To: Faculty and Administrative Staff, SCS

From: H. S. Gutowsky

Subject: Program Evaluation

This report was prepared in response to the attached directive from the Academic Affairs Office. As you will note in the directive, the report is an initial step in the development of a more intensive, in-depth, periodic review of the activities of the University.

The report was requested as a substitute for the 1971-72 annual report. It contains a good deal of information about our programs which will be of general interest to most or all of you. Also, it may help us to focus on aspects of our operations which should be studied and reviewed in more detail, whether as part of an overall in-depth evaluation or not.

For these reasons, the Executive Committee and I are having copies distributed to each of you. Additional copies are available from my office (Cindy Hardig 3-0710). We urge you to read the report. We urge you to send us your reactions and your suggestions for meeting some of our problems and improving the quality and effectiveness of our programs.

HSG:pr
Preface 1

1. The School as a Unit 1
   Resource outline summary 8
   Basic data and information listing 9

2. School Shops and Services 10
   Resource outline 18

3. Department of Biochemistry 19
   Resource outline 25

4. Department of Chemical Engineering 26
   Resource outline 35

5. Department of Chemistry 36
   Resource outline 44
   Programs of the department
      Analytical chemistry 45
      Inorganic chemistry 47
      Organic chemistry 52
      Physical chemistry, including biophysical 56
      General chemistry 58
      Environmental chemistry 61

6. Appendices A-D
TO: Deans and Directors
   Academic Units
   Urbana-Champaign Campus

FROM: Morton W. Weir
   Vice Chancellor for Academic Affairs

DATE: July 19, 1972

SUBJECT: Program Evaluation

As I mentioned in my letter of May 25, 1972, annual reports will not be required this year. Instead, I am asking you to have your departments complete the attached material and return it to me by November 20, 1972.

The attachments are three: (1) Program Review Questionnaire; (2) Unit Resource Outline; and (3) A listing of analytical data available from various Urbana campus and General University offices which may be an aid to self- or outside evaluation. Specific instructions for all three attachments appear below.

While your department heads and their program leaders are thinking about and working on this material, the SCOPE group, my staff, and I will be analyzing the written comments and opinions which have been submitted concerning the "Preliminary Report of the Study Committee on Program Evaluation."

The purposes of collecting information from all departments by November 20 are: (1) To require faculty members to begin thinking in terms of the sorts of questions which would likely be a part of an in-depth evaluation; (2) To learn which questions departmental faculty consider important and relevant to evaluation, and which they do not; (3) To aid the Committee on Program Evaluation (or whatever name is finally assigned to the committee) in determining which units or combination of units might undergo detailed evaluation in the spring of 1973 or during the 1973-74 academic year; (4) To discover particular problems which might require immediate solution.

The questionnaire itself was devised by my office, in consultation with certain members of SCOPE.

The responses to the present questionnaire will not be used to evaluate units or programs. We consider this to be a pilot testing of the procedure, particularly of these types of questions. Undoubtedly, the final questions asked, which will form the basic information for an in-depth evaluation, will be more detailed, but they will probably be similar to these. This test run will provide us with information as to their usefulness and to the variability in responses.
GENERAL INSTRUCTIONS

I. The Program Evaluation Questionnaire.

A. Dean of the College: The Dean should forward this questionnaire to the department heads or to directors of schools, as appropriate. (In the case of the Graduate College, each leader of a special unit should receive the questionnaire, although many of the questions will be inappropriate for some of those units.) If forwarded to a director of a school, the director must then determine its subsequent distribution. (E.g., to each department within the school, and, if appropriate, to each leader of school-wide programs.) The dean is free to send whatever instructions he wishes along with the questionnaire, but should refrain, at this time, from soliciting additional information for college purposes.

When the reports are returned from the various units to the dean, he may make remarks as appropriate concerning the reports when he sends them forward to my office. No attempt should be made to routinely summarize the material for an entire college; instead, the dean should remark on special problems or situations. In particular, if the dean is desirous of having units or sets of units within his college evaluated, he should so indicate.

B. Department Heads (or leaders of special separately budgeted units in the Graduate College): Department heads should respond to all 21 questions. However, if in response to Question #1, certain major programs or subprograms are identified within the unit, the leader of each such program or subprogram should be asked to complete Questions 3 through 9 and 14 through 16. The department head's response to these questions should be a distillation of the responses coming in from program leaders. ALL RESPONSES, FROM BOTH DEPARTMENT HEADS AND PROGRAM LEADERS, MUST BE SUBMITTED.

Department heads must themselves decide what is a "major program or subprogram," but the following guidelines may be helpful: (1) The research program of a single individual or a small group of individuals will probably not be a "major" program, unless it employs large numbers of individuals and serves as a major training source within the department. (2) Any area in which undergraduates or graduates specialize (e.g., Ph.D. in Psychology with a major area specialization in Clinical Psychology) will likely be considered a major program. (3) If the identification of programs and subprograms is difficult or uncertain, conferences with my office should help resolve the problem. (4) The department head should carefully examine the 21 questions, for their nature may be an aid in the determination of what might be considered a major program. If most of the Questions 3 through 9 and 14 through 16 are not appropriate for an activity which is potentially definable as a "program," then perhaps it is not useful to consider it as such, at least for the purpose of responding to this questionnaire.
II. Unit Resource Outline.

Both parts of this form should be completed by the department head or
by the director (in the cases of the Institute of Labor and Industrial
Relations, the Graduate School of Social Work, or of special units in
the Graduate College). No aggregation at a higher level is necessary.
If a department, school, institute, or special unit identifies programs
or subprograms in Question #1 on the Program Review Questionnaire, then
the department head or director must in Part II estimate what percentage
of the entire budget is devoted to each program so identified. It is
not necessary to estimate dollar amounts by object category (wages,
expense, etc.) at the program or subprogram level.

The purpose of this form is to provide this office with a brief out-
line of the resources available to the department, and a very rough
(percentage) breakdown of the total of these resources into programs.

