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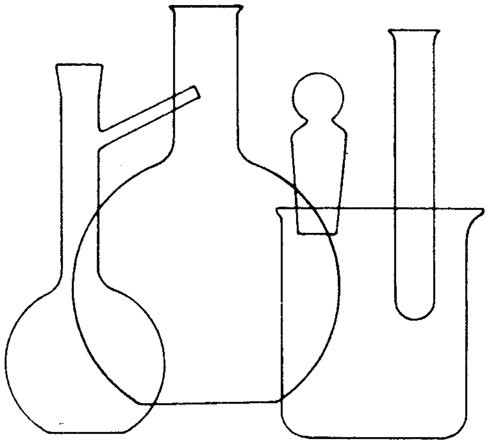

CHEMISTRY
IN THE
TWO-YEAR COLLEGE

VOLUME XVI 1975

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

Foreword

Volume XIV of Chemistry in the Two-Year College is the second for 1977. The first volume for 1978 will be puslibhsed soon.

The conference at Shelby State Community College was the final meeting under the fine leadership of Cecil Hammonds and it was at this meeting that Curt Dhonau accepted COCTYC Chairman-elect.

Ann Minter from Roane State Community College was Regional Chairperson and responsible for the program at Shelby State. Robert Burham from Grand View College was the editor for the conference and William Cheek from Central Piedmont Community College was the recorder. Taylor Barbee and David Darnall from Shelby State were in charge of local arrangements and exhibits.

The Forty-Eighth Conference was held at Cuyahoga Community College - Western Campus. This was the first meeting during which Doug Bauer was Chairman of COCTYC. The Regional Chairperson in charge of the program at Cuyahoga was Virginia Malik. Her help for the fine conference came from Florence Wolters Chew and Norbert Durnath who made local arrangements. They were both from Cuyahoga Community College. The editor for the conference was Cullen Johnson from the Metro Campus of Cuyahoga Community College.

Also included in this journal are papers from the Fiftieth Conference, which was held at Fanshawe College, London, Ontario. Peter Slade was the editor of that meeting and supplied the papers included.

The COCTYC express their sincere thanks for the fine job done by all who helped make these meetings and proceedings possible.

Jay Bardole
Editor

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SPECIAL APPROACHES TO CHEMICAL SCIENCE

An Integrated Chemistry Curriculum in a Natural Science Program

Richard Chalifoux
Vanier College (Snowdon Campus)
Montreal, Quebec

Presented to a Symposium on Teaching Instrumental Techniques: Allied Health Programs, at the Forty-Fifth, Two Year College Chemistry Conference, George Brown College of Applied Arts and Technology, Toronto, Ontario, Wednesday, May 28, 1975.

I. Natural Science Technology and the CEGEP College

The objectives of this paper is to present an informative insight into the Natural Science Technology program, now in its third year at Vanier College, and to illustrate the first phase of integration (unification) of the chemistry curriculum in order to meet the needs of the Natural Science student.

The Natural Science Technology program is a three-year course of study which trains students in two different areas of specifilizations:

1. Wildlife Management
   In this option, the student is trained to assist the progessional wildlife biologist and ecologist.
2. Animal Science
   In this option, the student is trained to assist the progessional veterinarian for a position either in a private clinic or in a research institute.

Vanier College is a CEGEP (College of General and Profesional Education) and its primary aim is to provide, at public expense, a thoroughly general and professional education, at the college level. Professional education means the systematic preparation either for a technological career or for advanced studies at a university. The CEGEP structure, which is quite flexible, is illustrated in Figure I.

Thus, both Natural Science Technology students in the Career Program stream and Pre-university students are involved in professional education. At the same time, both groups of students are continuing their general education through common courses in English, Humanities and complementary (elective) courses.

Hence, this structure permits diversification within a field of concentration.(1)

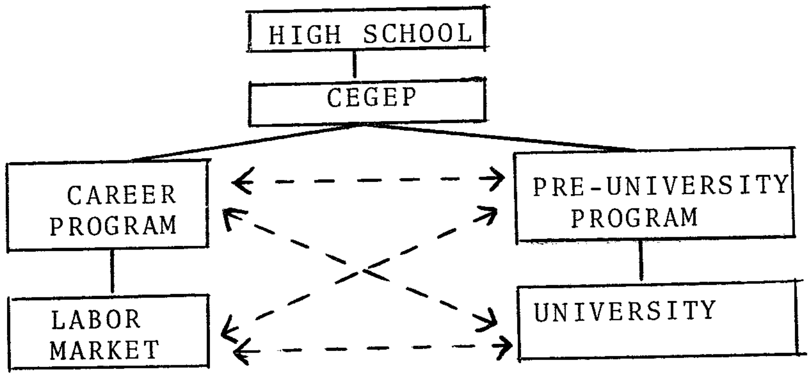


Figure 1

II. The Natural Science Technology Curriculum

The program concept, unique at the Snowdon campus of Vanier College, permits a high degree of curriculum integration, since all science courses in the program are offered by faculty members hired by the Natural Science Technology program. My role as a chemist, as I perceive it within the program, is to teach all chemistry courses to our students and to design these to best serve their needs. Figure II illustrates the curriculum for Year I. The student is exposed to a general education including General Chemistry, Organic Chemistry and Instrumentation. Detailed outlines of the chemistry curriculum will be discussed in the next section.

The second year also illustrated in Figure II deals with the acquisition of the general knowledge, terminology and laboratory techniques related to the biological world. The Biochemistry curriculum will also be discussed in the next section.

Year I

First Semester	Second Semester
English	English
Humanities	Humanities
General Biology I	General Biology II
General Chemistry	Organic Chemistry
Geology & Soil Science	Instrumentation
Complementary	Complementary

Year II

Third Semester	Fourth Semester
English	English
Humanities	Humanities
Botany	Biometry
Zoology	Animal Behaviour
Ecology	Animal Physiology
Biochemistry	Complementary

Figure II

Upon completion of these two common years of study, the student now chooses his/her specialization.

The curriculum in the Wildlife Management option (Fig. III) stresses both field work and practical experience. A Biological station located 40 miles north of Montreal, contains both laboratory facilities and student residences. In this natural environment, instruction by full-time faculty members provides an opportunity for intensive field training.

The student is exposed to techniques such as identification and taxonomy of plants, birds, mammals and fish, preparation of study skins, trapping and tagging techniques, limnology and aerial photography.

Close liason with the Federal and Provincial environmental and biological agencies ensures very close relevancy to the working situation.

The Animal Science option (Figure III)for the fifth semester is designed to train the students in specialized veterinary laboratory techniques, such as pathology, surgery, nursing and hygiene, breeding and reproduction, hematology, microbiology and radiology. The sixth semester is devoted to internship in government laboratories, research institutes and private clinics.

Year III

Wildlife Management Option

Fifth Semester

Fish Management Project

Applied Ichthyology
Applied Entomology
Fish Management
Plant Taxonomy
Soil and Water Microbiology
Surveying, Design & Mapping
Meteorology

Sixth Semester

Animal & Bird Management Projects

Applied Ornithology
Mammalogy
Small Game Management
Large Game Management
Birds & Waterfowl Management
Techniques of the Interview

Animal Science Option

Fifth Semester

Professional Information
General Pathology
Nursing, Hygiene and Surgical Techniques
Breeding and Reproduction
Veterinary Laboratory Techniques

Sixth Semester

Final Term Project
Laboratory Internship
Research Institute Internship
Private Clinic Internship

Figure III

III. The Chemistry Curriculum

A) General Chemistry 104

The primary objectives of this introductory course in general inorganic and physical chemistry are to:

1. Serve as a foundation for subsequent chemistry and biology courses.
2. Illustrate how chemical principles can contribute to the conservation of the environment.

Selected topics for the curriculum, illustrated in Figure IV were culled from Prof. R. Gymer's text: Chemistry, An Ecological Approach (Harper and Row, 1973).

Relevant topics such as air pollution, municipal water treatment, and the nitrogen cycle can be easily incorporated into the General Chemistry 104 syllabus.

Quantum theory and the chemical bond (with emphasis on the covalent bond) are treated near the end of the semester so as to prepare the student for bonding in Organic Chemistry 204

General Chemistry 104 Topics

1. Preliminaries - Mathematical Operations
   Scientific Measurement
2. Electrons, Atoms and Molecules
3. Chemical Calculations and Stoichiometry
4. The Gaseous State
5. The Physical Properties of Solutions
6. Chemical Equilibrium
7. Proton and Electron Transfer
8. Electrochemistry
9. Quantum Theory
10. The Chemical Bond

Figure IV

The laboratory outline is illustrated in Figure V. The choice of laboratory experiments is intended to aid in the achievement of the following objectives:

1. Development of skills and confidence in laboratory techniques.
2. Appreciation of precision, accuracy and error in scientific measurements.
3. Training in the derivation of conclusions from experimental observations.
4. Illustrating chemical principles in the form of concrete examples.

In the classroom, experimental evidence is also emphasized by demonstrating "quickie" experiments via an overhead projector.

General Chemistry 104
Laboratory Outline

1. The Chemical Laboratory - Tools of the Chemist, Safety Precautions
2. Determination of the Density of Nuts, Bolts and Marble
3. Periodic Properties - The Halogens, Third-Period Hydroxides
4. Determination of the Molecular Weight of CO_2
5. Calorimetry and Heat of Neutralization
6. Equilibrium and Le Chatelier's Principle
7. Determination of the % Acetic Acid in Vinegar
8. Electrochemistry - The Galvanic Cell, Electrolysis
9. Synthesis of Copper (II) Oxalate

Figure V

B) Organic Chemistry 204

Part of the lecture content is conventional and dedicated to the study of the properties of the major functional groups, using a simplified mechanistic approach. The text employed is by Prof. C. Snyder: Introduction to Modern Organic Chemistry (Harper and Row, 1974).

My objectives for this course are to:

1. Stress the relationship between the structure and function of organic molecules.
2. Permit the student to appreciate how the organic chemist thinks.
3. Prepare the student for Biochemistry 304.

In order to hopefully accomplish the above, consumer and biological chemistry topics are incorporated into the lectures by means of Scientific American reprints (W.H. Freeman and Co.). These topics, which also motivate interest are shown in Figure VI.

TOPICS INJECTED INTO THE ORGANIC CHEMISTRY 204 LECTURES TO STIMULATE STUDENT INTEREST

1. Chemistry of the Petroleum Industry
2. DDT and Ecological Damage
3. Steroid Chemistry
4. Odour and the Olfactory System
5. The Visual Process
6. Food Additives
7. Dyes
8. Pheromones
9. Fats, Soaps and Detergents
10. Alkaloids and Drug Chemistry
11. Polymer Chemistry

Figure VI

In the laboratory, the student examines the physical and chemical properties of the major functional groups, appreciates stereochemistry via the molecular model experiment, and is exposed to basic techniques such as recrystallization, liquid-liquid extraction, distillation and vacuum sublimation.

C) Instrumentation 101

This course is essentially one in both qualitative and quantitative analytical chemistry, presenting techniques which our students will probably require in a modern biological laboratory.

To cite a few examples, in the classroom the environmental chemistry of natural waters is taught and in the laboratory the identification and separation of inorganic anions and some cations are carried out. This is assimilated quite well with the use of field kits in limnology.

Similarly, experiments related to spectrophotometry prepare the potential Animal Science student for clinical chemistry, such as blood and urine analysis.

Photography is incorporated into the curriculum on an individual project basis which permits familiarity with a Single-Lens-Reflex camera and film development. This technique is important for subsequent courses when the student is required to present a technical report with a permanent reproduction of his/her work.

The outline of Lecture and Laboratory Content is shown in Figure VII.

INSTRUMENTATION 101
SYNOPSIS OF
LECTURE AND LABORATORY CONTENT

1. Qualitative Analysis of Inorganic Ions and the Environmental Chemistry of Natural Waters.
2. Volumetric Analysis
3. Gravimetric Analysis
4. Methods of Separation and Identification
    A) Paper and Thin-Layer Chromatography
    B) Gas Chromatography
5. Colorimetry and Spectrophotometry (UV-VIS)
6. The Spectroscope
7. Flame Photometry
8. Radiography
9. Photography

Figure VII

Some of the apparatus employed by the students on a rotation basis include:

1. A Unicam SP-600 UV-VIS single-beam spectrophotometer.
2. A Sargent-Welch Chem-Anal single-beam spectrophotometer (an excellent visual aid also)
3. A Coleman Model 21 Flame Photometer
4. An optical bench to illustrate the dispersion of light by a grating (another good visual aid).
5. A Gallemkamp Gas Chromatograph with Omniscribe strip-chart recorder.

D) Biochemistry 304

The lecture content, illustrated in Figure VIII, is designed to make students aware of basic biochemical phenomena and is the strongest link between chemistry and physiology. Clinical cases related to health problems are analyzed using acquired principles which hopefully will illustrate to the student why biochemistry is important in Natural Science. A text which will meet the instructional objectives for the next semester is presently being reviewed.

BIOCHEMISTRY 304
SYNOPSIS OF INSTRUCTIONAL OBJECTIVES

1. Carbohydrate Chemistry
2. Lipid Chemistry
3. Protein Chemistry
4. Enzymology
5. Nucleotides and Vitamins
6. Carbohydrate Metabolism and the Mitochondrion
7. Lipid Metabolism
8. The Metabolism of Ammonia and Nitrogen-Containing Monomers
9. Molecular Genetics
10. Photosynthesis and the Chloroplast
11. Molecular and Cellular Regulation

Figure VIII

The laboratory part of the course, illustrated in Figure IX, has a dual objective: First, to illustrate biochemical principles by doing experiments, and second, to learn basic biochemical techniques.

Biochemistry 304

Laboratory Outline

1. Chemical Properties of Carbohydrates
   Mutarotation of Glucose in Water.
2. Spectrophotometric Determination of Glucose in Water.
3. Paper Chromatography of Amino Acids.
4. Chemical Properties of Egg Albumin.
5. Enzymology of Polyphenol Oxidase.
6. Chemical Properties of Triglycerides, Soaps and Detergents.
7. Extraction of Lecithin and Cholesterol from Egg Yolk.
8. Visible Absorption Spectrum of Spinach - Leaf and Red Autumn-Leaf Extract.
9. Electrophoresis of Serum Proteins on an Agarose Medium.
10. Separation by Gel Filtration of Vitamin B_{12} and Dextran.

Figure IX

Reference

(1) Vanier College Calendar, 1975.

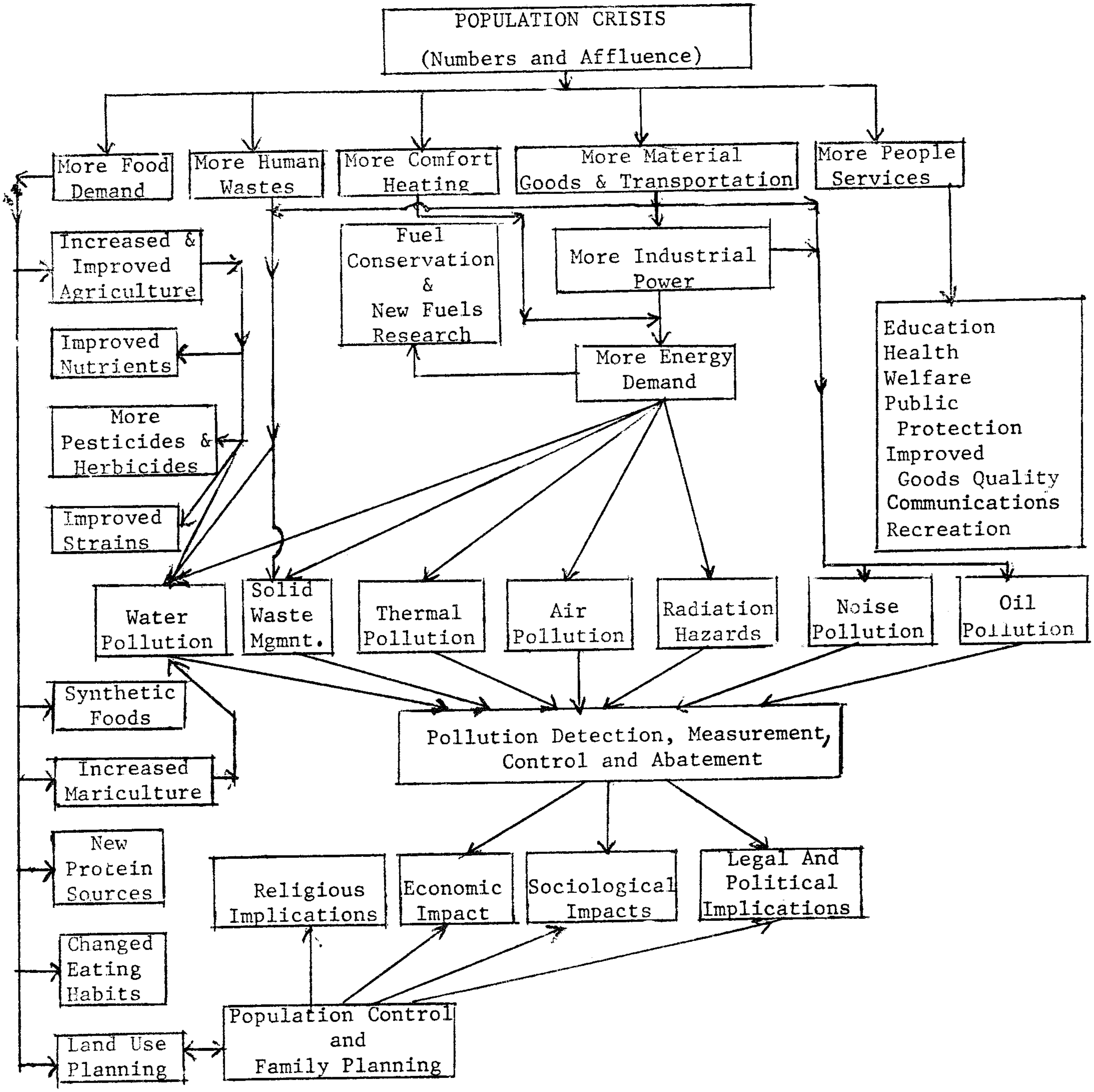
Use of Energy and Environmental Problems in Chemistry Courses

W.G. Sink
Davidson County Community College
Lexington, NC 27292

Presented to the Forty-Seventh Two Year College Chemistry Conference, Shelby State Community College, Memphis, Tennessee, November 1, 1975.

After designing and implementing a basic course in environmental studies, I am convinced that this area offers many problems and exercises that would be very challenging if incorporated into chemistry courses. Figure I shows something of how these problems are tied together in the environmental course. This shows many possible chemistry-environmental interfaces.

Under increased food production, chemistry is greatly involved with improved plant nutrients, the development of more effective but less hazardous pesticides and herbicides and the development of synthetic foods. Chemistry and physiology are brought face to face in the search for birth control materials and procedures. The search for new energy sources greatly involves chemistry. The depletion of resources, e.g. fossil fuels and the search for more efficient uses and recycling procedures depends on the chemistry of these materials. A large portion of today's chemists depend on the petrochemicals industry. More and more chemists will become involved in the detection, measurement, control and abatement of environmental pollutants.


POPULATION CRISIS
(Numbers and Affluence)
More Food Demand
More Human Wastes
More Comfort Heating
More Material Goods & Transportation
More People Services
Increased & Improved Agriculture
Fuel Conservation & New Fuels Research
More Industrial Power
Improved Nutrients
More Energy Demand
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Health
Welfare
Public Protection
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Solid Waste Mgmnt.
Thermal Pollution
Air Pollution
Radiation Hazards
Noise Pollution
Oil Pollution
Synthetic Foods
Increased Mariculture
Pollution Detection, Measurement, Control and Abatement
New Protein Sources
Religious Implications
Economic Impact
Sociological Impacts
Legal And Political Implications
Changed Eating Habits
Land Use Planning
Population Control and Family Planning

Figure I

In connection with population growths, I use the interest growth formula which is derived in Figure II. Form (II) is used for calculating doubling, tripling...times by lettin R = 1, 2...n. Form IV is used for calculating the growth rate required to give R in time, T.

Time Periods (T)	Final Amounts (P_f) Accumulated at End of n Perio (P = initial principal; i = interest rate)
0	P
1	$P + Pi \qquad = \underline{P(1 +}$
2	$\underline{P(1 + i)} + P(1 + i)\ i = P(1 + i)(1 + i) \qquad = \underline{P(1 +}$
3	$\underline{P(1 + i)^2} + P(1 + i)^2\ i = P(1 + i)^2(1 + i) = \underline{P(1 +}$
4	$\underline{P(1 + i)^3} + P(1 + i)^3\ i = P(1 + i)^3(1 + i) = \underline{P(1 +}$
T	$= \underline{P(1 +}$

From this we can write: $P_f = P(1 + i)^T$

OR, $P_f = P(1 + g)^T$ where g = growth rate

$P_f/P = R = (1 + g)^T$ ÷ by P and letting $P_f/P = R$

$$\log R = T \log (1 + g) \qquad (\text{I})$$

$$T = \frac{\log R}{\log (1 + g)} \qquad (\text{II})$$

$$\text{Or, } \log (1 + g) = \frac{\log R}{T} \qquad (\text{III})$$

$$(1 + g) = \text{antilog} \left[\frac{\log R}{T}\right]$$

$$g = \text{antilog} \left[\frac{\log R}{T}\right] - 1 \qquad (\text{IV})$$

Figure II

In chemistry, we have numerous logarithmic (exponential) relationships and this simple non-calculus approach might be used to illustrate exponential growths to non-science majors. Two specific areas are photometry and reaction rates. Starting with the growth assumption that

$$\frac{dP}{dT} = KP$$

we obtain

$$\log R = \frac{K}{2.303} \cdot T$$

Form (I) of the above growth formula is seen to be of this form where

$$\log (1 + g) = k/2.303$$

$$\text{and } g = k$$

This turns out to be a good approximation for values of $g \leq 0$.

This growth formula can be applied to the depletion of a non-renewable source such as represented in Figure III. The total area under AFG represents total reserves. The shaded area under AH represents the amount used to-date. Thus if we want the time for using one half of the total amount available, the Area AFG/2, the ratio R becomes

$$\frac{\text{Area AFG/2}}{\text{Area AH}}$$

and T can be calculated for any production growth rate from Form II, Figure III. These results are of vital interest to chemists as applied to raw chemical feed stocks, particularly fossil fuels used in the manufacture of fertilizers, fibers, plastics, solvents, antifreezes, dyes, drugs, etc.

