment has been read or the correct answer calculated. It is finished only when the reading material is understood and when similar and even different problems can be solved without reference to notes or books. The assignment is finished only when learning has been accomplished--NOW, not planned for some future time.

HOW TO LEARN FROM THE LABORATORY

"How to Learn from the Laboratory" is discussed next. Again it is stressed that the student who learns NOW is the student who is prepared to learn. In the laboratory, "prepared" means having read the experiment before the period begins, knowing what is to be done, and having prepared a laboratory notebook for data entries, if such are required. Advance Study Assignments, if any, should be completed before the class. A student fully prepared for an experiment can often complete the entire experiment, including the writeup, during the laboratory period. That student will learn what the experiment is to teach DURING the laboratory period. If the write up cannot be completed during the period, it should be finished as soon thereafter as possible, surely by that evening. It takes less time then, and more is learned, than at any later time. If the report is not written until six nights later, just before it must be turned in, a price will be paid in both time and learning.

HOW TO PREPARE FOR AND TAKE A TEST

"How to Prepare for a Test." To the student, this is where the payoff comes. The student who has, each day, learned NOW is nearly prepared already. All that student must do is to review the material to be tested. This material is neatly condensed into compact lecture and textbook review notes and solved problems. It is not necessary to reread the textbook, a monstorous and impossible task. Instead the textbook becomes a reference book to clarify those items that need clarification when studying notes.

Reviewing for a test is broken into parts. In the long range, the student anticipates the test, and makes sure study time is available. Conflicting demands are taken care of in advance. The student is constantly alert to hints in lecture that a topic may appear on the exam. In the intermediate range, about a week before the test, the student begins a daily review of a portion of the test material. If objectives are available, he uses them, and sure he can do what each one says. If they are not available, he might write what you think they might be. A concept list might be prepared, or a practice exam written and taken by the student. We talk about how to face up to and face down the "little foxes" that would spoil the vine, things like worry, lack of confidence, and anxiety. What O'Connor calls "read and destroy notes," things to be memorized, are written. Physical necessities, pencils, erasers, and a calculator that will last through the test, are assembled. And one other thing: sleep is recommended.

In the close range, just before the test, the student is encouraged to concentrate on basics and troublesome areas, and to master them. Review the concept list. Just before the test, read and destroy the read and destroy notes. Get into the test room early, and consciously relax a few moments before the test begins.

Test taking techniques are also discussed. For the greater part, these are the usual suggestions, such as scanning the entire test, setting up a rough schedule, approaching first the questions whose answers are known, or the high point questions, and not lingering on a problem that is proving difficult. Comments are also made about "freezing," or "blockin and ways to break loose from it.

EVALUATION

We are only in the second semester of this program, so our evaluations to date are limited. By far, the most frequent student comment last semester was, "I wish I did some of the things you suggested." This comment was usually made just before the student handed me a drop slip. There were several individual comments in which students would talk about specific topics. One girl asked if she could use some of the material in a church newsletter that was put out for college students. In general the comments have been very favorable.

In planning for this meeting I distributed an evaluation questionnaire to my class. Students were asked to judge each part of the series, classifying it as very helpful, helpful or not helpful. The lecture and test preparation topics received very helpful marks from about 2/3 of the respondents. "Helpful" was checked most frequently among the other topics. The largest "not helpful" vote, 8%, was cast for the laboratory. Asked to what extent they had adopted some of the suggestions, 27% checked "large extent," 48% intermediate, 23% just a few, and one person out of 62 who answered said not at all. Perhaps the most critical question was whether or not we should develop this series further and continue to offer it. The response was decisive: 91% said yes; only 9% said no.

* * * * *

The purpose of this discussion is not to lay before you an experiment that has been tested and perfected, but rather to suggest that finding ways to help the student learn how to learn might improve learning by some students as much as other innovations in pedagogy. Perhaps it will open doors in your thinking much as O'Connor and Grotz opened them in mine. If you have had experience in these areas, I'd like to hear about them. What we teach and how we teach is important. But in the last analysis, what the student learns is the only thing that really counts.

Summer Immersion in Chemistry

Geoff Rayner-Canham
Sir Wilfred Grenfell College
Corner Brook, Newfoundland, Canada

Presented to a session on Inovative Teaching at the Seventy-Second Two Year College Chemistry Conference, Clark County Community College, Las Vegas, Nevada, March 26, 1982.

Between one-third and one-half of students entering a science program at the college lack any chemsitry background. For these students we offer a one-semester preparatory basic chemistry course. We decided to also offer this course as a summer immersion program lasting four and one-half weeks. Our experiences with this course over the six years which it has been offered have shown us the potential and unique features of such a course.

The students devote their full time to this very intensive course which comprises fifty three one-hour classes, ten three-hour labs, eight half to two-hour mini-labs and nine evening problem sessions. Evaluation is by means of seven half-hour tests, a one-hour midterm exam, and three-hour lab and a two-hour final exam. Particular features of the course are the mini-labs, the lab exam, the use of a student tutor and the extra-curricular activities and each of these is discussed below.

<u>Mini-Labs</u>

It is general practice to devise experiments that will fill the available timeslot, yet there are many good experiments and laboratory experiences which are of a short duration. These can be such topics as preparing and diluting a standard solution or examining the properties of non-metallic elements.

Lab exam

We particularly feel that the lab exam is a very worthwhile activity. A typical exam would consist of a quantitative measurement, particularly a titration, and a qualitative experiment, such as the identification of an unknown compound. The crucial difference from a regular lab session is that procedural details would not be provided. Instead, students are expected to devise their own procedures based on similar (but not identical) work in preceeding sessions. It came as a pleasant surprise that students looked upon the lab exam with anticipation rather than with fear, though it should be noted that the exam was presented to them as a chance to prove that they could work competently and unaided in a lab environment.

Student tutor

An important role is played by a student tutor. We hire a sophomore student to conduct evening tutorial (recitation) sessions. Several of the introverted students find it hard to discuss their chemical and personal difficulties with the instructor but feel much more comfortable with the student tutor. The course instructor and student tutor meet daily to discuss the work covered and the difficutlies encountered. The student tutor also acts as an assistant during the laboratory sessions.

Extra-curricular activities

As a break from mental activity we also organize evening mixed soccer and softball games, though it is often difficult to drag the students away from their studies. Tours are arranged to the local hospital laboratories and to the local cement plant laboratories. A one day hike and picnic in the nearby National Park takes up one Saturday in the program.

There are five main advantages to offering this course in the immersion form. Firstly, the students concentrate exclusively on chemistry. Most instructors have encountered the difficulty of maintaining the interest of students when there is a test in another subject during the following class period. In the immersion course, students can devote all their time to chemistry, without the distraction of other studies.

The class itself is a homogenous group. Students must have a fairly high motivation to give up part of their summer. We also select which applicants will be admitted into the course. In our experience, students with weak mathematical high school grades have great difficulty with the rate of coverage of material. Such students are therefore advised to take the course in the regular semester format where they can simultaneously take remedial mathematics. We have also learned by experience that it is particularly important to exclude students who have a previous exposure to chemistry. Such students can intimidate the beginning students and they also may have previously learned a different methodology of problem solving.

A particular advantage of the summer course is that the laboratory is available throughout the course, thus it can be used much more extensively. By the end of the course, the students regard the lab as "home". It is not only the ability to use the labs frequently that is useful but also that sessions can be set to follow the appropriate topic. For example, after introducing the theory of dilution problems, students can immediately move to the laboratory and spend a mini-lab session practicing pipetting and diluting solutions. In practice, the early days of the course mainly consist of he theory classes but towards the end, the laboratory sessions predominate.

One classroom is dedicated exclusively to the chemistry course for its duration. This enables the room to be set up with all the demonstrations, equipment, charts, etc., that will be needed for the day. It also makes it possible to adjust the length of a class session to match that required for completion of a particular topic. As there are about five more class hours than in the regular semester it is possible to include more demonstrations and audio-visual materials in this program.

It is in part because the students are admitted on basis of motivation and ability that we find an excepionally high enthusiam and dedication. Another important factor, however, is group spirit (or peer pressure, to put it in a different perspective). Even though students come from different locations throughout the province of Newfoundland and Labrador (a total area equal to that of the state of Califorina) and from different social strata, they rapidly acquire a remarkable cohesiveness.

The course material includes only the basic concepts of chemistry, each one which is treated in depth. The topics are: matter, measurement, atomic theory, compounds (bonding and nomenclature), mole concept, chemical reactions, gases, solutions, periodic table and stoichiometry. We were unable to find a suitable text which covered the basic principles throughly and in a readable manner. Over the last six years, we have developed our own text "Foundations of Chemistry" by G. Rayer Canham, A. Last, R. Perkins and M. van Roode, which is to be published by Addison-Wesley in January 1983 (note: the text will contain some additional topics to those mentioned above).

The instruction of the course involves very close liason of the instructor with the other people involved in the course. As a minimum, we have needed a lab instructional assistant, a student assistant/tutor and a lab technician.

A final point of information concerns the length of the course. It is important for there to be a "digestion time" between the end of the course and the examination period. Thus the course itself finishes in the four weeks. The last half week consists of review, laboratory pratice, the lab exam and the final exam.

Performance of the students is always excellent, the pass rate never being lower than 90%, unlike the equivalent course in the regular semester where much lower pass rates are the norm.

Again, it should be emphasized that the group is not representat of the total annual students intake. Performance in subsequent chemistry courses is difficult to generalize because even with the course they are disadvantaged compared to students who have had a full two-year high school chemistry program. However, in cases where students have deteriorated in grade, this has often been to a level consistent with their performance in other courses.

This course is a stimulating (if exhausting) experience for the instructor and it is strongly recommended for any institutio facing the problem of students lacking chemistry.

TRENDS AND CONCERNS IN GENERAL CHEMISTRY:

Some Personal Reflections of a Textbook Aurthor

H. Eugene LeMay, Jr.
University of Nevada
Reno, Nevada 89557

Presented to a session on Textbook Philosophy at the Seventy Fourth Two Year College Chemistry Conference, Clark County Community, Las Vegas, Nevada, March 26, 1982

In the fall of 1972, Ted Brown and I statred sharing ideas about a general chemistry text. I had taught from all of the popular texts of that time and although I could live with most of them, I felt that some improvements could be made. I've heard it said that textbooks are born from the egocentric beliefs of authors that no one has yet written quite the proper book, but they can. I guess that is where we were coming from.

There were five major concerns or goals that shaped our writing efforts. We sought

1. to make the text a useful pedagogical tool for the student - to be student oriented with many study helps for students.
2. to convey the importance, excitement and fun of chemistry to the reader.
3. to relate chemistry to other areas of science and technology and to the world around us.
4. to employ a consistent problem-solving approach as much as possible and to use dimensional analysis.
5. to express concepts and ideas with clarity and make the text easy and enjoyable to read.

The result was Chemistry: The Central Science. That text is not in its second edition. It has been a commercially successful book; I like to think that we were able to accomplish much of what we set out to do, and that we have had a positive effect on general chemistry. However, I would be less than realistic if I did not recognize that it is not yet a perfect book. I have plenty of advisors and critics to remind me of that. As a result, I am constantly thinking of what we should be doing in general chemistry and how we should be doing it.

My thinking is focused by three general questions that apply to any course we teach:

1. What is the purpose of the course? This question helps us decide what material to teach.
2. What are the abilities of the students? This question helps us to decide the level of material and our approach in presenting it.
3. What are the interests and vocational objectives of the students? This question also helps in choosing both material and level and is especially useful in the selection of examples and applications.

I'd like to amplify on each of these three questions and where they have led me in my thinking:

Purpose of the General Chemistry Course - I think that we have a consensus about the purpose of the general chemistry course; it handles many types of students, attempting to give an overview of chemistry while still providing a foundation from which further studies in chemistry can be pursued. Thus, we need to provide chemistry that is useful to students with a variety of vocational objectives and not chemistry just for chemistry's sake.

The evolution of the mainstream freshman chemistry course from an introductory inorganic chemistry course to a more general survey has caused some problems and raised some as yet unresolved questions. The foremost of these is the role and nature of descriptive chemistry in the general chemistry courses. Do students need descriptive chemistry? What constiutes descriptive chemistry? How much descriptive chemistry should there be? How should it be organized and integrated into our courses? The concern, as I perceive it, is not so much a desire to go back to the old-fashioned descriptive chemistry course of the 50's. Rather, it is a recognition that we can focus too much on chemical models and theories to the point that we lose sight of chemistry as an experimental science; futhermore, we can become so abstract that students have difficulty handling the material, and they lose sight of its applicability to real-life situations. In addition, if students come to see theories and general concepts as the reality, they lose sight of the many chemical facts that we cannot yet completely explain.

Since I've touched on the matter of abstract material, let me note one trend that I see in present general chemistry texts - the increased use of photos. A few years ago several major text had no photos, only line drawings and pretty air-brush drawings of orbital and molecules. The absence of photos merely promoted the idea of chemistry as abstract and outside the realm of the real world. However, I'm not convinced that color-plates inserted in the center of a text is worth the expence.

As we consider the content of our courses, we not only face the problem of what material to put in, but also what to leave out. Everyone has a favorite topic that they want left in. It's hard for text authors to cut material; consequently text become encyclopedic.

Student Abilities - The way we teach general chemistry is shaped not only by our beliefs about the purpose of the course, but also about the abilities of out students. I think that we are presently seeing students that are more serious about their studies than the students of 5-10 years ago. However, their seriousness should not be equated with their abilities. We are seeing poorer math aptitudes and lower reading abilities. We are also seeing more foreign students and more older students who have forgotten their basics and need to rebuild their study skills. Whenever we face a class of general chemistry students, we encounter a wide diversity of interests, backgrounds and abilities. We run the risk of losing some, boring others. This diversity poses one of our real challenges as teachers. I see texts responding to this challenge with lots of study helps, as well as with attractive and inviting page layouts. The more effective texts also carefully define new words before they are used to describe or explain chemical phenomena, and avoid talking down to the students. Students also need to see where we're going in the courses and to appreciate the need for theories or abstract concepts before they are explained.

The problem of arriving at a proper level for a text is complicated by the fact that the ultimate consumer (the student) is not the one who choses the text. Thus textbook companies and authors must aim their pitch at instructors. I'm not saying that instructors have no appreciation for student problems, but I think we tend to know much about chemistry than how learning occurs. We often operate under the illusion that by "presenting the material" students learn it.

I see many texts as doing a good job of organizing material and summarizing it for one who already comprehends it. A good text however, is not a lengthy summary of our knowledge, but rather a pedagogical device. What appears to the mind of an experienced chemist to be a logical order for a sequence of topics is not necessarily the best order for presenting new material to a student encountering that material for the first time. The best way to organize material after it is understood is not always the best way to organize it so it will be understood in the first place.

For example, it may be useful to develop some topics at several levels of sophistication through a text as fuller understanding is needed. Sometimes an idea has to settle into a student's mind and be used a while before we can build upon it with further related ideas. The repetition associated with discussing a topic several times at increasing depth can be used to good advantage. However, when this spiral approach is used in a text, the instructor needs to be aware of it and recognize its value. Otherwise, the tendency is to completely develop a topic when it is first encountered and then move on to another topic. One place where the spiral approach can be used to good advantage is in dealing with acids and bases.

There is another pedagogical reason for presenting material so that it is not necessarily most compactly arranged. Sometimes it isn't good to present closely related ideas together because they are readily confused in the mind of the student (moles, molarity, molality; or molarity and normality).

The task before us is to challenge students without overwhelming them. I've seen instructors successfully introduce very complex ideas at a level that I would judge to be beyond the abilities of most students in our classes. However, they succeed because of their enthusiasm, interest, and ability to communicate the idea. We can't uncouple instructor and student interest in topics.

Interests and Vocational Objectives of Students - The interests of the student can be a strong motivational tool. In order to do the work necessary to learn chemistry, a student needs to see that chemistry is important in understanding our world. I think that texts are currently doing a good job of relating chemistry to biological and medical problems. However, I think we need to do more to relate chemistry to engineering, especially during this time of growing engineering enrollments. I'm not sure how to accomplish this task, but it seems to me that more information is needed on the properties of common structural materials.

Concluding Remarks - Let me close by making a few remarks that I didn't know how to place in my outline.

1. We can get too "cute" in our applications, pedagogy and relevance. Some people want to teach "jest plain ole chemistry".

2. Textbook authors often want to please everyone. The result is all texts end up looking alike. The similarities between texts is also influenced by the fact that many different publishers rely on the same reviewers. In addition, publishers want to make a profit, so they are hesitant to publish books that are too different. Perhaps we need a forum for publishing revolutionary approaches to general chemistry.

3. As an author who has listened to much advice and taken much, I worry about losing the initial direction and tenor of my text - that it become something that I no longer recognize myself.

4. Finally, let me close with a quotation from the Bible: "Of the making of books there is no end, and much study wearies the body." (Ecclesiastes 12:12b).

Dare to be Different in the Learning Process

Donald A. Drumn
Columbia-Greene Community College
Mudson, New York 12534

Presented to an Inovation in Teaching Symposium at the Seventy-Second Two Year College Chemistry Conference, Monroe Community College, Rochester, New York, October 16, 1981.

Students require experiences and challenges to develop patterns and methods of thinking. Students learn effectively when practical solutions to current problems are presented in various learning environments. This project provides an exciting and competitive challenge for groups of students in Organic Chemistry.

GROUP AUCTION PROJECT

Groups of students will attempt to design the most profitable method of solving these hypothetical environmental problems. You may assume that all capital costs for required equipment, labor, and materials for plant construction will be covered by a government or private agency grant. The groups should research the problems and determine which, if any, of the problems would be profitable. The groups will then bid against each other during an auction for the projects, keeping in mind that the cost of the original bid must be recovered to avoid bankruptcy. Excess profits are yours. It is not necessary to bid on every problem. The team with the greatest profits and best legitimate solutions wins "the prize".

Problem #1

A large western city wants to sell its old landfill site, an area approximately 400 acres in size. The area is covered with an average of 100 ft. of municipal waste and has been used for landfill purposes for approximately 80 years. The weight percentages of commonly recycled materials in fresh municipal garbage are: 8.4% ferrous metals; 0.6% aluminum; 0.3% copper, 9.7% glass; 45% burnable paper and organics.

Problem #2

An electrolysis industry is required to clean up six acres of a site containing waste by-products. Approximately 200 tons of metals and metal compounds have been dumped at the site. Preliminary analysis yields the following weight percentages in the waste: 6% silver; 2% cadmium; 2% mercury; 9% lead; 40% iron; 20% copper; 11% zinc; and 10% nickel.

Problem #3

The Love Chemical Co. has been disposing of steel barrels of organic wastes by burying them in the Hook Canal. The company attorney has advised the Board of Directors to get rid of the site. Approximately 4000 (55 gal.) barrels containing chemical manufacturing by-products and solvents are buried at the site. According to a preliminary investigation, the wastes consist of the following volume percentages: 15% benzene; 15% toluene; 15% chloroform; 15% trichloroethylene; 3% phosphorus; 15% nitorbenzene; 10% chlorophenol; and 12% chlorobenzene.

Problem #4

G.E. must dispose of 2000 barrels of insulating mineral oil containing polychlorinated byphenyls in concentrations ranging from 100 to 800 ppm.

Problem #5

A wreckage firm owns a large piece of land which has been used as an automobile graveyard. About 10,000 junk cars and several thousand tires are located on the site. The land and graveyard are for sale.

Problem #6

A densely populated area of nearly 1 million people produces and must dispose of 2,800 tons of used motor oil each year.

Problem #7

A sugar processing factory, which produces about 7 tons/day of cane pulp by-products is located within a few miles of a large sawmill which produces nearly 3 tons/day of bark and sawdust waste. Both industries must find a way to dispose of their by-products.

Problem #8

Griff Brothers Corp. manufacturing plant contains 300 barrels each of the banned pesticides Mirex, Lindane and DDT. State law requires that the firm dispose of the pesticides.

Problem #9

An electric plant burns a high sulfur fuel which produces a harmful gaseous effluent. The gas reacts to form acid rain downwind from the plant. Analysis of the stack gas indicates that the plant is discharging 11,000 tons of SO_2 per year. The company must clean up its emissions.

Problem #10

There is a 200 acre farm for sale. Because of pollution and bad land management practices, the soil has been rendered unsuitable for agricultural purposes. However, there is a layer of limestone averaging 100 ft. in depth underlying the farm.