III. Basic Data and Information Listing.

We have provided you with a listing of available data and information
which can be provided to a unit upon request (although some costs may be
involved if certain data are requested). The department head or director
should indicate which of these many categories of data and information
would: (1) Be useful to the department as a part of a self-study or for
internal management purposes and (2) Be appropriate as a part of an
evaluation of the unit. That is, indicate which of these data categories
you would like to have available for self-study if your unit is chosen
for an in-depth evaluation, and which you believe are indicative of
significant features or characteristics of your unit.

I realize that we are asking for a great deal of information and that
there is bound to be confusion the first time through. However, I believe
the effort to be necessary and I hope that you will find it worthwhile. I
also believe there is much to be gained by the entire academic community
through this introspective effort.

If you have any questions concerning the enclosed material or need help
in determining the definition of programs in your unit, please feel free to
phone Roger Martin in my office (333-4523).

Good luck and thank you in advance for your cooperation.
PROGRAM REVIEW QUESTIONNAIRE

1. Outline the structure of your unit (separately budgeted entities such as School, Department, Institute, or Center) in terms of any programs or subprograms which exist within it. (E.g., subspecialties in which undergraduates or graduates may concentrate their study, etc. Give estimates of numbers of undergraduate or graduate majors in each of these areas of concentration.)

2. Outline the operational structure of your unit. How and by whom are policies set and operating decisions made? (E.g., headship or chairmanship; major divisions, if any; major standing committees; level of student input, etc.). This outline should provide the reader with a succinct picture of the decision-making and advice-rendering apparatus of the unit.

3. What other programs on campus bear a relationship to yours? (E.g., interests in common; students and staff in common; methods in common; similarity of courses, etc.).

4. What are the major objectives and long-range goals of your program? To what extent are these objectives and goals explicit and shared within the program and unit?

5. What criteria, quantitative or other, should be used to determine the degree to which you have reached the objectives and goals given in question number 4?

6. What do you see as the role of your program in the education and development of undergraduate and graduate students?

7. Cite any important examples of innovation and change that have occurred within your program during the past five years (i.e., since September, 1967). Describe changes currently planned but not yet carried out.

8. Would you classify your program as being geared more toward the study and/or solution of (a) long-range basic problems of research or scholarship, or (b) problems, the solution of which will likely lead to rapid changes in some aspect of our culture or environment?

9. How does your program rank nationally? Have any formal comparisons been made of your program with similar program at other institutions? If so, list these comparisons here and forward copies of the report with this questionnaire. (Do not forward copies of generally available studies, such as the A.C.E. reports.)

10. What do you consider to be the five major problems now confronting your unit? (For example, type of organizational structure of unit, college, or campus; faculty quality and productivity; teaching loads; student quality; quantity or quality of space; operating funds; ability to initiate new efforts, etc.) Discuss each of the five items.
11. Aside from providing additional money, what could be done by the department, college, or campus to help you solve the problems outlined in question number 10?

12. Describe the procedures and criteria you use to assess the quality of undergraduate or graduate teaching by (a) faculty and by (b) graduate teaching assistants.

13. What training in instructional methods do you provide for teaching assistants? For faculty?

14. Is there demand for instruction in your program (graduate and undergraduate) which has not been met? If so, please describe (include both current course overload and student interest not now covered by courses).

15. Describe the student guidance and counseling which you provide to your majors (including job placement).

16. Describe ways in which you chart or monitor the progress of your undergraduate and graduate students as they work toward the completion of a degree. Also describe ways in which you monitor the first job placement of the graduates from your undergraduate and graduate programs. (If you have information on where they go and what they do, please include with this questionnaire as an Appendix. E.g., how many undergraduates go on to advanced degree work; what percentage of your Ph.D's found appropriate jobs, etc.)?

17. Describe the procedures used and the factors considered in your unit for making recommendations concerning salary increases, promotion, and tenure.

18. List the names and rank of faculty (instructor or above) lost from your unit in each of the past 5 years. Also give the position into which each individual moved (type of job and location) and the reason for the faculty member leaving, if known. Do not include persons whose appointments were considered temporary. For each individual indicate if the departure constituted: (a) a serious loss; (b) a moderate or mild loss; (c) a neutral condition in terms of loss to the department; (d) an opportunity to upgrade the level of faculty quality. Further, indicate those individuals which your unit made an effort to retain (matching or partially matching offer, improvement of space, etc.).

19. What measures of cost-effectiveness would you consider valid for your unit?

20. Please comment on any of the foregoing questions which you believe to be inadequate as a part of an information base for an in-depth evaluation. Are there any questions which, in your judgment, should be asked?

21. Would you like to work with the Committee on Program Evaluation (COPE) staff during the spring of the 1972-73 academic year or the fall of the 1973-74 academic year in doing an in-depth study of your unit or would you prefer to postpone such a review for two or three years? Explain
PROGRAM REVIEW QUESTIONNAIRE

Fall, 1972

SCHOOL OF CHEMICAL SCIENCES

1. Structural outline of unit

The School of Chemical Sciences consists of three departments - Biochemistry, Chemical Engineering, and Chemistry - held together by many strong common interests and served by a School administrative office and a set of centralized shops and services. Each of these four major components has in turn a more or less complex structure, as outlined below. Undergraduate and graduate enrollments in each of the areas of concentration are given in the table at the end of this section. Separate reports are included for each of the three departments and for the School's shops and services as a separate unit in themselves. In this questionnaire we address the matter of the whole School as a larger unit.

Biochemistry offers an undergraduate LAS major, and at the graduate level, M.S. and Ph.D. degrees. In addition, the department teaches several service courses at the 300 level; and a large fraction of the enrollments in its courses for undergraduate and graduate majors come from other departments. One of its faculty is funded via the School of Basic Medical Sciences.

Chemical Engineering sponsors two programs, the specialized undergraduate curriculum and the graduate program, the latter offering M.S. and Ph.D. degrees. As in the case of biochemistry, the first two years of the chemical engineering program are taught via courses offered by other departments.