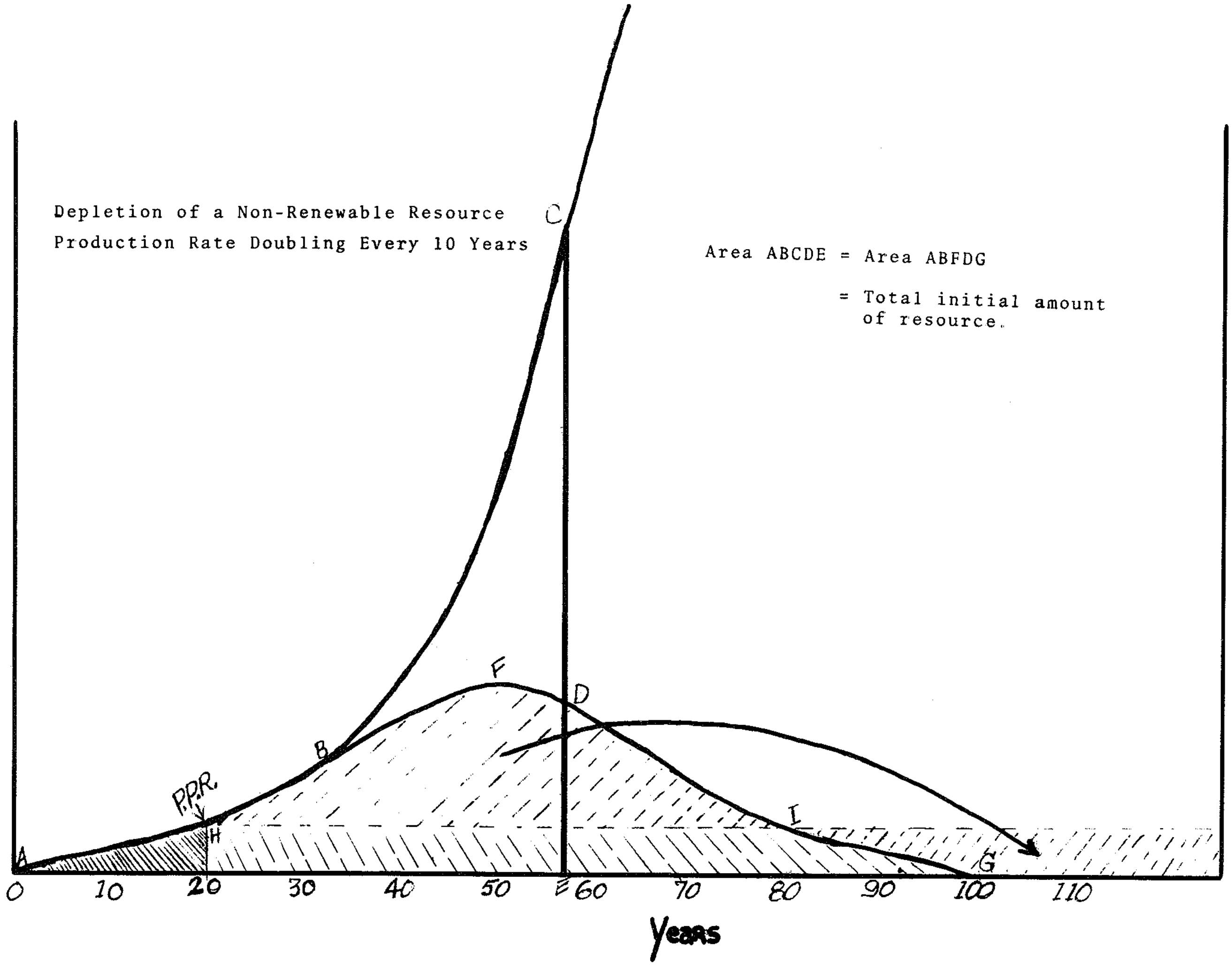


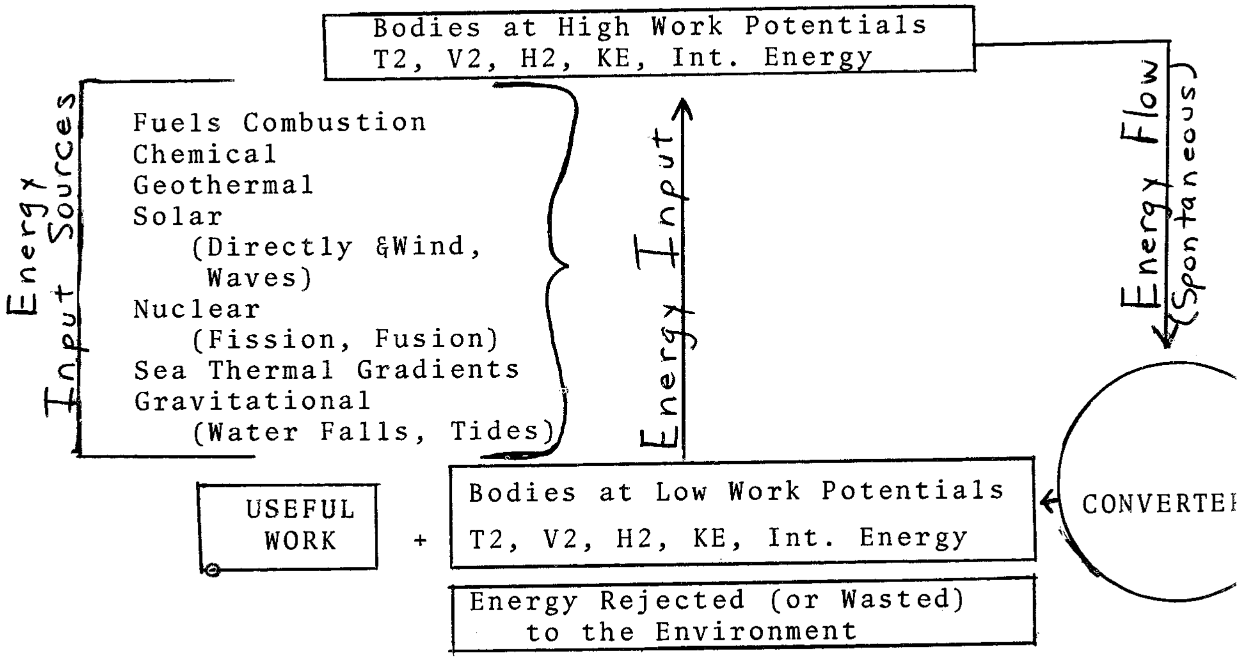
Figure III

Although the mass of earth's current 3.5×10^9 plus people is only 2.65×10^{-12}% of the mass of earth, at 2% annual population growth it would take only 1578 years to convert the entire earth mass into people mass at an average of 100 pounds per person. This clearly shows the absolute impossibility of continued 2% growth.

The energy crisis provides good opportunities to illustrate the laws of thermodynamics. To understand our energy problems, students must understand that work can be accomplished only when energy is transferred from a body at high potential to one at a low potential and that work input is required to restore the bodies to the higher energy potential. Further, since no work process is 100% efficient, the energy of an isolated system gradually becomes less and less available.

Figure IV summarizes the transformations by which work may be obtained from major types of energy and the major energy sources for transferring energy to bodies at higher work potentials.

ENERGY TRANSFORMATIONS



Energy Type	Converter	Lowered Intensity Factor (Pot
1. Heat	Steam Engine or Turbine	Temperature, T
2. Position (Mechanical)	Water Turbine	Height, H
3. Electrical	Electric Motor	Voltage, V
4. Kinetic	Flywheel	Speed, S
5. Chemical	Internal Combustion Engine or Battery	Internal Energy, E

Figure IV

In Figure V, the water at (H_2) can flow to (H_1) through a we water driven motor which pumps water back to (H_2). Because of frictional losses, less water is pumped to the higher reservoir than flows to the lower one so that gradually all water will be at the lower level and the entire system will be warmer because of the heat from the frictional losses. But this heat is not available to do work since it cannot flow to a lower temperature reservoir. Similarly, the hot and cold water could be used to operate a propane boiler driven turbine and pump a given amount of water back to the higher reservoir. Eventually the hot and cold water reach an equilibrium temperature between T_2 and T_1 and the energy is no longer available to do work.

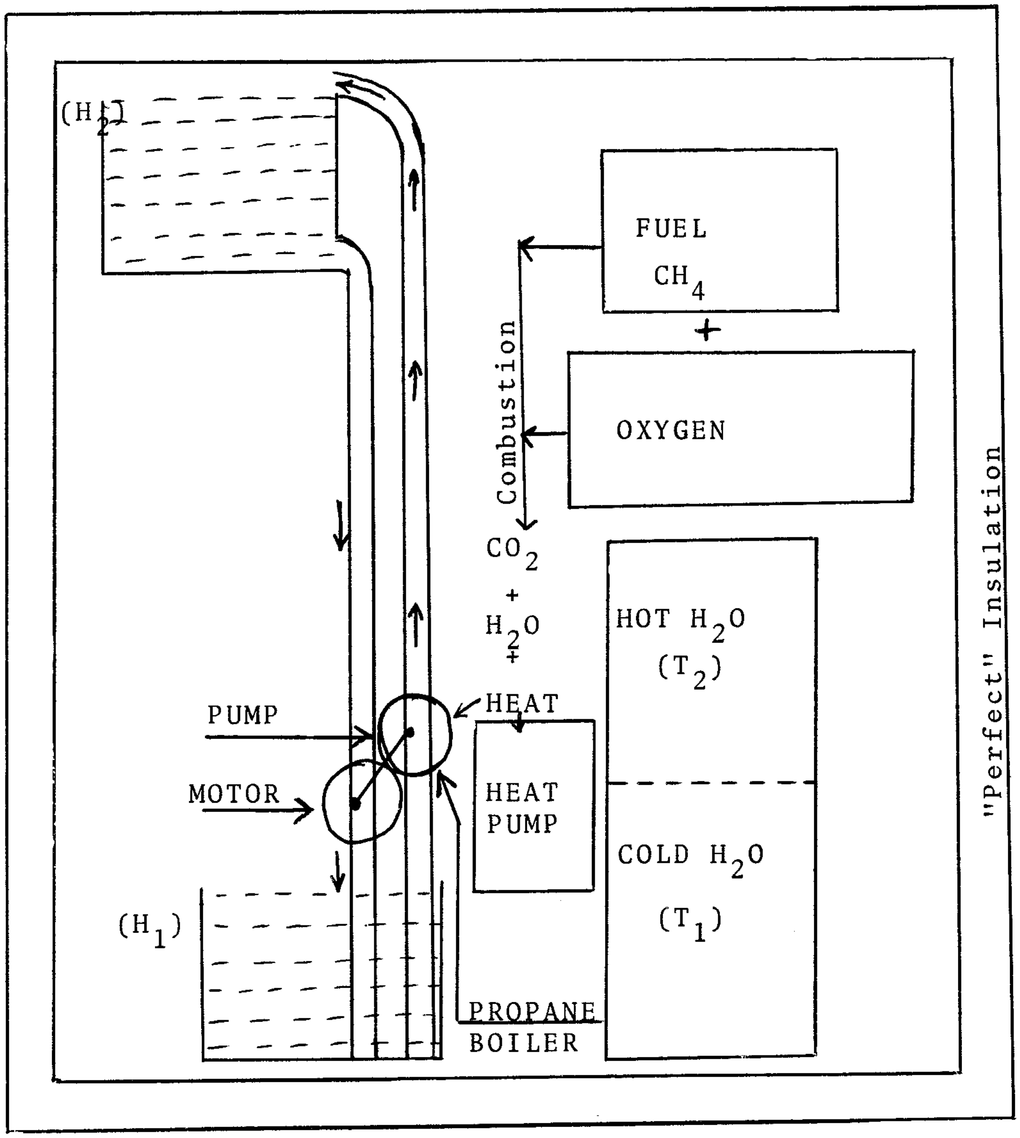


Figure V

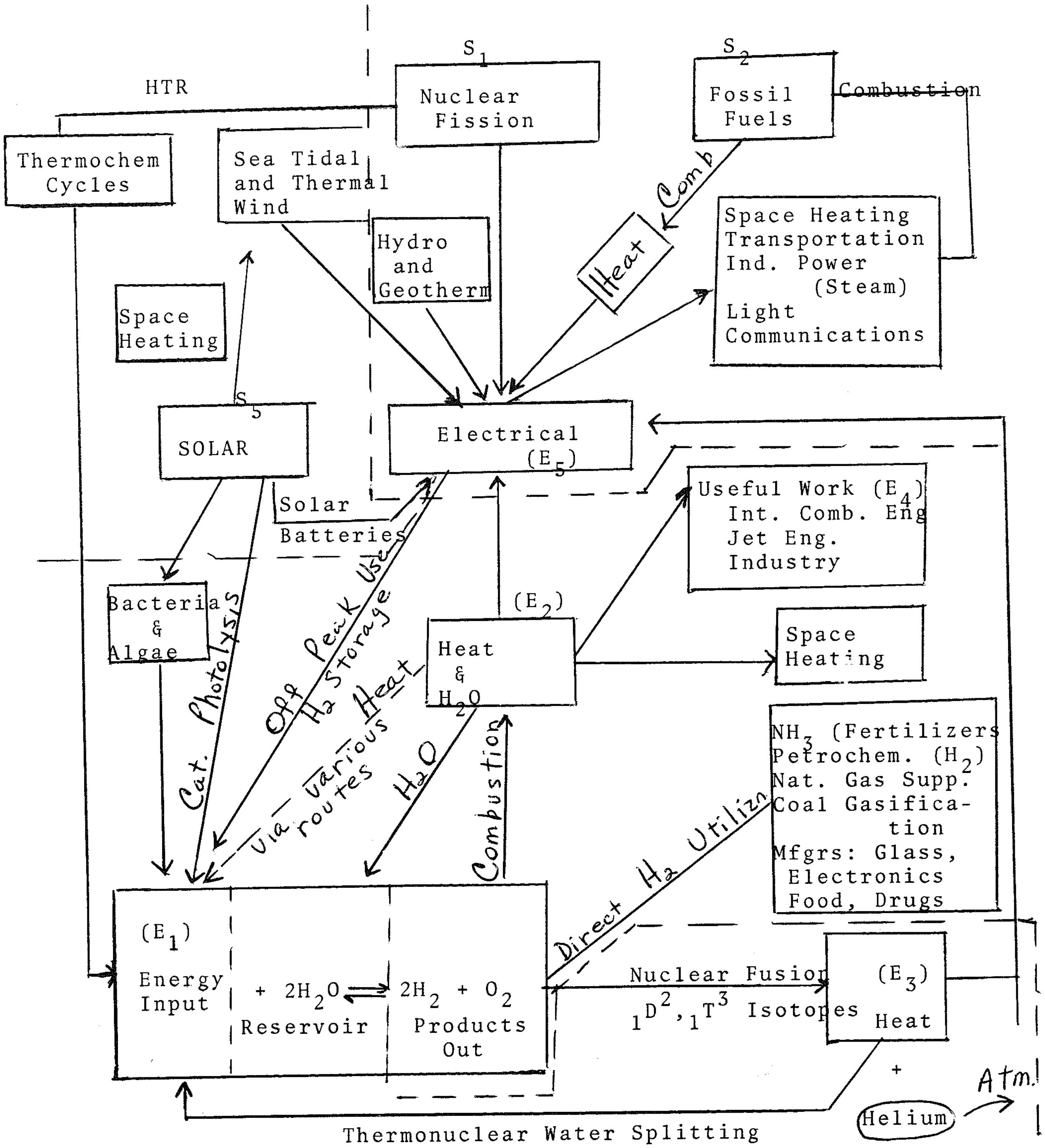
Still further, the CH_4 (representative of a fossil fuel) can be burned and used either to drive a heat pump to restore the hot and cold water separation or drive the water pump to restore a given amount of water to the reservoir at (H_2). No when the hot and cold water again reach an equilibrium temperature and the reservoir water is again at the lower level "we have had it" unless some outside energy source can be brought into our system. Earth is very much like this system except for two important aspects: (1) solar energy can enter continuously (2) as earth tends to warm, excess heat can be re-radiated into space thus tending to prevent excessive warming.

Some important energy supply and demand relationships are summarized in Figure VI. Here again several chemistry interfaces are apparent. These relationships are separated into blocks by the use of dash lines. The upper right hand block summarizes the present situation with fossil fuels supplying the major portion of our current energy needs.

In the lower right hand portion nuclear fusion offers some potential for heat to generate electricity with a portion used to separate the hydrogen isotopes from water. The upper left hand portion indicates the possibility of solar energy supplements through direct space heating and indirectly through tides, winds, sea thermal gradients and solar batteries.

The "ideal" solution lies in the water reservoir (lower left hand block).

If water can be split into hydrogen and oxygen, then they can be recombined through combustion to simply reform water and release the energy to supply man's energy needs wit no environmental pollution problems. The ultimate splitting energy source is solar which minimizes the thermal pollution problem, also, since earth can never intercept more solar energy than it does now or has in the past. The uses of hydrogen and oxygen in the chemical industries are well known. Thus, we need to instigate research on every possible means of utilizing solar energy to split water including chemical means--catalytic photolysis and thermochemical cycles are currently receiving attention.



$E_2 = E_1$ (Theory)

$E_3 \ggg E_1$

$S_1, S_2 \rightarrow E_5 \rightarrow E_1 \rightarrow E_2 \rightarrow \begin{cases} E_4 \\ E_5 \rightarrow E_6 \\ E_7 \end{cases}$

Practical for Off Peak Use

S_1 & S_2 Limited

S_3, S_4 "Free"/Limited Amt.

S_5 "Free"/Abundant

The Hydrogen Economy Energy Relationships

Non-Traditional Chemical Careers

Halley A. Merrell
American Chemical Society
Office of Local Section Activities

Presented to the Forty-Seventh, Two-Year College Chemistry Conference, Shelby State Community College, Memphis, Tennessee, October 31, 1975.

We all know that chemists are people who practice chemistry. However, it is important to be fully aware that chemists are versatile and resourceful people whose training also permits them to pursue gratifying and successful careers in many areas outside of the mainstream of chemistry. It is now my pleasure to introduce a new ACS Program -- CAREERS NONTRADITIONAL -- designed to focus on the opportunities that derive from this versatility and training.

When chemistry majors considered job opportunities in the 1960's, their concern was not over simply finding a job--openings were plentiful. They wanted the right position, at a good salary, in an attractive community. In the present economic climate, the emphasis is on simply finding a meaningful job. In this respect, there may be many more good jobs available to chemists than commonly realized, and chemistry majors need to become aware of these opportunities in planning their careers.

The two traditional paths for a new B.S. in chemistry are graduate school or a position with a chemical company, usually in the laboratory. But some chemists have found work available with many other kinds of employers -- museums, banks and insurance companies, publishers, highway, health and police departments, and all kinds of manufacturers outside of chemistry. And even in the large chemical companies chemists do work that is far removed from the laboratory -- in sales, advertising, information storage/retrieval, patent law, and finance. Let's take a brief look at some of the "typical" career where we find people with chemical training.

Science Writing -- Training in chemistry can be very useful to someone who wants to write science news for the general public, to take complex scientific topics and invent analogies that will make them understandable to the nonscientific layman.

Chemical training teaches a student to think analytically and that is helpful. Also, knowledge of scientific concepts and language enables him to handle the material without being snowed by the scientist or the scientist's work. He can take a four or five page scientific paper and, without apprehension, proceed to try to understand it. He may have to study it carefully, but he is confident that understanding will come more often than not.

In the future, scientists will be treated less kindly by the daily press. Their controversies will be aired more often in the press, and some scientists may be criticized. They haven't been treated that way enough so far because so many science writers can identify with the interests of the scientific community.

Crime Fighting (or Forensics)-- Forensic chemistry is an expanding field and students should be encouraged to consider it. New laboratories are opening and older established ones are expanding and acquiring new facilities to keep up with case loads. Part of the expansion is due to the large increase in the use of illegal and dangerous drugs. Part is due to the nationwide increase in all kinds of crime. Part is due to recent Supreme Court decisions, which have reduced police reliance on interrogation, leading to confession, and forced more dependence on physical evidence and its analysis in the solution of crime.

Making access to the lab easier for the investigating officer not only adds to the case load of the lab, but involves it even more in the day-to-day fight against crime. In Kentucky, for instance, a Secure Evidence Transit (SET) system increased the lab's case load to 86% the first year.

Training police officers in the searching of crime scenes for physical evidence, use of crime scene search kits, and even employment of full-time evidence technicians add also to the crime lab's case load and effectiveness.

Giving evidence in court about laboratory findings is an important part of a forensic chemist's function. The most brilliant bench work is useless to a police laboratory unless the chemist can communicate it effectively to judge and jury. That takes presence of mind, composure, and sometimes a thick skin, for defense attorneys have been known to attack an expert's intelligence, veracity, and morality in their zeal to win an acquittal.

Defense attorneys sometimes agree to accept without question written lab reports. When that happens it is because the conclusions of the crime laboratory or the individual criminalist are of such high repute and so trustworthy that defense attorneys know it is useless to question them.

Most modern police laboratories are well equipped with sophisticated instrumentation. For some drug identifications, spot tests and crystal analysis can be used. But most drug and other analyses rely on instrumentation such as ultraviolet and infrared spectrophotometry, neutron activation analysis, gas chromatography, mass spectrometry, electron probe analysis, differential thermal analysis, electron microscopy.

To prospective forensic chemists, practitioners say one of the satisfactions of the profession is the knowledge that their work is contributing to an accurate and efficient functioning of the criminal justice system. They are also generous with practical advice. They suggest that undergraduates take as much analytical chemistry, particularly instrumentation, as possible; a course in law, especially constitutional law, another in botany, biology, microscopy, mathematics, especially statistics and public speaking.

Art Conservation-- Chemists and other physical scientists have caused considerable stir in museum circles in recent years. They have helped to detect frauds like Yale University's "Vinland Map". They have helped to penetrate the manufacturing technologies of early man, to restore paintings and sculpture, to date art and artifacts, and to determine the optimum environmental conditions for displaying and preservind art and artifacts. Many museums are gaining access to chemical knowledge through the efforts ot museum scientists and a growing corps of "conservators" now being trained in part in chemistry at several colleges and universities.

Museums are well aware of the contributions that physical scientists can make. The main problem is that most of them can't afford to maintain a chemist in a modern laboratory. Even those with adequate resources are handicapped in some cases by restrictions placed on funds by their endowments.

Museums without full-time physical scientists and even some who do employ them often contract with outside consultants for projects that require major inputs of chemical knowledge. Radiocarbon dating, for example, almost always is performed outside the museum.

The field of museum scientists is a small one, and the realistic outlook is that the nation's 5000 museums of art, history, and natural history offer relatively few job opportunities for chemists in the immediate future.

In the field of art conservation, however, the outlook is more optimistic. There is a critical shortage in both this country and abroad of conservators equipped to treat the growing number of art and historic objects that are in need of immediate and expert attention.

A conservator has been described as "... an alloy of thre abilities. First of all, he is a person who actually works on the object and treats it; second, he is a scientist, able to recognize the nature of the materials he is dealing with, what has happened to the object, and what he can do to change it and to preserve it for the future; third, he is a curator with knowledge of art history so he can see the significance of the object he is treating."

Professional conservators are being trained in graduate programs in museum work at several universities and art institutes.

Undergraduate chemistry majors who plan to apply to one of the graduate programs should take as many courses in art history and studio art as possible -- a minor in these areas is recommended. Conservation of our valuable artistic and historic objects offers a unique career for those with an interest and talent in combining science and art.

Chemical Information -- Particularly in the chemical, petroleum and pharmaceutical industries, chemists working with information search, retrieval and transfer are key personnel. In one company, for example, the chemical literature section performs about 100 chemical searches a month, including pre-patentability searches for the company's patent attorneys. The section is also responsible for the selective dissemination of information in chemistry throughout the research department, and in this capacity distributes a weekly alert system on chemical patents for chemists and patent attorneys in the company. The information chemists there also are expected to make recommendations for improving and enlarging the chemical information system -- suggesting, for example, what new indexing services might be subscribed to and stored in the computer. These responsibilities propel the literature chemist into administration, management, planning, and budgeting.

Not all research laboratories in industry are endowed with such sophisticated information system. But most industries are beginning to expand their chemical information systems, and this should create some openings in the field for young chemists.