Problem #11

120 tons of 15% radioactive wastes in nitric acid solution are stored in East Valley, Oregon. The waste is a by-product of a nuclear reactor and the local people want to get rid of the material.

Student solutions to the problems vary in quality and cost effectiveness. A team of students successfully bid $300,000 for barrels of waste chemicals (Problem #3). The assumptions included the following:

a) each chemical may be combusted at temperatures near 2200-2400°F with residence times greater than two seconds;
b) combust organic chemicals in cement or steel industry kilns to tie up phosphorus must be identified before determining plan of action;

d) phosphorus cannot be burned safely and therefore must be reacted in water or oxidized to form acid.

The combustion of the organic chemicals provided a source of synfuels. Alternative solutions were discussed. Students sought information from professional consultants, officials from the cement industry and the Department of Environmental Conservation, and the literature. Students evaluated Federal and State regulations, toxicities, and safety practices during project analysis.

For each problem, student teams evaluate and attempt to develop:

a) safe, practical and cost effective recycling and recovery procedures;
b) mathematical procedures;
c) reasonable estimates and assumptions;
d) chemical and physical methods;
e) alternative solutions;
f) economic solutions.

As a result of this project, the student grows professionally. Students learn to use all the available resourses to make important decisions about common problems. More importantly, students learn the state of the art and develop a sense of creativity. Students enjoy the excitement, competititon and challenges generated by the Auction Project.

Introductory Chemistry for Applied Technologies

James R. Hicks
West Hills Community College
Coalinga, California 93210

Presented to a session of the Seventy-Fifth Two Year College Chemistry Conference, Normandale Community College, Bloomington, Minnesota, May 8, 1982.

Present-day college chemistry courses are designed primarily to meet the academic requirements of a baccalaureate degree and are oriented to serve the student in four areas; preparatory or remedial general chemistry liberal arts and nonscience majors, allied health curricula, and general chemistry for science and engineering majors. A fifth category is needed for students who are forgotten in the physical science curriculum: a developmental nonbaccalaureate course designed to meet the needs of the students in skill vocations and applied technologies. Students in these areas can be potential, conscientious employees performing nonprofessional services in the health and safety functions of the health professions, food services, water departments, industrial arts, the environment, ect. The course can serve returning mature citizens who may find it useful as a re-orientation to science.

It is common for two- and four-year colleges to use various achievement test results, in combination with high school grades to counsel students into the appropriate level of instruction for the Science and English courses. For example, in English courses, students with ACT[1] Achievement scores of 20 or greater enroll in the regular introductory baccalaureate level English course. Students who score 15 through 19, take a grammar and syntax course, and those with a score of 14 or less enroll in a reading and vocabulary course. The above ACT criteria scores categorizes 37% of the community college students as having the necessary literacy level for the regular college Science and English courses, while 63% are in the need of grammar-syntax or reading and vocabulary training.

Table 1 Percentile Ranks of ACT Test Standard Scores

Competence Level	SS	Eng. Test Men	Eng. Test Women	Eng. Test Total	Math. Test Men	Math. Test Women	Math. Test Total	Soc. S. Test Men	Soc. S. Test Women	Soc. S. Test Total	N. Sci. Test Men	N. Sci. Test Women	N. Sci. Test Total	Composite Men	Composite Women	Composite Total	SS
	36																36
	35																35
	34																34
	33																33
	32				99		99										32
	31				98		98	99	99	99	99		99				31
COMPETENCE	30				97	99	98	98	98	98	98	99	98				30
LEVEL	29				96	98	97	96	96	96	95	98	96	99			29
	28		99		94	98	96	94	94	94	93	97	94	98	99	99	28
	27		98	99	92	97	94	91	90	91	89	94	91	97	98	97	27
24.6%	26	99	96	98	89	95	91	87	87	87	84	91	87	95	96	95	26
	25	98	94	96	85	93	88	83	82	83	79	87	82	91	93	92	25
English 1A	24	96	89	93	81	91	85	78	77	78	73	82	77	67	90	88	24
	23	93	84	89	76	89	81	74	73	73	68	78	72	82	85	83	23
Baccalaureate level	22	89	77	85	71	86	77	68	67	67	63	73	67	76	80	77	22
	21	85	75	79	65	82	72	61	60	61	56	68	62	69	73	71	21
	20	79	61	72	60	78	67	55	54	55	52	61	56	61	66	63	20
32.5%	19	72	52	64	55	75	63	49	48	48	46	55	49	54	58	55	19
English 51	18	63	42	55	49	69	57	42	42	42	41	49	44	46	49	47	18
	17	54	33	46	41	62	49	37	36	37	36	43	39	39	41	40	17
A Writing Course	16	46	26	38	34	54	41	32	30	31	30	37	33	32	34	33	16
	15	39	22	32	26	45	33	27	26	26	25	31	27	25	27	26	15
42.8%	14	32	17	26	20	36	26	22	21	22	20	25	22	20	20	20	14
	13	27	13	21	15	30	21	19	18	19	16	20	18	15	15	15	13
	12	22	10	17	11	23	16	16	15	15	13	16	[illegible]	11	11	11	12
English 52	11	17	8	14	8	18	12	13	12	12	10	12	11	8	8	8	11
	10	13	6	10	6	14	9	10	9	10	7	8	8	5	5	5	10
	9	9	4	7	5	11	7	8	7	7	5	6	5	3	3	3	9
Reading & Vocabulary	8	7	3	5	3	8	5	6	5	6	3	4	3	2	2	2	8
	7	5	2	4	2	6	4	4	4	4	2	2	2	1	1	1	7
	6	3	1	2	2	4	3	3	3	3	1	1	1				6
	5	2		1	1	3	2	2	2	2							5
	4	1				2	1	1	1	1							4
	3					1											3
	2																2
	1																1
	Mean	16.0	18.4	16.9	18.7	15.8	17.6	18.7	18.9	18.8	19.4	18.1	18.9	18.3	18.0	18.2	
	S.D.	4.9	4.8	5.0	5.8	5.7	5.9	6.3	6.2	6.2	6.1	5.7	6.0	4.9	4.7	4.8	

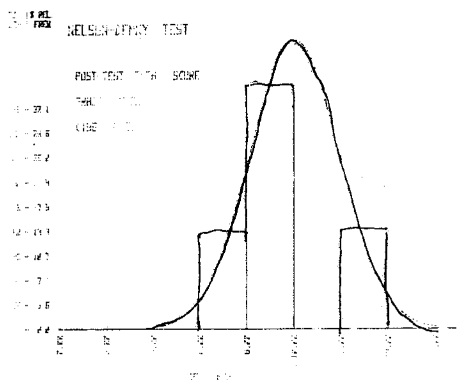
Number of Colleges 118
Number of Students (Men) 33,737 (Women) 21,385 (Total) 55,122

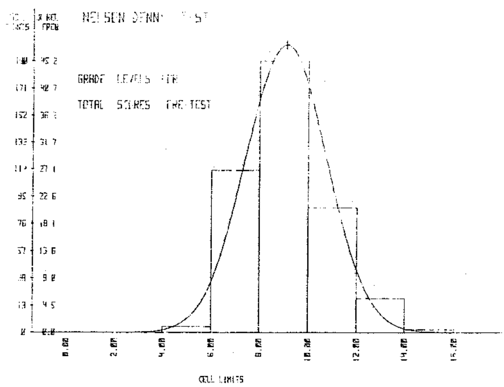
ALL REGIONS, LEVEL 1

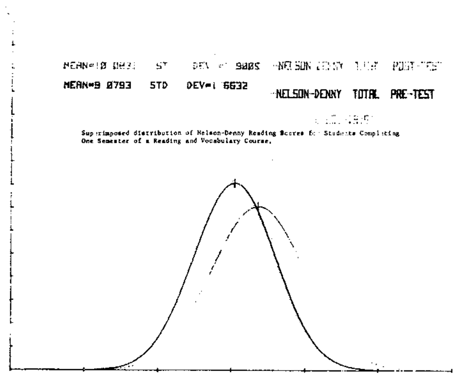
Classification of English course competence levels for West Hills College compared on a national ACT scale.

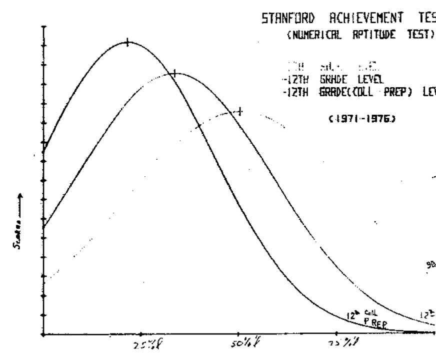
The reading level of the students at West Hills College, with ACT Achievement score of 14 or less (approximately two-fifths of our community college enrollment), was analyzed by studying ten years of Nelson-Denny Reading Test scores. The Nelson-Denny[2] was given before and after the student completed a remedial reading course. Computer analysis of the Nelson-Denny reading scores indicates a pre-remedial mean grade reading level of 9.08; post-test 10.08; a gain of one grade level accomplished in one semester of instruction in the reading and vocabulary course. The initial pre-test scores of all West Hills College students for the ten-year period in the low-level category (an ACT score of less than 14) had a mean score of 8.1 grade level. Many of these students did not enroll in/or finish the reading course and post-test data are not available.

Futher measurement of the abilities of these students was made by using the Stanford Achievement Test of Numerical Competence.[3] These scores indicated a 9.0 grade level, and were approximately at the 20th percentile rank for the 12th grade college prep level students. Quantitative test measurements for our students with ACT test scores of 14 or less qualify them at the achievement level of ninth graders. For many reasons, a vast number of high school students stop intellectual development at the ninth grade level, and have only a limited degree of Piaget's "conceptual" level of psychological development. Unless the student is merely unprepared (no psychological problems), it is doubtful whether the students with low academic achievement scores will progress to the "conceptual" level, or if the educational system has the means to effectively move the student upward in conceptual development. The West Hills College ten-year mean for a one-grade level literacy improvement with one semester of English instruction would not qualify the low-level student to achieve in courses requiring baccalaureate level competency.









The baccalaureate chemistry courses are primarily oriented to the quantitative nature of chemistry and have their greatest success with those students who have scored in the upper part of the general achievement scale in their high school classes. It is doubtful, because of their theoretical and quantitative nature, that chemistry courses of the above orientation can serve the vocational and the general education needs of the nonbaccalaureate-oriented student.

In many cases, students in the low-scoring academic category will not have the background to appreciate the scientific or conceptual approach. Students stay away from chemistry and other sciences because they believe the material does not have applicable meaning to their vocational goals. There is an abundance of preparatory texts on the market. The theoretical and quantitative nature of these texts have little appeal to the skill-oriented achievers, and leads them to select courses other than chemistry to fulfill their science requirement.

To meet the needs of students with ACT scores of 14 of less, West Hills College developed a one-semester introductory chemistry course for applied technologies. It was designed to provide an essential knowledge of applied chemistry which will motivate and train the nonacademic, underachiever, reluctant learner, the unprepared, or whatever classification the community college uses, to become interested in science. The course intends to serve students who do not have the potential to succeed, do not qualify, or who would be perceived as having no future desire to enroll in a college level chemistry course. The material is essentially oriented to provide applied value for those students enrolled in vocational programs such as automotive and diesel mechanics, agriculture, electronics, business, health services. It also serves to illustrate how chemistry can change our culture. The course satisfies a natural science requirement for an Assosicate in Art degree.

Introductory chemistry for the applied technologies can be taught in a way which will prepare the skill-oriented students to develop a "liking" for science. Students, who achieve at the lower one-third expectation of the college norms, function, in terms of Piaget, at the "concrete operational" level. The educational philosophy in the West Hills course is to build on personal confidence gained by the student through observations which are known confirmations of experimental fact and familiar applications. Instruction is built on positive attitudes toward the learners and on their active involvement in the learning process. The course creates the possibility of aiding the student's search for personal identity and competence, and these enhancement factors are highly significant.

The profile of the students who enroll in this course indicates they have little numerical competence. In fact, it is desirable to have students enrolled who have had no algebra or previous chemistry. Competition from academically experienced students is likely to intimidate those of lesser ability. For the most part, the low academic achievers have been counseled into skill-courses where the main learning activity has taken place during the class instructional period, and there is minimal home work or study required. This level of student expects the same pattern of teaching and learning in the science courses and will continue a passive attitude toward academic study away from the classroom.

The beginning students in science identify with practicalities. A thing works or it does not. The laboratory part of the course provides the skill-oriented student with accomplishments, satisfaction and security through immediate evidence. The course gives him an identity with success and ultimately aids him in recognizing employment goals. Thus, by experiencing some basic fundamentals of science, educational and career goals become more realistic and obtainable.

The instructor in the lecture and especially in the laboratory should be sincere and patient. These students need continuing reassurances and skill demonstrations. Emphasis on good laboratory skill and technique is essential. The lectures teach principle and application and each lecture session requires the student to perform written exercises during the lecture period. Unfinishes work is returned at the next class period for evaluation. The course is void of the usual stoichiometric calculations in both the lecture and laboratory.

The material for the course was developed from my own notes and journal references. The laboratory assignments are concerned with experiments on "anti-freeze"; milk products; acids, bases, salts; pH; water softening and purification; graph interpretation; soil chemistry, reactions of household chemicals, analysis of fruit juices for vitamin C; identification of ions commonly assoicated with the above topics, and the identification of bacteria. Many of the laboratory experiments require the use of an electronic calculator for evaluating experimental data.

INTRODUCTORY CHEMISTRY FOR APPLIED TECHNOLOGIES

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INTRODUCTORY CHEMISTRY FOR APPLIED TECHNOLOGIES

LABORATORY EXPERIMENTS

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3. The Measurement of Volume in the Metric System
4. Calibration of the Volume of a Test Tube
5. Calibration of the Volume of a Tablespoon in the Metric System
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7. Weighing- Determination of the Amount of Zinc on Galvanized Iron
8. Calibration of the Volume of a Medicine Dropper

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29. Plate Count for Bacteria

-Sprectrochemical Methods

30. Iron in Vitamin Pills
31. Phosphates in Household Detergents, Soils, or Urine

The nonacademic achiever, for the most part, may be unmindful of the many technical opportunities available in industry. He is not likely to take the initiative to obtain information on job availability and criteria from employer interviews, or from such resources as the public or school library, or the school counselor. Thus there exists the need for providing the students with a direct exposure to the many possible technical jobs. The course offers opportunities for field trips which expose the students to many occupational options. Our excursions have taken us to milk processing plants, hospital laboratories, food processing plants, fertilizer plants, water and wastewater purification plants. The students who enter this course are expected to develop saleable skills, use reference sources, and follow written instructions.

Our twelve-year experience with this course suggest it serves the student who desires knowledge of applied chemistry related to the needs of a technological society. It has opened up educational as well as job opportunities. This course may also function in a subtle manner whereby the students, as citizens, increase their understanding or the need for basic science in society.

REFERENCES CITED

(1) American College Testing Program, "College Student Profiles", 1966, Iowa City, Iowa, p. 34.

(2) Nelson, M. J., Denny E. C., Nelson-Denny Reading Test, Houghton Miffen Company, 1960, Boston.

(3) Gardner, Eric R., et. al., Standford Achievement Test-Numerical Competence Test, Harcourt, Brace & World, inc., New York, 1965.

A LIMITED SELF-PACED, INDIVIDUAL MASTERY LEARNING SYSTEM

Jerry L. Krause
Hibbing Community College
Hibbing, Minnesota 55746

Presented to a session at the Seventy-Fifth Two Year College Chemistry Conference, Normandale Community College, Bloomington, Minnesota, May 8, 1982.

Encouragement to design a limited self-paced, individualized, mastery learning system was received from Professor John Roueche's presentation at a northeastern Minnesota community college staff development day and his book A Modest Proposal: Students Can Learn. The laboratory program was patterned after that designed by the chemistry faculty at Hamline University. The reasons for attempting this innovation are evident in the following objectives for the innovation: (1) increase student performance, (2) increase student success, (3) to provide flexibility so that adults with full-time lives would have a chance of succeeding in chemistry.

Figure 1 shows the descriptions for the courses in which this method of instruction is being used. Chemistry 111 and 124 will be examined in most detail since these courses have the greater number of students.

Figure 2 compares the traditional format with the innovative one.

Figure 3 presents the statistical data for Chemistry 111 and Figure 4 presents that for Chemistry 124. The new format was first used fall quarter, 1980. After this first quarter, one procedural adjustment was made in both courses. The pace of laboratory work was tied to that of testing and tests not taken by the slow schedule (which allows the class to be completed over a two-quarter period) were recorded as zero. This change contributed to the increased success in Chemistry 111 for Spring 1981 and Fall 1981. Because at our school there is a significant percentage of students who register, but put forth such little effort that it is difficult to say they honestly tried, a second rate of success is calculated which only counts students attempting the class who take more than one-fourth of the exams.

It is obvious that the student performance did dramatically increase. It is equally obvious that the rate of success did not, although it should be recognized that in Chemistry 111 the rate is presently up to previous levels. It cannot be stated unequivocally the increase in student performance in Chemistry 111 is due to the method of instruction as the text book was also new Fall 1980. However, in Chemistry 124 the method of instruction must be the reason for the improved performance since the same text, similar tests, and a higher grading scale were used. For the first time students who did not succeed (complete) could not say the chemistry was beyond them as they had averagee or above average scores on the tests taken.

Figure 5 shows the basic laboratory program for Chemistry 111 and 124. As stated earlier, only when the laboratory was done correctly was completed. Besides being a confidence builder, the mastery of these basic techniques creates the true image of scientific research; it only has value if it is done right.

That the student had trouble with the freedom given to them is understandable. It is not possible to typify the students who had the greatest difficulty. Some young (18-20 year old) and some older (25-50) finished the course before the end of one quarter. A similar percentage of each group didn't finish the course. It is obvious the Chemistry 111 students seem to do better than the Chemistry 124 students. This is not so understandable. It is now recognized that it was an error not to offer three hours per week of lecture in Chemistry 124 as was done in Chemistry 111, but even this does not explain why the Chemistry 111 students (a majority never had a chemistry course) coped much, much better than the Chemistry 124 students in the same individualized laboratories.

Figure 6 offers a possible explanation of the Chemistry 124 students' lack of success. It is possible that they do not have sufficient time to do the work required by this course.

Not only are they averaging 16.7 credits, but these credits most likely are in those courses considered to be most academically difficult.

In conclusion, the limited self-paced, individualized, mastery learning system reported in this report does give most students with desire and a willingness to work a better opportunity to realize their potential than did the traditional method of instruction.

Figure 1

Chem 111 Aspects of Chemistry

An introductory course in chemistry consisting of topics in general and organic chemistry requiring a minimum of mathematics. Emphasis is on contemporary application.

Designed as a liberal arts offering for general education and allied health science student needing four credits in chemistry. Lecture: 3 hours per week; Lab: 2 hours per week; Recitation: 1 hour per week. Prerequisite: None. A Chemistry 124 - Chemistry 111 sequence may not be taken to meet the laboratory science requirement.

Chem 112 Aspects of Chemistry

Continuation of Chemistry 111 consisting of selected topics in organic, consumer and biological chemistry and contemporary technical problems.

Designed as a liberal arts offering for general education and allied health students needing eight credits in chemistry.

Chem 124 General Principles of Chemistry

Basic concepts of Chemistry, atoms, molecules, and ions; chemical formulas and equations, thermochemistry, physical behavior of gases, electronic structure of atoms, cnemical bonding, physical properties of molecular substances; nature of organic compounds; liquids and solids; changes in state.

Designed for those students whose program requires two or three quarters of introductory chemistry. These students typically are in health related programs, engineering, or science. Lecture: 4 hours per week; Lab: 2 hours per week; Recitation: 2 hours per week. Prerequisites: High school algebra or equivalent.

Chem 125 General Principles of Chemistry

Solutions; colloids; chemical kinetics; chemical equilibrium; participation reactions; acids and bases; oxidation and reduction.

Designed for those students whose program requires two or three quarters of introductory chemistry. These students typically are in health related programs, engineering, or science. Lecture: 4 hours per week; Lab: 3 hours per week; Recitation: 1 hour per week. Prerequisite: Chemistry 124 or equivalent.