Chemistry is the largest and most complex of the three departments. At the undergraduate level, it offers both an L&S major and a specialized curriculum in chemistry. The graduate program includes not only M.S. and Ph.D. degrees in chemistry but also an M.S. in the Teaching of Chemistry and a cooperative program with Physics which jointly offers a Ph.D. in Chemical Physics. Furthermore, there are several areas of specialization in the Ph.D. program - analytical, biophysical, inorganic, organic, and physical chemistry. These areas are reflected in our internal operational structure, mainly at the graduate level but also to an appreciable extent at the undergraduate level. However, there are no formal areas of specialization in the undergraduate LAS chemistry major or in the chemistry curriculum.

More than half of the undergraduate registrations in the department are in service courses offered for students majoring in other programs. These come primarily from engineering, agriculture and the biological sciences. More than half of our instructional load is in our beginning (freshman-level) courses which are administered via a separate internal structure called the General Chemistry Program.
School Shops and Services is that part of our School's operations and structure which distinguishes it from three independent departments. The organization of our centralized shops and services reflects the evolution into a School of Chemical Sciences of what started as a Department of Chemistry shortly after the University opened in 1867, and which operated as a single department for virtually all of the intervening period until 1970, when we reorganized as a School with three departments.

The School administration is responsible for glass blowing, machine and electronics shops, and for more specialized research services which include a microanalytical lab, molecular spectroscopy (NMR, IR, UV, Raman, ESR) and mass spectrometry labs, a radioisotopes lab (campus-wide facility), and also a computer center (IBM 1800 and remote entry to the campus IBM 360/75). There are School administrative, placement, and business offices. The latter operates a wide range of ancillary central services such as receiving and mail room, a stores system, communications, and laboratory maintenance. These School shops and services are designed and operated to meet the various needs of all of its programs, at all levels and in all disciplines.

**Numbers of undergraduate and graduate majors**

(Fall, 1972)

<table>
<thead>
<tr>
<th>Department - Program</th>
<th>Undergrad.</th>
<th>Graduate</th>
<th>Post-doc</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Biochemistry</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S&amp;L major and pre-professional</td>
<td>100</td>
<td>70</td>
<td>17</td>
</tr>
<tr>
<td>M.S. &amp; Ph.D. programs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Chemical Engineering</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specialized curriculum</td>
<td>156</td>
<td>53</td>
<td>2</td>
</tr>
<tr>
<td>M.S. &amp; Ph.D. programs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Chemistry</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S&amp;L major and pre-professional</td>
<td>292</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specialized curriculum</td>
<td>151</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M.S. - Teaching of Chemistry</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M.S. &amp; Ph.D. programs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analytical</td>
<td>35</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Biophysical</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inorganic</td>
<td>58</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Organic</td>
<td>101</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Physical</td>
<td>75</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Unspecified</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ph.D. in Chemical Physics</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>699</td>
<td>417</td>
<td>64</td>
</tr>
</tbody>
</table>
2. **Operational structure**

The School has a Director and an Executive Committee. The Executive Committee has seven members including the Director who serves as its chairman. Three members are executive officers of the three departments; an additional member is elected from each of the three departments by the faculty of the School voting at large. Major standing committees of the School besides the Executive Committee include Affirmative Action*, Courses & Curricula*, Student Advisory (all students), Building & Space Allocation, Graduate Student Exams, Service Facilities*, Library*, and Safety*. Committees marked with an asterisk include two to four students, who are nominated by the students (based upon a student-generated election), as is the Student Advisory Committee.

The School has a tradition of strong central leadership associated with a variety of channels for informal as well as formal input into policy determination and operating decisions. The Executive Committee meets regularly every two weeks, with special meetings called for the more complex and vital concerns such as developing priorities for budget requests and reviewing recommendations for faculty promotions. Major curricular proposals or other matters of central interest to faculty in all departments are referred to the faculty, in a meeting or via a mail poll.

Policies are determined by the Director, with the advice of the Executive Committee and, as appropriate, with recommendations from a standing committee. The chairmen of some of the latter, especially the Service Facilities Committee, serve as "action" people to implement policy or operational decisions in their province. Many of the operational decisions are delegated by the Director to persons such as the Business Manager, Assistant to the Director, Administrative Aid, Placement Officer, or the individual responsible for supervision or operation of a particular shop or service.

3. **Relation to other programs**

From a structural and operational standpoint, the School of Life Sciences is probably the unit most closely related to us on the campus. They are also an experimental science with very strong interests in chemical principles, techniques, and processes. Other experimental sciences with which we share many common interest are agriculture, engineering, physics, and geology. In addition, our students require a solid foundation in mathematics, the extent of which depends upon the particular area in the chemical sciences.

4. **Major objectives**

The major objectives and long-range goals of the several educational programs of the School are considered under each of the three departments separately. It seems most appropriate here to consider the objectives of the School structure and services. In brief, the major objective of the School per se is to promote and produce something which is substantially more than the sum of three free-standing departments.
An important way in which the School seeks to accomplish this goal is to provide higher quality and less costly services on a centralized basis than would be feasible in three departments separately. These are discussed in the questionnaire for the School shops and services. Another way is to encourage "interdisciplinary" interactions by working together closely on a day-to-day basis. However, the most important objective probably is the setting and maintenance of high standards of student and faculty achievement.

These objectives are perhaps less explicit than they should be, due in large part to our recent reorganization (September, 1970) as a School. Prior to that time there was extensive debate about the role of a School structure, during which a very strong consensus was developed about its objectives and desirability.

5. Criteria for attainment of objectives

The subjective views of our faculty and students are probably as good a criterion as any. Outside opinions from heads of free-standing biochemistry, chemical engineering, and chemistry departments could be used, as could a comparison with the School of Life Sciences. The quality and extent of interdisciplinary effort is another significant criterion.

6. Educational role of the program

This question is treated in detail under each of the three departments which is directly engaged in teaching. The School's educational role is to promote interdisciplinary efforts and to speed the transfer of new initiatives from one department to another, e.g. use of videotapes and PLATO.