Let me just mention some of the other areas where we may unexpectedly find people with chemical degrees at work; chemical company management - particularly for young people who have also obtained an MBA degree; patent law - either as patent agents or patene laisons in industry or even as patent examiners and patent attorneys; as safety engineers or related jobs with OSHA or EPA: in Banking, particularly where large banks have substantial accounts with the oil or chemical industry.

The story is obvious then. Chemistry is a rewarding career and a life as a chemist has much to offer. We are all aware of that. But chemistry and chemical training may be the key to a meaningful career in a field or area your students have never even considered. Help your students learn more about these NONTRADITIONAL careers. Help them keep the career door open wide. The possibilities are limitless.

A Summer Triple-Accelerated General Chemistry Sequence

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Presented to the Forth-Seventh Two-Year College Chemistry Conference, Shelby State Community College, Memphis, Tennessee, November 1, 1975.

For the past three summers we have offered a 3-accelerated sequence in both freshman general chemistry and general biology. This past summer we added to the accelerated program a math sequence in analysis - the math sequence requi for most transfer programs other than math, science, or pr professional programs such as engineering, pre-medicine, p dentistry, and pre-pharmacy. In the triple-accelerated program in a 10 week quarter, the student completes a 3 quart sequence for 12 quarter hours credit; therefore, each "qua is approximately 3 weeks and 1 day in length. What we are doing here might be regarded as comparable to the Berlitz system of studying a foreign language - *the total immersio approach*.

The students live, eat, sleep and breathe chemistry f 10 weeks. There is a 3 1/2 hour lecture 3 days and a 3 1/ hour lab twice a week.

Because we have been interested in how our students c pare with their peers nationally, last spring at the end c the regular academic year, all students completing freshma chemistry were given the 1973 form of the ACS Cooperative Test in General Chemistry. The summer group of students w also given the test.

During the summer 45 students started the sequence ar 33 finished with a grade of D or better. On the ACS test the percent rank of the summer students ranged from 10 -

The ACS General Chemistry Test consists of 70 multip choice items. We reviewed the test in regards to the cho of the topics covered in our course and found that 63 of 70 questions were directly and specifically covered in ou course.

In addition, we reviewed the ACS Test in terms of th items which would logically have been included on our reg third quarter final examination and found that 27 of the 63 items covered at Roane State would fall in this catego The ACS Tests were graded on both basis and we found ther was no significant difference in the adjusted scores for the entire sequence and for the third quarter of the sequ for the summer group. A comparison of the average run sc of the regular year students and the summer student showe that the summer scored considerably higher.

This does *not* indicate, I don't feel, that we did a ter job during *the* summer than during the regular year. ever, it does give us some assurance that the accelerated proach has *some* validity and *may* be appropriate for some dents.

Some of the selection factors operating differently the regular year students and the accelerated summer stuc are listed below.

1. The student population is different in terms of ability and background. The summer students tend t more career oriented and may wish to accelerate towa their career goals. Some others had failed during t year and were repeating the course so they had had s exposure, however unsuccessful, to the subject.

2. We all know the downward slope of the retention curve on Learning versus Time and there is a difference in 9 months compared to 10 weeks.

3. In both cases, the students could have earned up to 250 points before the ACS test. In an effort to reduce the anxiety level - some of the students were really up-tight about the exam - they were told they would not have their grades reduced by poor performance on the ACS test. The test could only not affect their grade up to that point, or improve it. This probably contaminated the students performance on the test since some of the C students were happy with their grades.

In conclusion, I recommend consideration of such an accelerated sequence only if you have motivated, somewhat above average students and chemistry instructors with the stamina of a race horse.

INDIVIDUALIZED CHEMISTRY

Some Problems with Audio-Tutorial Programs

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Presented to the Forty-Seventh, Two Year College Chemistry Conference, Shelby State Community College, Memphis, Tennessee, November 1, 1975.

Since the publication, "An Audio-Tutorial Program in Allied Health Chemistry"[1], there have been many inquiries such as "How do you start an AV program?", "May I see some sample mimicourses?" Before you begin you should have some warnings.

First, you may not even like the way an AV program is conducted. Go to visit a school where there is a successful program and then decide if this is the route you wish to follow. Purdue University is famous for its biology AT and is a good place to spend a day as a student. Select a program about which you know little or nothing and learn the minicourse as one of your students would.

Secondly, for chemistry you need a laboratory that is free for the AV work only. If you have the place to house the program and you are certain that this is a better route than the one you are following, give AT a trial with only a few minicourses.

The job just now begins with writing of the programs. The minicourse (or whatever you'll call one unit) takes much time to prepare. You'll need released time during the school year or a free summer to just get started. Tape a lecture and use this as a script for a minicourse, then plan the student handouts that you need to go with it. The minicours will need a variety of activities. It's a good chance to integrate lab and lecture, demonstrations, models, clinical studies, and film loops, but you need much time for preparation.

Get cassette players, head phones, the hand-outs of your program, cassette tapes, lab materials, etc., and give it a try. Let the students critize freely.

For even one program you need more contact with the students than you use in the traditional lab-lecture teaching. Besides a free laboratory to do the work, you'll have to be available to answer questions as they arise. The AT area must be manned all day. The AT program does not replace the teacher - it demands much more of him.

The advantages of the AT program are many. The student may proceed at his own pace. For you, the teacher, it means that you cannot have just two or three exams for the sessio You'll need many quizzes for each minicourse and students will not be all taking a test on the same unit at one time. You'll also need time to review and discuss materials with your students. You'll have to assign discussion periods wi small groups. Your grade keeping will be more complex, par- ticularly if you allow the student retesting and how else d you know that the student is ready to go on to the next uni

You'll probably find that you are never completely sat isfied with your minicourses and they should be rewritten, revamped, and updated so you'll find that the job is never done.

Don't use an audio-tutorial program unless some of you colleagues wish to go the same route. An open lab is best if utilized for several sections and/or courses. You canno do the program alone.

Even if very successful, there will be times when the AT program just cannot be utilized as you wish. Cassette players are always in need of repair, students sometimes accidentally erase tapes, financing is not available for th help you need, etc. The problem we met for the fall quarte of 1975 was that of a hige enrollment, many more than the AV program could handle.

AT teaching is great, but beware of its shortcomings before you commit yourself.

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[1] Laughlin, Ethelreda and Norbert Kurnath, "An Audio-Tutori Program in Allied Health Chemistry", J. Chem. Educ., 52: 7 (1975).

An Audio-Tutorial Self-Paced Approach to Chemistry for Allied Health Students

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Presented to the Forty-Seventh, Two Year College Chemistry Conference, Shelby State Community College, Memphis, Tennessee, November 1, 1975.

Students who enroll in Introductory Chemistry do so because they plan a career in allied health. These students bring a variety of backgrounds to the course. The paramedical student in a two-year program usually takes just one chemistry course. In this course the student is exposed to most of the chemistry, biochemistry and clinical chemistry she is going to get during her college career.

The challenge to the instructor to meet the needs of the students for this course is very great. An audio-video-tutorial program is one approach that we are trying at Penn Valley Community College. This program offers an alternate method for the students to approach the subject of chemistry.

The AVT course utilizes the text General Chemistry by Wendlandt, Geanangel, and Barry. The publisher is the Merrill Publishing Company. Audio tapes accompany the text and are bought as a package. In addition to the text and audio tapes, video tapes have been made at Penn Valley covering each topic the student covers in the text.

Packets are prepared for the students. The first packet includes all the materials necessary for Minicourse I, Section A. After the students have successfully passed the examination for this section they are given the packet for the next section.

Each packet includes (1) Objectives and (2) Study Materials. The objectives are as specific as we can make them. The study material sheets list the audio tapes for the unit, video tapes that must be viewed for the unit, and include written materials that help explain particular topics that are difficult for the students.

Successful completion of examinations covering Sections A and B are required for Minicourse I before the student can progress to Minicourse II. Successful completion of examinations covering Sections A and B are required for Minicourse II before the student moves on to Minicourse III. Minicourses III and IV each have one examination. A comprehensive final examination is given.

Examinations are taken by students when they feel ready. They are reminded periodically of a schedule given at the beginning of the course which allows everyone to know whether they are going fast enough to finish by the end of the semester.

A grade of 70% is required in order to move on to the next section or minicourse. There is a penalty for retaking a test. The first retake carries a 5 point penalty. The second retake has a 15 point penalty and the third retake penalty is 25 points.

The material covered is the same as offered in the lecture sections. It consists of four minicourses arranged in the following manner:

Minicourse I - Introduction to Inorganic Chemist
Minicourse II - Introduction to Organic Chemistry
Minicourse III- Introduction to Biochemistry
Minicourse IV - Biochemistry and Clinical Chemistr

The Objectives and Study Materials are given below.

SECTION I-A OBJECTIVES

After completion of Minicourse I, Section A, the student should be able in a written examination to:

1. Demonstrate his understanding of the basic structure of the atom.
2. Write the electronic configuration of the first 36 elements, using suborbitals, when given the atomic number.
3. Obtain information from a periodic table such as atomic number, atomic weight, valence electrons.
4. Write chemical formulas, name compounds from chemical formulas, determine number of atoms in a compound when given the formula.
5. Calculate the molecular weight of a compound using a chart or table.
6. Demonstrate his understanding of the various types of chemical bonding.

SECTION I-A INORGANIC CHEMISTRY STUDY MATERIALS

The material in this section includes 7 units with tapes in General Chemistry by Wendlandt, Geanangel and Barry; 6 handouts and 1 video tape.

Units with Tapes

Unit 1	An Introduction to Chemistry
Unit 4	States of Matter and Atomic Mass Scale
Unit 5	Chemical Combinations
Unit 7	Electronic Structure of the Atom
Unit 9	The Chemical Bond-Ionic Bonding
Unit 10	The Chemical Bond-Covalent Bonding
Unit 11	Chemical Formulas and Equations

Handouts

1. Objectives for this Section
2. Useful Equivalents-Weights and Measures (reference)
3. Common Ions with their Valence Numbers

4. A Periodic Table (reference)
5. A List of Material to be omitted from Text-Tapes
6. Atomic and Molecular Structure
   (correlates with the video tape)

Video Tape

Atomic Structure and Bonding

SECTION I-B OBJECTIVES

After completion of Minicourse I, Section B, the student should be able in a written examination to:

1. Define a mole, molarity, normality, molality, and titration.
2. Perform calculations involving molarity, including those containing specific gravity data.
3. Perform calculations involving normality, including titration problems.
4. Perform calculations involving molality, including freezing point depression and boiling point elevation problems.
5. Define, recognize and give examples of an Arrhenius acid and base, and a Lowry-Bronsted acid and base.
6. Calculate the pH and pOH of a strong acid or strong base given the hydrogen ion or hydroxide ion concentration.
7. Demonstrate an understanding of buffer systems and be able to show how a buffer pair will react upon the addition of acid or base.

SECTION I-B INORGANIC CHEMISTRY STUDY MATERIALS

The material in this section includes 2 units with tapes in General Chemistry by Wendlandt, Geanangel and Barry; 5 handouts and 1 video tape.

Units with Tapes

Unit 15	Solutions
Unit 16	Acids and Bases

Handouts

1. Objectives for this Section
2. Examples of Problem Solving Involving Solutions and pH
3. Problem Assignment on Solutions for Student Practice
4. pH Problem Set for Student Practice
5. A simplified Log Table

Video Tape

Molarity, Normality, pH (C-038)

SECTION II-A OBJECTIVES

After completion of Minicourse II, Section A, the student should be able in written examination to:

1. Define and recognize the two main branches of orga ic chemistry.
2. Demonstrate a knowledge of the types of bonds exhibited by carbon atoms.

3a Demonstrate a knowledge of the characteristics of alkanes.

3b Name chain and cyclic alkanes using the IUPAC system; draw formulas knowing the IUPAC name.

3c Complete balanced chemical equations involved in th synthesis and reactions of alkanes.

4a Demonstrate a knowledge of the characteristics of alkenes.

4b Name chain and cyclic alkenes using the IUPAC syst draw formulas knowing the IUPAC name.

4c Complete balanced chemical equations involving the synthesis and reactions of alkenes.

5a Demonstrate a knowledge of the characteristics of alkynes.

5b Name alkynes using the IUPAC system; draw formulas knowing the IUPAC name.

5c Complete balanced chemical equations involved in th synthesis and reaction of alkynes.

6a Demonstrate a knowledge of the characteristics of the benzene ring, including the type of bonding exhibited.

6b Name aromatic compounds using both the IUPAC system and the ortho-meta-para system.

6c Complete balanced chemical equations involved in th synthesis of substituted benzenes.

SECTION II-A ORGANIC CHEMISTRY STUDY MATERIALS

The material in this section is presented in 1 unit of General Chemistry by Wendlandt, Geanangel and Barry; 4 handouts and 1 video tape.

Unit with Tape

Unit 21 Organic Chemistry: The Hydrocarbons

Handouts

1. Objectives for this Section
2. Definitive Rules for Nomenclature of Organic Chemis

3. Organic Chemistry Problem Set (Pages 1-4)
4. Outline of Organic Chemistry, Section I (correlates with video tape)

Video Tape

Organic Chemistry, Section I

SECTION II-B OBJECTIVES

After completion of Minicourse II, Section B, the student should be able in a written examination to:

1a Recognize and write the functional group of an alcohol and be able to draw a representative alcohol.

1b Name alcohols using the IUPAC system.

1c Complete balanced chemical equations involved in the synthesis and reactions of alcohols.

2a Recognize and write the functional group of an aldehyde. Draw a representative aldehyde.

2b Name aldehydes using the IUPAC system.

2c Complete balanced chemical equations involved in the synthesis and reactions of aldehydes.

3a Recognize and write the functional group of a ketone. Draw a representative ketone.

3b Name ketones using the IUPAC system or by using the common name.

3c Complete balanced chemical equations involved in the synthesis of ketones.

4a Recognize and write the functional group of an ether. Draw a representative ether.

4b Name ethers by using the IUPAC system or by using the common name.

4c Complete balanced chemical equations involved in the syntehsis of ethers.

5a Recognize and write the functional group of an organic acid. Draw a representative acid.

5b Name organic acids by the IUPAC system or by using the common name.

5c Complete balanced chemical equations involved in the synthesis and reactions of organic acids.

6a Recognize and write the functional group of an ester. Draw a representative ester.

6b Name esters by using the IUPAC system or by using the common name.

OBJECTIVES (con'd)

6c Complete balanced chemical equations involved in the synthesis and reactions of esters, including soaps and detergents.

7. Identify a saccaharide as a triose, tetrose, pentose, hexose; as a disaccaharide, trisaccaharide, or polysaccaharide.

8. Draw the structures of D-glucose, L-glucose, D-fructose, D-glyceraldehyde, and L-glyceraldehyde.

9. Demonstrate an alpha or beta linkage or a disaccaharide.

SECTION II-B ORGANIC CHEMISTRY STUDY MATERIALS

The material in this section is presented in 2 units of General Chemistry by Wendlandt, Geanangel, and Barry; 3 handouts and 1 video tape.

Units with Tapes

Unit 22	Organic Chemistry: Compounds and Their Identification
Unit 23	Organic Reactions and Polymers (frames 1 - 11 only)

Handouts

1. Objectives for this Section
2. Organic Chemistry Problem Set (pages 5-9)
3. Outline of Organic Chemistry, Section II (correlates with video tape)
4. Carbohydrates

Video Tape

Organic Chemistry, Section II

SECTION III OBJECTIVES

After completion of Minicourse III the student should be able in a written examination to:

1a Recognize and write the functional group of an amide. Draw a representative amide.

1b Name amides using the IUPAC system or by using the common name.

1c Complete balanced chemical equations involved in the synthesis and reactions of amides.

2a Recognize and write the functional group of an amine. Draw a representative amine.

2b Name amines using the common name.

2c Complete balanced chemical equations involved in the synthesis and reactions of amines.

3. Name the biologically active amino acids when given the structure.

4. Using chemical formulas, demonstrate the formation of a peptide bond.

5. Put three given amino acids together in a prescribed order to form peptide bonds.

6. Name a simple peptide.

7. Define simple and conjugated proteins.

8. Given a protein, or section thereof, demonstrate where chymotrypsin, pepsin, trypsin, carboxypeptidase and aminopeptidase will act. Write the specificity for the above enzymes or knowing the specificity, name the enzyme.

9. Demonstrate a basic understanding of the structure and function of enzymes.

10. Match substrate with enzyme and visa-versa.

11. Identify the three main components of a nucleotide.

12. Name the purine and pyrimidine bases found in nucleic acids. Name the specific bases when given the formula.

13. Name the pentose sugars found in nucleic acids. Name the sugars when given the strucutre.

14. Demonstrate a basic understanding of DNA replication, including base pairing.

15. Demonstrate a basic understanding of protein synthesis, including the functions of ribosomal RNA, transfer RNA and messenger RNA.

SECTION IV OBJECTIVES

After completion of Minicourse IV the student should be able in a written examination to:

1. Write the glycolysis cycle, either in its entirety or any part thereof, including chemical structures, compound names, enzymes and coenzymes.

2. Identify quantitatively the points in the glycolysis cycle of ATP consumption or production. Determine net ATP yields in the presence and absence of oxygen. Determine ATP yields under specific malfunctioning conditions.

3. Write chemical equations for the conversion of pyruvic acid to either lactic acid or ethanol. List conditions when each reaction would occur.

4. Write the Krebs Cycle, either in its entirety or any part thereof, including chemical structures, compound names, enzymes and coenzymes.
5. Identify the points in the Krebs Cycle of energy production. Determine net ATP yields for the Krebs Cycle alone and combine glycolysis - Krebs Cycle under given conditions.
6. Show where and how given compounds may be funneled into the glycolysis or Krebs Cycle. (aspartic acid, glutamic acid, alanine)
7. Write an example of the beta-oxidation of hexanoic acid including enzymes, coenzymes, chemical formulas and energy production.
8. Compare energy yield between the oxidation of one mole of hexanoic acid and one mole of glucose.
9. Correlate the vitamin with the deficiency disease associated with it.
10. Be able to answer all questions on Biochemistry Review.

SECTION IV
BIOCHEMISTRY AND CLINICAL CHEMISTRY STUDY MATERIALS

The material in this section is presented in 2 units of General Chemistry by Wendlandt, Geanangel, and Barry; 8 handouts and 5 video tapes.

Units with Tapes

Unit 24	Fats, Carbohydrates and Bioenergetics
Unit 27	The Chemistry of Foods and Medicines

Handouts

1. Objectives for this Section
2. Glycolysis and Pyruvic Acid in Absence of Oxygen
3. Tricarboxylic Acid Cycle
4. Beta-oxidation of Fatty Acids
5. Metabolism-Diabetes Mellitus
6. Summary of Important Vitamins (correlates with video tape)
7. Biochemistry Review and Answers
8. Conversion of 3 Amino Acids to Compounds in TCA Cycle

Video Tapes

1. Glycolysis and Krebs Cycle	(C2-022)
2. Krebs Cycle	(C2-004)
3. Fatty Acids	(C3-006)

4. Clinical Chemistry C15-015)
5. Vitamins

A self-paced course can be much more time consuming to the instructor than the traditional lecture course if paraprofessional help is not available. Fortunately, Penn Valley has an AIDP Grant that funds a paraprofessional person for assistance in this program. She is located in the departmental area for easy access by the students.

The paraprofessional person is available 15 hours per week to assist the students in problem areas. She serves as a combination taskmaster, tutor and cheerleader for the students.

The audio tapes are checked out to the students by the paraprofessional person. They are provided with the tape, a player and earphones. Study carrels are available in the departmental area for the students' use. A few sets of audio tapes are available in the Learning Resources Center. This allows students access to the tapes any time the college is open. The video tapes and video monitors are checked out to students through the Learning Resources Center.

There are advantages and disadvantages to any teaching approach.

Some advantages of the AVT system are:

1. The audio tape or video tape can be stopped and replayed as needed.
2. Before an examination, units can be easily reviewed.
3. Students go through the units at their own rate.
4. Learning materials are available 14 hours per day so as to provide maximum flexibility in students' schedules.

Some disadvantages of the AVT system are:

1. Some students will not keep on schedule.
2. Students' questions cannot be answered as they arise but must be delayed.
3. Record keeping on the part of the teacher can be burdensome.

The AVT approach to Introductory Chemistry at Penn Valley was not intended to replace the more traditional means of teaching chemistry, instead it was instituted so students would have an alternate way of learning chemistry. Teacher dedication and student interest are essential in any learning endeavor and there are many ways by which these can be achieved.

APSI Chemistry Courses for Nursing Students

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Presented to the Forty-Eighth, Two Year College Chemistry Conference, Cuyahoga Community College, Western Campus, Cleveland, Ohio, March 6, 1976.

The Personalized System of Instruction (PSI) method and the typical chemistry course for nursing students are each possessed of unique features which seem complementary, and which would seem to make the two eminently suited for each other. Accordingly, a PSI chemistry course was developed to include general chemistry, organic chemistry, and biochem istry, in a one-term course for nursing students in a diplom program or an associate degree program. Experience with thi course has confirmed that the PSI format offers advantages for the nursing student which are absent in the traditional lecture-exam format. Also, the PSI format seems even better adapted for fulfilling the unique needs of the nursing student in chemistry than it is for the science student in chemistry.

What are the features of a PSI course which make it so particularly well-suited for the student preparing for a career in the Allied Health professions? The answer evolves from an examination of the manner in which this student's educational needs, in a course such as chemistry, differ so dramatically from those of the science student.

What is the science student saying to his instructor? This student, who may possible have an interest in becoming a chemist, is saying, "Let me ramble through this subject with you at leisure. Let me discover new insights and perspectives as I explore this subject."

In contrast, listen to what the nursing student is saying to the instructor, "Tell me exactly what it is that I need to know of this subject for my career, and let me learn these things as quickly and as efficiently as possible." The PSI format is a tailor-made response to the cry of this student.

In a typical PSI course, the student is given a text ar an accompanying PSI student study guid the subject matter of the course is quantized into discrete packages of information, perhaps into twenty units. For eac of these units, the student is given a set of four clearly described learning objectives for that unit. The text mater ial to be studied in order to achieve mastery of these objec tives is described, and a set of practice problems is also assigned for these objectives. When the student feels ready he takes a quiz on this unit. This unit quiz contains four questions, each one correlated to one of the unit objectives. There are four possible quizzes for each unit, and the student is given any one at random. This quiz is graded immediately by a proctor. If the student has demonstrated mastery of the unit objectives, his grade on the quiz is "passed", and he goes on to work on the next unit. If the student has not demonstrated mastery of the unit objectives, his grade on the quiz is "tried" with no penalty. This student then goes back to restudy the objectives, text, and practice problems for that unit, and then takes another quiz - a similar but different quiz for that unit, until he is able to demonstrate mastery of the objectives for that unit. At all times in this sequence of events, the student is encouraged to seek individual help from the instructor. The student's final grade in the course is dependent on the number of units mastered.

It is clear from this description that the PSI format can be effective in eliminating the anguished complaints of the Freshman nursing student that there is a tremendous amount of material in the chemistry textbook, and that there is no clear indication to the student as to which concepts need to be emphasized and which concepts can be omitted.