Figure 2

	Traditional	Self-paced, individualized, mastery learning system
Ch 111	30-50 minute lectures	30-50 minute lectures
	8 or 9 - 110 minute laboratories (24 student limit)	5 - Individualized laboratories More time allotted for one on one interaction
	10-50 minute recitations (24 student limit)	
	Tests taken once at scheduled time during lecture periods.	Tests taken outside of lecture period at students' timing. May be repeated once.
	Laboratories done once; graded on scale 0-20.	Laboratories repeated until done correctly.
Ch 124	40-50 minutes lectures	10-50 minute lectures
	10-50 minute lecture recitations	5 - Individualized laboratories and final
	8 or 9 - 110 minute laboratories (24 student limit)	Much time allotted for one on one interaction.
	10-50 minute laboratory recitations	
	Tests taken once at scheduled time during lecture periods.	Tests taken outside of lecture period at students' timing. May be repeated once.
	Laboratories done once; graded on scale 0-20.	Laboratories repeated until done correctly.

Figure 3

Chemistry 111

	(F-81)	(S-81)	(F-80)	('79)	('78)
Rate of Student Success (10th day)	32/44 (73%)	12/20 (60%)	31/58 (53%)	33/44 (75%)	29/48 (60%)
Rate of Student Success (more than 1/4 work)	32/38 (84%)	12/13 (92%)	31/45 (69%)	33/39 (85%)	-----

Grades Earned:						
	A	14	5	18	3	6
	B	11	6	10	14	11
	C	5	1	2	10	9
	D	2	0	1	6	3
Average Percentage Scores of Students not Earning Credit		70%	76%	71%	40%	---
Percentage of Students earning Credit in one Quarter		50% (22/44)	50% (10/20)	36% (21/58)	82% (32/39)	60% (29/48)

Figure 4

Chemistry 124

Rate of student Success (10th day)		21/32 (66%)	30/57 (53%)	27/36 (75%)	40/51 (78%)
Rate of Student Success (more than 1/4 work)		21/29 (72%)	30/41 (73%)	27/35 (77%)	40/46 (87%)
Grades Earned					
	A	6	14	3	6
	B	7	14	10	9
	C	5	2	10	15
	D	3	0	4	10
Average Percentage Scores of Students not Earning Credits		71%	85%	53%	54%
Percentage of Students earning Credit in One Quarter		9% (3/32)	23% (13/57)	75% (27/36)	78% (40/51)

Figure 5

Laboratory

Balance

15 separate wieghings
Liquid transfer
Solid transfer

Pipet & Volumetric Flask

Use of graduated pipet
Use of volumetric flask
Use of transfer pipet

Volume of gas as a function of temperature and graphing

Use of thermometer
Use of meter stick
Use of Bunsen burner

Analysis of data to find straight line plot

Possibilities: y vs x
y vs log x
log y vs x
log y vs log x

Titration

Make NaOH solution
Standardize NaOH solution
Determine equivalent weight of solid acid

Library Research

Primary article is partial requirement

Figure 6

Fall - 1981

Chem 111	12.9 credits	45% p.t.	15.5 hours/week
Chem 124	16.7 credits	50% p.t. 5% f.t.	16.6 hours/week

Strategies for Mastering Introduction to Chemistry

Martha Thompson and LeRoy Breimeier
Vincennes University
Vincennes, Indiana 47591

Presented to a session of the Seventy-Third Two Year College Chemistry Conference, Central Piedmont Community College, Charlotte, North Carolina, December 4, 1981.

Abstract - "Strategies for Mastering Introduction to Chemistry"

There will always be some students who can't or don't earn a passing grade in chemistry; however, there are students who can be taught how to read and study chemistry which will improve their knowledge of and letter grades in chemistry.

The reading and chemistry departments at Vincennes University designed a reading course paired with Chemistry 103 to improve the reading and study skills of students who have

low academic records. The course teaches students how to get the most from lectures, textbooks, and laboratory procedures. This is accomplished in a two-credit hour, Reading in the Content Area course, which teaches the processes most applicable for learning chemistry.

Briefly, the reading course teaches students how to:

1) organize study materials and study time
2) formulate attitudes which enhance learning
3) take notes which improve studying and reviewing
4) read and mark the textbook and laboratory manual
5) memorize and retain the language and terminology of chemistry
6) study for and take tests
7) use a calculator

The pilot project of the paired reading and Chemistry 103 course included 12 students in each, experimental and control groups. Students were matched on their scores on a cloze test. The results of the t-test $(t-(11)=11.79)$ indicated that the experimental groups was far superior to the matched control in performance in Chemistry 103.

Chemistry instructors, will you please participate for a few minutes so I can demonstrate the basic premise of a paired course.

Please pretend you are students enrolled in Chemistry 103. The first day of class, the chemistry instructor enters the room, hands out the course outline, explains the grading system and briefly describes the chemistry course. At the end of the hour, he introduces the reading instructor. She begins:

How many of you have never before taken a chemistry class? Raise your hands.

You may have looked through the textbook and you now have some doubts about understanding what you tried to read from that book.

If you would like to insure your success in Chemistry 103, you may want to enroll in this new course: "Reading in the Content Area".

This 2-credit hour course will show you how to get the most information from your textbook, the lab manual, and the lecture. You will also learn how and when to study.

If this course sounds useful to you, please come to the first class meeting, and I'll explain in greater detail what you can expect to learn in Reading in the Content Area. We will meet next hour, 9:00 in Rm. 165, Humanities Building.

The following questions were asked by students the first class meeting.

Question 1: I have trouble taking notes. Will Reading in the Content Area help me?

Answer: Yes; first, I will attend the chemistry lectures and take notes. I will display my notes on the opaque projector and we'll compare notes. Secondly, I'll teach you how to take notes so you can

	review and use your notes.
Question 2:	I tried to read this chemistry book, and I can't remember or understand what I'm reading.
Answer:	There are some very specific ways to read this textbook and you will learn how to use your textbook and how to mark or underline the information you need to learn.
Question 3:	Someone told me I'd have to memorize the periodic table. Is that true?
Answer:	First, let me say that Mr. B., the chemistry teacher, is the only person who can answer that question. You will need to learn certain elements, and you may have to memorize. You will learn how to improve your memory and how to use mnemonic devices to memorize. The purpose of the reading course is to teach a process for reading, studying and learning and to show you how to apply this process to your chemistry course. The reading course will also help you learn the precise definitions for the terminology for chemistry. There will be a tutor available in Study Skills also to help you with the math computations. Thank you for participating.

The above illustrates how we interest students in taking the paired course. Instruction in the chemistry class continues as usual with two exceptions: 1) a reading instructor attends every chemistry lecture; 2) a cloze test is administered to all chemistry students for evaluation of the paired course.

The cloze test can be used to estimate the students' ability to read and understand the textbook you are using for your chemistry course. The cloze test included is a passage taken from 2nd Ed., Chemistry, An Introduction, by Sydney B. Newell, pg. 64. (Attachment A & B)

To construct a cloze test, you select a 200+ word passage from the textbook you use. Leave the first sentence intact. Delete every N^{th} word and leave the last sentence intact. Score by accepting only the exact word as correct. According to Bormuth, 40-50% correct indicates that a student can understand the textbook.

This cloze test was administered to the chemistry students, and the score on this test was used to match students for evaluation of the effect the paired reading course had on the student's final grades in Chemistry.

There were 12 students in each group (exp. & matched cont.). Final letter grades in Chem. 103 were converted to a scale of A-4, B-3, C-2, D-1, F-0, and W-0 and a t-test for the matched groups was performed by Dr. Frank Friedman, Inst. Researcher, Vincennes University. The results of the t-test ($t(11)=11.79$) indicated that the experimental group was far superior to the matched control in performance in Chemistry 103.

The evidence is inconclusive, but there will be four experimental paired courses to evaluate Spring, 1982.

Briefly, the content of the reading course teaches students how to:

1) organize study materials and study time
2) formulate attitudes which enhance learning
3) take notes which improve studying and reviewing
4) read and mark the textbook and laboratory manual
5) memorize and retain the language and terminology of chemistry
6) study for and take tests
7) use a calculator

Attitude and Organization

As you can see, a very positive attitude is used to interest students in the paired course, Reading in the Content Area. Students are encouraged the first class meetings to band together, support each other, get together to study and talk chemistry. The more time they think and discuss chemistry, the more frequently they will hear the vocabulary and concepts which they need to learn. Students are told to sit up front during lecture to see the instructor if they have questions, to attend every lecture and lab, to attend review sessions and to work with a tutor. The harder they work, the more they enjoy learning. Everything to insure success is done at the beginning of the semester.

Success can only be accomplished for students who can immediately grasp the necessity of studying at regular times, reviewing, practicing solving problems and/or testing themselves.

The students are told ways to organize their materials. There was a time that I thought this was only busy work and nonsense, but I have observed too many studnets trying to study who couldn't assemble the materials they needed to study. In line with organized study, students are taught how to take notes.

Taking Notes

The chemistry lecture is crucial to understanding and learning. The students are taught a systematic way to take notes. The Cornell System was taught because this system builds in the necessary review.

Briefly, students are required to use loose-leaf paper and a binder rather than the spiral notebooks. I really did not realize how important this could be until I experienced using the system.

(Overhead)

The system is explained and illustrated in Attachments C, D, & E.

For several class meetings we used the opaque projector to compare notes. We also practiced selecting key words for the left margin. This was a review session of 5-10 minutes during each class meeting until the habit was established.

Reading Chemistry Textbook

Study guides are probably the best aid you can give students to encourage reading the textbook. The sample study guide (Attachments F & G) prepared by the chemistry instructor also serves as a general outline for lectures. The students are told to either write out answers to study guide or indicate page(s) of textbook and/or lecture notes where the answers can be found. Students were also required to complete problems at the end of the chapters as assigned on the study guide.

A very few specific techniques for reading and marking the textbook were taught. Examples are:

1) Terms were circled and definitions underlined. (Attachments H & I). The words: is, are, called and means, indicate a definition follows. Teaching students a systematic procedure for underlining eliminates the textbook with whole pages highlighted. Underlining should provide for quick review, and only key words should be underlined.
2) Visual imagery can be taught because students must learn concepts which are usually more abstract than any other concepts they have previously encountered. (Attachment J). The passage should be read orally and force students to visualize.
3) Cause and effect is first taught by using simple paragraphs. Notation of cause and effect is like the sample enclosed. (Attachment K).
4) Reading laboratory procedures requires an awareness of the syntax of directions and then to pre-read and then refer to procedures during the lab work. The sample enclosed (Attachments L, M, N, & O) may be sold to the students. I have used S.Q. 3R with the chemistry students. SQ3R is a study method. I will continue to use it with chemistry students but simply write the abbreviation as SQR_3 - Survey, Question, Read, Recite, and Review.

Memorizing and Using Mnemonic Devices

Students who have never studied sciences have a new language to learn to read, write, and speak. The chemistry instructor cannot lecture without using the language and this forces students to acquire the language quickly. We found that memorizing the symbols and elements was imperative. Memorizing definitions of terms may not be in agreement with your desire to achieve understanding, but there must be at least a thimble of knowledge before students can begin to understand. Actually, teaching students how to memorize are techniques which you probably use.

The memory strategies include:

1) Acquire an interest
2) Select a manageable amount to learn - 7 is our magic number Wm. Jones - The essence of genius is knowing what to overlook. We practice selecting what is to be learned for long-term retention.
3) Learn to pay attention. Concentration and getting it right the first time are crucial. Students can be shown ways to improve listening and concentration. Terms often are not defined correctly because of carelessness.

4) Information can be organized to remember. A simple illustration of this is to tell someone to purchase:

cottage cheese	eggs	butter
milk	lettuce	hamburger
celery	chicken	corn

If you were told the same items in categories, they are easily remembered.

meat	dairy	vegetable
chicken	cottage cheese	celety
hamburger	milk	lettuce
	butter	corn
	eggs	

5) Recite and review frequently what you want to remember. Speak out loud - type it - write it. Drill flash cards are used.
6) Consolidate and review notes at regular times and select key words to remember. Key words can work like a magnate for remembering other information.
7) Mnemonic Devices - students enjoy making up these verses and words. "multiple disaster victims" = $\frac{M \times D}{V}$

Examples:

Oasis - 4 most common elements of earth's crust
Oxygen
Silicon
Aluminum
Iron

OCHN - 4 most common elements of the body
O oxygen
C carbon
H hydrogen
N nitrogen
These are fun and do, at least, stimulate interest.

Taking Test

There are a few tips which students need to be reminded of before they take the first test.

1. Look over the entire test.
2. Anwser all questions.
3. Anwser questions you know first.
4. Pace yourself.
5. Use all the time allowed.
6. Re-check math calculation if time allows.
7. Take a deep breath.

A series of slides from the University of Minnesota shows students how to be test-wise. The words which are absolute determiners in T-F items are taught. Examples: always, never, double negatives, ect. The multiple-choice, completion, and matching are included in the slide series. This year I will teach students to write the key words to anwser the who, what, when, where, why, and how in the margin of the test and then write the sentences to answer the essay question.

As a student in the chemistry class, I experienced the pangs of test anxiety and Connie would nearly freez up during test. The counseling center gave a demostration and lecture during the reading class in how to overcome test anxiety.

After the first chemistry test, I asked the students to write about how they had studied. Four samples (Attachments P-S) are included. Two, Sarah and Chris were B-A students, and you can see from the remarks how they were organized. The other two samples were mothers with children and enrolled in basic math. Kim did pass, and she did learn more about organizing her materials. Connie had to withdraw but did enroll in the summer and passed.

A good way to review for a final comprehensive test is to have students make up tests. The last few class meetings, we divided the lecture notes by dates and each student wrote questions over those notes on ditto masters. The copies were made, students answered the questions and checked their answers.

Using the Calculator

This year, I intend to include a short session or handout on how to use the calculator. Students will also be told to buy a calculator like the TI30.

SPACE AND CHEMISTRY

Solar Mesosphere Explorer to Study Ozone

James Stuart
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California 91103

Presented as a Keynote Address to the Seventy-fourth Two Year College Chemistry Conference, Clark County Community College Las Vegas, Neveda, March 26, 1982

Changes in the density of ozone in Earth's atmosphere that occur as a result of changes in the solar ultraviolet flux will be studied with instruments on board the Solar Mesosphere Explorer (SME), a satellite scheduled for launch on September 20, 1981.

Ozone is produced in the upper atmosphere from the association of atomic oxygen in a three-body reaction.

$$O + O_2 + M \longrightarrow O_3 + M \quad (1)$$

The atomic oxygen is produced in turn by the photodissociation of molecular oxygen by solar ultraviolet radiation of wavelength shorter than 242 nm.

$$O_2 + h\nu \longrightarrow O + O \quad (2)$$

The ozone is also photodissociated by solar ultraviolet radiation in the wavelength range between 200 and 310 nm. At this time of moderate solar activity, changes may occur in the solar ultraviolet irradiance in the course of a 27-day solar rotation. Instruments on the SME will simultaneously monitor these two regions of the solar spectrum and the distribution of ozone in the upper stratosphere and mesosphere, the region from 30 to 85 km. The altitude distribution of ozone will be measured simultaneously by three limb-scanning instruments: (1) an ultraviolet spectrometer measuring the back-scattered radiation between 255 and 310 nm, (2) an infrared radiometer measuring thermal emission at 9.6 μm, and (3) an infrared spectrometer measuring the 1.27 μm airglow emission arising from radiative decay of an excited state of O_2 that is the result of ozone photodissociation.

$$O_3 + hv \longrightarrow O_2(a^1\Delta_g) + O(^1D) \qquad (3)$$

Changes in the solar ultraviolet flux and ozone density may cause the temperture of the atmosphere to change. Temperature change also cause ozone changes since the rate of some of the chemical reactions, particularly reaction (1), are temperature dependent. The infrared radiometer on the SME will measure and pressure as a function of altitude by measuring the thermal emission from two portions of the 15 μm CO_2 band.

A further complication in tracing the effect of changes in solar radiation on the ozone density occurs in the upper part of the mesosphere. Solar Lyman alpha radiation at 121.6 nm which may vary significantly during a solar rotation is effective in photodissociating water vapor.

$$H_2O + hv \longrightarrow H + OH \qquad (4)$$

The products of water vapor dissociation react with ozone and atomic oxygen at these heights in a catalytic cycle which consumes ozone.

$$H + O_3 \longrightarrow OH + O_2 \qquad (5)$$

$$OH + O \longrightarrow H + O_2 \qquad (6)$$

To follow the cause and effect of this relationship, the solar ultraviolet spectrometer on the SME will measure solar Lyman alpha radiation and the infrared radiometer will measure the water vapor density in the atmosphere by measuring thermal emission in the 6.3 μm band.

In the upper stratosphere, water vapor is dissociated by reaction with excited oxygen atoms $O(^1D)$ atoms which are produced from the photodissociation of ozone, reaction (3).

$$H_2O + O(^1D) \longrightarrow OH + OH \qquad (7)$$

The hydroxyl radicals that are formed participate in a catalytic cycle in the upper stratosphere that consumes atomic oxygen and causes a reduction in the ozone density.

$$OH + O \longrightarrow H + O_2 \qquad (8)$$

$$H + O_2 + M \longrightarrow HO_2 + M \qquad (9)$$

$$HO_2 + O \longrightarrow OH + O_2 \qquad (10)$$

$$H + O_3 \longrightarrow OH + O_2 \qquad (11)$$

Changes in the amount of water vapor are therefore expected to cause changes in the ozone density in the upper stratosphere and mesosphere. The limb-scanning instruments on the SME will simultaneously measure the density of water and ozone as a function of altitude.

Nitric oxide and nitrogen dioxide form a catalytic cycle in the stratosphere which consumes ozone and atomic oxygen,

$$NO + O_3 \longrightarrow NO_2 + O_2 \qquad (12)$$

$$NO_2 + O \longrightarrow NO + O_2 \qquad (13)$$

Nitric oxide enters the stratosphere through the reaction of nitrous oxide with $O(^1D)$ atoms that are formed from the photodissociation of ozone.

$$N_2O + O(^1D) \longrightarrow NO + NO \qquad (14)$$

Nitrogen dioxide may be released in the strarosphere from the thermal decomposition of nitrogen pentoxide, an upper atmosphere reservoir of oxides of nitrogen.

$$N_2O_5 \rightleftarrows NO_2 + NO_3 \qquad (15)$$

A visible-light spectrometer will measure the density of nitrogen dioxide in the stratosphere by measuring the differential absorption of scattered sunlight at two wavelengths near 440 nm.

Energetic particle outbursts on the Sun lead to the penetration of charged particles into the mesosphere in the solar regions of the Earth (called solar proton or PCA events). These charged particles cause the dissociation of water vapor to create atomic hydrogen and hydroxyl radicals which catalytically destroy ozone. At lower levels these charged particles oxides of nitrogen from the molecular nitrogen and molecular oxygen of the atmosphere. If a significant number of solar proton events occur during the operational lifetime of the SME, the instruments will be used to determine the relationship between the magnitude of decrease in ozone and the flux and energy of the solar protons and the role of water vapor in the solar proton destruction of ozone.

The orbit of the Solar Mesosphere Explorer is planned to be a 540 km altitude circular orbit, sun-synchronous with the equator crossing occurring at 3 PM local time. The four limb-scanning instruments will view the atmosphere in the plane of the orbit. The satellite will be operated from a control center at the Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, Colorado. The SME investigator team consists of scientists from the Laboratory for Atmospheric and Space Physics and the Department of Astro-Geophysics of the University of Colorado, the National Center for Atmospheric Research, the National Oceanic and Atmospheric Administration Laboratory, and the Jet Propulsion Laboratory. The Solar Mesosphere Explorer mission is a progect of the National

Aeronautics and Space Administration and is managed by the Jet Propulsion Laboratory.