7. Innovation and change

The establishment of the School itself in September, 1970 was an important innovation, along with the formation of three separate departments. The School's (originally department) successful affirmative action programs for the recruitment of black non-academic employees and black graduate students is another example of important change. Also, the School and its faculty have contributed in a wide variety of ways to the establishment and strength of the new Institute for Environmental Studies. Other important areas in which efforts are underway but for which the outcome is less completely known are in the use of PLATO IV and in connection with the broad area of biophysics, biophysical chemistry and molecular biology.

8. Classification of program

Does not apply. The two categories indicated are more relevant to the educational programs of the departments.
9. National ranking

Does not apply. Our School structure is not only of recent vintage but it is almost unique. No national ranking is now available or likely to be for some time. See, however, the answer to question 5 above. ACE ratings of departmental graduate programs are included in the Roose-Anderson report (1971).

10. Five major problems now confronting the School

Each of the four main components of the School has unique problems of its own. In addition, the School as a unit has problems peculiar to it, and there are some of a character affecting several or all of the School's four components. The major ones of these are considered here, without attempting to put them into a definite priority order.

(1) Quality of space - Much too large a fraction of our space (over half) is ancient, obsolete and hazardous. The library is overcrowded and many of our shops and services (including the library) not only are in inadequate space but also they are very poorly located with respect to their clientele.

(2) Non-availability of funds for major improvements - The difficulties of having obsolete and hazardous space are compounded by the lack of non-recurring funds for major remodeling. Similarly, we face severe difficulties in initiating any new major efforts such as the use of PLATO and videotapes or new research programs requiring major equipment.

(3) Inadequate level of operating funds - This hurts all over. The elimination of state funds for equipment for the second year in a row is no way to save money.

(4) Increased budgetary and administrative constraints - The University as a whole has been subjected in recent years to intense external pressures which have greatly limited its capabilities to meet the needs of its educational programs. However, from the limited visibility of the department (or School) there appears to have been a singular lack of imagination or capability to absorb some of those pressures at the campus level and to reduce the burdens added to the lower echelons. Awkward, time-consuming position control and budgetary close-out procedures have been adopted. Incentives to good management have been eliminated. Appointment and non-appointment procedures have become increasingly formal, complex, and more concerned with form than with substance.

(5) Decreased federal support of fellowships and traineeships - Between 1967-68 to 1971-72, the number of graduate students in the School supported by federal fellowships or traineeships decreased from 136 to 74, a drop of 62 or roughly $300,000. In the same period, the tuition charges more than doubled. This has made it increasingly difficult for us to compete with other institutions for the really top quality students, on whom the vitality of our graduate programs depends so critically.
11. Some remedies

Unfortunately, four of the five major problems given under 10 depend upon additional funds directly or indirectly. Item (4) relates to the limitations placed upon us by the college, campus, or university in our making the most effective use of the resources and time available to us. One remedy would be to have university, campus, and college services rated by the users, with suggestions for improvements solicited. Another would be a similar rating of administratively required procedures.

12. Evaluation of teaching

None is carried out by the School per se. However, we have encouraged and aided student organizations in their efforts to rate courses and teachers, undergraduate and graduate, faculty and TAs. Four student groups have done this: the Advisor, student affiliates of the American Institute of Chemical Engineers and of the American Chemical Society, and our Student Advisory Committee. The latter has been concerned mainly with developing student recommendations as to promotion of faculty.

In addition, the performance of each TA is graded at the end of each semester by the faculty member(s) to whom the TA reports. Records of these grades are maintained in the School office and are used, along with the student-generated ratings, to select 1/3 to 1/2 of the continuing TAs who receive a merit salary increment, currently $200/year for a half-time TA.

13. Training in instructional methods

Each fall the School sponsors an orientation week for new graduate teaching assistants, excepting those in chemical engineering. It emphasizes instructional methods and problems besides familiarizing students with the School's operations and facilities.

14. Unmet demand for instruction

Does not apply. See departmental questionnaires.

15. Guidance and counseling of majors, including job placement

The guidance and counseling of undergraduate and graduate majors is done largely on a decentralized, departmental and/or area basis, as reported in the questionnaire responses of the departments.

16. Charting progress of students

As in the case of 15, this is handled on a decentralized departmental basis, except for job placement. Appendix A gives details of where all of our graduates go. The placement record is exceptionally good.
In addition, there is a semi-annual review at the School level of those graduate students whose progress seems marginal. This "low grades" review is made by the graduate advisors from each area (or department) and includes not only students with a GPA below 4.2 but also those doing poorly on the written cumulative preliminary exam, those beyond 2 1/2 years who have not completed the prelim exam, and those who are beyond the fifth year of graduate study with us. The review meetings are chaired by the Director.

17. Procedures and factors for promotion, tenure, and salary

Recommendations originate in each of the departments. As a matter of School policy, tenure is not granted at the rank of assistant professor (or below). The departmental recommendations for promotion are viewed and acted upon by the Executive Committee. The factors considered in recommendations for promotion and salary increases are those outlined in the LAS guidelines, i.e. quality and originality of instructional activities, informal as well as formal; originality and significance of research and scholarly work; quality and importance of other professional or institutional contributions.

18. Faculty lost

Does not apply. See departmental reports.

19. Measures of cost effectiveness

This really doesn't apply to the School as a unit. It does apply to the School's shops and services, which are treated in a separate questionnaire.

20. Comments

You might have asked for a brief listing of several important objectives of the program which it is believed are being done exceptionally well. I still think that question 8 is too obscure.

21. Evaluation timetable

I would welcome an in-depth study of our School during the spring or next fall. We have been engaged for several years in the continuing review and improvement of various parts of our operations. An in-depth study, particularly on a comparative basis with another similar unit or two, could speed up the process and give us a better idea of how others have solved or are solving problems, many of which are held in common.