Specifically, the PSI chemistry course for nursing students being described here is designed for three regularly scheduled class meetings per week. The course is based on the PSI student study guide developed by the instructor, and this study guide is correlated to a text on Chemistry for the Para-Medical Sciences by Grillot. The course runs smoothly for a class of fifty students under the direction of one instructor and two advanced student proctors. An instructor's manual containing all unit quizzes and answers is made available to the student proctors. The physical facilities needed are a large classroom with two proctor desks in front and a locked file for quiz sets. In addition, a small study room with a chalkboard should be available for individual student consultations with the instructor.

Since each student moves at his own pace in a PSI course, the question is often asked as to how one instructor can possibly direct a large class of students in which each student is at a different point in the course. The answer to this question lies in the development of the written PSI program. If the PSI program for the course is a well-written one, the class procedure will flow automatically, with each student busily going about his sequence of activities quite independently. This means that there must be a direct and clear correlation between objective, text material, practice problem, and quiz question for that unit in the PSI program. If the lines between these components are extremely clear to the student, he forges ahead on his own, and can usually progress through the units unassisted. The instructor's attention is required only occasionally, when for some reason, a student has trouble with a particular concept. Visitors to the PSI classroom often comment that they are surprised to find a scene which appears to be one of quiet busyness, - perhaps sometimes better described as one of controlled frenzy.

A well-written PSI program, which will allow the student to progress easily and independently from objectives to text to practice problems to quiz questions, and then on to the next unit, must scrupulously follow two cardinal rules: (1) Be Specific and (2) Be Repetitive. Ambiguity in the objectives must be avoided by the use of action phrases, such as "Draw a graph of the relationship between...", rather the use of vague phrases such as, "Understand the relationship between...". Diversity in the quizzes must be avoided by the repetition of the same question concept in four varied guises on each of the four possible unit quizzes. This reiteration of concept allows the student to be successful on his repeat attempt at the unit, after he has restudied the objectives, test, and practice problems. Also, this avoidance of variety in the quizzes will help to avoid an important problem leading to student complaints in an unsuccessful PSI course. If the four possible quizzes for a unit are all similar and of equal difficulty, a major contribution is made to the maintenance of student motivation and enthusiasm in the course.

In addition to a well-written PSI program, there are several other factors which contribute to the maintenance of high student morale which is the key to a successful PSI course. A simple, speedy, and efficient system must be developed for dealing with the sheer mechanics of administering, grading, recording, and filing several hundred quizzes each day. We have found our advanced student proctors to be extremely competent in assuming this responsibility, and they have been successful in keeping student complaints concerning waiting times to a mimimum. Also, close communication between the instructor and the proctors can pinpoint those parts of the PSI written program which are ineffective and in need of revision.

Another factor which is extremely important in a successful PSI class is the extra effort which needs to be made by the instructor to offer encouragement and interest to each individual student in the course. Because the student-instructor interchange which occurs through an exam is missing in the PSI format, the instructor needs to go out of his way to establish some personal contact with each student.

Lastly, an important factor in maintaining student morale is the presence of the instructor circulating throughout the classroom during the quiz period, to answer questions and to ensure that everything in the structure of the course is operating smoothly.

It might be interesting here to point out that feature of the PSI format which was most appealing to the instructor in this experience with nursing students. This was the realization by the nursing students that their grade in this chemistry course was determined only by themselves, and not by the instructor. This feature relieves the chemistry instructor in a nursing program of heavy pressures from students who are gravely concerned about their grade in the chemistry course. Since this concern of nursing students with their chemistry grade seems to be a fairly general phenomenon everywhere, the advantage of placing responsibility for the final grade directly with the student seems to add to the unique suitability of the PSI format in a chemistry course for nursing students.

As for the students themselves, they noted unanimously that the feature they appreciated most in the PSI course was the ability to work at the pace which was most comfortable for them at that particular time in the course. Also, most students noted that they quickly formed small study groups clustered around those easily-identifiable students who were proceeding rapidly through the course, and that they enjoyed studying in these small groups with a peer tutor. In this nursing group, more students than usual repeated the oft-heard comment from PSI students that it was in this PSI course, that for the first time, they really learned how to study.

Another advantageous feature of the PSI format in a nursing school course derives from the fact that most students in a PSI course finish all or most of the units in the course and achieve a high grade in the course. The administrative staff in the nursing school program is generally not unduly concerned over this manifestation of grade inflation, and asks only of the chemistry instructor that the students be exposed to the material in the course and involved in an effort to learn the material. Also, the administrative staff seemed unusually responsive to the PSI concept of placing the responsibility for learning into the students own hands, as this seems to be a major objective of the nursing program.

An excellent route for developing one's own PSI program for a course is, first, to use in the classroom a program which has already been developed by someone else. It will quickly become apparent, during this period of use with students, which are the effective features of a PSI program which can then be incorporated into one's own program.

CAI for Beginners

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Presented as a workshop at the Forty-Eighth, Two-Year College Chemistry Conference, Cuyahoga Community College - Western Campus, Cleveland, Ohio, March 6, 1976.

Delivery of the lesson now often called "learning facilitation," can only be successful when executed by an instructor ("facilitator") of average to better quality. Good lesson material organization can only come from the mind and hands of a good author.

In 1966 Silvern and Silvern outlined five major criteria which can be used to evaluate authorship. Authors should score high on:

- job and task analysis
- establishment of behavioral objectives
- preparation of criterion tests
- development of course outlines to the level of course application
- writing of detailed lesson plans.

In the same paper the authors state that it is difficult to identify the underlying skills of each criterion. The "phantom"-like author was labeled "instructional programmer".

Now, a decade later, only a few outstanding "instructional programmers" have been identified, and educators continue to struggle with the setting of measurable, pedagogically acceptable criteria and criterion-tests.

Impatience has overtaken many amongst our ranks. Methodology "fads" have emerged by the handful and only a few have become accepted as valuable tools.

Both good and bad authors, whether they can teach or not have turned to computer-use and notably to the activities collectively labeled as CAI (computer assisted instruction). This unfortunate offspring of impatience is an attempt at improvement of instruction not learning. The "workhorse" computer has often become a convenience-tool for the instructor, and has become a source of apprehension for the student.

CAI is of little value to the student unless student needs are the center of the author's activity. The real value for the student is a summative process; instructor and CAI and student result in CAL (computer assisted learning). The three components of CAL must be further defined.

AUTHOR

A good author has the following qualities:

- is a behavioral objectives addict.

- can organize a course, modules of a course, lessons of a module, components of a lesson, and specifics of each component in reverse order, that is to say starting with the ultimate objectives of the course and working back to the lowest level of prerequisite.
- has a reasonable affinity for the Keller-PSI plan
- is an actor who is not going to be replaced by the computer
- loves the student.
- does not have an affinity for computer programming.
- sees some value in logic and the scientific method(s) of problem-solving.
- is creative and hopefully innovative.
- wants to use the computer to enrich a course and so to improve learning.
- is willing to spend considerable amounts of time on lesson detailing.

THE LEARNER (student and instructor) must also quality.

Not every student will succeed in CAL-types of experiences. Instructors do well to be certain that none of the students are computophobics. In the event that students show a traumatic reaction to forced computer-use, the instructor must either remove a student's anxiety through appropriate activities or must offer to the student an alternate method of achieving.

The CAL-author is less likely to cause apprehension in students than the traditional CAI-type author would. The careful CAL-author will remove what I label CIA (computer induced apprehension) from peers, students and supervisors. This apprehension can be comprised of one or more of the following sensitivities (or falacies):

- technology dominates
- teachers are being replaced
- students are not treated as individuals
- machines are destructive, not instructive
- computers make mistakes

The AUTHOR LANGUAGE (Tool) must be very versatile but must never be the end to which all resources are put.

A good CAL-author language will:

- support a directed dialogue between the instructor and student.
- allow for unexpected comments to be a part of every action.
- readily respond to each of a number of student actions, decisions or questions.
- not require any programming knowledge from instructor or student.
- ideally support graphics and a number of audio-visual functions.

- be easily modiviable to incorporate innovation, technical advances or pedagogical developments.
- be so versatile as to allow use by any instructor in any discipline.
- have a very simple instruction-set.
- be usable regardless of the type of terminal used by the author or student.
- allow for maximum security.
- create the basic statistical data required for evaluation of student achievement.
- readily facilitate use by students who may have a greatly varying inventory of prerequisite expertises.
- force the instructor to maintain a high level of pedagogical activity rather than allowing a recession into mechanical activities and resulting oblivion.
- support any type of activitity normally associated with CAI: testint, quizzing, drilling, simulation, gaming, tutorial, etc.
- allow for the use of scientific and other specific languages.

A Sampling of Author-Languages

Criteria for the author language are demanding. The author language that measures up must of necessity be powerful. A number of commercial as well as custom-made author languages exist. Most of these were based on rather large computer systems; Coursewriter II and Coursewriter III, as well as TUTOR may be familiar names to you. Very recently some minicomputer producers have invested heavily in educational products, and PILOT and DECAL can be mentioned as author languages written for use on minicomputers.

With the advent of the smaller, less costly machines and very sophisticated software packages any community college can now afford at least a closer look at CAL if not implementing it in-house.

The system at my home base, Camosun College, is utilizing DECAL as author language, which uses BASIC as the programming language. The author language was modified slightly to make it pedagogically more acceptable to faculty. A number of instructors and instructional support staff members are not engaged in writing lesson materials to be entered into the CAL-library. Representation spans all of the College Divisions. Indeed, a flexible, open-door, comprehensive community college such as Camosun aims to be can ill afford ignorance o on CAL.

Some Practical Problems

It has been said that "punching a terminal key" is vastly different from "delicately adjusting a stopcock." Certainly CAL does not and shall never succeed in replacing laboratory techniques. It can only be a significant enrichment factor for the laboratory experience. Just think of the exotic chemicals, the volatile multistage reactions, or the hazardous experiments which are still considered essential to the college curriculum. At least some of it can be simulated.

Chemical notation has been a traditional problem from which terminal-designers could not escape. As a consequence very little Chemistry course material has been published in CAL-format. As a prospective CAL-author you will have little course-planning to lean on. Only very recently a small number of "versatile" terminals have been marketed. This development promises to increase the flexibility of the minicomputer to a large extent.!

Systems and author languages that deviate from a standard code or programming language (and the majority of them does not presently conform to a standard of any sort) prevent an easy interchange of materials between colleges. Smaller colleges (less than 1,000) would do best to tie remotely into an existing system, while somewhat larger colleges (larger than 1,000) should consider starting modestly with a minisystem using a standard language such as BASIC-based PILOT or DECAL.

Some Basic Hints

It takes only a few individuals in a given college who are willing to sacrifice much personal time before CAL can get off the ground. Few, if any, successes were seen where entire institutions were involved in the "Go-NOGO" decision concerning CAL-implementation.

It takes some in -service training. Instructors should really qualify (be good authors) before they are allowed to use CAL. Peer-pressure is the most effective agent for the prevention of student apprehension or general system failure.

It takes a few basic skills. Probably the most valuable skill is effective flow-charting. You as participants, in this conference are now invited to use the DECAL-language for the purpose of gaining some initial experiences in CAL if you never authored, or to look at a minicomputer-based CAL-system if you are not really ready to write some lesson material.

The cooperation of the Berea High School in allowing me the use of their computer, and the assurance of Camosun's computer operations group that our own system would be active for these exercises, is sincerely appreciated.

POLYMER SCIENCE

Polymer Structure and Properties, A Summary

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Presented as a Workshop at the Forty-Eighth, Two Year College Chemistry Conference, Cuyahoga Community College, Western Campus, Cleveland, Ohio, March 6, 1976.

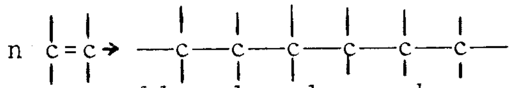
I. Primary Structure of Polymers

All polymers are formed by the creation of chemical bonds between relatively small molecules known as monomers. Polymers may consist of somewhat flexible long threadlike linear or branched molecules. In some instances the threads may be cross-linked to one another, giving a more rigid material. Polymers made from a single monomer are known as homopolymers, those from two or more are known as copolymers. (Polyethylene is a homopolymer; polyesters are copolymers).

Many synthetic polymers are made from natural gas or crude oil. Some are derived from cellulose. Natural-occurring polymers include starch, glycogen, cellulose, proteins and rubber.

A polymer matrix consists of molecules of varying lengths. The average molecular weight of synthetic polymers used in plastics, fibers, films and elastomers may be as low as 5000 or as high as several million. Among natural-occurring polymers, cellulose has average molecular weights between 300,000 and 500,000; starch (the amylopectin portion) average between 50,000 and 1 million; rubber averages between 60,000 and 350,000.

Chemical classification of polymers. Chemists frequently classify polymers according to the way in which the bonds are formed. Two classifications are addition polymers and condensation polymers. In addition polymers, the monomers contain double bonds and polymerization occurs by addition to the double bonds, as in

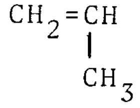
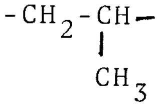
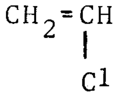
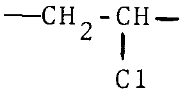
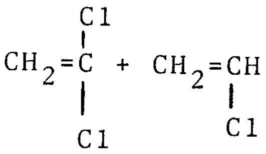
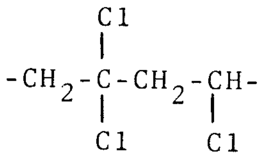
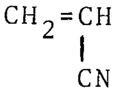
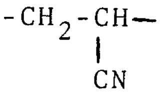


$$n\,C{=}C \rightarrow -C-C-C-C-C-C-$$

In condensation polymers, a small molecule such as water is eliminated between functional groups on the two molecules as in

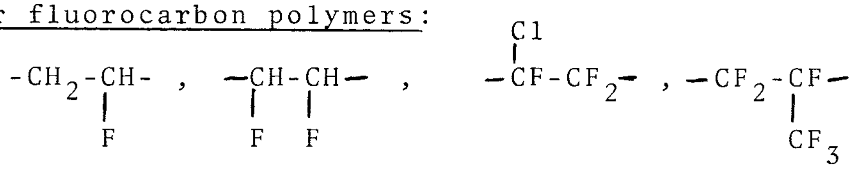
$$nH{-}O{-}A{-}OH \;+\; nH{-}O{-}B{-}OH \rightarrow -O{-}A{-}O{-}B{-}O{-}A{-}O{-}B{-}$$

Addition Polymers. Examples of commonly used addition polymers are:

Monomer(s)	Portion of Polymer Chain	Commercial Uses
$CH_2{=}CH_2$	$-CH_2-CH_2-CH_2-CH_2-$ polyethylene	Films, flexible plastics including bottles, toys, laboratory equipment.
 $CH_2{=}\underset{CH_3}{CH}$	 $-CH_2-\underset{CH_3}{CH}-$ polypropylene	Stronger than polyethylene. Used in dishwashers and washing machines, carpeting, films, fibers (fake furs), batteries.
 $CH_2{=}\underset{Cl}{CH}$	 $-CH_2-\underset{Cl}{CH}-$ polyvinyl chloride	Thousands of formulations exist. Rigid materials are self-extinguishing. Flooring, wall covering, pipes, waterproof clothing, shoes leather substitutes, records.
 $CH_2{=}\overset{Cl}{\underset{Cl}{C}} + CH_2{=}\underset{Cl}{CH}$	 $-CH_2-\overset{Cl}{\underset{Cl}{C}}-CH_2-\underset{Cl}{CH}-$ Saran^R	Films, pipes, fibers
 $CH_2{=}\underset{CN}{CH}$	 $-CH_2-\underset{CN}{CH}-$ polyacrylonitrile (orlon®, acrilan®, etc.)	Acrylic fiber - hosiery, sweaters, knit dresses, women's coats, carpets, blankets, fleece linings

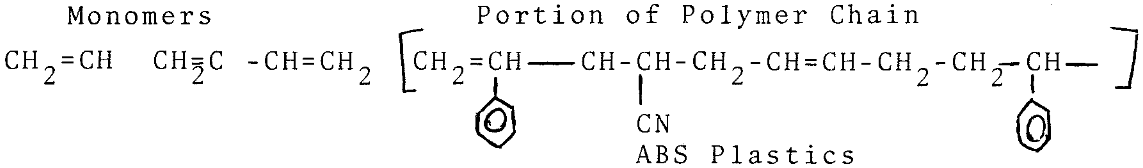
$CF_2=CF_2$	$-CF_2-CF_2-$ polytetrafluoroethylene (Teflon®)	Cookware coatings, bridge bearings, chemical pipes and valves.

Other fluorocarbon polymers:



$-CH_2-CH(F)-$, $-CH(F)-CH(F)-$, $-CF(Cl)-CF_2-$, $-CF_2-CF(CF_3)-$

Monomers   Portion of Polymer Chain

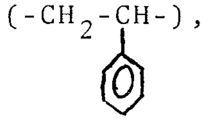


ABS Plastics

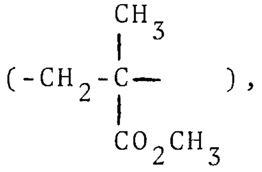
Commercial Uses

Electroplated plastics - electronic components, washer and caps, escutcheons

Others include: polystyrene (-CH2-CH-),

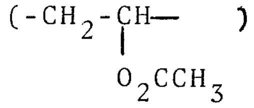


polymethylmethacrylate



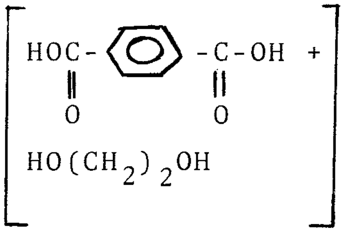
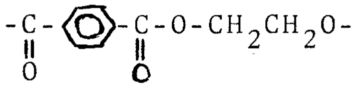
$(-CH_2-C(CH_3)(CO_2CH_3)-)$,

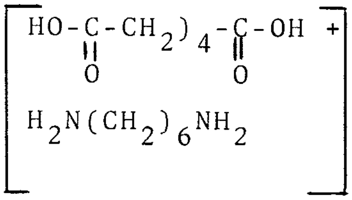
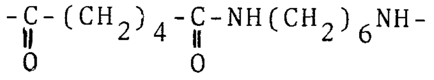
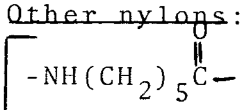
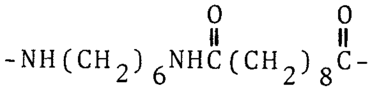
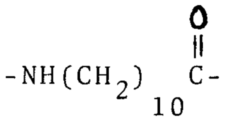
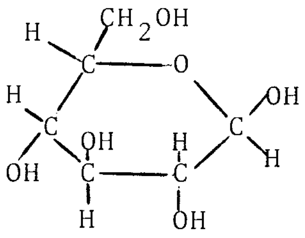
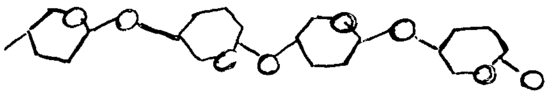
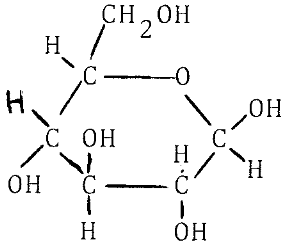
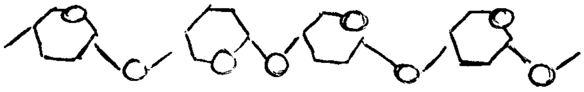
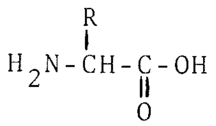
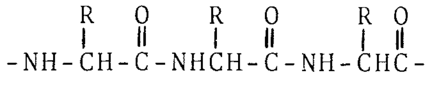
polyvinylacetate

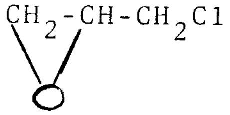


$(-CH_2-CH(O_2CCH_3)-)$

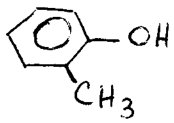
Condensation Polymers. Examples of commonly encountered condensation polymers are:

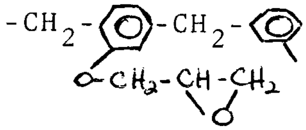
Monomers	Portion of Polymer Chain	Commercial Uses
	 polyster (Dacron, Mylar, Terelene)	Film and fibers; men's suits, slack coats, woven shirt carpets, sheets an pillowcases, draperies, tire cord.

Monomers	Portion of Polymer Chain	Commercial Uses
 $\mathrm{HO{-}\underset{\underset{O}{\Vert}}{C}{-}CH_2)_4{-}\underset{\underset{O}{\Vert}}{C}{-}OH}$ + $\mathrm{H_2N(CH_2)_6NH_2}$	 $\mathrm{-\underset{\underset{O}{\Vert}}{C}{-}(CH_2)_4{-}\underset{\underset{O}{\Vert}}{C}{-}NH(CH_2)_6NH-}$ polyamide (Nylon 6-6)	Films, plastic monofilament, fibers; electrical insulation (coating and switch parts); brush bristles; men's suits, work clothing, socks, knitwear, carpeting, tire cord, seat belts, rope.
Other nylons:  $\mathrm{-NH(CH_2)_5\overset{\overset{O}{\Vert}}{C}{-}}$ nylon 6	 $\mathrm{-NH(CH_2)_6NH\overset{\overset{O}{\Vert}}{C}(CH_2)_8\overset{\overset{O}{\Vert}}{C}{-}}$ nylon 6/10	 $\mathrm{-NH(CH_2)_{10}\overset{\overset{O}{\Vert}}{C}{-}}$ nylon 11
 β-D-glucose	 cellulose (linear polymer)	Structural material in plants
 α-D-glucose	 starch and glycogen (branched and coiled polymer)	Storage carbohydrate in higher plants and animals.
 $\mathrm{H_2N{-}\overset{\overset{R}{\vert}}{C}H{-}\underset{\underset{O}{\Vert}}{C}{-}OH}$ α-amino acid (~20 amino acids obtained from proteins)	 $\mathrm{-NH{-}\overset{\overset{R}{\vert}}{C}H{-}\overset{\overset{O}{\Vert}}{C}{-}NH\overset{\overset{R}{\vert}}{C}H{-}\overset{\overset{O}{\Vert}}{C}{-}NH{-}\overset{\overset{R}{\vert}}{C}H\overset{\overset{O}{\Vert}}{C}{-}}$ polypeptide (portion of protein chain)	Enzymes, cell membranes, muscles collagen; most abundant organic molecules in living cells.



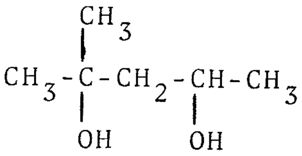
CH_2O



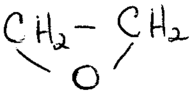


Epoxy resin

Molding powders electrical laminates, solvent and chemical resistant finishes, adhesives.



$CH_3-\overset{CH_3}{\underset{OH}{C}}-CH_2-\underset{OH}{CH}-CH_3$



$HO(C_2H_4O)_a(C_3H_6O)_b(C_2H_4O)_cH$

polyols nonionic surfactants (molecular weight 900-4000) This is an example of a block copolymer.

Wetting agent, nonionic detergent used in shampoos, hair dyes, bleaches skin and hair conditioners, cosmet cosmetics, mouthwashes, tooth pastes, antiperspirants, bar soaps, detergent tablets, dishwashing formulations, pharmaceuticals.

II. Relation between structure and bulk properties.

Important bulk properties of polymers are those that make the polymer matrix suitable for use as one (or more) of the following: flexible plastic, rigid plastic, film, fiber, elastomer, adhesive, surface actant.