SOLAR MESOSPHERE EXPLORER

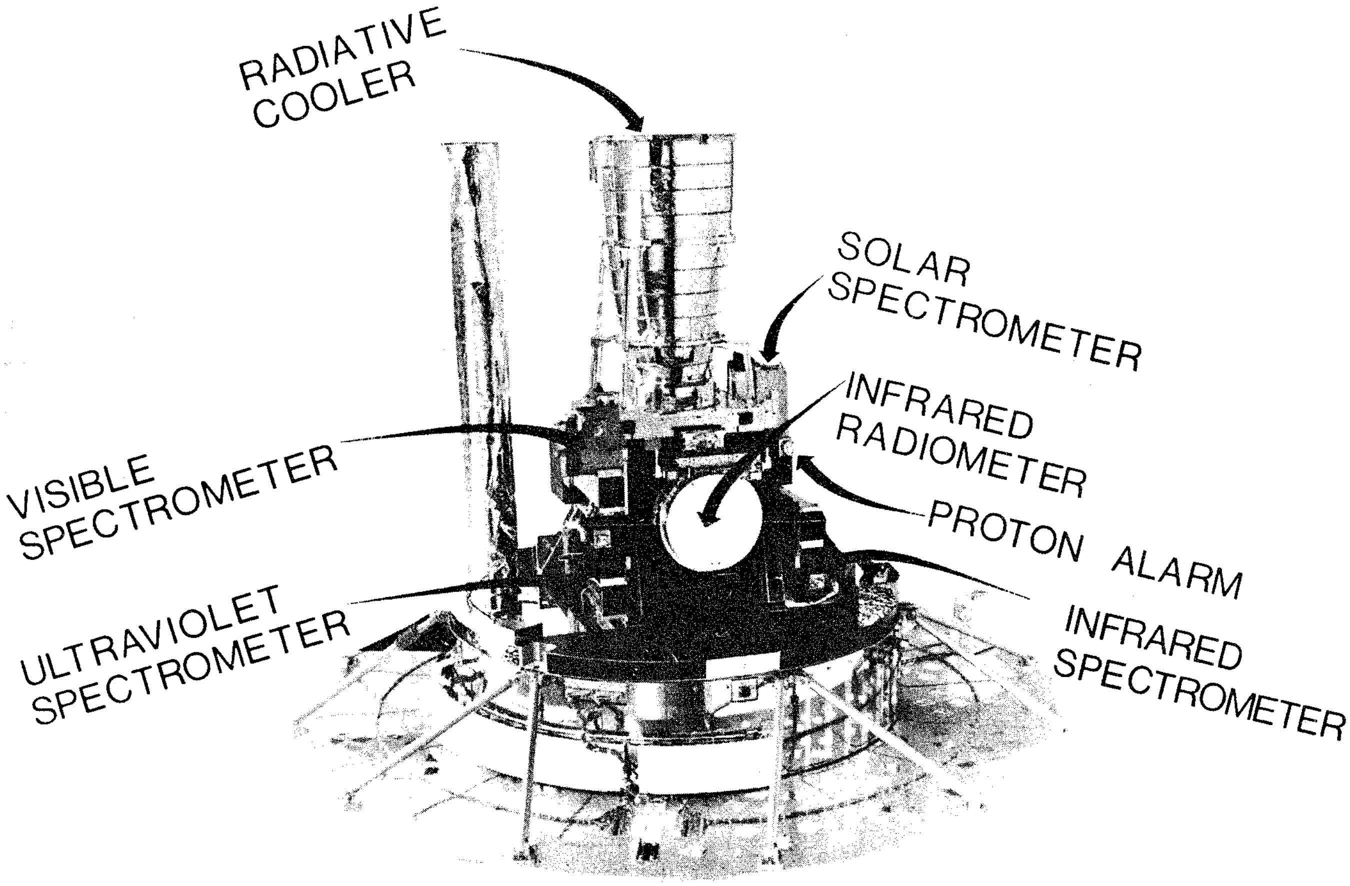


Figure 1. The Solar Mesosphere Explorer. Four limb-scanning instruments will be used to measure ozone, water vapor, nitrogen dioxide, temperature, and pressure. A solar spectrometer will measure the ultraviolet flux from the sun.

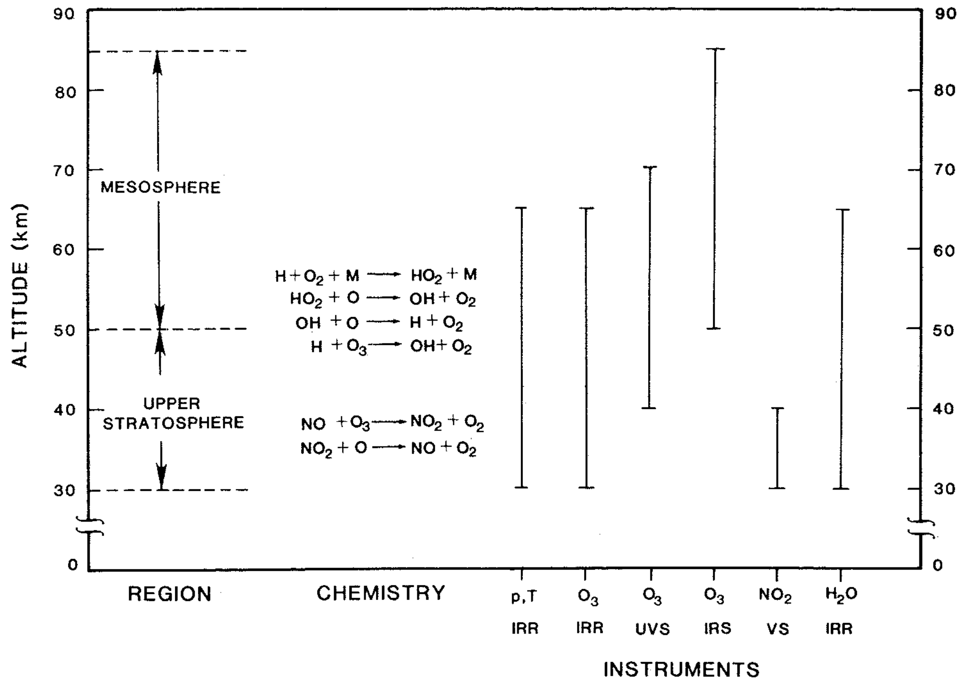


Figure 2. Altitude regions to be studied with the Solar Mesosphere Explorer. Vertical bars on the right show the altitude range covered by the limb-scanning instruments and the physical quantities which they measure. The chemical equations to the left show the altitude region where the nitric oxide-nitrogen dioxide and atomic hydrogen-hydroxyl-hydroperoxyl catalytic cycles occur.

Space Simulation: Outer Space on Earth

Jerry A. Walker
McDonald Douglas Astronautics
Huntington Beach, California 92647

Presented as a session on Chemistry in Inner and Outer Space at the Seventy-fourth Two Year College Chemistry Conference Clark County Community College, Las Vegas, Nevada, March 27, 1982.

INTRODUCTION

Space and space exploration have been a part of our lives now for over twenty years. Our telephone calls are routinely routed through communication satellites, television picture are beamed to us from long distances and we see from our armchairs the wonders of Mars, Jupoter and Saturn. Yet the environment of space is a very harsh one compared to our cozy earth with temperature extremes from hundred of degrees below zero to hundreds of degrees above boiling; radiation storms, solar flares and vacuum.

Because of this, for every new satellite or space vehicle that is launched thousands of hours of testing and simulation are run to ensure that the satellite or other space vehicle will be able to function in space. One of the important ways we do this is known as space simulation. In space simulation chambers we can expose a spacecraft to the vacuum of space, the extremes of temperature and other conditions all without ever leaving the ground.

WHAT IS AIR?

In order to understand the importance of space simulation we need to ask Bill Cosby's question: What is air? Or rather, is space just the lack of air?

Most commercial satellites are in orbit aroud the earth at an altitude of 22,300 miles. At this altitude the velocity that is required to keep the satellite in orbit exactly equals the rotational velocity of the earth. This makes satellite appear to be stationary above us. This orbit is known as a geosynchronous orbit, meaning in synchronization with the earth.

At this altitude the air pressure has decreased to well below $1x10^{-9}$ mm Hg or $1x10^{-11}$ pounds per square inch, which is the normal vacuum limit of most space simulation chambers. In order to put this into perspective it is helpful to consider the number of molecules per unit volume or the number density. Normal atmospheric pressure 14.7 pounds per square inch contains 10^{19} molecules per cubic centimeter. At $1x10^{-9}$ mm Hg there are 10^{7} molecules per cubic centimeter which represents a decrease of 10^{12} or one thousand billionth of normal atmospheric pressure. And at geosynchronous orbit the pressure is further reduced so that there are only a few molecules per cubic centimeter.

Yet at $1x10^{-9}$ mm Hg even though there are 10 million molecules in every cubic centimeter the mean free path or the average distance between molecular collisions has grown from 10^{-6} cm to 10^{9} cm or over 6,000 miles!

The general features of the atmosphere are shown in this slide. The shaded part of the figure represents the maximum and minimum particle concentration. It is important to note that the molecular density varies both with time and with the amount of solar activity. At an altitude of 200km or 280 miles or less the atmosphere is essentially air, a mixture of nitrogen and oxygen. Between 200km and 1000km the atmosphere is principally atomic nitrogen and oxygen which may be largely ionized during periods of high solar activity. Above an altitude of 1500km or 2000 miles the atmosphere consists of neutral atomic hydrogen, free protons, electrons and some helium.

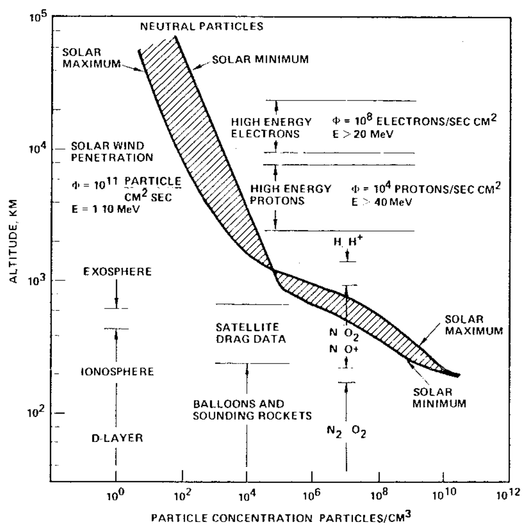
At an altitude of 450 to 650km (600-900 miles) the important transition from ionosphere to exosphere takes place. The exosphere is that region in which negligible molecular interactions occur. Molecules in the exosphere have the same kinetic energy throughout with their temperature varying 900°K at night to 1600°K during the day.

As you see on this slide, in general, the higher the altitude the higher the molecular energy; some particles have energies of over 40MeV. This is due to the decreasing denisty of the atmosphere. This next slide shows the solar spectrum in space vs on the earth. The measured intensity in space is given as 1353 watts/m^2 as opposed to a value on earth of around 800 watts/m^2. This means the 550 watts/m^2 difference is the energy absorbed by the atmosphere, some of which causes the ionization of the upper atmosphere. The extra solar intensity in space coupled with the rarefication of the atmosphere leads us to one other significant problem: heating.

When a spacecraft is in orbit around the earth it can see periods of intense heat and cold as it moves in and out of the earth's shadow. These temperatures can range from 300-400°F down to -300°F. These severe temperature extremes can induce high stresses in materials and components and due to the lack of air these parts can only cool by radiating to space - a very inefficient heat transfer mechanism. On the other hand when a spacecraft is hidden from the sun the spacecraft radiates all its energy to cold dark space (a perfect blackbody) and can reach temperatures of -300°F. And to make the situation worse if one side of the spacecraft faces the sun and one side faces deep space there can be a temperature difference of 400-500°F across the spacecraft. All in all an extremely uncomfortable environment.

VFR572

ATMOSPHERIC PROFILE



HOW IT'S DONE ON EARTH

This is the Space Simulation Laboratory of the McDonnel Douglas Astronautics Company, Huntington Beach, California. It is here and at other facilities like it across the country that space simulation work is done. In this facility there are 6 space simulation chambers ranging in size from these small 5' x 6' chanbers to our large 39' diameter sphere as shown here. These chanbers are basically stainless steel vacuum chambers, but they have some very unique characteristics.

All of these chambers are similar in design and operation so I'll use the large chamber to show how the space environment is simulated on earth. First some facts and figures about the basic chamber which is called S-1. The vacuum vessel is 39 ft in diameter and sits on a 1-1/2 million pound reaction block. It has a 30 ft diameter removable lid weighing 18 tons through which test specimens are placed in the chamber. There are 4 mechanical pumps and 4 oil diffusion pumps which can evacuate the chamber to a pressure of $1x10^{-8}$ mm Hg in approximately 8 hours. The mechanical pumps are 2 stage pumps and are used to reduce the chamber pressure to $5x10^{-2}$ mm Hg where the oil diffusion pumps take over.

The reason for having two types of pumps is due to the characteristics of the pumps and gas kinetics. The mechanical pumps are a displacement type pump similar to any common water pump, etc. They operate by moving a certain volume of air from one side of the pump to the other. This technique will only work, however, while there is a fairly high gas density; above approximately $1x10^{-3}$ mm Hg. In this region the gas flow can still be thought of as normal or viscous flow.

However as the pressure in a vacuum system is further and further reduced, the gas molecules tend to be evenly distributed throughout the entire chamber according to ideal gas law. Since the molecules are in constant, rapid motion, no concentration of molecules is probable. And since the number of molecules is constantly being reduced, the space between molecules must increase correspondingly. This is the reason that the mean free path or distance between collisions increases. Also as the pressure is reduced the number of molecules naturally being given off by the chamber becomes a larger proportion of the the gas load on the pump. At a certain point, depending on chamber surface area, chamber material and pressure an equilibrium is reached where the number of molecules being "outgassed" by the chamber equals the number of molecules pumped away by the mechanical pump. At this point, usually around $1x10^{-3}$ mm Hg a mechanical pump becomes ineffective.

This is where the oil diffusion pumps are used. An oil diffusion pump operates by spraying a stream of very low vapor pressure oil downward, physically colliding with air molecules and "pumping" them away. The exhaust of a diffusion pump generates a high enough concentration of molecules so that a mechanical pump can then exhaust them to the atmosphere which a diffusion pump cannot do by itself. S-1 has (4)

50,000 L/S diffusion pumps which are tied to (4) 1200 CFM mechanical pumps.

S-1 is also equipped with a liquid nitrogen shroud system which provides the "cold, dark space" environment. This shroud lines the interior of the chamber and is painted black on one side to absorb heat energy, very much like a solar panel on your roof. This shroud has an emittance of greater than 0.9, approaching the value for a perfect blackbody which absorbs all energy and reflects nothing. The shroud is liquid nitrogen cooled and can abosrb 300 KW of energy and still remain at temperature. As the shroud operates at liquid nitrogen temperature or -320°F an interesting side benefit occurs - the shroud acts like a pump! Since the distance between molecular collisions (the mean free path) at high vacuum is extremely large, statistically the chances that a molecule will strike the chamber wall or the shroud is far greater than the chance the molecule will collide with another molecule. Also because of the vapor pressure of most gas molecules if they reach liquid nitrogen temperature they condense or freeze. Therefore, as the gas molecules strike the shroud they freeze to the surface and although the molecules are still present in the chamber they are all on the shroud and out of the main volume. They have been cryogenically pumped away or "cryopumped."

Behind the liquid nitrogen shroud is another shroud which operates using low temperature helium gas and serves as the main cryopump for the chamber. This is because although the liquid nitrogen shroud will "pump" most condensible gases such as water vapor, air is made up of 78% nitrogen which the liquid nitrogen shroud will not pump. However at a temperature of 20°K (-423F) all gases except hydrogen and helium can be cryopumped. This system has a pumping speed of 3,000,000 liters/second for nitrogen gas.

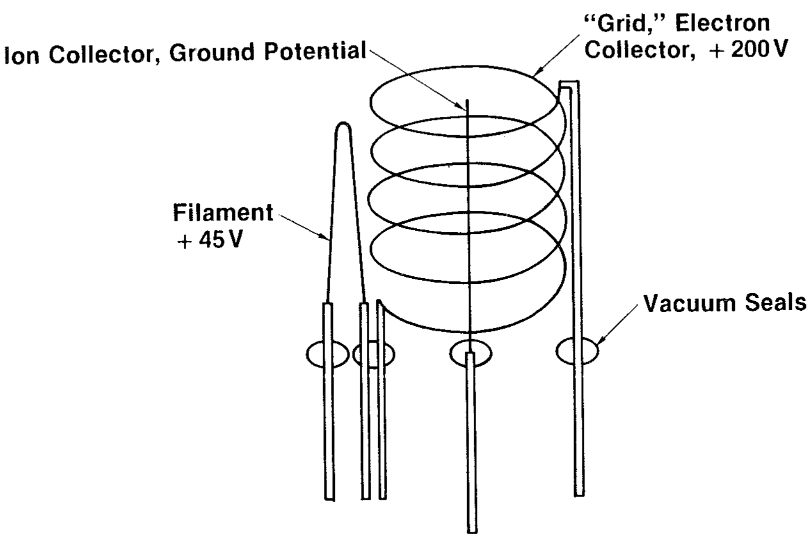
So in combination these 3 systems; mechanical pumps, diffusion pumps and cryogenic shrouds, the chamber pressure as shown can be brought from atmospheric pressure to $1x10^{-9}$ mm Hg or deep space vacuum in eight hours. S-1 has operated lower than this but normally operates in the $1x10^{-8}$ of $1x10^{-9}$ mm Hg range which leads to the question "How do you know what the pressure level is?". The pressure in the chamber is measured using a device known as an ionization gage. This gage has a hot filament held at 25-50 volts above ground potential. This generates electrons which are accelerated through the grid striking gas molecules in the grid volume and ionizing them. These are then attracted to the collector which is held at ground potential. The vacuum level is then proportional to the number of ions collected which is proportional to the number of molecules present in the ionization gage volume. So what we measure when we measure vacuum pressure is really the number of particles per unit volume or number density.

If this technique is further developed by accelerating the ions produced and then "aiming" them through four rods whose voltage levels and hence their electromagnetic field is varied with time, the ions can then be separated according to their mass as shown in this slide. This device is known as a quadrupole mass spectrometer or a residual gas analyzer and is used to determine the gas constituents remaining in the chamber after it has reached ultimate pressure. If a spacecraft is in the chamber any gases being given off or "outgassed" by the spacecraft can be seen. In this example the mass peaks of Amu's 14 and 28, from N_2 can be easily seen as well as other familiar gases. Amu 18 represents water vapor which is also seen in Amu 17 (HO^+) and Amu 16 (O^+).

In order to simulate the intensity of solar radiation in space, arrays of infrared lamps are used. These lamps provide a fairly good simulation of the sun in space as the vast majority of solar radiation falls in the infrared region. Most infrared lamps provide a frequency spectrum of light as shown in this slide. As you can see there is a frequency shift between the infrared lamp and the sun; so the simulation is approximate, not perfect. These lamps are used in large or small arrays depending on the size of the test specimen. They are used typically in two modes; to provide a constant solar input to a test article or to provide a variable input such as seen by a spacecraft orbiting the earth. In this way a spacecraft can be heated to high temperatures by the infrared lamps and then cooled to low temperatures by radiating to the liquid nitrogen shrouds.