Submitted by: H. S. Gutowsky
Director
RESOURCE OUTLINE SUMMARY

FY 1972-73 (Estimates)

SCHOOL OF CHEMICAL SCIENCES

Summary by source of funds

<table>
<thead>
<tr>
<th>Budgetary Unit</th>
<th>State $</th>
<th>CRR $</th>
<th>Trust $</th>
<th>Total $</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shops &amp; Services</td>
<td>1,115,600</td>
<td>234,300</td>
<td>134,000</td>
<td>1,483,900</td>
</tr>
<tr>
<td>Biochemistry</td>
<td>384,900</td>
<td>65,700</td>
<td>831,800</td>
<td>1,282,400</td>
</tr>
<tr>
<td>Chem Eng.</td>
<td>257,100</td>
<td>26,300</td>
<td>296,800</td>
<td>580,200</td>
</tr>
<tr>
<td>Chemistry</td>
<td>1,695,500</td>
<td>222,400</td>
<td>1,640,300</td>
<td>3,558,200</td>
</tr>
<tr>
<td>Totals</td>
<td>3,553,100</td>
<td>548,700</td>
<td>2,902,900</td>
<td>6,904,700</td>
</tr>
</tbody>
</table>

Summary by usage of funds

<table>
<thead>
<tr>
<th>Unit</th>
<th>Academic Staff $</th>
<th>Non-Ac. Staff $</th>
<th>Wages $</th>
<th>Expense $</th>
<th>Equipment $</th>
<th>Total $</th>
</tr>
</thead>
<tbody>
<tr>
<td>S &amp; S</td>
<td>273,700 (19.3)</td>
<td>474,800 (46.5)</td>
<td>130,800</td>
<td>385,600</td>
<td>219,000</td>
<td>1,483,900</td>
</tr>
<tr>
<td>Bio.</td>
<td>673,500 (66.8)</td>
<td>111,100 (13.1)</td>
<td>22,000</td>
<td>336,500</td>
<td>139,300</td>
<td>1,282,400</td>
</tr>
<tr>
<td>Chem.E.</td>
<td>371,000 (34.4)</td>
<td>39,100 (4.8)</td>
<td>8,200</td>
<td>142,300</td>
<td>19,600</td>
<td>580,200</td>
</tr>
<tr>
<td>Chem.</td>
<td>2,198,700 (226.0)</td>
<td>259,000 (31.5)</td>
<td>40,600</td>
<td>732,800</td>
<td>318,100</td>
<td>3,558,200</td>
</tr>
<tr>
<td>Totals</td>
<td>3,516,900 (346.5)</td>
<td>884,000 (95.9)</td>
<td>210,600</td>
<td>1,597,200</td>
<td>696,000</td>
<td>6,904,700</td>
</tr>
</tbody>
</table>

1 Figures per FY 1971-72 Expenditure Synopsis, excluding indirect cost charged on grant and contract funds. Indirect costs average about 24% of the direct costs given.

2 The NSF equipment grants for the service facilities (NSF 28262-$64,000 & NSF 33523-$70,000) are listed in the School Shops & Services rather than in the Chemistry Department where the accounts are assigned.
BASIC DATA AND INFORMATION LISTING

Fall, 1972

SCHOOL OF CHEMICAL SCIENCES

The Program Review instructions, 1972-73 Academic Affairs Directive No. 6, listed types of data and information available at the campus level and asked for an indication of which categories would (1) be useful as a part of a self-study or for internal management purposes and (2) be appropriate as part of an evaluation of the unit. A review of the listing indicated that the information needs of the different areas and departments of the School are very similar. Therefore, only one consolidated response is given for the School; indicating those we'd like to have available and for what purpose. However, the data would presumably be made available by department, or area, as appropriate.

<table>
<thead>
<tr>
<th>Category of data and information</th>
<th>Internal management</th>
<th>In-depth evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty activity data</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Non-academic staff activity data</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Student &quot;crossover&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Faculty turnover</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Faculty salary and promotions</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Racial, sex and ethnic composition, staff and students</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Grade distribution data</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Student course and instructor evaluations</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Placement and proficiency data</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>FTE staff per FTE student</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>NASF per FTE student</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Graduate fellowships and assistantships</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Graduate faculty</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graduate student enrollment</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Graduate degrees conferred</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Teaching loads, IU's/FTE</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Graduate degree completion rates and times</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Undergraduate enrollments and degrees</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Term enrollment projections (SCRR)</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Quality of student input (both UG &amp; G)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Quality of student output (both UG &amp; G)</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>
1. Structural outline of unit

Under this heading of School Shops and Services we include all functions and personnel not assigned to one of the three disciplinary departments. These operations of the School per se may be divided into two categories - shops and service labs, and administration and central services.

The shops and service labs consist of glassblowing, machine and electronics shops; microanalytical and radioisotopes labs, the latter being a campus-wide facility inherited from the Graduate College; a computer center with an IBM 1800 and a remote entry terminal to the campus computer; and molecular and mass spectroscopy labs.

The administration and central services includes the School's administrative office, which also handles much of the Department of Chemistry administration, a Placement Office and a Business Office. The latter is responsible for the operation of several auxiliary services such as the mail, receiving, duplicating and key room, a stores system, communications and laboratory maintenance.

All of these functions, except those of the Department of Chemistry office, are provided for all persons and programs associated with the School or any of its three departments, whether undergraduate or graduate, formal instruction or research. Because of our operational structure and the basic similarity in the broad objectives of these different shops and services, only the present single report is being provided for them, with care being taken to spell out any significant differences. Enrollment figures are given in the report for the School as a unit.

2. Operational structure

The Director is in charge of the School office. The Placement Office and Business Manager report directly to the Director. The shops and service labs operate in a more decentralized manner. The Service Facilities Committee of the School is responsible for recommending basic policies and budgetary priorities for those facilities; their recommendations are acted on by the Director, with the advice of the Executive Committee in major matters. The Chairman of the Service Facilities Committee also plays an important role in the administration of the facilities, reporting as a line officer to the Director.
The Service Facilities Committee includes academic staff representatives having expertise and strong interests in the diverse areas and needs which exist today. The Committee has also strong graduate student representation, four out of a total of 12. Each of the research services or shops is assigned to a faculty member (or two) who has overall responsibility for operational decisions for the facility, for recruitment of its personnel and for meeting its space, budget, and equipment needs. Each facility also has a full-time supervisor who is responsible for its day-to-day operations including management of its personnel and budget. In the case of the Computer Center and Radioisotopes Lab, both functions are handled by the same person, a faculty member.