A simple model that helps show how polymer structure relates to properties suitable for the above uses can be described as follows: In a flexible plastic, the polymer matrix can be thought of as similar to a very large plate of cooked spaghetti, except that the polymer chains are considerably longer and have a greater tendency to coil. In the matrix the chains are haphazardly oriented and intertwined. Also the chains are relatively easily displaced by an external force, making the matrix flexible and relatively soft. The flexibility of plastics can be increased by adding a plasticizer, a substance that acts like an internal lubricant.

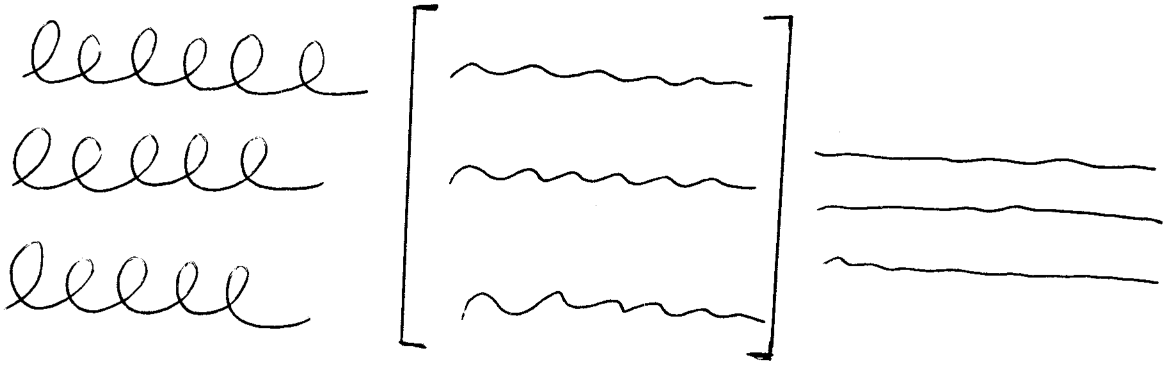
Compare PVC records with PVC raincoats.

If chemical cross-links are formed between chains, the matrix becomes more rigid because the movement of the chains relative to one another has become more restricted. The more cross-links the more rigid the matrix. Compare a rubber band with the sidewalls and the tread stock of tires. The crosslinking is least in the rubber band, greatest in the tread stock.

For films, fibers and elastomers, the threads in the matrix must be generally oriented in one or two dimensions. (Passing a wide-tooth comb or small rake through a plate of spaghetti would serve to orient many of the pieces of spaghetti in one dimension.) In polymer manufacture some orientation is achieved by extruding molten polymer through small holes in spinnerets. After extrusion the filament is cooled and the matrix dries and hardens. Within the filament the polymer chains remain highly coiled, for the most part, and generally oriented along the long axis of the filament.

The threads can be uncoiled by stretching or drawing the filaments. Drawing may occur at room temperature or above. Polymers that remain in the stretched position after drawing are likely to be good films or fibers. Those that recoil quickly after drawing are likely to be good elastomers.

An important feature that enables polymer chains to remain uncoiled after drawing is the formation of crystallites in the drawn matrix. Crystallites form when the uncoiled chains consist of a regular arrangement of small atoms. In such cases neighboring chains can lie close together and exercise attractive forces on one another over relatively long distances. This attraction and orientation amounts to crystallization in the region where it is strongest; it serves to resist the tendency of the chains to recoil. We can represent crystallite formation on drawing as follows:



parallel coiled threads in filament

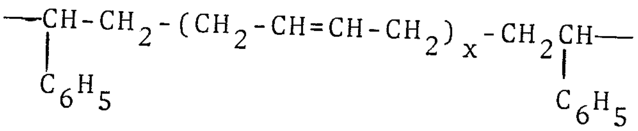
uncoiled threads in drawn filament

attracting and oriented threads in crystallite

Fibers are formed by one-dimensional extruding and drawing, films by extruding in sheet form and two-dimensional drawing. (Sometimes two dimensional drawing is accomplished by blowing the warm extruded sheet with air much like blowing up a balloon).

Good film or fiber forming polymers are polyethylene, polyacrylonitrile, polyesters and polyamides. All of these consist of a regular arrangement of rather small and/or highly attractive groups bonded to the polymer backbone.

In elastomers the tendency to crystallize is minimized in many cases by the presence of bulky groups occurring irregularly among the chains. This prevents close-packing of chains and reduces the attractive forces between them. Having no major force to maintain them in the uncoiled configuration, the chains return spontaneously to the coiled arrangement. Most synthetic rubber sold today is known as SBR (styrene butadiene rubber). This is a copolymer made from about 25% styrene and 75% butadiene. Its structure can be represented by:

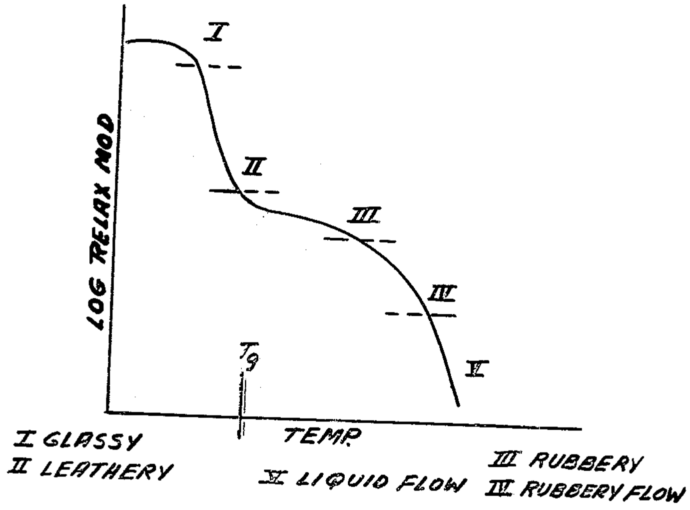


$$-\underset{C_6H_5}{\underset{|}{CH}}-CH_2-(CH_2-CH=CH-CH_2)_x-CH_2\underset{C_6H_5}{\underset{|}{CH}}-$$

Note the occasional bulky phenyl, C_6H_5, group and the long coilable butadiene residue. Note also the double bonds that can be used in vulcanization. Vulcanization usually involves heating the polymer with sulfur, which reacts with the double bonds to form -S-S- cross-links. Occasional cross-links serv as anchors to prevent tearing apart of the matrix. Large numbers of cross-links give hard rubber.

Temperature plays a role in elastomer properties. If th temperature is too low, the elastomer chains will recoil only very slowly, functioning more like an easily-deformed plastic. The following figure shows how properties of a polymer can change with temperature.

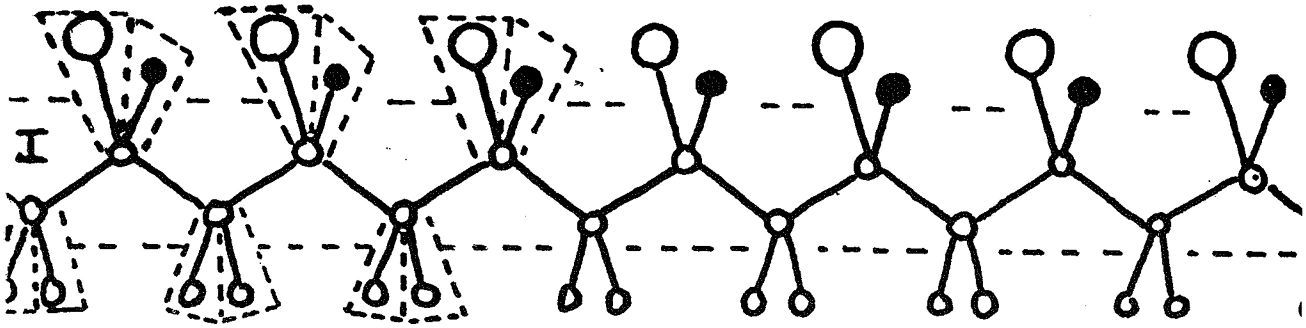
PROPERTIES OF AMORPHOUS POLYMERS



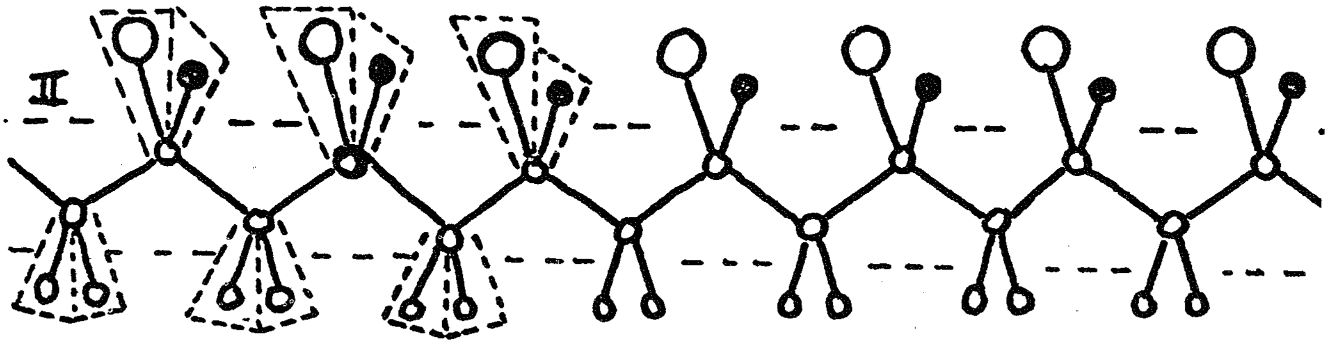
III. Secondary Structure in Polymer Chains - Stereoregularity and Coiling.

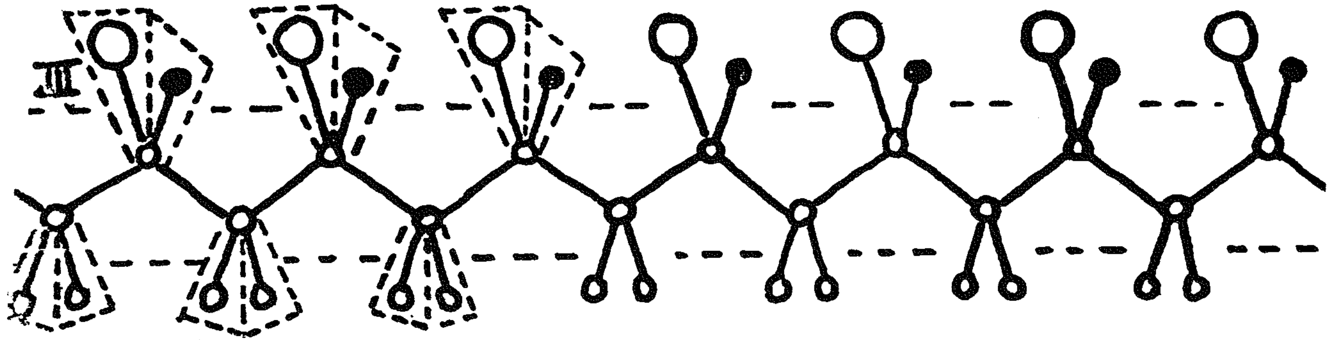
The tetrahedral geometry of saturated carbon atoms and the trigonal planar geometry of doubly-bonded carbon atoms lead to what is known as a planar zig-zag conformation in the chains of certain polymers including polyethylene, polyvinylalcohol, polyesters and cis and trans polybutadiene. Helices are formed in polymers bearing bulky groups that do not pack readily when confined to planar form. Examples are polypropylene, polymethylmethacrylate, starch and proteins.

The planar zig-zag conformation can be visualized if one could take the following structure and bend the substituents attached to the polymer backbone so that one substituent moves in front of and the second behind the planar zig-zag backbone. No real chain is imagined to remain in this planar configuration except in crystallites. Instead the chain assumes a <u>random coil</u> configuration. An idea of a random coil can be obtained by bending the backbone forward or backward about 60° along several of the zig <u>or</u> zag lines.



If the chain contains asymmetric centers (as in $CH_2\text{-}\overset{H}{\underset{X}{C}}\text{-}$), it is possible to prepare <u>stereoregular</u> polymers - those with nonrandom configurations at these asymmetric centers. <u>Isotactic</u> polymers of the type $-CH_2CHX-$ have identical configurations at each asymmetric center. This can be illustrated by taking the following sketch and folding each O group back (or front) and each ● group forward (or back); i.e. all O groups are on the same side of the backbone plane. Syndiotactic polymers of the $-CH_2-CHX-$ type have alternating configurations at the asymmetric centers; i.e. the O groups alternate from side to side of the backbone plane. Try this with the sketch on the following page also.



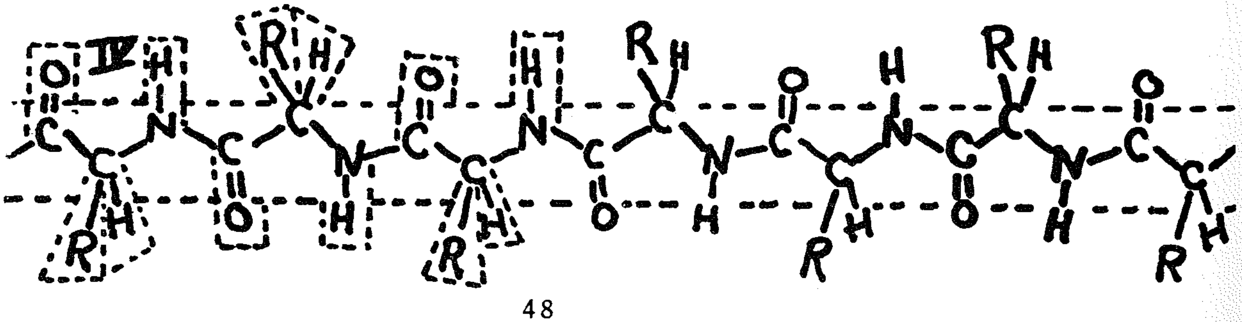


X-ray diffraction studies tell us the number of monomer units in each coil or repeating unit in helical polymers. The nomenclature here is illustrated by $H,2_1$; $H,3_1$; $H,18_5$; where H represents helix, the large number represents the number of monomer units, the subscript represents the number of repeating units. For example, $H,2_1$ means there are two monomer residues per coil; $H,18_5$ means there are 18 monomer residues for each five coils.

The preceding 2 sketches can be used to illustrate certain aspects of helix formation. The helix in isotactic polypropylene is represented $H,3_1$. We can begin to visualize this by placing illustration number 2 on the desk and smoothing it out so that all segments lie in the same plane. Now fold along every other bond in the zig-zag and in the same direction (make the angle of bend about 60°). Place the helix vertically before you and note that the coils move to the right in crossing on top of the pencil. This is a right-hand helix. Turn the helix upside down. Is it still a right-hand helix?

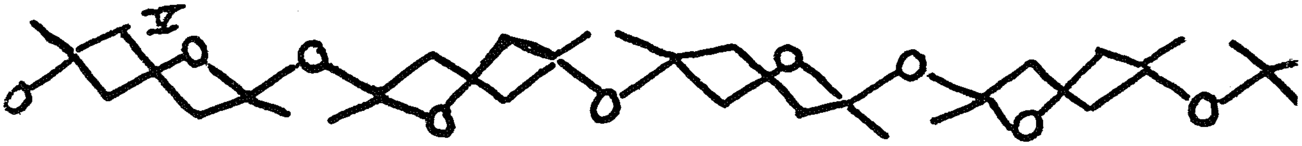
The $H,2_1$ helix occurs in syndiotactic polypropylene. To visualize this, smooth out illustration 3 and starting at one end, crease (to about 60°) along every bond in the backbone, changing the direction of fold each time. Is your helix a left-or a right-hand one? (The chirality will depend on the direction of the initial fold. As a result helices of each chirality are found in equal amounts of syndiotactic polypropylene).

Some polypeptides contain $H,18_5$ helices. The next sketch can be cut out and folded to illustrate this. Simply fold to about 60° on each bond coming to and from the CHR groups, first forward, then back and so on. Holding one end of the chain horizontally before you so the sequence from left to right is N-CHR-CO—, the N-H points up, and the bond connecting N and CHR is folded away from you, the helix should be right-handed with all C=O groups pointing down, and all N-H groups pointed up.

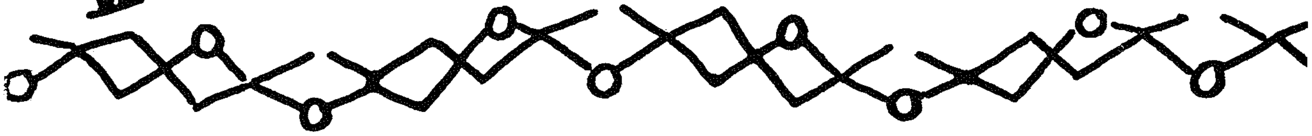


Illustrations 5 and 6 illustrate the bonding of glucose units in cellulose and starch (and in glycogen) respectively. Cellulose is said to be a linear polymer more suitable for the structural material in plants; starch is a more fluffy material due to its helical structure and its considerable branching. Textbooks list the starch helix as right-hand $H,6_1$.

V



VI



CHEMISTRY LABORATORY

Pyrolysis Chromatography-A Versatile Laboratory Experiment

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Presented to a Symposium on Innovations in Teaching Chemistry at the Forty-Ninth, Two Year College Chemistry Conference, Bronx Community College, Bronx, New York, April 2, 1976.

Pyrolysis, the thermally induced breakdown of complex materials in the absence of air, is a subject of great practical and theoretical significance which is virtually ignored in the undergraduate curriculum. This is a lamentable situation on the one hand due to the industrial significance of pyrolisis in the processing of wood, coal, and petroleum into a host of consumer products and industrial chemicals.[1] On the other hand the virbrationally induced cleavage of bonds in pyrolysis results directly from details of molecular structure and the fragments formed may serve to identify the original molecule (as in mass spectrometry) or to provide hints to later synthesis. Analytically, the pyrolysis fragments are subjected to gas chromatographic analysis using either a "finger printing" against known patterns or a comparison of retention times with those of industrial pure materials. 2--4 In light of the proven importance and seemingly rather typical analytical techniques involved it seems only that complexities of experimental design has prevented significant study of pyrolysis at the undergraduate level. In the present paper a versatile undergraduate laboratory experiment using pyrolysis coupled with gas chromatography is described. All special apparatus are easily constructed using readily available materials and the experiment may be variously slanted to apply to organic,[2] analytical,[3] environmental,[5] or industrially oriented courses.[1]

Apparatus and Set Up

The pyrolysis chamber is constructed using a 12 x 150 mm pyrex sidearm test tube into which a right angle glass tube (purge line) extends through a one-hole rubber stopper. (Fig. 1) A section of 1/8" surgical rubber tubing is attached to the side arm and is to serve as the sampling septum. As shown in this and further diagrams the pyrolysis chamber is equipped with ball joints to facilitate ease of operation and to allow a series of students to sequentially insert new pyrolysis chambers into the line of support equipment as described below.

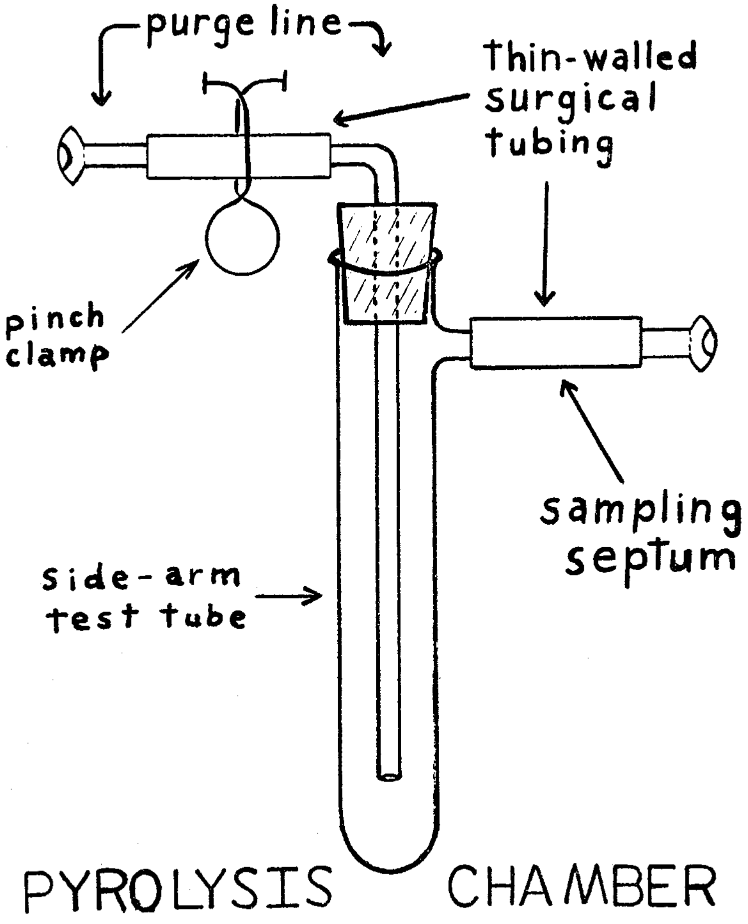


Figure 1

In Figure 2 the purge line of the pyrolysis chamber has been attached to a source of an inert gas and the sampling line similarly attached to a line terminating in a pneumatic trough. The purge cycle illustrated in Figure 2 is necessary to remove residual oxygen and other gases from the chamber. Once the pyrolysis chamber containing the sample to be analyzed (0.1-0.2 g) has been securely attached, the clamps are to be opened and one 250 ml bottle of gas to be collected by water displacement. If a 12 x 150 mm side arm test tube is used as the pyrolysis chamber, this provides a x10 excess of sweep gas without encouraging undue waste of the purge gas. The purge gas should be identical with the carrier gas to be used in the later gas chromatographic analysis. When the purge cycle is terminated, both clamps are to be closed and the pyrolysis cycle may begin.