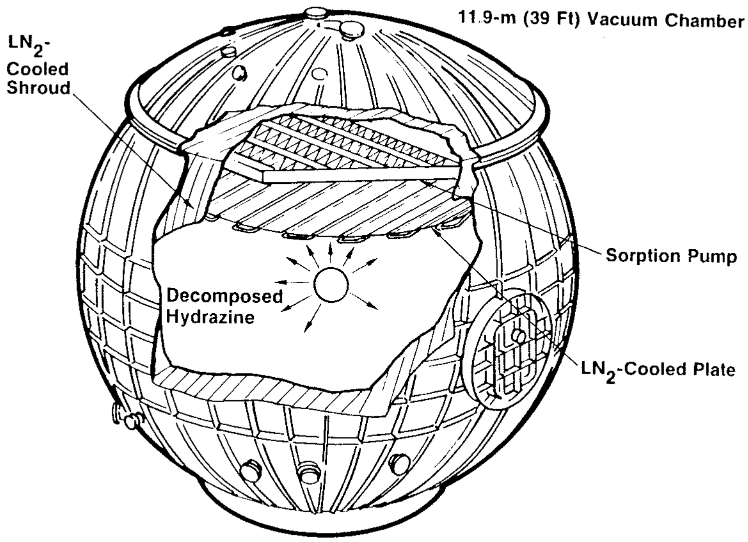
VFR571

IONIZATION GAGE



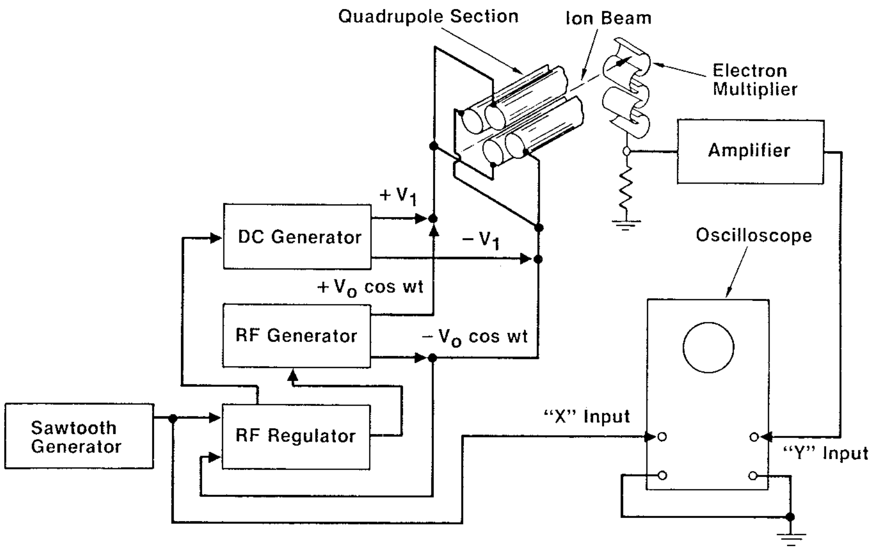
VFO827

FULL-SCALE CRYOPUMP



VFR617

QUADRAPOLE MASS SPECTROMETER

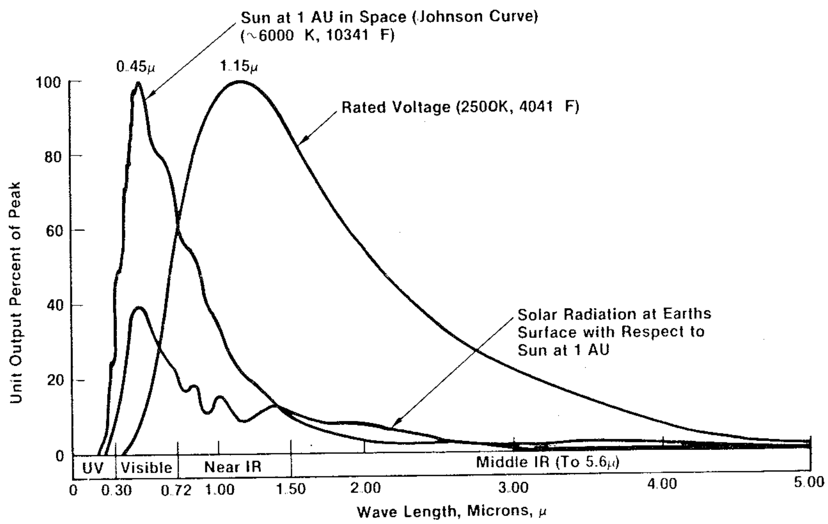


If a constant solar input is required at a closer frequency than an infrared lamp array can provide the chamber is equipped with 60 KW and 100 KW solar simulators. These simulators use large xenon lamps to provide a solar intensity like the sun in space. The simulators provide a large, highly uniform beam and the 60 KW simulator shown here can also be easily mounted on our smaller chambers for test uses.

The next slide shows a typical test specimen and the sequence it goes through in the laboratory. Originally, the laboratory was designed as a class 1000 clean area but has never really been used that way. These next two slides show a typical test specimen - our PAM-D spacecraft being lowered into the chamber for thermal vacuum testing. PAM stands for Payload Adapter Module and is designed to operate from the payload bay of the space shuttle. The space shuttle can only operate in low earth orbit due to lack of sufficient fuel and so in order to place a satellite in geosynchronous orbit (22,300 miles) a secondary spacecraft is required. The test of the PAM spacecraft was a 21 day, round the clock test and exposed the spacecraft to the thermal conditions it was designed to operate under. These modes were deep space facing or cold mode, earth facing or ambient mode and sun facing or hot mode. The white covering you see on the spacecraft is a multilayer thermal blanket designed to thermally isolate the spacecraft and its payload from the external environment. At the time the satellite is launched the upper part of the covering is opened to allow the satellite to leave. The rest of the PAM spacecraft is reusable and returns to earth with the shuttle.

VFR570

SPECTRAL OUTPUT



Another test recently run in S-1 involved a spacecraft which used hydrazine (N_2H_4) as its fuel. During the test the spacecraft's engine was to be fired several times. When the engine is fired the hydrazine fuel breaks down into its component parts nitrogen and hydrogen which the chamber pumping system must pump away. Since hydrogen's molecular size is the smallest of the elements and its vapor pressure is low, hydrogen is one of the most difficult gases to pump away. This test required the construction of a sorption pump, that is a pump which would absorb the hydrogen rather than attempt to freeze it out. This pump was made of lead wool and activated charcoal and was cooled to 20°K (-424°F) to allow it to operate most efficiently. With this pump and the chamber's normal pumping system the spacecraft's engine could fire for up to 3 minutes at a time while at space conditions.

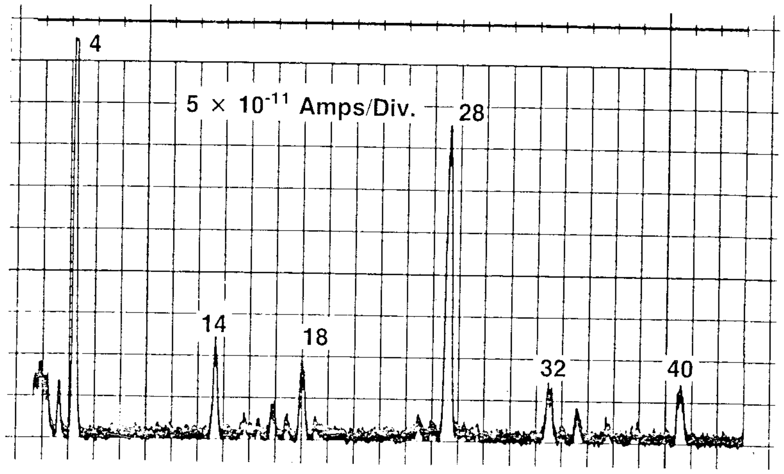
All operations in the S-1 chamber are controlled from this control room which overlooks the chamber itself. All vacuum instrumentation, shroud controls, infrared lamp power and test instrumentation is located here. Although the chamber has never had a person in a spacesuit inside, the chamber does have 2 airlocks for this purpose. For this reason S-1 has an emergency repressurization system which can bring the chamber from high vacuum to 5 psia in 30 seconds.

This computer controlled data acquisition system is used to monitor chamber temperatures and spacecraft data during test. The system is extremely flexible and can be used to monitor up to 400 channels of temperature of other data. As an example the PAM test required 250 channels in itself and we used a second system like this to thermally control the environment the spacecraft was exposed to. These systems also have extremely powerful graphics and analysis capability and allow us to analyze and make changes to a test as it is being run.

As you have already guessed the equipment and facilities required for space simulation are very expensive. However, our experience in testing has shown that even after careful analysis a spacecraft must be tested to ensure that it will perform as required in space. And for McDonnell Douglas the results of these tests are seen in a record of over 150 successful spacecraft launches like the Delta Launch Vehicle shown here.

VFR602

MASS SPECTROMETER DATA



CHEMISTRY IN THE FUTURE

From Genesis to the Book of Revelations: Chemistry Texts Written in America(N)

Derek A. Davenport
Purdue University
West Lafayette, Indiana 47907

Presented as a Keynote address to the Seventy-First Two Year College Chemistry Conference, Oakland Community College, Southfield Campus, Southfield, Michigan 48034, May 8, 1981.

The Abstract

In the beginning there arose from out the formless void one chemistry encompassing Scandium and Scammony, Batytes and Bird-lime, Gypsum and Guts. But chemistry knew sin. It grew fruitful and multiplied. More in sorrow than in anger it brought forth organic and inorganic and analytical and physical chemistries. These in turn begat today's hyphenated-hybrids and who knows what tragical-comical-historical-pastoral chemistries lie ahead? Thus over the years the term "general chemistry" has evolved from near tautology through pedagogy to near opprobrium. Today's general chemistry texts try to

be the "Alpha and Omega, the beginning and the end, the first and the last," and though Dr. Johnson may have been right when he averred that "no man ever read a book of science from pure inclination" they sell to the tune of one million a year. Some of these are tasted, others swallowed, some few chewed and digested. More are selectively colored with a yellow felt-tip pen or else are read by proxies (or lecturers) who often achieve a certain base authority from others' books. Eighty slides will be used to illustrate those fossils of forgotten importance - the general chemistry texts of the past two hundred years. They in turn will serve to prompt an idiosyncratic and at times even peevish commentary on the past and present state of the art of teaching general chemistry.

The Brief Chronicle

On April 7, 1776 James Boswell reports Samuel Johnson as owning: "There are few books to which some objection or other may not be made." Now the Great Cham was not of course referring specifically to books of science, for had he not himself written a Life of Boerhaave and did he not sometimes find solace in the hermetic arts?

> "He sometimes employed himself in chymistry, sometimes in watering and pruning a vine, and sometimes in small experiments, at which those may smile, should recollect that there are moments which admit of being soothed only be trifles."

However he recognized more clearly than many have since that books of science are not primarily intended to give pleasure: the "Joy of Cooking" perhaps, the "Joy of Chemistry", surely not? Science books are meant to instruct: agreeably where possible, disagreeably where not.

> "People in general do not willingly read, if they can have anything else to amuse them. The progress which the understanding makes through a book, has more pain than pleasure in it....No man reads a book of science from pure inclination."

Contrary to the wishes of the good Doctor ("I am willing to love all mankind, except an American.") the United States did win its political independence in 1776, but in chemistry it remained a satrapy of Europe, and particularly of Great Britain, for many years to come. In spite of Joseph Priestley, the bonds were more to Scotland than to England and most of the early American chemists were direct or indirect students of Cullen and Black. Even as late as 1833 we find only a handful of the forty or more chemistry texts available from Mr. Auner's Bookstore at 331 Market Street in Philadelphia of domestic origin. The rest came from Europe though many of these were in editions pirated for the American market. There were some notable exceptions. William MacNeven of the College of Physicians and Surgeons in New York issued an "Exposition of the Atomic Theory of Chymistry and the Doctrine of Definite Proportions" as early as 1819. This includes an appendix of

"Chymical Exercises by the Pupils of the Laboratory" and it has a charming, and very American, dedication to those same (Gentlemen) students. It was not however universally admired since the following year one reviewer wrote:

> "The theory of definite proportions will, we fear, prove a stumbling block to chemists; for with idea that calculation may in many instances take the place or improve experiment, the process of actual analysis may be lost in the imposing dress of mathematical formulae and chemistry be no longer an art which interrogates nature."

An art which interrogates nature. What a marvellous description of the science of chemistry! This book serves to remind us of the important role which medical schools played in the early development of chemistry in this country. Also on Mr. Auner's list we find texts by Benjamin Rush (largely plagiarized from the lecture notes of Joseph Black) and by Robert Hare and two volumes by the father/son Benjamin Silliman dynasty which was to dominate the American market through the middle of the Nineteeth Century.

What were these early texts like? Though the word "general" was considered superfluous their essential content was not too far distant from today's general chemistry texts. Some topics would serve equally well: sulfur, nitric acid, alcohol, silver, cerium. Others are contemporary topics in period dress: silex, barytes, oxymuriatic acid, gypsum. A few are rarely found nowadays though their relevance is undeniable: scammony, bird-lime, guts, jallop, putrefaction and morbid products of animals. Perhaps they may be subsumed under biochemistry which breeds like a perstlence in today's freshman books. We find little that is quantitive and virtually nothing to be called theoretical: ripeness, fact, and utility is all. Demonstrations were not merely a part of the lecture, they were also incorporated (with formidable illustrations) in the textbooks. A particularly choice example is shown in Silliman's "Elements of Chemistry" in which the professorial demonstrator grasps with one hand (well wetted with brine) the ear of an ox (newly felled) while with the other hand (also wetted with brine) he simultaneously touches the leg of a frog (recently amputated) to the ox's compliant tongue. The results are electrifying. Today's student would not be impressed but it might be salutary to remind them that the origin of all their computing marvels is to be found in the twitching of a frog's leg.

> "People have now-a-days (said he) got a strange opinion that everything should be taught in lectures. Now, I cannot see that lectures can do so much good as readomg books from which the lectures are taken. I know nothihg that can best be taught by lectures, except where experiments are to be shewn. You may teach chymistry by lectures. You might teach making of shoes by lectures."

When Wilhelm Ostwald acted as mid-wife to the brain-child of van't Hoff and Arrhenius, physical chemistry was born and general chemistry was never to be the same again. At first the impact was small. The section on principles at the beginning of the book was merely stiffened with mathematics while the main bulk remained a systematic treatment of descriptive inorganic chemistry. At this time Scottish authors made a marked comeback with Smith, Kendall, Walker, and Findlay slowly yielding to those mid-Western Hibernians, McPherson and Henderson. In a sense the last-mentioned authors provided a link with the present since a direct lineal descendant of their 1913 text is still in print, co-authored by the editor of these proceedings, Tom Lippincott.

Space does not permit an account of the discussion of current texts here. This is perhaps fortunate since lible is easirer to prove than slander and while it is possible to be dispassionately ascerbic about extinct publishing houses and dead authors it is harder to be so about the living - if not always the quick. Somewhere between Milton's lofty sentiments:

> "Books are not absolutely dead things, but do contain a potency of life in them to be as active as that soul was whose progency they are; nay they do perserve as in a vial the purest efficacy and extraction of that living intellect that bred them."

and Johnson's

> "No man but a blockhead ever wrote, except for money."

justice no doubt lies.

Adapted in part from J. Chem. Educ., 54 268 (1977).

Chemistry Toward the Year 2000

Ralph W. Gable
Davidson College
Davidson, North Carolina 28036

Presented as a part of a Panel Discussion "Chemistry Toward the Year 2000" at the Seventy-third Two Year College Chemistry Conference, Central Piedmont Community College, Charlotte, North Carolina, December 4, 1981.

What are the prospects for chemistry and chemical education during the next twenty years? As a participant in the liberal arts tradition I propose to face this question of twenty years into the future by taking a historical view; that is by looking some two hundred years into the past. I would like to draw a brief lesson from a textbook written just over twenty years before the Chemical Revolution which we associate with Antoine Lavoisier.

"Elements of the Theory and practice of Chymistry" by Pierre Macquer was seen by the author as laying out "essential truths," rather like a book on geometry instead of presenting what he called the "jumble of facts" he ascribed to the older textbooks. After presenting Robert Boyle's operational definition of elements, he identified the principal ones as Air, Water, Earth and Fire. The rest of the 150 page section called "Theory" is essentially descriptive chemistry of animal, vegetable, and mineral materials interspersed with explanations based largely upon the concept of phlogiston. This section closes with the theory of construction and operation of laboratory vessels and furnaces.

The "Practice" section is very practical. It is a 450 page laboratory manual with detailed procedures for the preparations of various chemicals from available raw materials. The total book provieds a rather complete introduction to contemporary chemistry...before the revolution.

Macquer was not called upon to peer into the future as our panelists have been, but several expectations seem to be present in the book. Without undue violence to the words of the book or the spirit of the times I suggest these themes.

Now that chemistry had been established as a true science, "founding its principles and procedures on solid experiments, and on just consequences deduced from them," the author had every expectation of continuing advance and refinement of his understanding. In particular he could look to improvement and refinement in the Chemical Affinities propounded by Geoffroy, providing even greater simplification in predicting chemical reactions.

Satisfaction with current theory seems to have been rather general; although a number of areas of less that adequate understanding were pointed out. Theory, except for phlogiston, does not seem to have been a precise tool.

Quantities are of course mentioned in laboratory instructions, but there is nothing to suggest that quantitative measurements might have any intrinsic interest. Particles in the sense of atoms or molecules are mentioned as parts of explanations, but only in qualititive ways. Balances are not mentioned at all!

There is certainly no indication of the obscure work in far-off Scotland by a medical student, Joseph Black, who carried materials through a series of reactions, weighing the products accurately at each step. Within the next twenty years the novel instrumentation of the analytical balance allowed Lavoislier to utilize a concept of conservation of mass in chemical reaction. In shortly more than twenty additional years John Dalton showed that atoms having definite masses as well as identities could lead to immensely fruitful (quantitative) predictions.

Still, "Elements of the Theory and practice of Chymistry" was an excellent textbook. It presented a body of knowledge, facts of reaction, theory, and instrumentation of the day in such a way that a student could obtain a good grasp of the chemistry of that time. Current theory was presented with confidence, but without arrogance, to assist the organization of information and allow a reasonable chance at making predictions in new situations. Instruments of the day, largely laboratory vessels and various heating devices, were considered from both theoretical and pratical viewpoints. And the importance of careful experimentation was stressed.

And here we are. With better communication of the present day we are more aware of current developments, but incorporating them into chemical education rather than adding to "the jumble of facts" may even add to our own problems. Chemical education must help the student learn to cope with this continually changing disciplice. We need to teach the foundation as they are currently understood, promote as awareness and some comprehension of newer concepts, discoveries, and techniques, and instill a modicum of humility with respect to our own proper place in the continuing story of chemical science.

Chemistry Toward the Year 2000

Conrad Stanitski
Randolph-Macon College
Ashland, Virginia 23005

Presented as a part of a Panel Discussion "Chemistry Toward the Year 2000" at the Seventy-Third Two Year College Chemistry Conference, Central Piedmont Community College, Charlotte, North Carolina, December 4, 1981.

Eye of newt, toe of frog, and tribal totems were prime reagents called upon by ancient soothsayers as they attempted to divine the future. In our current, sophisticated age, such recipies seem frivolous. And so, as I gazed at the tea leaves in my Tollen's test-plated Florence flask to discern chemical education's predilections a score of years hence, an instrumental aphorism appeared: the retrospectroscope is a most powerful instrument. Unfortunately, retrospectroscopes and hindsight will not suffice today. Instead, we are to be seers, the Jean Dixon's of the chemical set; and so, undauntedly, we plunge forward.

One thing we know for sure----by the time the children of our current traditional, college-aged students reach college, the twenty-first century will have begun. In contemplating the sweep of change that could occur in chemical education during the interim, several points will be raised for consideration. These points are in no order of emphasis or priority.

We should keep in mind the speculative nature of these proposals. A line from a 1646 play by Pierre Corneille may be appropriate: "Guess if you can; choose if you dare". With this admonishment, let us turn to some of these conjectures.

1. Laboratory Costs-- Silver nitrate is not the only sacred cow which will go; as a replacement, ion-selective electrodes for chloride and other titrations have the advantage of being a one-time cost item. With regard to costs: A. How many of us have done a cost analysis of each experiment in our laboratory program? B. What thoughts have we given about replacing/eliminating/substituting for expensive experiments?

2. Computer Simulation-- Many general chemistry programs have high first-term attrition. One way to reduce laboratory expenses in these is to have no laboratory work during the first term. In this way, only the "survivors" from the first term would be creating laboratory expenses beginning with the second term. Computer simulation of experiments during the first term is another alternative. Titrations, law of constant composition/stoichiometry, and specific heat/calorimetry experiments are candidates for computer simulation/graphics. However, without benefit of actual laboratory work, will students think that hydrogen oxide has the same properties as lithium oxide?

3. Video Teaching-- It is not too far-fetched to consider the following scenario: An acknowledged "master" teacher delivers, by simultaneous telecast, the lectures for the entire general chemistry course to all general chemistry students throughout a two-year college or a university system, not just at the local campus. Video tapes or discs of the lectures make review available and convenient. This type of format frees other chemistry faculty for areas of their experitse such as laboratory instruction, curriculum development, or computer-assisted instruction.

4. Computerized Word Processing/Data Analysis-- Advances in these areas will permit speedy assimilation and processing of laboratory data enabling rapid evaluation of norms and grading ranges for experimental results. Word processing capabilities will allow you to write/pring customized laboratory experiments designed by you to fit your courses and budget and to conveniently update them yearly

5. Organic Chemistry and Video/Computer Graphics-- Perhaps students in organic chemistry, rather than using ball-and-stick models, will buy a video disc containing all the 3-D stereochemical projections in multicolor which can be tied into a home/dorm video screen. This output can then be converted to a printout. Molecular topology and stereochemistry will gain added attention due to breakthroughs in biochemistry and catalysis.