3. Relation to other programs

Some of the more specialized shops and services such as the glassblowing shop, the microanalytical and radioisotope labs, do not have counterparts elsewhere on the campus. For the others, similar operations, though not so highly centralized, are found in the School of Life Sciences, in Physics, and/or in the Colleges of Engineering and Agriculture.

4. Major objectives

The main objective of our shops and services is to provide support for the strong graduate research programs in the School. In addition, the technical services construct and provide maintenance of undergraduate teaching equipment. The Business Office is organized to relieve the academic staff - including postdoctoral and graduate students - of routine business affairs. The functions handled by the Business Office include: financial budgeting, reporting and control, building maintenance and remodeling, supply and equipment procurement, nonacademic and student recruiting and payroll, movable equipment records, room scheduling, mail distribution, and xerox copying.

Supplies and equipment used in a chemical laboratory have many unique requirements. To aid in locating supplies the Business Office maintains an up-to-date catalog and pamphlet file and has two purchasing specialists. A systematic follow-up procedure in the Business Office insures us of prompt service.

The long-range goal is the improvement of the current services in scope and responsiveness to needs as well as in cost-effectiveness, and a timely introduction of new major research instruments when they become available. A first rate research service should reflect the rapid developments in new research techniques and instrumentation because only in this way can the School maintain high quality undergraduate and graduate education.

These objectives and goals are widely known and strongly shared throughout the School. They could be more explicitly stated. Consideration is being given to the preparation and distribution of an operational handbook which could serve this purpose as well as be a useful guide to staff and students, especially newcomers.

5. Criteria for attainment of objectives

For all of the shops and services, central criteria are their quality, breadth and effectiveness, as judged by the users. Also helpful would be
cost, quality, and breadth comparisons with similar operations elsewhere, on or off the campus, including productivity (e.g., number of analyses, sophistication of items produced, etc.).

6. Educational role of program

This doesn't apply very directly. However, we do have an open-door policy with most of the shops and research services whereby students can learn to operate much of the equipment and do some or all of the work associated with their own research. This aspect, as well as the quality, sophistication and breadth of our research services is a major component of the research part of our graduate programs, of our senior research programs, and of our advanced undergraduate laboratory instruction.

The shops and research services are absolutely essential in order to have a strong graduate program. Without service facilities it will be impossible to maintain the high quality of the graduate program. Many of these research facilities are also used for undergraduate teaching; this is the only way to make undergraduate students aware and familiar with the latest developments in modern research equipment. The Business Office and storerooms also play an important practical role in running the laboratory courses for undergraduate students.

7. Innovation and change

A substantial number of major as well as many minor changes have been made in our shops and services during the past five years to extend their breadth, improve their quality, and increase their efficiency. The three most important innovations are probably the following:

(a) **Mass spectrometer lab** - This has gone from a single, obsolete isotope ratio instrument to one of the most advanced, computerized centers in the United States and abroad, with five, first-rate spectrometers.

(b) **Molecular spectroscopy lab** - This has been materially strengthened by the addition of several major, newly developed instruments - a laser Raman spectrometer, a 220 MHz superconducting NMR spectrometer, and a C-13 Fourier transform spectrometer. Comments by visitors as well as comparisons by our own staff with facilities at other universities support our facility now being one of the best in the United States.

(c) **Systems group** - This was initiated by our Business Office to automate a wide variety of operations such as storeroom records, stock, and reorders; billing of xerox charges; equipment inventory; financial statements. It's been the key to our surviving the budget crunches we've had.

Other important additions include the following:

(d) **Photographic and slide service** - This was assigned to our Electronics Shops as an adjunct to its printed circuit facility.

(e) **Electronics maintenance** - of commercial instruments was set up as a separate section in the Electronics Shop to handle better the rapidly increasing work load. For example, they now keep going the videotape players used in Chemistry 101-102.
(f) An Information Center on outside granting agencies and programs was added to the Business Office.

(g) A Remote-entry terminal to the CSO 360/25 computer was installed in our computer center.

Two significant reductions were made in the services:

(h) Storeroom activities were consolidated, mainly in Noyes Lab, which enabled us to eliminate two positions (by normal turnover).

(i) The Radioisotope Lab underwent a detailed budgetary review which led to a substantial reduction in its State-supported budget.

Other major changes currently planned or under study include: the replacement of ESR and wide-line NMR spectrometers in the Molecular Spectroscopy Lab; the acquisition of a photoelectron spectrometer; the addition of Fourier transform capability to the 220 MHz NMR spectrometer; further consolidation and improved efficiency in our storeroom operations; the need for better facilities for electron microscopy; and some reorganization of the School (and Chemistry) administrative office to better meet the new and changing demands being placed upon it.

8. Classification of programs

Does not apply. See departmental responses.

9. National ranking

Does not apply, except perhaps for the more specialized research services such as the mass and molecular spectroscopy labs. As is, the latter two rank highly on the basis of informal, anecdotal type comparisons. Comparisons with other institutions probably could be devised. See comments under 5 and 7.

10. Five major problems now confronting the shops and services

These are very similar to those listed in the report for the School as a unit. The emphasis differs somewhat, however, so additional comments are offered here.

(1) Quality of space - See School report. The services for which this is a problem are the glassblowing and electronics shops, the mass spectrometer lab, and the computer center.

(2) Lack of state and institutional funds - The recent reductions of state and institutional funds have had a major adverse impact not only on current operations but also on future operations and developments. Even though we have temporarily survived the operating (wages and expenses) fund reductions, by prudently reducing program segments and shifting more
costs to research funds, the lack of funds for non-recurring equipment, maintenance, and remodeling is rapidly becoming critical. As our facilities and equipment become obsolete and inoperative, the quality of the programs involved naturally suffers. Also, staff time spent wrestling with reduced budgets and their effects has been at the expense of more productive endeavors. Future developments depend upon adequate funding and will probably be in direct proportion to the resources received.