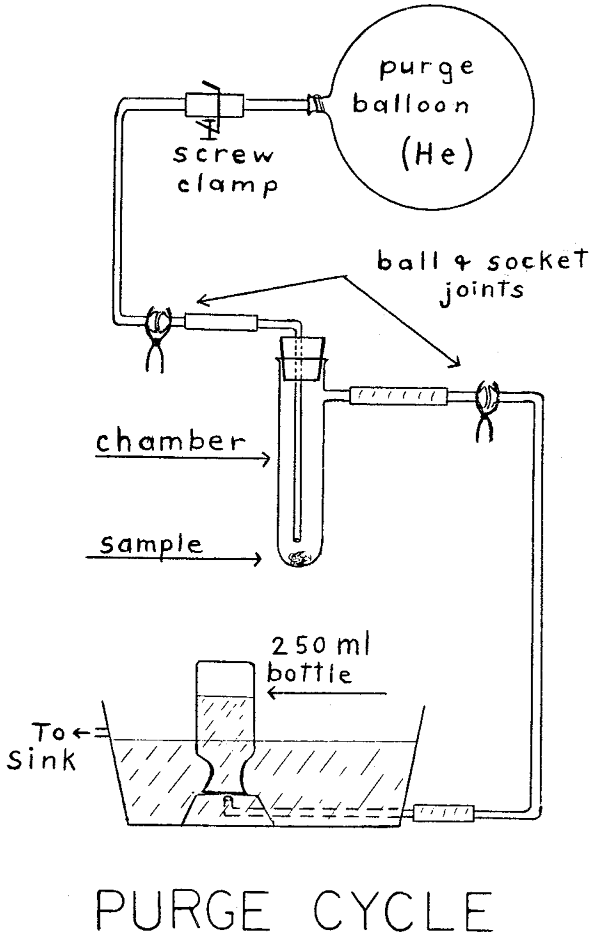
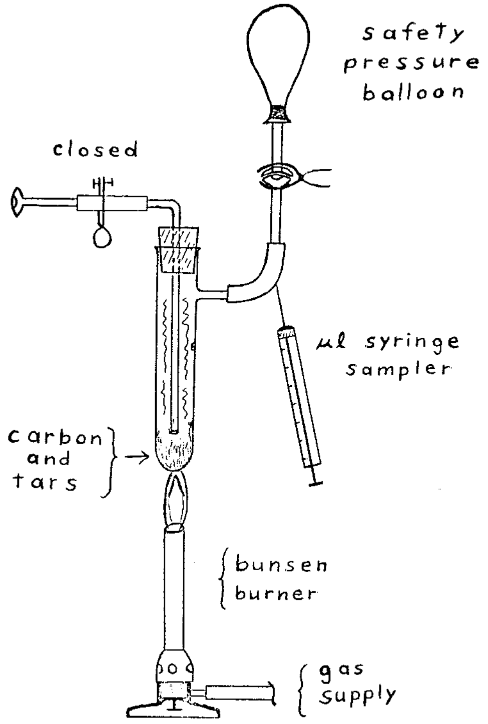


Figure 2

In Figure 3, the pyrolysis cycle, the purge line is closed and the sampling line has been attached to a deflated balloon held in place with rubber bands. Since the balloon is to prevent build up of pressure when heating a closed system, it should be pretested to withstand a 30 cm expansion (a x10 safety factor over what is expected). The pyrolysis is effected by intense heat from the inner blue cone of a small bunsen burner flame applied directly to the bottom of the tube. In order to ensure that pyrolysis has taken place, carbon or tarry materials must be observed in the chamber. Otherwise the sample may have simply vaporized. However, one must heat only the bottom of the tube to avoid distillation of high boiling liquids into the sampling line. Once decomposition of the sample is observed, the relatively cool gases in the sampling line can be collected and analyzed. Sampling is carried out by inserting the needle of an ordinary G.C.-syringe through the 1/8" thick surgical tubing of the sampling line and withdrawing the plunger to the appropriate mark (10 1 may be considered a reasonable minimum for thermal conductivity detection).



PYROLYSIS
GAS SAMPLING

Figure 3

The sample collected will consist primarily of low molecular weight gases with minor quantities of vapor from low boiling liquids. Unless the chamber has been overheated, no condensation will occur in the syringe held at room temperature. (If overheating is allowed, tarry materials may build up in the syringe and necessitate cleaning the syringe with acetone before the next sample is taken.) The sample in the syringe is held at room temperature temporarily until it can be injected directly through the septum of a gas chromatograph. The column and conditions should be preset to correspond to the expected products. However, using organic compounds will result in primarily hydrocarbon with some partially polar fragments so that a SE-30 column operating at approximately 100°C is recommended to emphasize the former while a DC-200 column operating at approximately 80-90°C might be chosen to obtain a more general separation.

Results and Discussion

In the work reported here, only one of the possible applications has been investigated; pyrolysis chromatography has been used to identify polymer samples. This is a particularly useful application for those cases in which fully cured rubbers, epoxys, and other totally insoluble materials are to be investigated and when thin films are not immediately available for IR analysis. In such cases advantage is taken of the observation that specific polymeric materials decompose when heated under reproducible conditions to give rather specific products. A comparison of the gas chromatograms of a restricted set of pyrolyzed polymer samples allow immediate identification of a specific member of the set by finger printing. Alternately, the identity of the specific components can be determined by a comparison with retention time of individual samples of the possible pure components.

As illustrative data three polymer samples were collected and given to a student for identification. The first, a brittle clear plastic pill box proved to be polystyrene. The second, a discarded plastic graduate cylinder and the third, some crushed plastic drain pipe were known to us to be polypropylene and polyvinyl chloride, respectively. These were pyrolyzed (0.1-0.2 g) individually and their chromatograms recorded using a Perkin Elmer F-11 chromatograph with flame ionization detector. The column used was a 6 foot long 1/8" diameter, 10% SE-30 (silicon gum rubber) on chromosorb W held at 95°C with N_2 carrier gas being used. The experimental results are reconstructed in Figure 4 with the exception that in the case of polystyrene one further peak of very low intensity was observed at 2.7 min. and similarly for polypropylene a further low intensity peak was present at 2.8 min. Note that the first peak in each case is shown attenuated by a factor of ten with respect to the following peaks shown at a relative attentuation of one. Although the lower molecular weight components are similar in each case, the chromatograms are clearly unique for each material.

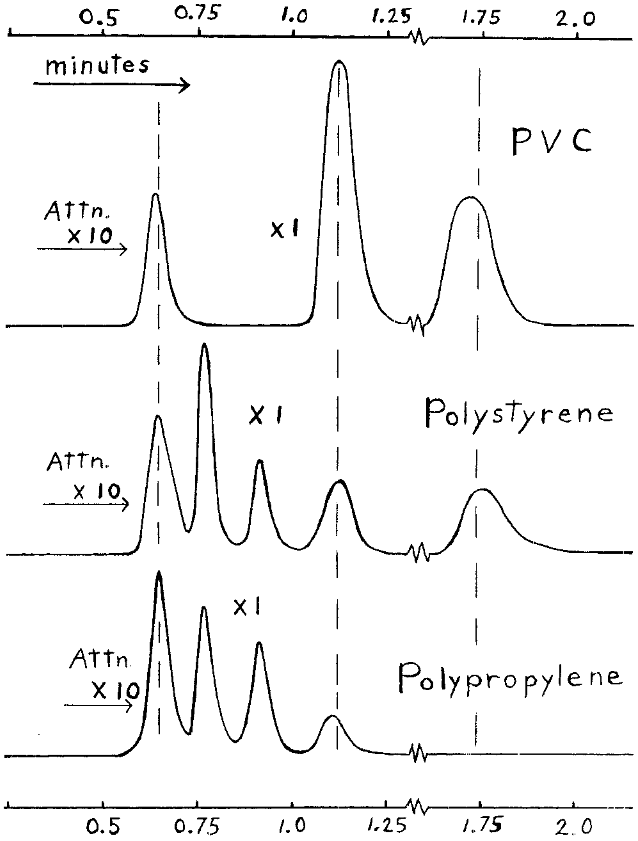


Figure 4

In this case no specific attempt was made to identify the components but reference to published data (Figure 5) allows a comparison of results.[6] Note that the HCl reported to be the major gaseous component of polyvinyl chloride is not detected by flame ionization. Thermal conductivity on the other hand would easily detect it. The literature data reproduced below in Figure 5 represent the case where all components are to be accounted for. In the case of the student data presented here, only the low molecular weight organic materials are of interest and thus compare primarily to the entries Methane, Ethylene, and Other Aliphatics in Figure 4.

It should be pointed out that although the pyrolysis apparatus is a closed system and thus does not directly release products to the atmosphere during operation, the experiment should be set up in the hood. This is necessary because some release of gases is inevitable during clean up.

Particularly in the case of polyvinyl chloride, the known carcinogen vinyl chloride may be released. For this reason also, the system should be put through a purge cycle before opening for clean up.

% (weight)	Poly-ethylene	Poly-styrene	Poly-vinyl chloride
H_2	0.5%	......	0.7%
CH_4*	16.2%	0.3%	2.8%
C_2H_4*	25.5%	0.5%	2.1%
other* aliphatic	18.9%	0.1%	0.8%
B,T,X	16.9%	7.8%	4.8%
Styrene	1.1%	71.6%	....
other aromatic	12.1%	16.0%	22.4%
HCl	....	....	56.3%
C	0.9%	0.3%	8.8%
Σ	99.4%	96.6%	98.7%

Figure 5

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(3) K. Ettre and P.F. Varadi, Anal. Chem., 35, 69 (January, 1963).

(4) B.C. Cox and B. Ellis, Anal. Chem., 36, 90 (January, 1964).

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Evaluating Lab Work

David Dean
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Presented to the Fiftieth, Two Year College Chemistry Conference, Fanshawe College, London, Ontario, June 10, 1976.

In many chemistry courses (including those at Mohawk College up to two years ago), the laboratory work and theoretical course work are taken as one course for administrative purposes. This means that students receive one mark for their combined theory and lab work and no real indication exists as to whether the students practical work is significantly different from his theoretical course work. It is my contention that the first place to start in the attempt to evaluate practical lab work is to separate theory and lab courses and to issue separate marks for these on the student's transcript. This move helps to focus attention on all aspects of the practical lab program and forces the instructor to look for evaluation data in as many places as possible within the total pattern of lab work. Too often, the marks assigned to a few lab experiments are tossed in with assignment marks and term tests from the theory part of a course and lab assessment is subjugated to the "easier to obtain" theory mark.

It is also important in practically oriented programs to show the strengths and weaknesses of students in the various types of labs they encounter. With separate grading it is relatively easy to show that a student possesses a high degree of skill as an analyst i.e. a good technician for analytical type skills, but the same student may be weak in an organic lab where different skills are required. The lab evaluation techniques I use are best appreciated in their relative significance, in terms of the separate course evaluation I have just discussed, but they can still be employed in an integrated course.

Different types of labs require different types of evaluation. Obviously, in an analytical lab where skills can be judged on the basis of results obtained, part of the lab evaluation will be based on pre-analyzed lab samples. This is an old and quite satisfactory approach, at least in part, to assessing manipulative skills, adherence to procedures, cleanliness, weighing techniques, and the whole integrated process which over a period of several weeks and several samples separates the skilled lab technician from his sloppy and slower classmates. Many labs, however, such as the Physical Chemistry area in which I work do not lend themselves so readily to a comparison of "right" answers and in fact it is not always a right answer that motivates a particular lab exercise in the first place. I will address my remarks primarily to this type of general lab work and explain the evaluation method in terms of the general lab objectives.

Traditionally a chemistry lab requires that students perform a preplanned experiment on a regular basis, usually once a week, and sub a "lab report" to the instructor at the end or at various times in a semester. Sometimes a prelab report is also required before starting the lab and a marking scheme may be attached to both prelab and final lab report. It has been my experience that this approach to marking does not fulfill my objectives for the lab and students find the reporting process time consuming and not very closely related to what might be expected from them in industry.

In abbreviated form the objectives for the students in my lab are:

1. To obtain a working knowledge of a broad range of traditional physical chemistry equipment such as water baths, viscometers, refractometers, temperature measuring devices and specialized equipment.
2. To be able to set up equipment for special functions, make simple repairs to glass apparatus and build or modify minor items to complete an experiment.
3. To keep accurate, complete records of all experimental data, calculations, graphs, etc., in an appropriate, permanent hard covered notebook.
4. To write concise summaries of experiments for submission as lab reports.
5. To develop a sense of independence and judgment in dealing with physical chemistry practices.

Assuming that you agree that these are reasonable objectives, how do we evaluate them? Frankly, I don't pretend to know how to assess whether a student can really exercise good judgment in all lab matters, but other items are easier to cope with. The overall approach is based on combination of the following items:

1. Prelab preparation in a hard covered permanent lab record book.
2. Pre-printed, summarized lab report forms.
3. Performance marking - a subjective evaluation of each lab period.
4. Practical exam.

Most experiments are two weeks in length and a report is required for each one. At one time students were required to do all experimental work including prelab, calculations, rough data, graphs, etc., in their standard, hardcovered lab notebooks and to hand in these on a regular basis for marking. This has several drawbacks. Students hesitate to record data as they collect it and to do trial graphs because they end up with a "messy" lab book which they then fear to hand in expecting a poor mark. Consequently, they resort to copying data out twice, scribbling on notepaper or shirt sleeves, and otherwise poor lab practices. On reflection, I realized that this does not parallel industrial practice because lab work books are never circulated as reports to management. Instead, relevant data is extracted, summarized, analyzed and circulated as a concise report covering several weeks work. The compromise solution we have arrived at requires the student to complete prelab work including data tables in a hard covered notebook and to keep all data, calculations, etc., in this book. It is marked only at the end of the semester and marks are based on completeness rather than neatness. For example rough graphs, calculations, rough conclusions and explanations are expected to be there. When the lab is completed, preprinted summary sheets are filled in, appropriate graphs are attached, conclusions and explanations are completed and the lab report is submitted. This report is carefully checked for errors and returned with comments and a grade out of a maximum of ten. Reports containing major errors or of a general quality worth less than six out of ten marks are returned to the students as "Incomplete" and they must be corrected and returned.

Performance marking is a subjective evaluation of a student's general lab behaviour including the adequacy of his preparation for the lab and efficient use of his time. I mark on the basis of a maximum of five marks for each lab session. Absence from the lab for any reason means a mark of zero for that session. This is not looked on as a penalty but rather a matter of earning marks for work done - no work, no marks. The usual mark for an adequate lab performance, which means good technique, business like approach to getting on with the job, organization of jobs, and proper use of notebook, would be four out of five marks. A mark of one, two or three would result from different levels of default in the above areas. A mark of five is reserved for special effort such as carrying out extra experimental runs at a different temperature or perhaps using any extra lab time to complete calculations and plot some of the data. Performance marks are posted at the end of each lab day and students are invited to question their marks in order to learn how to improve their performance.

Since the labs are usually two weeks in length a total of ten performance marks and ten lab report marks are possible for each lab.

The final lab class of each semester is reserved for a practical exam. This exam only counts for a total of ten marks in the overall evaluation but passing the practical exam is one of the mandatory requirements for passing the lab course. Since students usually work in pairs throughout the year, awareness of the practical exam requirements discourages weaker students from hiding behind their partners in the regular lab classes. For example, all students are expected to use and set a differential type thermometer for one or two experiments, but it is impractical for me to check each group and be sure they do this. However, since each student knows he may have to set up the thermometer for the exam he makes sure he gets a turn at the required work.

The practical exam is run by giving each student a list of eight or ten lab tasks from the range of labs which they have performed during the year such as measuring the refractive index of a solvent or measuring the surface tension of a liquid. The students enter the lab one at a time and choose by random drawing, four or five of these lab tasks which they then proceed to complete. Each task is assessed a mark and often this mark is subjective, especially when the student must discuss the operation of a constant temperature bath or set up a U.V. - visible spectrophotometer.

Practical exams are time consuming, difficult to run for large classes, very demanding on the instructor, and a general aggravation. They are also the best way to assess an individual student's mastery of simple lab tasks and often the only time a student finds out for himself if he has learned the lab skills properly. For example in one class the practical exam at the end of the third semester isolated six students out of twenty-five who displayed a serious deficiency in using the analytical balances even though they had completed a semester of analytical and physical chemistry and in most cases thought they were doing the job properly.

Taken on balance, I believe the approach I have just described gives the right combination of marks to assess students in the type of course I am giving with the general lab objectives I have outlined. Let me assure you however, that an adequate evaluation requires a great deal of time, promptness in marking and continued vigilence during lab periods. Unless you have assistance it is impractical to employ all of these techniques for classes of more than twenty-five students. About half that number is preferred.

Laboratory Evaluation in the Training of Technicians

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Throughout the far flung edifice of our scientific and technological age there exists one broad foundation upon which all else is built. This is the concept of reliable and reproducible data and it is at this level that the laboratory technician is expected to perform. In light of this observation, the training of laboratory technicians and particularly the evaluation of their laboratory work takes on critical significance. It is to this problem and particularly to the second and terminal year in the training of laboratory technicians to which I wish to address my remarks.

During a student's second year at Mohawk Valley Community College and in the Science Laboratory Technology program he is required to enroll in the three quarter sequence of courses Instrumentation and Laboratory Techniques I, II, and III which acquaints the student with those aspects of organic, analytical and instrumentation which he might reasonable encounter in professional work. Since the courses consist of 6 hours of laboratory and 2 hours of lecture per week, one correctly concludes that the emphasis is on the practical rather than theoretical.

The realistic evaluation of laboratory performance is thus a critical concern of instructors in this sequence. In this evaluation the following are major factors:

1. Quality Control: (accuracy, precision, percent yield, purity of product and etc.) -----30%
2. Record Keeping: (notebooks systematic recording of all work as a legal record -----30%
3. Laboratory Technique: (procedural errors, breakage, punctuality and general attitude) -----20%
4. Practical Exams: (completion of assigned tasks using laboratory facilities without references or directions) -----20%

In all of this work the use of unknowns having accepted values and the continual involvement of the instructor in the laboratory are pivitol for success. However, instructors cannot be omnipresent so that other features have been built into the laboratory to compensate. First, the student must prepare the procedure in the notebook before entering the laboratory. Second, each experiment is designed with controls and check points to provide feedback on progress. Third, a student foreman is designated for each experiment. It is the job of the student foreman to prepare in advance to be a reference person on that experiment and to consult with the instructor in advance if necessary. The student foreman is also to look over and sign the quality control report of his fellow students before it is handed in. In this way many errors in laboratory technique are corrected which otherwise be missed by the instructor and in addition students are encouraged to accept responsibility and to work as a team. The student foreman receives an evaluation of his effectiveness from fellow students of 50% and from the instructor of 50%. Students enrolled in this program have generally responded well and upon graduation have readily found employment in various industrial, clinical, and research laboratories.

CO-OP CHEMISTRY

Co-op and Chemistry

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Presented to the Fiftieth, Two-Year College Chemistry Conference, Fanshawe College, London, Ontario, June 10, 1976.

Cooperative education is based on the principle that academic study, integrated with alternating terms in a structured working environment, develops graduates of a high academic and professional stature.

Stated simply: Experience is an excellent teacher.

The University of Waterloo was founded in 1957 with a co-op Engineering program. Other faculties have accepted this concept and it has played a major role in the growth of the University. Currently 5,485 students, representing 44% of the undergraduate enrollment are registered in co-op programs.

There are 230 students registered in co-op chemistry.

An analysis of work term locations for chemistry students in 1975 showed the following breakdown by business in diminishing order: Chemical, Provincial Government, Mining, Plastics, Pulp and Paper, Steel and Aluminum, Federal Government, Pharmaceutical, Hospital, University, Food, Petroleum, Power, Brewing, Business Machines, Tobacco, Cement.

In most cases the co-op chemistry students work as laboratory technicians in production and research and development laboratories.

Hal Luker will be discussing the role of the coordinator which includes a good amount of effort in soliciting the participation of employers in a co-op program.

Once an employer enters the program, the duration of participation becomes almost entirely the responsibility of the co-op student. The employer's long-term commitment to co-operative education is related directly to the performance of students during their work terms. The employer's justification for continued involvement is certainly not purely altruistics. The advantages are very practical. The system can be used to spot talented employees during their undergraduate years, to assess them on the job, and to attract them back as graduates with proven business experience. Many organizations, due to their size, are restricted in the long term benefits, but do however, have positions which are made available to enthusiastic co-op students. These positions may be somewhat routine for full time employees, but offer excellent experience to students.

But whatever the employer's motivation, the success of co-op rests directly upon the shoulders of our students.

Following is a quotation from the labour gazette in an article on the Waterloo program in 1970:

> "The principle behind co-operative education is that there should be no separation of academic programs and work experience. Both are prerequisites to a sound education and should be present in the student's formative years."

The University must present a core of basic knowledge in the classroom which will ensure that the practical experience is meaningful.

A student is expected to demonstrate professionalism in attitude as well as in performance on the job. Work term supervisors are urged to keep students fully informed of their progress. The success of a work-term is often dependent upon the willingness of a supervisor to give the student a degree of special guidance in a new environment.

As in the case of the employer, advantages to the student are quite practical. A new meaning is given to studies, a closer tie-in between theory and practice, an increase in motivation and maturity, and a greater orientation toward the work world. The student is able to use the income from work-terms to help pay the University costs. With two years of practical experience built into their education, students are exposed to good opportunities at graduation.

Comments on co-op students by professors are interesting. Where a comparison between regular and co-op students can be made, it is observed that co-op students have a different attitude.

They appear to be more stimulated and committed to their studies, and have developed interests and priorities toward applied work in the real world. They are better organized in laboratory situations.

Where comparisons cannot be made, the main comment relates to report writing. Professors are impressed with the calibre of reports and the strong correlation between work expected and the academic level of the student. Although there are practical advantages to the University, cooperative education also offers advantages that have an intellectual basis.

It is argued that a typical University today is an artificial environment--it is an unnatural congregation of people selected for very specific purposes, and frequently drawn from a restricted socio-economic stratum.

Students in such an environment tend to develop a philosophy and set of values that usually go unchallenged within the campus, but are criticized away from it. In fact, it can be said that adolescence is prolonged. One reality that seldom intrudes is that of the work-a-day world.

Cooperative education, by contrast, integrates industrial experience and the classroom. Work provides the link to reality, and the University benefits because it assumes a more vital role in the community.

The Man in the Triangle

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Presented to the Fiftieth, Two-Year College Chemistry Conference, Fanshawe College, London, Ontario, June 10, 1976.

The international symbol for co-op education contains a traingle whose sides represent the three indispensible parts of a co-op system -the student, the college, and the employer.

Not shown in the logo is the guy who figuratively moves around the triangle, making sure that the interfaces of these three entities are friction-free and healthy. He is the Co-op Coordinator, or as we at Fanshawe more awkwardly call him, a field liasion officer.

The triangle is a busy arena. At any given time the Coordinator has students in the field whom he must visit, a group of students in college whom he must get to know, and for whom he must find good related Co-op work terms- soon. Somewhere, he has to find time to call personally on employers in the never-ending process we call job development. Job development is finding employers who will provide related work experience for undergraduate students, and pay them. It is a tough job of selling.

Since I started job development for our Science Laboratory Technology program in 1972, I estimate that it takes about 20 calls to get one employer to participate. This may not be true of all disciplines, because laboratories tend to be equipment - intensive rather than personnel - intensive operations.

Wooing an employer for co-op is a challenging operation with many variables in play. Some of these variables are:

1. Have you contacted the right person in the organization?
2. Does the Company have a genuine need for such personnel?

3. Does the Company view co-op as a legitimate part of education or as a frill?
4. How does the Company view Community Colleges? Does it see them as legitimate post-secondary institutions? (Many science-oriented companies are strongly University oriented.)

If the answer to any or all of these questions is "no" the coordinator has a tough selling job on his hands, and in the extreme cases he might decide to forget it for now and move on.

Once an employer becomes involved in co-op, the Coordinator must concern himself with keeping the employer in the system. Contact with the employer is the key - not too much contact, but enough to maintain good communication and good relations.

One of the mutual benefits of co-op stems from the continual liaison provided between the College and employers by both the Coordinator and the student. This flow of information has actually resulted in course material and sequencing being altered here at Fanshawe to better reflect the needs of our participating employers.

One important and difficult part of the Coordinator's job is the actual planning of the co-op student's training during the work term. Ideally, this should occur in all cases, and should involve the student's supervisor, the Coordinator, and the student. Unfortunately this idealized version of co-op experience is not available, simply because the demands of the employer's business will not allow it. The student is often hired to do a specific job, which will not allow the kind of diversification of training that we would like to see.

The employer performs another important function - that of evaluating the student's performance. The Coordinator sometimes has to diplomatically urge the supervisor to do a thorough and sincere evaluation - it is for the student's benefit.