6. Diminishing Science Skills and Increasing Science Shyness-- Reticence and fear are traditional feelings among the majority of science-bound students, especially those initiating studies in chemistry and physics. As much as we would wish otherwise, this aspect will remain if we are to believe certain studies made of the problem. The level of pre-college science education is a factor contributing to science shyness. A report by the National Research Council, The State of School Science, and the Science Education Databook from NSF present data for concern. Among these data: (1) high school (HS) chemistry accounts for only 19% of HS science courses while 21% are labeled as "others", that is other than chemistry, physics, biology, or second year biology; (2) 13% of HS science teachers teach courses they feel unprepared to teach in science; (3) 25% of HS science courses have no laboratory activities or ones which are held less than once per week.

As increasing numbers of older students attend college, we will be faced with students whose science background will be even less current than that of our conventional group of students. "Chemophobia" will be even more apparent and severe in this former group than in the latter.

7. ORP Chemistry: Is There Life After "Blast Furnace" Chemistry?-- ORP chemistry is the kind I had as an undergraduate in the 50's. You remember those good old days-- Occurence, Reactions, and Properties of selected elements exemplified by the coverage of blast furnace operations. After the contortions made by chemical curricula toward mini-physical chemistry during the 1960's and early '70's, many courses are shifting back to a more descriptive approach. This is not a movement back to ORP chemistry but one that applies chemical principles rather than rote memory to the study of descriptive chemical phenomena. Thematic orientation of courses around areas such as energy, industrial technology, or consumer chemistry are other avenues for curricular reform.

And so, there are several terms in the rate law equation for curricular revision. Among them: (1) Economics-- This will be an all-pervading determinant for many programs. Two-year colleges were in the vanguard of amny significant, creative, student-oriented chemical education activities during the 1960's and '70's. Let us hope that a tight purse will not stifle additional creativity; (2) Remediation- this will grow in intensity and variety as poorly-prepared science students continue to be our raw material; (3) Safty and Waste Disposal-- We will be legally and morally more moved to be responsible for laboratory safety and for the proper handling and disposal of laboratory program effluents; and (4) Graduate School Training-- Unfortunately, most people teach the way they were taught. In many graduate chemistry programs, teaching and laboratory assisting are viewed as unpleasant diversions from research activities. Efforts such as Project Teach at the University of Nebrasks are encouraging attempts at producing some graduates with some sense of pedagogical strategies and techniques. As industry outbids academe for new Ph. D.'s, it is a fervent hope that those who take teaching positions do so as their first choice rather than viewing it as an unexciting and less-than-desirable alternative to invoke only when employment is not obtained.

Chemistry Toward the Year 2000

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

Presented as a part of a Pannel Discussion "Chemistry Toward the Year 2000" at the Seventy-Third Two Year College Chemistry Conference, Central Piedmont Community College, Charlotte North Carolina, December 4, 1981

In 1955, a group of American leaders in goverment, industry, and education recorded their prophecies for 1980 in a book called "The Fabulous Future, America in 1980." Among other things, they predicted: (1) The national debt would be slashed; (2) cancer would be cured; (3) mail would be delivered across the continint by guided missile; (4) there would be an enormous surplus of oil unless chemists could figure out more ways to make plastics and fibres from it; (5) energy would be virtually free--real estate developers would offer free electricty with a $20,000 house; and (6) the average family income would be $8,000.

So much for the accuracy of predictions. If we are that bad at predicting, why bother? Perhaps there are two good reasons for making predictions, even if we aren't all that good at it. First, we can express our hopes and dreams for the furure. If we wish hard enough--and work hard enough--perhaps we can make predictions come true. The second reason to make predictions is that by forcasting catastrophe, we may help to head it off. In 1962 Rachel Carson predicted a Silent Spring if we didn't stop the indiscriminate use of pesticides. It appeared that she might be right before we got things turned around with the environmental movement of the late 1960s and early 1970s. In 1969, Paul Ehrlich predicted the end of life in the oceans by 1979. It didn't happen, but it might have if he (and others) had not focused our attention on the problem.

Recently Carl Sagan estimated that there is a 50% chance that people now alive and under 35 years of age will die in a nuclear holocaust. We can only hope that by making such a prediction, Sagan will help to ensure that it will <u>not</u> come true.

Now, gazing into a crystal ball (which, unfortunately has been etched by a sodiun hydroxide solution for a few decades), I'll venture a few predictions of my own.

(1) The increased use of minicomputers in every facet of our lives, inculding the classroom.
(2) The thorough integration of chemical principles and applications in all our chemistry courses.
(3) A discovery every bit as revloutionary as Neil Bartlett's noble gas reactions.
(4) That colleagues whose jobs depend in part on enrollments in courses for nonscience will still look down on those of us who teach those courses.
(5) That $2YC_3$ will be alive and still blessed with people willing to do hard work that makes these meetings such remarkable learning experiences.
(6) That chemistry will survive as an honored profession and that it will continue to contribute to the public welfare.
(7) That chemistry will change in ways we can't possibily imagine today (because the underlying discoveries have not yet been made).
(8) That second law of thermodynamics stil will be valid (and largely ignored by economists, politicians, and others).
(9) That the enrollment crunch will not be as severe as others have predicted.
(10) The before the end of the century, higher education will see better times (economically) and that our students will be better prepared upon entering college.
(11) That a group of people in the year 2000 will be making predictions concerning the first decades of the 21st century (and that their predictions won't be any more accurate than ours).

Chemistry Toward the Year 2000

Margot E. Schumm
Motgomery College
Rockville, Maryland 20850

Presented as a part of a Pannell Discussion "Chemistry Toward the Year 2000 at the Seventy-Third Two Year College Chemistry Conference, Central Piedmont Community College, Charlotte North Carolina, December 4, 1981

I do not claim to have a crystal ball whoch is more penetration than any of yours, but like all of you I do have a point of view and it is this I would like to share with you this afternoon.

To meet the inevitable changes in the thrust and scope of chemistry which are to come, we must educate our students by giving them the tools with which to continue learning:

1. Facts,
2. Enquiring and inquisative minds,
3. The ability to ask questions and to plan experiments which will provide the anwsers,
4. The ability and integrity to interpret the results of these experiments as objectively as possible,
5. The ability to keep accurate and complet notes and records,
6. The ability to think analytically and critically,
7. The ability to communicate effectively,
8. A willingness to accommodate to change, and last but not least,
9. Creativity.

While few would disagree with many of the points just enumerated, achieving these objectives is becoming every more difficult. In my experience, today's students do not know how to study, how to read, how to write, how to analize or how to organize and remember important facts. Their brains have been permitted to become flabby. What is even more disturbing is that by now some of the products of the permissive educational policies of the past decade or two have become teachers themselves and this serves to compound the problem.

In addition, students fear chemistry as much as if not more than math. Many of us spend more time and energy trying to cope with and aleviate this anxiety than we do in teaching chemistry. For who can learn anything if instead of listining to a lecture they are thinking: "This is so hard, I'll never be able to understand it!"

With such poorly prepared students many of us face the problem of having classes in which as many as half the students are not likely to pass. I have such a class this semester, a sophomore organic chemistry class. In desperation I asked the student to hand in an outline after each lecture. The outline was to include those points which they thought would need to remember organized in such a way that they would be easy to remember. The results were enlightening. What I got were rewritten and in a few instances xeroxed lecture notes, some so full of mis-statements and miscomceptions that I began to womder what I had actually said. No one had even attempted to do what I had asked.

I have no easy solutions to those problems possibly none of us do. However, these problems do not arise in college they are the culmination of what as gone before and it is here we must also make changes.

Classroom teaching has too long been our focus as chemical educators. We must begin to educate the public as well.

I just attended a Chatauqua short course entitled "Science, the Media, and the Public" in which I learned that the American Physical Society has regular one minute educational radio announcements as well as a regular television program. To my knowledge, the American Chemical Society, has only the radio program, the program called Men and Molecules. I have never heard this program and I listen to the radio daily. How many of you hear or have ever heard these broadcasts?

There are many thimgs we could do for example, we might dramatize important historical events such as the argument over phlogiston in a way which could help people to understand that there has always been controversy over scientific theroies. We could also broadcast dramatizations of some of the Christmas lectures such as Faraday's Chemical History of the Candle. Programs of this kind maight serve to take some of the fear and mystery out of the word chemistry.

This summer I attended the Sixth International Conference on Chemical Education which was held at the University of Maryland. Chemical educators from eighty countties attended. At the conclusion of the conference the assembled membership passed eight resolutions a nember of which address some of the concerns I have mentioned:

Resolution number 3:

(3) Teaching at (elementary and secondary) school level. Education of students at school level in science is fundamental to the development of the individual as a scientist and as a constructive member of society. It is therefore recommended that:

3.1 Professional training appropriate for the task of primary and secondary school teaching be provided.

....

Resolution number 4:

(4) Teaching at tertiary (college and university) level. There is a need for greater effort involing new approaches to curricula, and in improving teaching, at the tertiary level. It is therefor recommened that:

4.1 Continued support should be given for courses and other activities aimed at improving teaching of chemistry at tertiary level.

4.2 The career structure of chemistry teachers at tertiary level should be more related to contributions to teaching and to chemical education research and development. To this end further efforts should be made to develop objective methods of evaluating contributions to teaching.

Resolution number 7:

(7) Attitudes to Chemistry. Attitudes to science are largely formed before the age of 14 and the infulence of home, local community and primary school are important. It is

therefore recommended that:

> There should be continued support for programmes aimed at (i) improving science teaching in primary schools (particularly those concerned with science courses in primary school teachers training); and (ii) bringing a critical appreciation of science to parents and to the general public especially through the media.

Resolution number 8:

(8) Chemical Education and Society. A current trend, which will continue in the 1980's, and which should certainly be encouraged, is the close relationship of chemical education to society and to future needs. It is therefore recommended that:

8.1 Ways should be found for including more material on the society, economic, tchnological, legal (including patents, licences, technology transfer, etc.), cultural and ethical aspects of chemistry in curricula at both school and university levels.

8.2 Chemistry courses at all levels should make students aware of the role of the chemist in society and of the present and future role of chemistry in society.

8.3 In curriculum planning attention should be paid to the possible future directions of chemistry so that students learn what the challenges will be tomorrow as well as what they were in the past.

8.4 Chemistry courses should include instruction on information storage and retrieval.

8.5 Encouragement should be given for the development of chemistry courses and media presentations for adults (particularly those with no formal scientific education who through their work are involved with chemicals).

I would like to leave you with the words of Harvard physicist Gerald Holton. Dr. Holton made these remarks when delivering the 10th annual Jefferson Lecture, which is the highest honor the federal government confers in the humanities. Dr Holton was the first scientist to be so honored.

> "Don't think only of the puzzles that scientists of the past are setting you"..."recap the attention of the scientist to the business of the rest of mankind. We must fuse the powers of the scientific mind with the need to eliminate social infirmities."...We must put science and technology "in the service of national possibilities and social hope."....We must "use science and technology for enhancement of man's freedom and happiness."

Re-inventing the Educational Wheel, Strengthening the Spores, or Increasing the Circumference for the '80's

Robert Brasted
University of Minnesota
Minneapolis, Minnesota

Presented as a Keynote address to the Seventy-Fifth Two Year College Chemistry Conference, Normandale Community College, Loomington, Minnesota 55431, May 7, 1982.

When one is honored by an invitation to speak with a group of dedicated teachers many months in advance of the event, a title seems relatively easy to come by. When the event draws near the responsibility of weaving a story about the title takes on new dimensions. It is egotistical for me to believe that you will be exposed to something that is truly: (1) Entirely new; (2) Brilliantly different; (3) Eminently challenging, and/or Disturbingly provocative. Now that I ponder on these last caveats, they are not very different from what the title of this talk suggests. Just how much new and original has been developed in our discipline - one that we mutually enjoy and indeed in which we seek new and more dffective ways of doing things. That is why we are here.

I admit to thinking along the lines of the wheel and spokes some years ago. I had been given the charge of summarizing an entire four-day (and night) conference on international education with regard to its accomplishments. This was the ivth (the numbering system is a bit fuzzy) international conference on chemical education in 1975. As I recall, I had to spend most of an entire night developing these words of wisdom in a hotel room in Madrid (later in the week it was partially demolished by some citizens who seemed to be somewhat dissatisfied with the political situation). As I reviewed notes, abstracts, position papers, I felt that I had been there before. For instance one far thinking and imaginative person from a developed country described in a formal paper in detail the "Object in a Box" experiment, which I am sure you all remember from our chems and CBA days of the late 50' even of identifying a beaker, cylinder, sphere, or what have you in a shoebox by rotating, shaking, and so forth, other less obvious situations were uncovered that led me to the conclusions that as the wheel rotates we hopefully return to certain basic principles, which may now be better understood by new techniques of learning.

In this discussion, I am sure that you will see some prejudices and hang-ups that may even smack of provincialism. However, I hope that such will not be the case since I would also hope that some three decades or more in this area have proven otherwise.

Among several terms that grew over the past few decades and represent a few of my prejudices is the term "Behavioral Objectives". I still neither take kindly to it, nor do I really know what my (or my students) behavior has to do with any part of teaching. I do not see many references to it now-but I would not bet the family farm on its reappearing. We do indeed take a firm stand on what we hope to accomplish in a course, whether we call it by the above term or not. We work our way through a course of instruction producing students ready to move on to bigger and better things. Totally, I have assumed that our objective in this game are to train young (and sometimes not so young) students to be better than their mentors. Obviously without this training, and towards this end, we as a nation will stagnate and die. I worry, and hope you also do that our industrial system is failing to fortifying its own wheels with new spokes, strengthened spokes, and even wheels with an enlarged diameter. How often do we read of an industry increasing its sphere-not useing its own product of research but pather by buying someone elses plant or a foreign patent.

But to return to wheel and its spokes, what have we really done that is new? What have we tried that has done little to either put in the new spoke or strengthen weak ones? Where should we put our priorities? Would a larger wheel be better?

It is tempting to try to anwser the last questions first. Most of you would have anticiapated the "way to go" as via the chip. I'll resist for the moment all good and great things that the computer has done and will do for us in the decade or decades to come. I have troubles, as a consultant to one of our local shops, the control data corporation, understanding today much less tomorrow . In the field tomorrow and the decade to some are bewildering. Reinvention in this area of educational endeavour will represent collapse.

At the risk of over-simplification, we as teachers fight the battle on two major fronts: (A) What do we wish to teach, and (B) How best can we teach it?

The wheel (or the pendulum might be used as well) analogy could not be clearer in our move from the purely memorized descriptive approach in teaching chemistry at the introductory level to the virtually orthogonal nearly pure principles approach (unfortunately, often referred to as watered-down physical chemistry). The former was responsible for the near demise of inorganic chemistry as a discipline and did little to endear the subject of chemistry to the hearts of the introductory of first-year student. The latter, or the principles approach, attracted attention; we have to give it credit. It performed a worthwhile service in moving towards a 'why' attitude on the part of the student. Isn't this the basic goal of the total educational process?

In so doing, materials of many sorts; text, hardware, demonstration approaches, were devised to apply physical concepts in support of the explanations of chemical change.

Unfortunately, too often the authors and originators of written material tended to ignore (forget, or perhaps they never really knew) the fact that there really was a chemical change, a chemical phenomenon that was involved. Others in the production line of the printed word were so enamoured with the partical in a box, the black body, and whatever else is necessary to appreciate wave functions and molecular orbitals, that large chunks of texts required a stage of mathematical sophistication not normally within the scope of entering students.

Does this situation belong under the title that I have chosen? I beleive that it does. Each author about whose work I know, fondly claims a return to the descriptive basis of teaching chemistry. In most cases, I believe them to be sincere. There are different routes and devices, ranging from the qualitative analysis piggyback books to large numbers of chapters covering representative and transition elements to incorporate the "real world" of chemistry within the principles approach. I believe we have improved the wheel and its durability, if not functionality. Where there is still an improper balance, the knowledgeable and imaginative teacher has the liberty of both expanding, as well as excising, material from the text. I believe that our rotating wheel is well exemplified in the production of an inordinately large number of texts that do little more than those immediately preceding them. I don't believe that it is necessary to tailor make a textbook for every lecturer in the business.

The philosophy of instruction in the laboratory has gone through a similar cycle. There was a time when an introductory laboratory was predicated on test tube reactions, equation writing, and blank-filling-in books. When one's office is located (as mine is) at the entrance (as well as the exit) of one of three laboratories, each desked for anywhere from 110 to 173 students, and when one's door is always open, one is always sensitive to remarks made by students coming and going. The above-mentioned kind of a laboratory, with its repetitive Albeit descriptive test-tube experiments, was on a disturbingly large number of occasions described by the in-going and out-going students as being "Mickey Mouse". It didn't take a lot of staff meetings to reach the agreement that ended up by two staff members writing a new manual introducing more challenging types of experiments. A recently published comprehensive study entitled "Profiles in Learning" made it evident that, although we did not have a "Mickey Mouse" lab, we <u>still</u> had one that left students after two or three quarters with just about a zero feeling for Descriptive Chemistry and the niceties of chemical change this was not unique to Minnesota. The wheel needed more rotating, or perhaps needed strengthening by compromise. A few of the principles and technique type experiments were replaced by some of the reaction-type, where the student had the opportunity to observe fizzing, color changes, precipitates of various physical types and hues, but still maintaining a very unpopular requirement of writing and balancing equations. There is a large number unknowns and unstructured work.

A small, but well respected, group of educators from Japan and the United States met recently here in Minnesota to attack "again and again" the problems that are part of a chemistry course for the non-science oriented student for reasons unknown-called "the citizen". You and I have "been there before". Was this a case of wheel inventing or even spinning? The NSF and ACS thought not, and so the IIIRD Japan/USA Seminar was held. Time and again we could wee the reappearance in our discussions of old philosophies. We had a chance to exchange ideas on an international scale, where rather strong educational and social differences exist in our countries. Time does not permit even the briefest review of all of the issues, but one that was extremely fruitful, and concerning which there were more similarities than differences in our respective systems, was in the broad arena of "case studies" which obviously brought into focus the total environment. I harked back to a great and well-known educator at Harvard who used this case-study approach decades ago. We, indeed, were enlarging the wheel and strengthening the spokes, not just re-inventing it.

What do we have now as a result of development and what do we see in the future to provide better learning experience to achieve our so-called objectives? Are there experiments in technique and technology which have not fulfilled promise? Will we rotate and in time re-invent certain of these techniques? It would be improper to the point of my having the non-existent crystal ball to judge all of the intents to improve the learning process. I lay no claims, for instance, to more than the practical side of the psychology of learning. In fact, in my journeyman approach to this area, I see the wheel rotating and, more often that not, simply spinning. Too often we seem to attach names, either of individuals or of ideas and do nothing more than repeat accepted educational philosophies.

We often have moved more like the pendulum than like the wheel, from a virtual zero concern for the student with learning difficulties to the other extreme of adjusting course content and even modifying curricula for the maladjusted, underprepared, and/or under-motivated student. At times, course content and good science have been lost in methodology. There have been a variety of systems developed, and I hope that there will be many more to attend to the other end of the student ability spectrum, the <u>well-prepared</u> and/or <u>bright</u> student. Incidentally, these two students need not be the same person.

Let me voice a few prejudices regarding a few techniques that have had a small total impact, though certain of them have been influential in developing better ideas. I could rank the teaching of a full chemistry course by PSI or PSL (Keller or some legitimate or illegitimate offspring of this concept of learning) as being far from the top of my approach for the way I would hope to instill the desire to learn. To give all my reasons would not be the best use of your time as a listener, or of mine. A couple of my pet peeves might serve as points of agreement or even more likely, of disagreement.

1. I am less than confident that a student who has perhaps not even completed a full year's course will be the best of all tutors for the struggling student who is perhaps six months less mature. I am in full agreement that "teaching is the best way of learning" however, it's too bad to inflict that kind of a philosophy on the learner.

I am sure that <u>my</u> own tutorial capabilities as a second term freshman left something to be desired even in the dark ages of my first year in college. At the expense of speaking with forked tongue, I of course did become involved in dialogue with other students. Study groups are strongly urged as a learning method.

2. I am uncomfortable with a system that says - fail as often as you wish - no penalty - eventually you can fill in the right blanks in a quiz essentially identical to "X" number that you have taken before and claim 90-percent expertise of that area.