(3) **Geographical location of various services and shops** - The present scattered location of several of the service laboratories and shops creates a considerable problem. For example, the mass spectrometry lab is located in the Noyes Laboratory but 95% of the users are in the Roger Adams Laboratory. Similar situations exist for the other shops and services listed under (1) above.

(4) **Staff recruiting, retention, and upgrading** - Inadequate funding has added to our staffing problems. It is difficult to recruit qualified technical and professional staff in an open job market where we must compete with private enterprise. The lack of adequate merit funds makes it difficult to retain competent staff who can obtain much larger salaries elsewhere. Also, this campus lacks the in-house training commitment and programs designed to upgrade present staff's skills and abilities.

(5) **Campus administrative and business services** - Difficulties with increased administrative requirements and with budgetary problems have consumed a great deal of time and thought at all levels in the campus organizations. Nonetheless, services and personnel attitudes received from the campus Business Office have been a perennial problem, which is becoming more acute. Campus business policies and procedures are antiquated, in most areas, with the requirements and personnel tending to police rather than to serve. With a few outstanding exceptions, the majority of campus level business functions impede rather than foster progress.

Also, on occasion we have had cause to believe that the non-academic personnel office is less interested in helping us to solve our problems than it is in avoiding problems elsewhere [see 18 (4)].

11. **Some remedies**

   Items (1) - (3) and the first part of (4) are dependent upon additional funds, directly or indirectly. The last part of (4) and all of (5) are matters best solved at the campus level.

12. **Evaluation of teaching** - Does not apply.


14. **Unmet demand for instruction**

   Does not apply in the literal sense. However, in terms of unmet demands for the services provided, there are several. The machine shop has a very substantial backlog of jobs. Moreover, there has been a steady increase in the fraction of its workload which requires extremely high caliber work of instrument maker level. The molecular and mass spectroscopy labs are understaffed to operate and maintain the equipment at the work loads they're handling. See also the last paragraph of 7.
15. Guidance and counseling of majors, including job placement

Of these functions, only that of job placement is handled at the School level. The Placement office of the School is a full-time operation, with facilities used exclusively for that function. Included in the office is a comprehensive library of vocational books, brochures, pamphlets, and other printed materials supplied by publishers, professional organizations, industries, and governmental agencies.

The chief service of the office is the scheduling of and arrangements for industrial and governmental on-campus recruiting. This includes the distribution to students of pertinent information relative to the visits, the holding of a semi-annual panel discussion by industrial representatives on "How to Interview", and the scheduling of interviews with visiting recruiters. The office also provides counseling of students, assistance in planning and preparing for interviews, and for the careers which they are seeking; assistance to students desiring part-time and summer employment to meet college expenses and to acquire experience which may be helpful in their career planning.

The office also maintains mail and phone contacts with prospective employers. This enables the office to provide current information on available opportunities to students and to alumni wishing to relocate, for use in applying by mail.

Traditionally, much of the information about academic openings in the major universities comes directly to individual faculty members who work together informally to insure that well qualified students are encouraged to apply. In addition, the Placement Office has extended its services to include many academic positions. The office keeps in touch with chemical science departments across the country and maintains a current file of academic positions including the information received by our faculty.

16. Charting progress of students

Does not apply in the usual educational sense. However, the 1971-72 report of the Placement Office is attached as Appendix A. It includes detailed statistics for the placement of our graduates, including jobs, graduate and professional work, and geographical location.

17. Procedures and factors for promotion, tenure and salary

The supervisor of each shop or research service discusses the performance of each employee with the faculty advisor and the rating is then submitted to the Business Manager and Chairman of the Service Facilities Committee who make the recommendations for the salary increases or promotions to the Director of the School. The Business Manager develops recommendations for the other non-academic staff, in consultation with the supervisors involved.

The main and only factor in making all of these recommendations is the quality and quantity of work of each individual employee. A general review of the overall performance of each technical shop or research service area is carried out at least once a year by the Service Facilities Committee.
18. Faculty Lost

Does not apply in a literal sense. However, the losses of supervisory level personnel and those in the more skilled positions do have a substantial adverse effect upon the performance of our shops and services. So such losses are listed below.

<table>
<thead>
<tr>
<th>Year</th>
<th>Name</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>1967-68</td>
<td>Van Damme, Frans</td>
<td>Supervisor of Glass Shop</td>
</tr>
<tr>
<td></td>
<td></td>
<td>He left in order to take a better-paying and more responsible position with much better facilities as Instructor at Virginia Polytechnic Institute, Blacksburg, Virginia. His loss probably was neutral in its effects. He is an excellent glassblower but his performance as Supervisor was not outstanding. Efforts were made to retain him.</td>
</tr>
<tr>
<td>1970-71</td>
<td>Tucker, Sam</td>
<td>Electronics Research Engineer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>He was recruited here in order to set up the maintenance section of our electronics shop [See 7(e)] and did an excellent job of it. Strong efforts were made to retain him, and his departure was a serious loss. He left to take a higher paying position as head of an electronics shop at the University of Utah. He and his family preferred to live in &quot;a different part of the country&quot; and he wanted the challenge of running his own shop.</td>
</tr>
<tr>
<td>1971-72</td>
<td>Banks, Troy</td>
<td>Engineering Draftsman</td>
</tr>
<tr>
<td></td>
<td></td>
<td>He left to take a higher paying ($1,500) industrial position, as a draftsman with Procter and Gamble in Cincinnati. His wife strongly preferred to live in that community so there was no point in our trying to retain him. He is a very pleasant and a conscientious worker, so his departure was at least a moderate loss. He was employed as an apprentice in our black recruitment program so we were pleased, in some ways, to see him &quot;better himself&quot;.</td>
</tr>
<tr>
<td>1971-72</td>
<td>Henderson, Charles</td>
<td>Senior Lab Mechanic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>He left to go into private business, managing a lumber mill. He is an excellent machinist, who is very well qualified to be an instrument maker and who was on the promotion register for that position. However, we could not get his position reclassified in our shop, in spite of the fact that our ratio of instrument makers to lab mechanics is the lowest of any major machine shop on campus. We tried unsuccessfully twice to do so. He left in disgust. His departure was a serious and unnecessary loss.</td>
</tr>
</tbody>
</table>

Besides those whom we've lost, it seems important to note those who have been approached about or offered other positions and whom we have persuaded to stay. This list, in alphabetical order, includes the following:

- Anderson, Ronald - Director of Electronic Services
- Cook, J. Carter - Spectroscopist in charge of mass spec lab
- Matejcek, Paul - Mass spectroscopist
- O'Brien, Donald M. - Supervisor of glass shop
- Thrift, Robert L. - Spectroscopist in charge of molecular spectroscopy lab
In all of these instances, the departure of the person would be a serious loss and strong efforts have been made to retain them.