The triangle analogy in co-op is really quite apt, in that the three parts are indispensable to the whole. In co-op, education is the name of the game and the student is the central figure. Co-op exists for students. Benefits to the employer and to the institution are very real, but the student is, must be, the major beneficiary. Student contact by the Coordinator, then is a most important matter.

It starts almost as soon as the new co-op student arrives at College. In S.L.T. students are given a couple of weeks to become acclimated to the College before the Co-ordinator introduces himself and the co-op to them, first in groups, then individually. One of the first things we talk to new co-op students about is mobility - or lack of it. Mobility means willingness to move to where the job is. Students have all kinds of reasons for not going - anywhere.

Co-op education, as I said, is for the student, and the co-ordinator as my boss has said, has to come to grips with the question, "Am I an educator or a job jockey?" It is very important that the student be reassured that he or she is not merely being processed as grist in the mill, but that the College, both the academic and Co-op Divisions see him or her as an individual with goals and needs that we are earnestly trying to help the student identify, reach, and fulfill. Somehow, we have to get the student functioning as a member of the team - not just passively having something done to him, but actively participating in what can be an exciting and rewarding experience. The Coordinator needs a large portion of interpersonal skills to bring this off, and of course, he only partially succeeds. The important thing, in my opinion, is not to merely pay lip service to the importance of the student, but to really feel it.

This brings me to another problem indigenous to Community Colleges, and that is the connotation of localism in the world "Community". This affects both students and employers. Many college students attend their local college for reasons of economy and security, and these same reasons account for any reluctance to go farther afield even for excellent work experience.

Distant employers often wonder (and ask us) what we are doing raiding Humber's or George Brown's or Seneca's or Centennial's territory. We explain our presence in terms of the uniqueness of Co-op, with its year-round availability of student employees. I see this problem as unique to Community Colleges, because at the traditional University level, the question of geographic jurisdiction would not likely arise. A good co-op program, especially if it is located in a smaller center, absolutely demands a catchment area for co-op work far beyond the boundaries of the immediate community. Fanshawe co-op students have found work terms right across Canada, and even outside the Country.

A pretty typical question right now is "what happens to co-op in times of economic recession?" To be frank, when employers face business cutbacks and may be reducing their regular work force, it is not realistic to expect co-op to be unaffected. There really is no answer, except to ride out the storm and redouble the efforts to place students. One very important factor here is student morale. The Coordinator owes it to the student to be honest about job prospects and to encourage the student to work independently to find a suitable job- even an unrelated one. In a sense it is part of the student's education to learn that neither College or Co-op is a magic key - that hard economic facts are to be faced by everyone. A lesson, if you like, from the school of hard knocks.

Finally, I would like to share with you an observation I have made. In the Chemistry labs of Canadian Industry, Education and Government, there appears to be a limited number of suitable openings at any given time, whether co-op or permanent. In any discipline, and in co-op in general, the job market has a saturation point. Some members of the Canadian Association for Cooperative Education worry that the co-op saturation point is being approached, at least in this part of Canada. It behooves us then, to keep the number and appropriateness of our co-op programs under rational control. That saturation point might be moved upscale, perhaps if we can continue to bring new employers into the system, while retaining our old friends.

So, if there are any employers (or potential employers) in the audience, may I recommend that if you have not participated in co-op, try it. If you are participating, good for you! The man in the triangle certainly appreciates it.

PEDAGOGICAL APPROACHES TO CHEMISTRY

The Technological Threat and the Teaching óf College Chemistry

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The Value of Theoretical Perspectives

The theme that underlies our discussions is probably as frustrating and tiresome as it is important, for often we become impatient of those who offer theoretical perspectives in place of real assistance for that domain of practice which is our professional concern.

However, there is as necessary a relationship between theory and practice in education as there is in any field of study, and it seems appropriate, before I move into my major arguments, that I explore this relationship a little further. After that, I want to use two theoretical perspectives to initiate some debate about college chemistry teaching. The two perspectives are the technological threat, and the distinction between education and training.

I find it helpful to explore the relationship between theoretical perspectives and practical considerations by working from examples. And just to show that frustration about this relationship exists in fields other than chemistry teaching, I select an instance from the field of medicine. Most cases of meningitis, I am told, occurring in children aged between two and five in the region of Quebec City are a function of a given strain meningococcus, which is sensitive to the antibiotic ampicillin, and can be treated successfully with daily doses of this drug. Yet, in teaching pathology, medical instructors would be wise to avoid giving such information as a prescription or recipe for medical practice since meningitis can be the consequence of different micrococci, in different localities for different age groups. The medical student, expecting ready cures for every disease is surely to be dissatisfied with the pathologist who suggests that ampicillin is effective in only ninety per cent of cases where causal agent, location, and maturity are known.

To my way of thinking, two significant points can be discerned from this example. First, there appears to be a tension between theoretical knowledge and practical application such that, beyond a certain point, the medical knowledge itself provides no security as to what constitutes right action and, since there must be action, we recognize at this point, that the practitioner prescribes his treatment in the absence of absolute guidance from research. The second point also concerns this tension, for the example reveals that the medical student harbors certain expectations about decision making in medical practice. It is as if he operates in the belief that for every choice point, there is a right course of action to be pursued, and that the rightness of this course of action if known by medical instructors because medical research deals with right answers. This sort of expectation indicates clearly that, not only is there a tension between theoretical considerations and practical application, but that the medical student is unaware of this tension.

Before I capitalize upon the notions of tension and expectation, let me offer a second example which is very familiar to college chemistry instructors. The classical picture of atomic structure was disrupted when between 1925 and 1930 the theory of Quantum Mechanics was built from the ideas of Schrodinger, Heisenberg and Dirac. Professor Toulmin notes in the introduction of Quanta and Reality that this theoretical perspective required us to abandon the view that future states of atomic particles, and indeed of all particles, can be precisely calculated if we know their present mass, speed and position. According to this new perspective, Toulmin writes:

> . . . questions about the future behaviour of physical systems could be answered only statistically. One could calculate the average rate at which nuclei of some radioactive substance would disintegrate, but not the precise moment at which one particular--or even the next--nucleus would break up, nor the exact number which would disintegrate during any chosen second of time.[1]

I anticipate that we recognize the tension here between theoretical considerations and the practical world as commonplace. We have come to understand that the assumptions underlying the quantum mechanical theoretical perspective deny us the leisure of observing a one-to-one correspondence between theory and world. This denial, as I have implied, is built into the perspective and shows clearly the particular tension that characterizes the sciences between our theories and what they are invoked to explain.

It is evident, I think, that scientists, by virtue of their involvement with theory and observation, are aware of the tenuous nature of the relationship between the two. My concern, however, is if students of science have gained this awareness. I rather think that they have not and instead that they hold an expectation of science which cannot be fulfilled. Briefly, it is the expectation that science deals with right answers and absolute truth, and consequently that the information gleaned from the study of science is sufficient for making decisions about policy and conduct. This sort of unrealistic expectation is most fully revealed in writings that speak to the technological threat.

The Technological Threat Perspective

Before I venture into the body of the theoretical perspective which deals with the technological threat, I wish to make two points very clear. The first reviews the function of a theoretical perspective and the second focuses on what this particular theoretical perspective is not about. As we can anticipate from our knowledge of science, the primary function of a theoretical perspective is an ordering or organizing one. Galileo's perspective ordered the universe in a way that differed from the order afforded by Ptolemy's perspective. Mendeleev's perspective had great power for organizing; and the introduction of probability in the form of quantum mechanics has surely caused us to look at the world differently. So, theoretical perspectives can be seen as large conceptualizations which bring a novel way of looking at and speaking about natural phenomena.

My second point is that it would be a mistake to take the position that in duscussing the technological threat I am in some way criticizing science and teachers of science. As I hope to show, the opposite is the case for, if my understanding is correct, it is not science itself but the lack of an appropriate understanding of science by society which gives rise to the technological threat. And it would follow from this that efforts by teachers of science to instill an appropriate understanding of the discipline would do much to diminish what is perceived to be a threat.

So my object in discussing the perspective of the technological threat is not to inveigh against science, but to point up a significant feature of science and how it is understood, with the intention that this perspective throw light on what the responsibilities of teaching chemistry at the college level might be.

As I have indicated, the concern about the technological threat seems to revolve around the thought that there is an inappropriate understanding about the capabilities of science, and hence of technology, at large in the society. Three related elements appear tc comprise this unwarranted understanding of science; science is objective, the product of scientific work is absolute truth about ourselves and about the world in which we live, and science is value-free.

A few selected references will show, I think, that this particular view is abroad. Roszak, in his Making of a Counter Culture suggests that society has a debilitating and erroneous view of the nature of science and of what qualifies as knowledge. Society's view of reliable knowledge is, he argues:

> ...knowledge that is scientifically sound, since science is that to which modern man refers for the definitive explication of reality. And what in turn is it that characterizes scientific knowledge? The answer is: objectivity. Scientific knowledge is not just feeling or speculation or subjective ruminating. It is a verifiable description of reality that exists independent of any purely personal considerations. It is true ... real ... dependable .... It works.[2]

Here Roszak is implying that science and scientists are wrongly revered for, contrary to the public view they do not have direct access to reality except through the ideas and conceptualizations with which they organize data. Schumacher states this well-known phenomenon about human perception and the intervention of human ideas very succinctly:

> The way in which we see and interpret the world depends very much indeed on the kind of ideas that fill our minds.[3]

Earlier I mentioned the type of expectation which appears to accompany a naive understanding of any theoretical perspective. For Roszak, society holds the expectation that science is objective, and hence produces absolute results in the form of facts; and Schumacher makes it evident that such an expectation is foolish and naive. Teachers and practioners of science know full well that the tension between theory and data in science invalidates this naive perspective. We, in this century, have come to live with uncertainty, with data that doesn't fit simple conic sections, and with the notions of probability. Yet, there appears to be a fulg between that understanding and the general public's and unfortunately, I believe we should include here our students.

Let me produce some evidence which suggests how widespread this erroneous expectation of science might be. A recent study by Jungwirth shows that the view of science as "fact-collection" and "dealing with absolute truth" was surprisingly prevalent among twelfth graders, university students, and university professors. It was found that the "fact-collection" image of scientific knowledge:

> ... increases with age and experience to the fifty per cent level, dropping only slightly in the opinion of university professors. Similarly, the absolute truth image persists at around 20 per cent, disappearing only among the university professors.[4]

There is evidence, too, to support the argument that society as a whole has this sort of expectation of the scientific enterprise. Recent data, presented in a study by Etzioni and Nunn[5] show the percentage of the American public indicating a great deal of confidence in various institutional areas, such as religion, the military, the press, labor, and so forth. According to surveys conducted in 1973, science was ranked second equal with education at 37 per cent, with medicine first at 54 per cent. Accordingly, science has in some way captured a sizeable proportion of the U.S. public's confidence, and it is difficult to account for this confidence unless it is a direct consequence of society's expectation that science is objective, that it delivers hard and absolute facts, and that it is value-free. Such an explanation is appealing if for the only reason that the offer of absolute truth is too tempting to refuse in the midst of the tensions and uncertainities of everyday existence.

The final element of this improper understanding about science is the belief that science is value-free. This element is clearly related to the objective "fact-collecting" view of the discipline, for here we get the image of scientists looking at nature without preconceptions. But our understanding of a theoretical perspective is that it gives the scientist some framework within which he pursues his research. That he selects his framework testifies both to its being valued, and to the absurdity of the idea of a value-free science.

Values enter research in other ways, and we would be remiss to ignore the possibly conflicting pressures which motivate research in the sciences. Ideally, I suppose, it would be tasteful and proper to exclaim that research in the sciences emerges out of a sense of wonder and curiosity. Yet, as the availability of resources for the support of research dwindle, so it is likely that the research that _is_ funded, and thus the research that is proposed, will lean increasingly toward the research scientist's perception of what is required or deemed significant by potential funding agencies.

So, we see a striking element of value judgment entering the practice of science research. Yet value judgments in scientific work are not exclusively the consequence of a research community's attempts to fulfill perceived societal and institutional needs, for contrary to the societal expectations of science mentioned above, the discipline of science itself is rigidly secured to values, values without which the discipline could not exist. While for the chemist and the chemistry teacher these values are known (although perhaps not frequently articulated), the existence of these values would come as a real surprise to a society which holds science to be objective, value-free, and inspiring of confidence. Nevertheless, it is the case that science *values* experience as the arbitrator for knowledge claims, that science *values* the belief in an orderly and real universe, that science *values* causality. Such values are not empirically determinable, they are instead metaphysical, and have been adopted by the discipline out of choice, not out of nature. We have other metaphysical values in science for, as Margenau in his chapter "Metaphysical Requirements of Constructs"[6] argues, we require our constructs to be logically fertile, multiply connected with other constructs, permanent in their application of phenomena, extensible over a wide range of phenomena, and lastly, elegant.

So science is far from being value-free, and this is in agreement with our understanding that science is a human endeavor, one which attempts to make sense out of the world by using humanly inspired rules to generate useful theories, laws, and explanations. But it is surely apparent that this understanding contradicts severely the naive societal expectation that science is value-free, and the implication of this contradiction is consequential to how society perceives the role of science in human affairs. That is, if science is seen as objective and the source of all reliable knowledge, then values must emerge from elsewhere, which allows easy entry to the doctrine that values are a matter of taste, and personal taste at that.

The theoretical perspective that I have been sharing, then, brings for us a novel outlook on how society and novices in science view science. This perspective emerges from considerations about the so-called technological threat. Briefly, it is considered a threat to society if there are at large inappropriate understandings about the nature and function of science. I have attempted to show that society tends to view science as an enterprise which produces absolute, reliable and objective knowledge by activities that are entirely free of human values. This view of science is potentially threatening for it bestows on science and technology a power that it does not and cannot possess.

The general outcome of our discussion so far is that if indeed this view of science is widespread, then we have a society with inappropriate beliefs about and expectations of science, and these beliefs and expectations are inappropriate for they fail to square with what we understand to be the metaphysics of science.

The Educational Theoretical Perspective

Now that the technological threat, as a theoretical perspective has served its purpose and brought into sharp focus a potentially serious inadequacy in society's understanding of science, we can look for a perspective from which some suggestions for ameliorating the difficulty we have located might emerge. Not surprisingly, the issue is very much an educational one, and there are probably as many offered solutions as there are teachers of chemistry at the college level. So, our particular dilemma is not so much one of deciding which solution is the most acceptable, but of identifying a useful way of addressing the problem. In short, our search is for a theoretical perspective which clearly delineates the range of discussion so that proposed solutions do not pass each other in the night but center clearly on the problem.

I think that a suitable perspective exists in the contrast between education and training and in the fashion in which we use these terms.

Instead of citing numerous arguments from educational theory,[8] I wish to move directly to the point of suggesting that a continuum exists between education and training, and that one's place upon this continuum is a function of the intent of his teaching. At the one end, training, the intent is to develop various skills which are used in specifiable situations, while at the other end, education, we generally envision something less predictable which might be associated with wisdom or understanding, of the sort that provides the recipient with an altered view of the world.

Quite clearly, we would be surprised if any teaching endeavour was either exclusively education or exclusively training, yet the characterization of the continuum in this way is of value when it comes to comparing the goals of teaching. For a brief moment let us return to the example of our medical student and compare the potential consequences of medical training and medical education, when taken to the extremes. First, in medical training the student is told what action to take for every symptom. In this case, he works mechanically, unaware of the research that supports his action and ignorant of the fact that whatever he does, cure is not certain but only probable. In the second instance, the student is informed (or educated about) the basis upon which curative measures are developed from medical research. This education provides the student with a deeper insight into his professional practice than is afforded by training alone.

With this in mind we can turn to the chemistry student and see that a similar difference between training and education applies. The student who is trained in chemistry knows the facts and the recipes, while the student who is educated might be expected to have comprehended the foundation of his discipline and the metaphysics which support it. For this student, there is no expectation that science is a matter of objective and absolute facts, and value-free statements about the world. The student educated in chemistry is in no danger of misinterpreting science nor of compliance with the technological threat.

Schumacher seems to capture the major problem of an exclusive training experience in the sciences when he writes:

> What is at fault is not specialization, but the lack of depth with which the subjects are usually presented, and the absence of metaphysical awareness.[9]

I believe that Schumacher has identified a primary feature which distinguishes education from training; education makes clear the metaphysical foundations of the subject matter under consideration while training does not. Now, I propose to use this characterization of ecucation for considering briefly how college chemistry teaching might incorporate the metaphysical foundations of science, and thereby might move toward rendering the technological threat impotent.

Education and College Chemistry Teaching

To my mind, a discussion of teaching needs to be built u upon the understanding that to achieve an end in teaching, appropriate means are to be provided, and that a logical relationship can be located here such that if we want to have students learn something of the second law of thermodynamics, it is more sensible to teach material related to that law rather than to the law of multiple proportions.

Similarly, if we intend to have students educated in chemistry (as we are using the word "educate") then it is necessary to make explicit statements about the metaphysical foundations of this discipline, rather than to omit explicit statements in the hope that the students will somehow happen on these things by themselves. Some might of course, but our obligation as teachers would be to insure that the teaching provides for all students to obtain this insight.

I can think of two major ways in which these ends can be achieved. First, since we are aware of the significant distinction between the theoretical matter and the data used in chemistry, it is important that the language used in chemistry teaching keep this distinction before the students. There is a vast difference between saying the carbon bond allows the formation of long carbon-chain molecules and making it clear that we account for these macro compounds by postulating a special sort of bond available to the concept of the carbon atom. Similarly we can make it quite clear to students that laws and theories are not objectively true or false, but are invented as convenient ways to explain certain data.[10] And if we reinforce this point as each area of the curriculum is introduced, the learning we intend of students might well become more meaningful and more deeply understood.

Second, and not surprisingly, a very powerful device for teaching about the metaphysics of science is the science laboratory. Here experiments can be readily adapted to make the following points evident to our students:

1. There is a tension between what we say happens "in theory" or "ideally", and what we can actually see happening, even when error is considered. (Are equilibrium constants constant?)
2. Nevertheless, scientists prefer or value simple relationships, so we make linear or smooth curves that "best fit" the data. (The best way to represent the characteristics of carbon dioxide gas, is when it is not a real gas, but an idealization, giving a smooth curve according to VanderWaal's conceptualizations.)
3. Theories, explanations, classifications, definitions and so forth are invented and are judged in terms of their usefulness. (We can classify substances in various ways depending upon our purposes.)
4. Constructs and principles in chemistry are related. (LeChatelier's principle and Arrhenius' theory on ionic solutions when working with buffers and so forth.)

Certainly, since the metaphysical principles listed here cut through all of chemistry, endless examples are available for teaching. This is true too for evaluation, and I should like to take a minute or so to consider how one might test for an understanding of the metaphysics of science.

This academic year I was privileged to have a PhD. chemist as a student. This student observed that there must be ways in which we can tap a general grasp of chemistry, without merely testing for recall and application. I suggested that the following sorts of questions might be worth trying, and I made some predictions about the responses we might obtain. Here are two:

1. What is the function of the law of conservation of mass? I predict students will merely state the law and miss the point that without agreement to submit to this idealized statement we could not do much chemistry.
2. What is the purpose of the periodic table of elements? The student who misses the point here will undertake the huge task of writing out the table, without mentioning that this conceptualization is astonishing in that it brings both order and explanation to what we know of the character and activity of elemental substances.

Of course the list can be enlarged, but I would prefer to summarize my remarks at this point.

Conclusion

I have tried to show how theoretical perspectives from different areas are to be valued for the way they point up unusual but significant issues in the professional practice of college chemistry teaching. I have argued that the perspective of the technological threat reveals that our students need to understand the metaphysical tenets of science, then I have shown how a consideration of the difference between training and education can be used to suggest ways of altering chemistry teaching (and testing) so that we can realize, if we choose, the aim of education.

Now it remains for me to offer an apology and to indicate something special about the responsibility of the college chemistry instructor. In my opening statements, I mentioned that we are frustrated by those who offer theory without considering too much the important details related to the task of teaching itself. I apologize for having frustrated you, and I regret that time constraints disallow an amplification on specific points about the content of teaching. On the other hand, I did protect myself in those opening remarks by making reference to the unwarranted expectation that theoretical perspectives appear to engender in society.

Perspectives and theories in education are no different. I therefore cannot provide you with the optimum point along the continuum between training and education. To do so would violate the nature educational theory, and would restrict the range of your professional autonomy. The decision to include a certain amount of explication about the metaphysics of science is for the teacher. In part, this decision is based on the teacher's judgment of the purpose of his professional activity and the degree to which his students deserve to be informed about the basis of the subject they are studying.

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Relevance of Research in Education to the Design of Instruction in Chemistry

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Introduction

Do we need to know what researchers in science education do and discover?

My answer to this question is emphatically yes. As much as a practicing chemist needs to know the results of basic research in chemistry so does a chemistry teacher need to know the results of research in science education in general and chemical education in particular.

There was a time, in the distant past, when students enrolled in sciences and engineering formed a select group of people who possessed all the prerequisite skills and abilities. Today, the situation is radically different. To maintain the economic and political well-being of our nation, we must produce a steady supply of technically well-trained people. Thus, a large number of students who would have been excluded under the old elitist system now have access to science and engineering courses in colleges and universities. However, a substantial proportion of these students do not possess the necessary prerequisite skills and abilities. This is especially the case in two-year community and junior colleges where an open-door policy is in effect.

Let me hasten to add that inadequate preparation of those enrolled in college science courses, particularly in chemistry is not solely an American phenomenon. A recently published article in Soviet Education[1,2] states that applicants to the Mendeleev Institute for Chemistry and Engineering "when asked to determine the amount of aluminum sulfide formed from heating 5 g aluminum and 5 g sulfur, assuming a 100% yield of reaction product, many answered unthinkingly: 10 grams of sulfide".

In today's era of mass education, traditional strategies of lecture-demonstration-discussion do not produce satisfactory results. Too many students fail our courses or withdraw in despair with shattered hopes and dreams. We therefore must modify our instructional design so as to allow each student to master, at some specified level, the concepts and principles we attempt to teach. This is not an easy task. When substantial responsibility for student success is put on instructional design, we need to know the findings of research in science education to help us achieve our goals.

What is instructional design?

To answer this question, we must first clarify what we mean by instruction. A useful paradigm may be stated as follows: instruction is a process which causes a transformation of the following type:

$$S_i \xrightarrow{\textcircled{I}} S_f$$

where S_i indicates the initial state of the student (S): S_f indicates the final desired state and Ⓘ indicates the interaction necessary to cause the transformation. According to this paradigm, instructional design consists of: (1) accurately describing S_i; (2) accurately describing S_f (2) formulating a system of interaction; and (4) assessment. The last step allows us to evaluate the accuracy of our descriptions (steps 1 and 2) and the effectiveness of the formulated system of instruction. Thus, if carried out systematically, instructional design can provide a means of educational decision making and improvement based on hard data instead of based on tradition, history, authority and hearsay.

Research and development in instructional design are still in a state of infancy. This is so because nearly all educational research is concentrated on discovering the basic principles of human learning, memory, motivation, etc. Designing instruction, however, is an applied science with its own logic[3] similar to architecture, engineering, medicine, computer science, management science, etc.