Where does the wheel and/or its spokes fit in this diatribe? I myself, with all my prejudices, still have produced modules and modular type materials, especially for the underprepared student, hoping that these tutorials will bring such students to the level of others in the class. In other words, I hope that I have developed a system of teaching, a mode based in some parts upon another system which in itself, <u>as a complete unit</u>, I have found abhorrent. I have visited enough universities and colleges to feel confident that only when teachers are willing to devote nearly one hundred percent of their time to this PSI app ach do we have anything approaching success. In other words, I have seen cases of essentially a tutorial approach with the senior staff member, something that denhgogially could hardly be criticized. But I believe that this system is too demanding on the staff member. It does little as an educational philosophy to impart a message of intensity and careful work the first time around. These should be guiding principles of life. At the expense of being trite, one may not have two, three, or ten chances to fail in a heart transplant, an extraction, the development of a proper growing culture, the production of a hybrid, a computer program for industry, or a calculation important in establishing a yield in a large scale chemical process. Why not impress on our students the benefits of doing something right the first time around.

When the inexpensive tape recorder and 8mm loop projector became available, there was the expected search for uses. Some have survived; others have died either sudden or lingering deaths. Our super-8 loop library gathers dust for one or more of several reasons. The mechanical production was imperfect and the utility, as well as acceptability, was marginal. Similarly, there has been resistance to the point of eliminating the seemingly good idea of using small tape players for special instruction to accompany, for instance, experiments and instruments in upper division courses. However, there has been a beneficial aspect in transferring this technology to what I considered useful audio-tape modules for the underprepared student, particularly in the less than exciting areas of instruction where more than one exposure is desirable but not worthy of excessive time in the lecture (balancing of equations, stoichiometry, equilibrium calculations).

On the more positive side, or I suppose we might say on the rim of the wheel that has not really had time to rotate, we have the computer's role in instruction. Obviously, this incredibly important instructional tool is "just hitting its stride". Those I work with tell me that in the not too distant future the electronics field in all of its ramifications will exceed in total gross dollars the automobile industry. At this particular point in time and in our economy, this is no earth-shaking prediction. However, to return to "the Spokes and the Wheels of the '80S", the potential bugs the mind. What has been accomplished already is incredible. However, just as we ballooned in the T.V. (open and closed circuit arena), I recommend making haste with some deliberation before turning over the entire instructional program, lecture, recitation, and laboratory (simulated) to one mechanical component. At the expense of redundancy, the A in CAI and CAL mean just that - "assisted". The '80S must see improvement and expansion in a variety of theaters. Let me mention but a few without being either encyclopedic or too obvious.

1. The cost factor. The wheel has rotated and is on a real down turn in the dollar cost or availability for funding large scale operations involving computers. One NSF program that may never recover is that of CAUSE (Comprehensive Assistance to Undergraduate Science Education). I am not violating confidences as a reviewer of proposals when I point out that many millions of dollars in the past few years have been awarded with a substantial fraction supporting innovative applications of computers - and, I am afraid, some that were not so innovative. Now the cost of the terminal, the disc, the drive, and shared time must be within the budget of institutions which depend upon the city, community, the state, and private resources for funds. Perhaps as important in the coming years will be a cost that is competitive with the ever burgeoning industry of our friends across the Pacific as well, the Atlantic, who are entering the solid-state and microelectronics business with enthusiasm. We are all competing in the foreign market place. But you and I can name score upon score of countries where educational development withers or is domant because of the cost factors, as cheap as we consider some of the devices to be. We have progressed (?) through the eras of a "chicken in every pot", to "two or more cars in every garage", to now a situation where we assume there will be "at least one computer in every kitchen". We have a powerful home educational component literally at our fingertips.

2. There is certainly a second very important need, as well as an area of improvement where wheel spinning must at all costs be avoided. Educators and those being educated both here and abroad are producing software packages. Some of these can be as expensive or more expensive than the hardware itself.

Libraries, exchange systems, evaluation, and refereeing processes must be standardized as well as developed. I know of some funded programs now underway that are attempting to publicize programs, creat new ones, and develop storage systems. Two of our very respected colleagues in the business are so involved and supported by the National Science Foundation: Lagowski of Texas and Moore of Eastern Michigan.

3. A caution rather than a need might be mentioned, showing a personal prejudice. It also suggests a pendulum reaching an amplitude, or a wheel in the process of rotating. I doubt that any new spokes have been inserted or even strengthened. This is a matter of creating programs essentially for the sake of impressing one's peers. Time required are considerable and <u>time</u> means money in producing a real working program, one in which the less stout hearted student is not to become frustrated. It seems inportant to preduce educational aids that cannot be easily duplicated using human resources. I think of a program that must have cost a great deal, teaching (and I use the term with reservations) the student how to fill a buret under one of our more popular and also very expensive systems. I wish that I had the skill to write that program, but I believe I, or any capable graduate or undergraduate student, could in a few minutes (or less, even) do the job more effective than did this program.

4. In this time of development, major and minor manufactures and assemblers of components are putting out machines, many of which (the manufacturers and, as well machines) do not talk to one another. We are defeating the purpose and slowing down development unless some standardization is effected in the '80s. We are somewhat in the same perdicament as color T.V. was decades ago or coding of structutes for on-line search used by chemical abstracts or other abstracting services, or cable T.V., to mention but a few areas that are either in a state of flux or were recently.

6. Although currently in the research area of primary publications, the application of the system of scientific on-line search can certainly be expanded to the educationally oriented current literature. The '80s should see large scale computer activity in this area. Substantial amounts of ACS time and money are being invested. I can see the time when a lot of re-inventing of the wheel can be eliminated with more dependable searches of the literature. I don't think that I am alone in periodically losing my cool when a fundamental research publication or as well a more pedagogically oriented one in the literature rambles on, ignoring what I have done and is indeed part of the past literature.

7. Not unrelated to the earlier comments on the consolidation and collation of programs, as well as "over-programming", is the production of software by students under direction of competent instructors. In the coming years, a multitude of such programs will be pouring out of the two, four-year, graduate institutions. We must see that only the best are given circulation. The programs must be designed for edification and not entertainment. Our division of chemical education

in the computer subcommittee is doing a heroic job, but much more needs to be done in the decade to come.

8. In summary, the paths ahead in the computer field lead to the production of some very strong spokes in our wheel of knowledge and perhaps to new ones, if not even new wheels. I think of a few special situations:

(A) The application as a diagnostic tool on directed study, remediation which may involve non-chemical areas, as well as chemical ones.

(B) Administrative functions which will give the teaching staff time for other and perhaps more important work. I think of grading, preparation of short multiple choice testing (as applied to system less than favorable in my opinion, in the teaching operation as noted earlier), record keeping, and grade production. The last mentioned happens to be one of several where my prejudices hang out. I want my students to know that no machine will make out the final grade. It will aid in figure manipulation, but each student is a person when the A's are separated from the B's and so on.

(C) The future is bright in simulation. Graphics and data processing are developed to a high degree of sophistication, so that everything from laboratory problems to socioeconomic and environmental problems can be given as students exercises. A qualification in graphics should be mentioned. On the previously mentioned on-line search now available in the chemical society offices there are at this moment, no facilities for including figures and graphics. Somewhat surprisingly, an experimental program now underway with about 300 users indicates that this is not a serious deficiency in a search. There is every expectation that within a year this capability will be included.

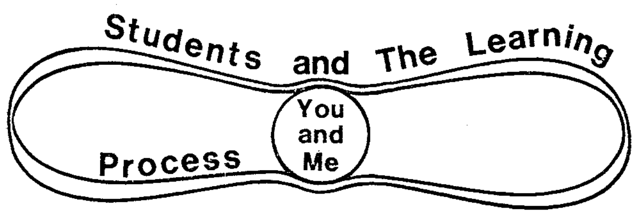
In conclusion, and perhaps as a summary, we might think of the dimension of the wheel not too frequently alluded to and that of its expanding circumference. I would hope that the spokes could do both, strengthen and expand. Do we have a right to expect more of our students through the numerous additions to our techniques and technologies? Will we in tertiary education be constrained in what we do because of limited abilities of students coming from the secondary schools? On the other hand, may the reverse be true? Can we expect more because of enhanced preparation?

I would like to see in the '80s this particular expansion and strengthening achieved by rotation. It is perhaps only a dream, with current Reaganomics, but I could see both goals in part achived by reinstituting the summer and academic year programs of the institutes of the '50s and '60s and a bit beyon, but not much. There are so many changes, so many important concepts, so many techniques that are of no use if we only talk to ourselves. The community of educators need a body and frame riding on our wheels of education that will bring all of these tools of the trade into the classroom, that is instructors with proper and the best in instruction.

At the expense of redundancy, the rotation that brothers me is a return to a completly descriptive approcch in instruction without stretching the intellectual skills of our students. We will never excite (a term that is over-used by many of us as we teach and develop materials) students with massive preparative recitations. As dangerous as over-theorizing and extensive and excessive mathematical expectations are, so is teaching to the mid or lower group only. A student not challenged is a student not taught. As enro-lments decline through demographic factors, we in the colleages and universities may fall into practices of lowering standards to gain retention. Our system of education differs from that found in many developed countries. We believe in giving everyone- a fair chance - providing as many as possible avenues, highways, and even paths and alleyways to prove competence. The late bloomer is not doomed in his or her search for higher education. Many of these pathways are essentially the spokes of our educational wheel. These tools in one form or another must be used to both aid poorly prepared students so that he or she can compete on the battleground of the classroom and laboratory, but as important in the decades to come, improve the problem-solving ability of our students as opposed to the ability (if that is the proper term) to stuff equations. Do we claim mastery of many segments of our courese by essentially solving relatively trivial exercises? This is a large order and is a challenge for both shaman and tribesmen alike. We won't get there by modifying grading practices that resist identifying the outstanding achievers. I hope we are not breeding a generation of persons who depend upon someone elses program to solve problems.

I know all the reasons for not using evaluation instruments; I happen to feel that they are needed. I hope that the swing of the pendulum,and/or the rotation of the wheel describing grading practices that refuse to do more than say pass/fail or worse,pass/no credit, does not go through full circle. Perhaps I am a lone voice in the wilderness. I know I am a voice that has howled too long.

I promised some concluding remarks as well as a summary. My conclusion is that we have manufactured a mighty big, and much more importantly, a mighty sturdy wheel. Let's hope that it supports and carries the educational wagon. It does indeed turn; at times it spins and goes nowhere. Unless our system can use it to move forward, to reconvince our funding agencies that aid to education in every sense of the word is the only way we can compete in the world scene then the wheel will warp, rust, and collapse. I am an optimist in that worldwide our wheel is respeceted and copied. Let's keep it strong and moving.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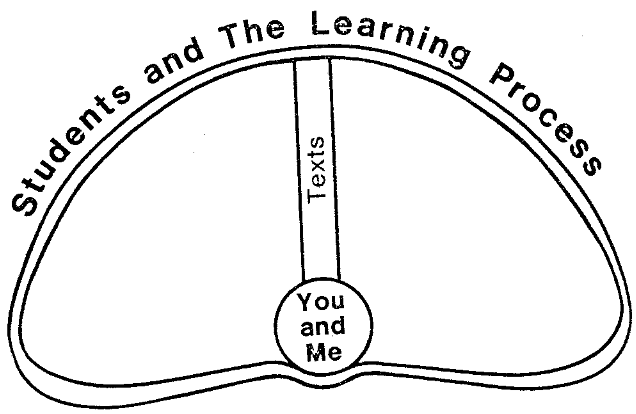
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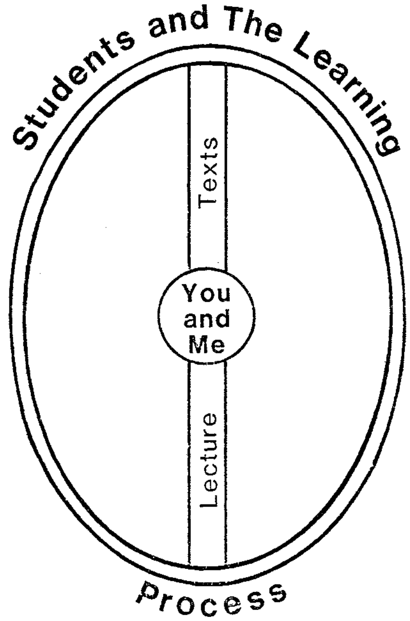
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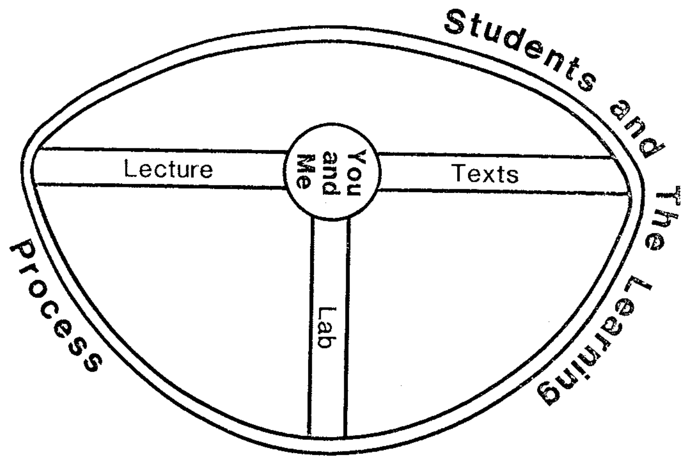
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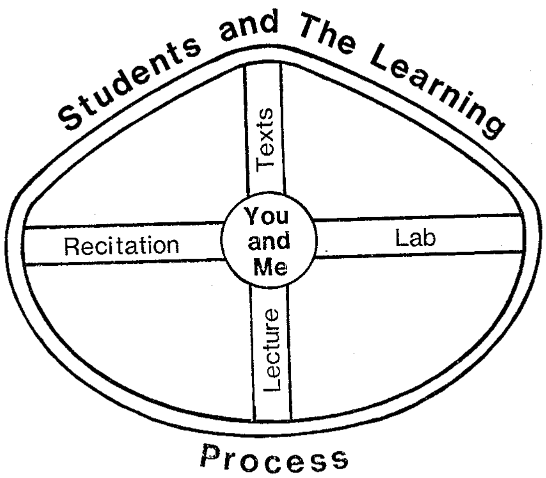
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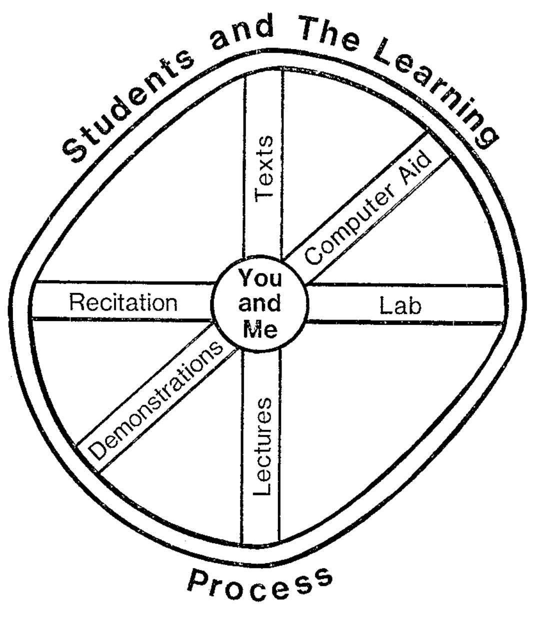
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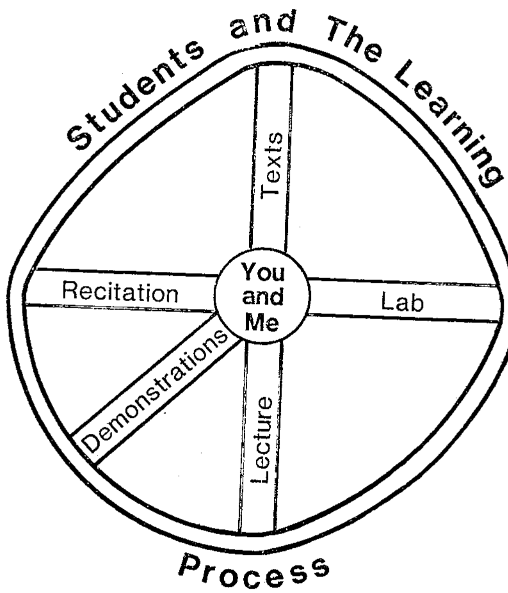
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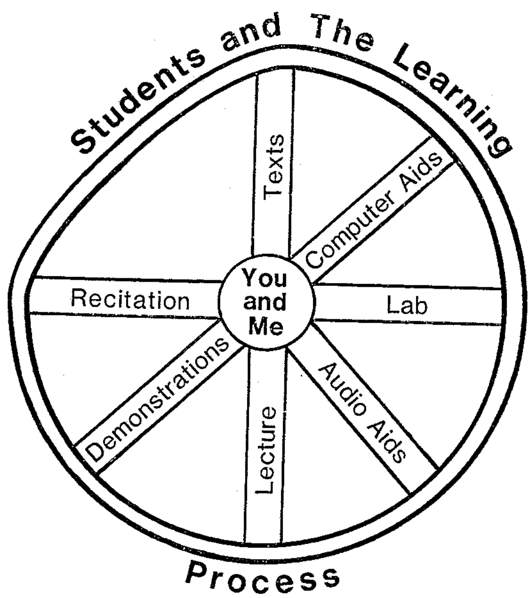
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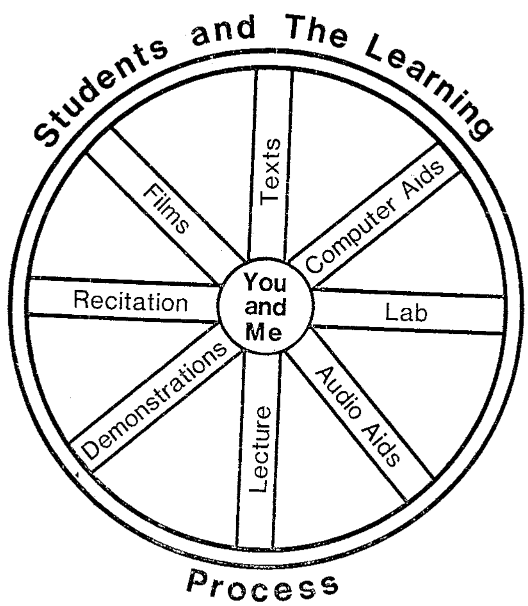
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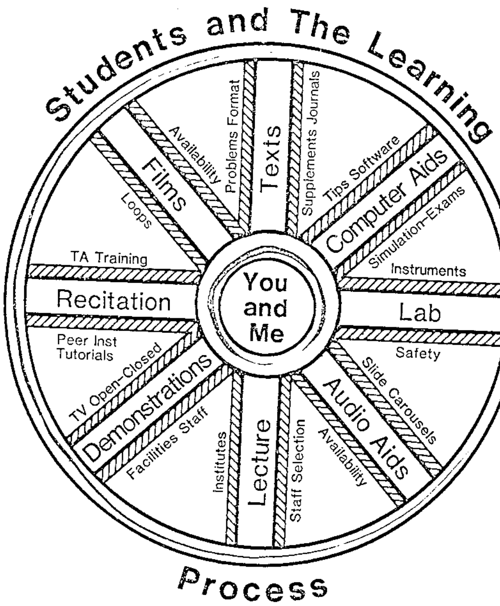

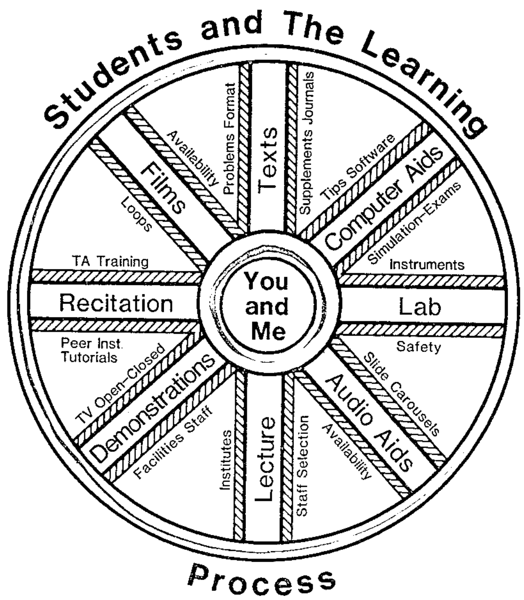
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SPECIAL TOPICS

The Role of the Student Chemistry Club in the Community College Program

Mike H. Freeman
Rt 9 Box 203
Charlotte, North Carolina 28208

Presented to a session of the Seventy-Third Two-Year College Chemistry Conference, Central Piedmont Community College Charlotte North Carolina, December 4, 1981.