II Components of Instructional Design

A. Description of S_i and S_f

A precise description of S_i and S_f depends on the student's age. Nevertheless, any such description should include the following, to the extent that they are germane to the learning task at hand;

- specification of the initial state of cognitive and psychomotor skills and abilities
- specification of the desired cognitive[4], affective[5] and psychomotor[6] goals, and
- some personality traits (cognitive styles)[7,8]

For learners up to age 14 or 15, the work done by Jean Piaget[9,10] in the field of intellectual development is very useful in describing S_i. Indeed, at least one nationally developed (NSF funded) elementary science curriculum (Science Curriculum Improvement Study, SCIS) utilized Piaget's theories in designing instruction[11,12,13]. Recently, there has been interest on the part of some high school[14] and college chemistry[15,16,17] instructors to utilize piaget's theories in designing instruction. We must be exceedingly careful in applying these theories to describe S_i for students older than 15 since, according to Piaget, by that age humans should reach the highest level of intellectual development, the formal operational level. Again, for these older students a caveat is necessary in interpreting their ability or inability to perform correctly certain Piagetian tasks. Contemporary Piagetian theorists hold the view that a person may be at the formal operational level for certain intellectual endeavors but not in others. Moreover, it appears that the concrete operational stage is a necessary one to reach the formal level for all learners in any new intellectual endeavor. Professor Thompson warns us that[18] "what the child *cannot* do should not be taken as indicative of what he *can* do".

Precise and explicit description of desired instructional outcomes is not easy when these outcomes describe anything other than knowledge of facts.[4] Indeed, the entire movement of writing behavioral objectives is spurned by many teachers because most such objectives written to date dwell on knowledge of facts but do not extend to comprehension, application, analysis, synthesis and evaluation which are the truly worthwhile instructional outcomes. However, the present emphasis on learning facts should not be construed as a theoretical limit to specifying higher levels of cognitive outcomes.[19] With increased research and development work in the field of instructional design, we will learn how to specify in precise and explicit terms behavioral objectives most valued by teachers. I must point out that the technical aspects of composing a behavioral objective have already been worked out.[20,21]

B. Description of Instructional System

1. Content of Instructional System

Once we have described S_i and S_f, we must formulate an instructional strategy. We have several choices here; discovery method, lecture-demonstration and individualized instruction. In its purest form, the first one is most inefficient and time consuming. The second strategy is very economical and efficient and has been used for more than 3000 years. Its success depends, however, on the homogeneity of S_i, a condition increasingly difficult to fulfill, especially in our community colleges dedicated to mass education. The third strategy, individualized instruction, seems to be very appropriate for the task of teaching a heterogeneous group of students. Whether we use the second strategy or the third, critical issues remain to be dealt with: selection of content, sequencing of content, teaching methods (printed materials, audio-visual materials, computer assisted materials, experimental-manipulative materials, etc.) and evaluation of student learning are a few examples.

Gagné and others have developed a very fruitful set of principles for designing an instructional system appropriate for college students.[22-30] In essence, these workers argue that it is necessary to establish a hierarchy of learning tasks and to sequence the content along such a continuum; the simplest tasks being taught first, and the more complex ones, which subsume the simpler tasks, being taught later. To be able to do this, the instructional designer must be competent in the subject matter. There are, however, some problems that persist; for example, whereas we must teach symbols of elements and formulas of compounds before we teach balancing equations, it is by no means obvious whether we should teach coordination compounds first and then electrochemistry or vice versa. At present, such problems can be solved only by empirical methods. A comprehensive theory of design which would assign a rank in difficulty to concepts is not available although for small amounts of learning an approach called task analysis[31] works satisfactorily.

I indicated above that the instructional strategy most appropriate to our students is individualized instruction. Individualization requires that all learning materials for an entire course be prepared and ready by the start of the course. Presently textbooks play in part, the role of prepackaged learning materials. But, ordinary textbooks are not adequate when lectures are either eliminated or drastically reduced in frequency. We therefore need to know what researchers in science education have to tell us about designing instruction. The teaching method most promising appears to be programmed instruction.

Programmed materials come in different forms: printed, audio-visual, computer-assisted, etc. The real design question is to predict the best combination of these materials to achieve the desired ourcomes (S_f). Presently, such a question can best be answered by empirical means although progress is being made in establishing criteria for optimal combination of various forms.[28,30] Proper programming techniques[32-34] and concept teaching[35] have been extensively investigated. In concept teaching, it turns out that one of the most important teaching components is to give not only examples illustrating the concepts but also non-examples.[36,37]

Utilizing programmed instruction is not widely accepted. Partly, the reason is due to the inauspicious beginnings of this method of teaching when most programmed texts produced turned out to be an endless sequence of sentences from which one or more words were missing. Partly, there is a reticence on the part of teachers who erroneously equate programmed instruction with "eliminating teachers". There is reason to believe that both of these shortcomings may be overcome as more intensive work in exploiting programmed instruction demonstrates its value to teaching chemistry to heterogeneous groups of students.

2. Delivery of Instructional System

Delivery of instruction can be in a fixed mode (lecture-demonstration) or flexible mode (individualization). A flexible mode of delivery would allow the student to learn at his or her own pace[30] and preferably at his or her preferred location[38] and thus is better than a fixed mode for our students. A personalized system of instruction (PSI) originated by F. Keller[39] and recently reviewed[40,41] has been gaining wide acceptance. The Keller plan itself or a modified version of it promises to be suitable to a wide variety of teaching needs and situations. Nevertheless, it has its own drawbacks including the requirement of assigning a room permanently for one course.[42] Several articles discussing the application of the Keller Plan to chemistry instruction have appeared (see reference 43 and references cited therein).

Most individualized instructional systems have a novel aspect; they require that the student master the content at a prespecified level of competency. This is achieved, on one hand by explicitly stating the learning outcomes for the students to take several equivalent tests on each unit until mastery is demonstrated, for example, at the 80 or 90 percent level. Thus, with this kind of criterion-referenced testing, many students get A's as opposed to getting B's and C's under the traditional norm-referenced testing. Bloom has forcefully argued that mastery learning be practiced in schools[44].

Although mastery learning is, in principle, a very achieveable goal, common sense belies the expectation that as many as 80 percent of the students in Chem 1A will earn A's no matter how much we extend the study time. What is probably more feasible is that we can expect mastery at a "C" level work with limited content and mastery at a "B" level or "A" level work with increasingly more sophisticated content included. I must admit that designing of instruction with such components is likely to be a complicated task.

C. Evaluation

A systematic approach to instruction requires that evaluation of the design be an integral part of the system. Properly conducted evaluations, preferably carried out by a third party, can yield invaluable information about the accuracy of our descriptions (S_i and S_f) and the effectiveness of the formulated instructional system. This, in turn, can help us revise and modify our design as many times as necessary until the desired goals are reached. Educational evaluation is still in its infancy but sound methodologies have been developed.[45,46,47]

III. My Research

Two years ago, I took a sabbatical leave to go to U.C. Berkeley to work with Prof. John Hearst and Prof. George Pimentel in the field of chemical education. Both of these professors are members of an interdepartmental graduate group called Group in Science and Mathematics Education, whose chairman is a physicist, Prof. Fred Reif. I chose to do research on teaching selected concepts related to stoichiometry. Several years of teaching had convinced me that at least 40 percent of our students in Chem 1A or Chem 51 (preparatory course to Chem 1A) at Skyline College had great difficulty in learning stoichiometry. Thus, research on designing instruction to teach stoichiometry and also some general cognitive skills which would help students learn chemistry in general and stoichiometry in particular appeared to be a worthwhile endeavor.

I decided to work with underprepared students enrolled in Chem 1A at U.C. Berkeley. These are students who either had no previous chemistry course (ca. 17 percent of those enrolled) or showed average to poor performance in a previous chemistry course. Most of these students find Chem 1A very difficult and either drop the course or receive a poor grade (C-, D, F). Stoichiometry is one area that these students find to be very difficult. Moreover, although stoichiometry is often used both in lecture material and in the lab, it is not extensively covered in the course. My goal was to identify the sources of the difficulties, to design instructional materials, and to test the effectiveness of these materials.

After some preliminary work with a small group of students for the purpose of describing S_i and S_f, I formulated the design criteria for an instructional system. This system consists of (1) a programmed book with three chapters (*Learning Stoichiometry*); (2) a box of atomic models (H,C,),N): and (3) a small two-pan scale with a special set of weighted atomic models.

My preliminary work as well as published research suggested that there are three cognitive skills essential in learning chemistry in general and stoichiometry in particular; *visualization of molecules*[48,49]; *proportional reasoning*[50,51] and systematic approach to problem solving[52]. My instructional system included the teaching of these skills in relation to stoichiometry.

After trying the effectiveness of the instructional system with small numbers of students and modifying it several times, I tested it formally during Spring '76 quarter at U.C. Berkeley. Using a pretest-posttest experimental and control group design, I have found very encouraging results. The mean score on a 50-minute posttest was 83.6 for the experimental and 59.2 for the control group. A t-test shows that this is highly significant ($p<0.001$). This also indicates that the knowledge gained by the experimental group is due to my instruction and not to Chem 1A. I am in the process of conducting a detailed statistical analysis to assess the effect of this instruction on student retention and success in Chem. 1A. Preliminary results are encouraging. A questionnaire evaluating my instructional materials indicates that 80 percent of the experimental group students expressed the opinion that their confidence in dealing with Chem 1A increased as a result of the instruction.

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Communications in Chemistry

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I woke up one morning to the following newspaper headline:

Professor claims high school students poorly prepared.

The article under the headline stated: At a recent seminar on high school - college interface, Professor X stated that Freshmen entering college today are not able to read, can't do algebra (even though they take calculus in high school), don't know chemical symbols, nomenclature, or how to balance equations (even though they take honors chemistry in high school). The fault, says Professor X, is that the high school teachers are not as well qualified as they should be, are only interested in creating an ego image for themselves by teaching in high school what should be held off until college. What we need are seminars, meetings, etc, so we can show the high school teachers what we need from them and show them how to achieve what we want.

The same day as the article appeared, I was scheduled to attend a science career day program for the area high schools. What do you think happened? The reception was pretty poor, and certainly, any cooperation from the high school teachers was well hidden.

If we are going to criticize others as a means of improving the quality of education, then we should channel the criticism to the right places. But before you criticize, think how you as a two-year college teacher would react when the professors from senior colleges and universities criticize your undergraduate chemistry courses and say that transfer students are poorly prepared, that two-year college teachers are non professionals because, after all, they only have master's degrees, and when they say that two-year college teachers are pedagogically oriented rather than subject matter oriented. You will appreciate and react to the criticisms about like the high school teachers would. So, rather than be critical, let's get involved and that involvement should be right at the heart of the matter, the elementary school. From Kindergarten through grades four or five, young children are initiating and building their basic skills in reading, writing and arithmetic. It is during these years that their curiosity and creativity is strong and should be nurtured. This requires teachers who have the competency to help the very young to understand the world around them and to help counteract those who laugh when they ask how high is up and what makes the sky blue. Many of these teachers are available through their college training and through special programs of the NSF. But we should take a look at how we can help, if help is wanted, and how we can get involved.

From a personal standpoint, I invite the elementary students and their teachers, through the elementary principal, to the college for a visit. I and several of my colleagues put on a science demonstration for those who have chosen to attend. It takes very little time after the first demonstration before we receive calls from others to repeat it and to continue the program year to year.

During the middle years, grades five through eight approximately, the quality of science teaching is of critical importance. It is during this period that the young people form attitudes toward science and technology that will remain with them for a lifetime. It is also at this age that decisions for or against science related careers are made. Teachers at this level of education need to be highly equipped to deal with the so called "Lost Generation".

Our involvement at this level is much more difficult.

However, when there is an opportunity to go to a school and talk with teachers, not from the standpoint of how you can help them, but from the point of view of offering the services and facilities of the college to the teacher and to the students, you should take advantage of it. The easiest entrance here is to have children of your own in those grades or to be on the school board or both. If one of your purposes in generating better communication is to get better qualified students coming to your college, then this middle school period is the period when you had better find entrance and be involved.

The high school years are interface years. For many these years of precollege science education form the foundation for higher education and they develop our pool of science-talented young men and women who will soon join the scientific and technological community. At this stage, we need to analyze how and why we should be involved. In order to achieve a higher level of articulation between high school teachers and college teachers, we need to better understand (1) if the high school teachers are interested, and (2) what is happening at particular high schools. We also need to understand what our purposes are in wanting to achieve better communications. I have already mentioned that one purpose is to get better students to our colleges. We should also be interested in high school liasons to attract more students and to improve transition periods and adjustments for students as they enter college. One other purpose might be to ultimately change high school course content or science curricula. I don't know how many of you know the meaning of curriculum. It originally meant a race course, from latin currere, to run, and there are still many today who believe, with good reason, that a curriculum is a run around.

Before we can sit down with high school personnel, we need to examine where <u>we</u> in the Two-Year Colleges are and where we are going. We have had very fast growth over the past 15 years. Along with that growth, there has been very little leadership at the two-year level. The only organization in the United States, on the national level that has dealt with curricula has been the $2YC_3$. The American Association of Junior Colleges (AAJC) has basically been an organization of administrators dealing with administrative problems and finances. The accrediting agencies have had little influence on curricula or course content. Not necessarily as a result of the lack of leadership, but certainly in conjunction, we find today a lack of uniformity in chemistry, chemistry offerings and curricular content. Our diversity is as much a problem to the high schools as the diversity of problems we face as we try to prepare students to transfer to four year schools.

Some of you will remember the discussions we had several years ago at various $2YC_3$ meetings about the need for a national standard for Junior College Chemistry course content, and we even discussed the possibilities of a high school standard course. The problem was then and still is that there are many different types of two-year schools which make a standard course difficult to achieve. And if we have such a diversity, can we expect high schools to gear their courses toward our needs? To what and to whom do they gear their chemistry courses?

To effect a better liason, we need to know what is happening and why things are happening in the high schools. We have all read that IQ's are going down, SAT's are going down, reading abilities are going down and we say the kids are geting dumber each year. We need remedial math, developmental reading, remedial science, etc, because kids aren't prepared. Before I go any further, let me state that when we talk about the "Dumb" kinds of today, we are being very unfair to a generation of people whose orientation happens to be different from ours. I find that kids today are very intelligent. Granted, many of them do poorly on IQ and SAT tests because they are not good readers, but that only makes them illiterate, not unintelligent and we should understand that for better communications.

Communications programs are being conducted at all levels, national, state and local. The most important aspect of communications, however, is on the local level. It is also the most difficult because it involved personalities, yet it can be the most effective level of achievement in the end.

What are the means of entry to the high school and teacher? I have over the years worked with and through the local section of the American Chemical Society. We have an education committee which invites high school teachers to participate in our programs. I call them up and invite them to ride with me to meetings. We have a yearly examination for the high school chemistry students. They and their teachers attend an awards dinner after and it is a good chance to get acquainted.

I am sure you have local career days, both in the high schools and in the colleges. This is another great opportunity to participate, if only to get acquainted with the teachers.

In Pennsylvania, we have educational intermediate units which are regulatory agencies of high schools systems. Working through this agency, I set up summer programs in chemistry for high school juniors who are selected by the high school chemistry teacher. This gives me another entry to the teacher which can ultimately lead to good discussions of course content and possible change, without getting into a critical mood.

One other technique is to write congratulatory letters to winners of the Westinghouse Science Talent Search. I am sure that these letters are shown to their teachers, which can be effective in having that teacher become acquainted with the college and possibly with the courses being taught at the college.

If more or better communications are needed, there is only one way that it will become a reality, that is for you personally to get involved and to open them up.

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If more or better communications are needed, there is only one way that it will become a reality, that is for you personally to get involved and to open them up.

COMMITTEE ON CHEMISTRY IN THE TWO-YEAR COLLEGE

Division of Chemical Education
American Chemical Society

1977 ROSTER OF COMMITTEE MEMBERS

Chairman — Curtis Dhonau, Vincennes University Junior College, Vincennes, Indiana 47591 (812-882-3350) (812-321-3952)
Past Chairman — Douglas J. Bauer, Mohawk Valley Community College, Utica, New York 13501 (315-792-5378) (315-896-6310)
Cecil Hammonds, Penn Valley Community College, Kansas City, Missouri 64111 (816-756-2800) (913-648-7069)
Ethelreda Laughlin, Cuyahoga Community College, Western Campus, Parma, Ohio 44130 (216-845-4000)
William T. Mooney, Jr., El Camino College, via Torrance, California 90506 (213-532-3670)
Chairman Elect — William W. Griffin, Hinds Junior College, Raymond, MS 39154 (601-857-5261)
Treasurer — Dr. J. Smith Decker 444 East First Street Mesa, Arizona 85203 (602-969-5466)
Editor — Jay Bardole, Vincennes University Junior College, Vincennes, Indiana 47591 (812-882-3350)
Membership Chairman — LeRoy Breimeir, Vincennes University Junior College, Vincennes, Indiana 47591 (812-882-3350)

Region I — Western States

Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming

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BIEVER, Keith J. (1978): Bellevue Community College, Bellevue, WA 98004 (206-641-0111)
HUBBS, Robert (1979): De Anza College, Cupertino, CA 95014 (408-257-5550)
GILBERT, Margaret (1979): Trinidad State Junior College, Trinidad, Colorado 81082 (303-846-5011)
LUNDSTROM, Richard A. (1977): American River College, Sacramento, CA 95841 (916-484-8137)
SCOTT, Peter (1977): Linn-Benton Community College, Albany, OR 97321 (503-923-2361)
STERNER, Wanda (1977): Cerritos College, Norwalk, CA 90650 (213-860-2451)
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TRUJULLO, Anthony (1977): San Joaquin Delta College, Stockton, CA 95204 (209-446-2631)
VANDERBILT, A. H. (1978): Sierra College, Rocklin, CA 95677 (916-624-3333)
WESTOVER, Ross (1977): Canada College, Redwood City, CA 94061 (415-364-1212)
WILLIAMS, Gordon (1978): Monterey Peninsula College, Monterey, CA 93949 (408-375-9821)
WYATT, William H. (1978): El Paso Community College, Colorado Springs, CO 80903 (303-471-7546)

Region II — Southern States

Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, Puerto Rico, South Carolina,Tennessee, Texas

Southern Regional Vice-Chairman (1977): W. G. Sink (1978): Davidson County Community College, Lexington, N.C. 27292 (704-249-8186)
ALLISON, Harrison (1977): Marion Institute, Marion, AL 36756 (205-683-2871) (Mail to P.O. Box 548, Marion, AL 36756)
BARTLEY, Edith (1977): Tarrant County Junior College, South Campus, Fort Worth, TX 76119 (817-534-4861)
CHEEK, William R. (1979): Central Piedmont Community College, P.O. Box 4009, Charlotte, NC 28204 (704-372-2590)
FREEMAN, Charles (1979): Mountain View Community College, Dallas, TX 75211 (214-747-2200)
GRIFFIN, William W. (1977): Hinds Junior College, Raymond, MS 39154 (601-857-5261)
HOWARD, Charles (1977): University of Texas,4242 Piedras Drive E S-250 San Antonio, TX 78284 (512-734-5381)
HUSA, William J. (1978): Middle Georgia College, Cochran, GA 31014 (912-934-6221)
INSCHO, F. Paul (1979): Hiwassee College, Madisonville, TN 37354 (615-442-2128)
KUCHERA, John (1979): Northern Oklahoma College, Tonkawa, OK 74653 (405-628-2581)
MILTON, Nina (1978): St. Petersburg Junior College, St. Petersburg Campus, St. Petersburg, FL 33733 (813-544-2551)
MINTER, Ann P. (1977): Roane State Community College, Harriman, TN 37748 (615-354-3000) (615-483-7124)
MITCHELL, John (1979): Tarrant County Junior College, Hurst, TX 76053 (817-281-7860)
SIMS, Joyner (1979): Chipola Junior College, Marianna, FL 32446 (904-482-4935)

Region III — Midwestern States

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

Midwest Regional Vice-Chairman (1977): Dean I. Elkins (1977): Henderson Community College, University of Kentucky, Henderson, KY 42420 (502-827-1867
BALLINGER, Jack (1977): Florissant Valley Community College, Florissant, MO 63135 (314-524-2020)
BURNS, Ralph G. (1977): East Central Community College, Union, MO 63084 (314-583-5193)
CLOUSER, Joseph L. (1978): Wm. Rainey Harper College, Palatine, IL 60067 (312-398-4300)
HITTEL, David (1977): Bay de Noc Community College, Escanaba, MI 49829 (906-786-5802)
JOHNSON, Cullen (1978): Cuyahoga Community College, Metropolitan Campus, Cleveland, OH 44115 (216-241-5966)
KOCH, Frank (1979): Bismark Junior College, Bismark, ND 58501 (701-223-4500)
MALIK, Virginia (1978): Cuyahoga Community College, Western Campus, Parma, Ohio 44130 (216-845-4000)
REDMORE, Fred (1978): Highland Community College, Freeport, IL 61032 (815-233-6121-Ext. 331)
ROBIN, Burton (1979): Kennedy-King College,6800 S. Wentworth Ave. Chicago, Ill. 60621 (312-962-3200)
SCHULTZ, Dorothy (1979): Jackson Community College, Jackson, MI 49201 (517-787-0800)
SOSINSKY, Jack (1977): Loop Junior College, Chicago, IL 60601 (312-269-8056)
SUSSKIND, Tamra (1979): Oakland Community College, Auburn Hts., MI 48057 (313-852-1000)
WEISSMANN, Katherine E. (1977): Charles Stewart Mott Community College, 1401 East Court St., Flint Michigan 48503 (517-845-3670)
WINKELMAN, John (1978): Illinois Valley Community College, LaSalle, IL 61354 (815-224-6011)
YODER, James (1979): Heston College, Heston, KS 67062 (316-329-4421)

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 (1977): C. G. Vlassis (1979): Keystone Junior College, La Plume PA 18440 (717-945-5141)
ADAMS, David L. (1977): North Shore Community College, Beverly, MA 01915 (617-927-4850)
AYER, Howard A. (1977): Franklin Institute of Boston, Boston, MA 02116 (617-423-4630)
BERKE, Thomas (1978): Brookdale Community College, Lincroft, NJ 07738 (201-842-1900)
Mother Bohdonna (1977): Manor Junior College, Jenkintown, PA 19046 (215-884-2361)
BROWN, James L. (1979): Corning Community College, Corning, NY 14830 (607-962-9242)
CHERIUM, Stanley M. (1979): Delaware County Community College, Media, Pennsylvania 19063 (215-353-5400)
CLEVENGER, John V. (1979): Lord Fairfax Community College, Middletown, Virginia 22645 (703-869-1120)
CUCCI, Myron W. (1978): Monroe Community College, Rochester, NY 14623 (716-442-9950)
FINE, Leonard W. (1977): Hosatonic Community College, Bridgeport, CT 06608 (203-336-8201)
HAJIAN, Harry G. (1978): Rhode Island Junior College, 199 Promenda Street, Providence, RI 02908 (401-311-5500)
JEANES, Opey D. (1979):John Tyler Community College, Chester, VA 23831 (804-748-6481)
SANTIAGO, Paul J. (1978): Harford Community College, Bel Air, MD 21014 (301-838-1000) ext. 252
SCHEIRER, Carl Jr. (1978): York College of Pennsylvania, York PA 17405 (717-843-8891)
SOLLIMO, Vincent (1979): Burlington County College, Pemberton, NJ 08068 (609-894-9311), Mail to Box 2788, Browns Mills, NJ 08068
STEIN, Herman (1977): Bronx Community College, City University of New York, Bronx, New York 10453 (212-367-7300)
WILLIAMS, Thelma (1978): New York City Community College, 300 Jay Street, Brooklyn, NY 11201 (212-643-8242)