Mike Freeman is currently a senior at North Carolina State University majoring in Wood Science and Technology, with a minor in Chemistry. Currently he holds the position of Program Co-ordinator of the Forest Products Research Society and Vice-Chairman of the School of Forest Resources-Forestry Council at North Carolina State University.

He attended Central Piedmont Community College from 1976 till 1979. While enrolled at Central Piedmont, he held the position of Chemistry Lab Assistant for a total of seven quarters. He also served as Senator-at-Large to the Math and Science Program Area Committee of the Student Government in 1977; Vice-president of the CPCC Chemistry Club from 1977 to 1978; President to the CPCC Chemistry Club from 1978 to 1979.

He received the first annual Ratcliffe Chemistry Award for outstanding achievements in chemistry and personal contributions to the total Central Piedmont community in June, 1980. Following the Award, he served on the interview committee for the second annual Ratcliffe Chemistry Award.

He is currently on a partial stipend/scholarship from Forshaw Chemicals, Inc. where he previously worked as an assistant chemist and quality control supervisor from 1979 to 1980.

Professional Affiliations:
- Member- American Chemical Society-Pesticides Division
- Member- American Wood Preservers' Association
- Member- American Association of Textile Chemist and Colorists
- Member- Forest Products Research Society
- Member- Socity of Wood Science and Technology

A B S T R A C T

The use of a student chemistry club in a community college program may bring recognition to students, faculty, and departmental administration. The chemistry club can help students overcome initial fears of entering into a new environment, aid in overcoming learning problems, form new and perhaps life-long friendships, and aid in the matutation process of the students involved. The benefits of the formation of a chemistry club far out-weigh any deficits evolved in the formation.

The Role of the Student Chemistry Club in the Community College Program

Clubs and campus organizations on a community college campus serve many varied functions. A few of these functions may be:
- to orient the student to the college atmosphere
- provide the student with a new peer group
- provide a mechanism for students and instructors to interact
- provide a pre-professional group for students to aid and help each other

When the students just enters into a community college program, he/she usually knows few to no other students in that program.

The college experience can be an initially frightening experience unless a good beginning is initiated. This good beginning may be achieved in different ways, one is the formation of a club or organization.

At Central Piedmont the faculty holds to the concept that, given enough time, most students can accomplish any learning task. This is especially important with the increasing demand on community colleges to provide the first two years of baccalaurate degree work.

The role of a student Chemistry Club can provide many benefits to both students and faculty members of the community college.

The Chemistry Club can help to install insight into the student concerning community issues and community affairs.

The faculty may benefit greatly from the organization of a student chemistry club also. In fact, the total campus can benefit from one faculty member donating a small amount of their time to advise a chemistry club.

Students working with a club gain knowledge about chemistry through the activities of the club, but also they may gain a new pride in their work and an increased maturity. As responsibilities are delegated in the club, students acquire the ability to take charge of situations to obtain the desired results.

This same method of logical problem - solving aids the student in successful completion of his/her college program.

The campus can also benefit from the activities of a chemistry club. As in many community colleges where students are only on campus for short periods of time, a certain type of apathy may occur. Activities such as guest lectures, campus speakers, presentation of student projects and field trips can aid in bringing students together on the college campus.

Faculty members may also benefit from a chemistry club. The faculty may select lab assistants, teaching assistants, or other students assistants from the chemistry club members.

Chemistry clubs can also provide such benefits to students as tutoring and group problem-solving sessions.

In summary, allow me to state a few of the significant benefits to the community college program that a student chemistry can achieve.

First, as a benefit to the student, a club can help to break-down invisible barriers to the new environment. This will help the student to form new peer groups in a new environment.

Secondly, the college campus benefits from the chemistry club bringing together the allied curriculums through club sponsored activities.

This also brings recognition to individual departments and aids in administrative recognition of faculty working with the students populus on extra-curricular activities.

One of the principal reasons for the formation of a student chemistry club is that the club will help to interest the students in the benefits of chemistry to the community. I feel that any increased stimuli in a student for learning is well worth the effort. The total role of a chemistry club in the community college program is multifaceted. The benefits of such a club far out-weigh the donation of minor funding for dues, a small amount of a facult faculty member's time, and the effort to make it work.

Chemistry for the Visually Impaired and Orthopedically Impaired

Roy and Dorothy Tombaugh
Lyndhurst Ohio 44124

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General Considerations

The inclusion of physically impaired persons in chemistry lectures and laboratories requires only a few changes in facillities and equipment. Consideration, kindness and creativity are the most important ingredients to meet the needs of these students.

There should be no major changes in curriculum or laboratory investigations because of the presence of physically impaired students in the class. Neither is it advisable to have a separate section, a 'special' for physically disabled persons. It may be necessary to decrease the size of material and equipment used and to alter techniques used in handling materials for those who have impaired manual dexterity. For those who are impaired visually it may mean a new concept of "see." It may require using new techniques plus non-visual senses for non-sighted students to make observations. For severely impaired persons it may necessitate an aide to handle equipment, chemicals, and other materials at the direction of the student. Handicapped persons expect to be tested and graded on the same basis as is the rest of the class. Reevaluation of criteria for grading laboratory work may be necessary.

A conference with the physically imparied students at the beginning of the year gives an opportunity to ask how they expect to manage in lecture and laboratory. Past experience with science courses and discussions with the counselor for the handicapped may have provided the solutions for many lecture and laboratory situations. The students should have a tour of the laboratory before the first session to acquaint them the location of equipment and chemicals. It may also provide the time to acquaint them with any specific hazards and safty procedures.

If lecturers verbalize as they write problems on the chalk board or as they present material on an overhead projector, they will aid not only the visually impaired but they will reinforce learning for all students. If as they draw sketches on the board, they describe the drawing in a standard manner, it will be easier for the non-sighted person to visualize. For a sighted person to have a means of communication for aiding a blind person in problem solving, a slant board with magnetic letters and numbers or a braille scrabble board with added symbols can be used. These means may also be used for a non-verbal person to express words and numbers when writing is also difficult. Visually impaired persons should examine equipment to be used in lecture-demonstrations before the class begins so visualization of the procedures and equipment is possible.

Note taking may be a problem for the deaf, blind and those with manual impairments. A tape recorder may suffice this need for some. They may tape the whole lecture and then edit the tapes. The deaf may take the tape to someone who can sign it to them. Multiple sets of notes taken by one or more volunteers is the method of choice in some areas. The notes are distributed at the end of each lecture to those needing such service.

Teaching the Orthopedically Impaired

There are a number of forms of orthopedic impairments so it is difficult to generalize regarding teaching procedures. Then too there is an increasing number of temporary disabilities which also disable students for varying lengths of time during the year.

Students in wheel chairs are not able to work comfortably at standard chemistry benches. One solution is to have an area of the laboratory with lowered counters to accomodate the average wheel chair. Better yet is to have cabinets removed from an area beneath the counter tops of one section so wheel chairs will fit under the lowered top. There is advantage in having a counter top which is movable so its height can be varied, it will not only accomodate persons in wheel chairs but also those who need to sit to do laboratory work and those who are below average in height and need a lower place to work in a standing position. For some persons of short stature, the solutiion has been to have a few steps connected to movable platform mounted on casters.

Among the solutions for working at standard 36" high laboratory benches is a platform chair designed by Dr. Robert Larsen. This consists of an oak desk chair or an oak laboratory stool nailed to a 20" x 24" wooden platform. Large ball bearing swivel casters located near the corners of the platform increase its stability. To meet the need of a platform chair which could be readily transported and stored for the temporarily handicapped the design was altered slightly. Roy Tombaugh used a folding metal chair which is bolted to the platform with wing nuts.

Moore and Blair designed a platform with a ramp onto which a wheel chair can be readily moved. The chair is held to the platform with a sturdy clamp. This provides a way to work easily at a 36" high bench.

Brindle described an Adjustable-Height Wheelchair to meet the needs of persons working at 36" laboratory benches. With this chair most of the equipment in a chemistry laboratory is accessible to the chair-bound student.

The weight-buret (Seils 1963) was originally designed to enhance accuracy in titration. It may serve also for a means for visually and orthopedically impaired persons to perform titrations. A 10 ml plastic wash bottle with a fine tip on the nozzel is the buret. The amount of solution is determined by weighing the buret before and after the titration. The blind place the beaker on a magnetic stirrer and use a light sensor to determine the change in color of the indicator. Other techniques for titration by blind persons are reported by Hiemenz (1972, Tallman (1978) and Lunney (1981).

Students with one arm and those with manual deficiencies may need clip boards for holding writing materials. They may also require a varity of clamping devices to hold labware. To meet the needs of a person whose hands are too weak to remove the rubber stopper from a tube containing a sample of blood sent for chemical analysis, Roy Tombaugh designed a stand which incorporates a clamping device to hold the blood tube securely. There is a forked lever which clips between the bottle and the stopper head bent in such a way that prying against the stand top removes the stopper easily. The clamping levers and the prying lever are such that minimal dexterity and little strength is required to operate them. This device is an example of one of many possibilities to assist those with physical handicaps in the laboratory.

Semi-micro chemistry may meet the need of some students with manual impairments. By using minature sized laboratory glassware, a person whose hands are barely movable, is able to perform chemical tests with a spot plate and a dropper pipet. 7 ml reagent bottles are held with little effort. Micro beakers, flasks, tubes and other labware extend the variety of investigations that can be performed. The procedures for the experiments remain basicly the same, only the size is altered.

Students with extremely short arms may need more than safety goggles. A whole face shield is needed to protect a face brought unusually close to the work area. Persons seated for laboratory should have a large, heavy laboratory apron for extra protection.

Teaching the Visually Impaired

Few blind persons have chosen to major in chemistry in the past. The visually impaired who have majored in other sciences and have included chemistry as a required or elective course are also a small group. Few persons with defective vision have studied chemistry as a part of a general education. These numbers have been small due to attitudinal barriers often based on false assumptions of the abilities and disabilities of visually impaired persons. With educational and legislative stimuli there is now a steady increase in the number of visually impaired persons studying science. As new instrumentation allows for greater independence in the chemistry department, more blind persons can be expected to enroll.

The Talking Calculator followed by ThermoVioce, a talking thermometer, are the first instruments to be marketed with audio output. Other instruments which have a digital readout and a BCD (Binary Cided Decimal) output may be interfaced with the Voice Synthesizer. More than one instrument may be interfaced to the same Voice Synthesizer. This interfacing does not interfer with the reading of numbers by sighted students. The cost of making most laboratory instruments available to the non-sighted becomes only the cost of a voice synthesizer.

Chemical calculations involving only arithmatic functions are efficiently done by blind students on a Japanese Abacus. The Talking Calculator makes additional computations readily available to the visually impaired. An ear plus may be attached to it so it may be used during tests without giving information to others.

ThermoVoice has one stainless steel probe which registers in the range of -10°C. to 110°C. making it a standard laboratory thermometer. It has an accuracy of ± 0.1°C. Only a few seconds are necessary for the probe to stabilize after being immersed in the material to be tested. Another probe registers from 27°C to 210°C. The instrument may be worn on a cord about the neck thus keeping it easily located. When the batteries need recharging it voices a warning, "Low...low...low." It may also be operated with an ear plug.

The Light Sensor is another instrument of critical importance for the visually impaired person in the science laboratory. It has a photoelectric cell connected to a sounding device. The greater the intensity of light registered, the greater is the pitch of the sound produced. It has a wide variety of uses. The difference in transmission of light between a clear and cloudy solution is detectable, thus giving information on the formation of precipitate. The tone will change as the color of a solution changes. When used in the same tests routinely the difference in sound between a few colors can be recognized. In chromatography the Light Sensor recognizes the location of spots of color on the paper. The penciled base line on the paper is also discernable. By using a sensor with a narrow opening, the location of liquid in buret, graduated cylinder of volumetric flask can be determined. Accuracy depends upon the instrument and the experience of the user and can be expected to approach that of visual readings.

The Audicator, the sound producing instrument used with one Light Sensor, registers changes for other devices also. The Liquid Level Indicator is a stinless steel probe which when connected to the Audicator emits a sound when a circut is completed when the prob touches a liquid. It performs with precision in filling a volumetric flask and another form is practical for filling a guest's coffee cup.

The 3M Braille Labeler has printed as well as braille symbols so a non-braille reader is able to prepare lables for reagents, shelves and directions on equipment. Another 3M Labeler has large print with raised letters. This is usable for persons with minimal vision, readable at a distance by sighted persons and slowly discernable by blind persons with tactile means.

Organic Model Kits are an asset for all students but of particular aid for visually impaired students in learning molecular formulas of organic compound and in balancing equations. Crystal models help students to visualize the arrangement of atoms within a crystal.

To measure liquids with fair accuracy, plastic syringes which have plungers knotched at varying volumes, are used. The triple beam balance is easily altered by means of a piece of tape at the mid=point. By placing a finger on the tape the non-sighted students easily determine when the scale is in balance. Knotches and grooves on the beams of the balance aid in enumerating the position of the weights. For the front beam which may be smooth, the student's braille ruler may be calibrated with the beam to give the value of the position of the weight.

Clocks and instruments with large markings may be given raised marking by the addition of Elmer's glue to the lines. Many pieces of equipment routinely used in laboratories have raised or depressed markings that are readable with tactile means. Raised line drawings or paper cutouts may be used to give the blind student a quick sketch to show information drawn on the board or shown in the text.

For more details on teaching chemistry to physically impaired persons, the March 1981 issue of the Journal of Chemical Education is devoted to this topic and Ken Reese.

To aid in understanding how a visually impaired person knows where items are located on the laboratory bench, a helpful article is found in Science, September 11, 1981 written by Landau, Gleitman and Speeka.

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American Printing House for the Blind, Inc. 1839 Frankfort Avenue Louisville, Kentucky 40206	Some supplies as the light probe as well as books in braille and large print.
Telesensory Systems, Inc. 3408 Hillview Avenue Palo Alto, CA 94394	Optacon
Braille Technical Tables Bank National Braille Association c/o Mrs. James O. Keene 31610 Evergreen Road Birmingham, Michigan 48009	Thermoform copies of math and scientific tables
Braille Book Bank National Braille Association, Inc. 422 Clinton Avenue, South Rochester, N.Y. 14620	College texts
Ornell Company Maxton, N.C.	Accessible House Trailers for Handicapped used at St. Andrews for seniors for independent living.
Radio Shack	Voice synthesizer.
Thermofax Corporation Slausen Avenue Los Angeles, California	Thermoform machine
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National Technical Institute for the Deaf Rochester Institute of Technology One Lomb Memorial Drive Rochester, N.Y. 14623	Note taker - special tablet. It is usable for those with impaired upper extremeties as it is for the deaf.
San Francisco Lighthouse for the Blind, Inc. 745 Buchanan Street San Francisco, CA 94102	Light Probe - $35.00

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175 North Beacon Street
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Coordinator, Industrial Sponsors – Don Roach (1982) Miami-Dade Community College, South Campus, 11011 S.W. 104 St., Miami, FL 33176 (305-596-1157)

ALLISON, Harrison (1983): Marion Military Institute Marion AL 36756 (205-683-2871) Mail to P.O. Box 548, Marion, AL 36756

BARBER, Ms. Anne (1983): Manatee Junior College, 5840 26th Street W., Bradenton FL 33505 (813-755-1511)

BARTLEY, Edith (1983): Tarrant County Junior College South Campus, Fort Worth, TX 76119 (817-534-4861) Mail to 7424 Continental Trail, Smithfield, TX 76180

DARNELL, David R. (1983): Shelby State Community College P.O. Box 40568, Memphis TN 38104 (901-528-6748)

HOWARD Charles (1983): University of Texas at San Antonio, College of Sciences and Mathematics Division of Earth and Physical Sciences, San Antonio, TX 78285 (512-691-4455)

HUSA, William J. (1984): Middle Georgia College, Cochran, GA 31014 (912-934-6221)

INSCHO, F. Paul (1982): Hiwassee College, Madisonville Tennessee 37354 (615-442-2128)

JEANES, Opey D. (1982): Mount Olive College P.O. Box 151, Mount Olive NC 28365

KING, Floyd (1984): North Lake College, 2000 Walnut Hill Irving Texas 75062 (214-255-5230)

KNIGHTON, Margaret (1982): Southern University, 3050 Cooper Road, Shreveport, LA 71107

MINTER, Anne P. (1983): Roane State Community College, Harriman TN 37748 (615-354-3000)

WELLS Darthon (1982): Louisianna State University at Alexandria, Alexandria LA 71301 (318-445-3672)

Region III – Midwestern States

Illinois, Indiana, Iowa Kansas Kentucky Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dekota, Wisconsin

Midwestern Regional Vice-Chairman (1982): Eidsness, Warren (1983), Normandale Community College, 9700 France Ave S., Bloomington, MN 55431 (612-830-9300)

Coordinator, General Membership – Cullen Johnson (1984), Cuyahoga Community College, Western Campus, Cleveland, OH 44130 (216-845-4000)

Coordinator, Industrial Sponsors – Ralph A. Burns (1983), East Central Community College, Union, MO 63084 (314-583-5193)

CLOUSER, Joseph L. (1984): Wm. Rainey Harper College, Palatine IL 60067 (312-397-3000)

CRAWFORD, Sam (1984): Johnson County Community College College Boulevard at Quivira Road, Overland Park, KS 66210 (913-888-8500)

ELKINS, Dean I. (1983): Henderson Community College, University of Kentucky, Henderson, KY 42420 (502-827-2867)

GROTZ, Leonard (1982): University of Wisconsin-Waukesha, 1500 University Drive, Waukesha, WI 53186 (414-542-8825)

JONES, Richard (1982): Sinclair Community College, Dayton, OH 45402 (513-226-7907)

KLEIN, Dave (1983): Kansas City Community College Kansas City KS 66112 (913-334-1000)

KOCH, Frank (1982): Bismark Junior College, Bismark, ND 58501 (701-223-4500)

KOLB, Doris (1983): Illinois Central Community College, East Peoria, IL 61635 (309-694-5011)

KREIGER, Albert (1982): Jackson Community College, Jackson, MI 49201 (517-787-0800)

REDMORE, Fred (1984): Highland Community College, Freeport, IL 61032 (815-235-6121, Ex. 331)

WINKELMANN, John (1984): Illinois Valley Community College, Rural Route One Oglesby, IL 61348 (815-224-6011)

Region IV – Eastern States

Connecticut, Delaware, District of Columbia, Maine, Maryland Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Virginia, Vermont, West Virginia

Eastern Regional Vice-Chairman (1982): Onofrio (Dick) Gaglione (1984), New York City Technical College, 300 Jay St., Brooklyn, NY 11201 (212-643-8242)

Coordinator, General Membership – Edmund J. Zoranski (1983) Atlantic Community College, Mays Landing, NJ 08035 (609-625-1111)

Coordinator, Industrial Sponsors – Onofrio (Dick) Gaglione (1984), New York City Technical College, 300 Jay St., Brooklyn, NY 11201 (212-643-8242)

BERKE, Thomas (1984): Brookdale Community College, Lincroft, NJ 07738 (201-842-1900)

Sister M. Bohdonna (Podney)(1983): Manor Junior College, Jenkintown, PA 19046 (215-885-2361)

BROWN, James L. (1982): Corning Community College, Corning, NY 14830 (607-962-9242)

CHERIM, Stanley M. (1982): Delaware County Community College, Media, PA 19063 (215-353-5400)

CUCCI, Myron W. (1984): Monroe Community College, Rochester, NY 14623 (716-442-9950)

HAJIAN, Harry G. (1984): Community College of Rhode Island, 400 East Ave., Warwick, RI 02886 (401-825-2258)

HINES, Lee (1983): Southern West Virginia Community College, Williamson Campus, Williamson, WV 25661 (304-235-2800)

SOLLIMO, Vincent (1982): Burlington County College, Pemberton, NJ 08068 (609-894-9311) Mail to Box 2788, Browns Mills, NJ 08068

STEIN, Herman (1983): Bronx Community College, City University of New York, Bronx, NY 10453

VLASSIS, C.G. (1982): Keystone Junior College, LaPlume, PA 18440 (717-945-5141)

ZDRAVKOVICH, Vera (1982): Prince Georges Community College, Largo, MD 20870 (301-336-6000)