19. Measures of cost effectiveness

The shops and services of the School lend themselves to several measures of cost effectiveness. For example, with the microanalytical lab and the mass and molecular spectroscopy labs, cost per analysis or per spectra (of a given type) can be determined and compared with commercial prices or with costs elsewhere on the campus or at other institutions. Another measure for the research services - the spectroscopy labs, the computer center, the radioisotopes lab - is the number of hours/wk the major items of equipment are in use. For the Placement Office, the cost per individual placed seems to be a reasonable measure, along with the fraction placed and an assessment by the users of the quality of the service.

Similar measures can be developed for the glassblowing, electronics and machine shops as well as for the Business Office. Comparisons with other campus units of the same type might be a good approach. Care will need to be taken to establish the quality and/or level of sophistication of a service as well as its unit cost. Ideally, a service will be both highly effective and of low cost. But if it appears to be of high cost as well as highly effective, the costs shouldn't be reduced at the price of effectiveness.

20. Comments

Question 18 asks for a list of faculty lost, with an analysis of the reasons and implications. This covers only one side of the question. The other, equally important side is a listing of those whom might have been lost, but weren't. Moreover, the two should be compared very carefully. If a unit is losing more first-rate personnel than it's retaining, and keeping more third-raters than it's losing, something is very, very wrong.

21. Evaluation timetable

See response under report for the School as a Unit.

Submitted by:

Jiri Jonas
(Past) Chairman
Service Facilities Committee

H. S. Gutowsky
Director
RESOURCE OUTLINE
FY 1972-73 (Estimates)
SCHOOL OF CHEMICAL SCIENCES
School Shops and Services (32-04)

PART I -- RESOURCE OUTLINE

<table>
<thead>
<tr>
<th>FTE Academic Staff</th>
<th>Related $</th>
<th>FTE Nonacademic Staff</th>
<th>Related $</th>
<th>Wages $</th>
<th>Expense $</th>
<th>Equipment $</th>
<th>Total $</th>
</tr>
</thead>
<tbody>
<tr>
<td>18.34</td>
<td>265,000</td>
<td>43.50</td>
<td>449,300</td>
<td>125,800</td>
<td>275,000</td>
<td>--</td>
<td>1,115,600</td>
</tr>
</tbody>
</table>

Institutional Funds (CRR)

| 1.00               | 8,200     | 3.00                 | 25,500    | 5,000   | 110,600   | 85,000      | 234,300 |

Grants and Contracts

| -- | -- | -- | -- | -- | 134,000 | 134,000 |

Totals - All Sources of Funds

| 19.34 | 273,700 | 46.50 | 474,800 | 130,800 | 385,600 | 219,000 | 1,483,900 |

1 This includes grants from the Research Board and their semi-annual allocation of funds for computing (CSO).

2 Direct costs only.

PART II -- ESTIMATED BREAKDOWN BY PROGRAM

<table>
<thead>
<tr>
<th>% Share</th>
<th>$ Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>55.3</td>
<td>$ 819,900</td>
</tr>
</tbody>
</table>

1. Shops and service labs (glass, machine, electronics, microanalytical, spectroscopy, mass spec, computer center, radioisotopes)

2. Administration and central services
   a. School and chem adm. office
   b. Business Office
   c. Mail & rec. room, placement, systems group
   d. Centralized maint., commun. and supplies

<table>
<thead>
<tr>
<th>% Share</th>
<th>$ Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.6</td>
<td>$ 97,800</td>
</tr>
<tr>
<td>7.1</td>
<td>106,100</td>
</tr>
<tr>
<td>6.4</td>
<td>94,400</td>
</tr>
<tr>
<td>24.6</td>
<td>365,700</td>
</tr>
</tbody>
</table>

Subtotals

<table>
<thead>
<tr>
<th>% Share</th>
<th>$ Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>44.7</td>
<td>664,000</td>
</tr>
</tbody>
</table>

Totals

<table>
<thead>
<tr>
<th>% Share</th>
<th>$ Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.0</td>
<td>$1,483,900</td>
</tr>
</tbody>
</table>

11/1/72
1. Structural outline of unit

The department is a unit within the School of Chemical Sciences. It offers both an undergraduate and graduate major in biochemistry. This fall there are 100 undergraduate students majoring in biochemistry and 70 students are enrolled in the graduate program. The 100 undergraduate majors is a rather surprising figure. Three years ago when the undergraduate biochemistry major was instituted we generously predicted a total of 100 undergraduate majors after five years. Thus in three years we have already reached the five-year estimate.

2. Operational structure

Biochemistry has a department head; however, with few exceptions it operates more closely to the chairmanship model. That is, major operational policies are normally established by faculty vote. Such policies include course structure and revisions, degree requirements for undergraduate majors and advanced degrees, establishment of priorities for new equipment and remodeling, and priorities for recruitment for new staff. Promotions from the assistant professor level to associate professor are considered by and voted upon by all associate and full professors. Promotions from associate professor to full professor are considered in a similar fashion by all full professors in the department. Teaching assignments are informally discussed both in and outside of regular staff meetings; however, the department head assumes the responsibility for making the assignments and for recommendations of salary increases.

3. Relation to other programs

Biochemistry is an interdisciplinary science bridging chemistry and the life sciences so there are several specialized areas which have close ties with us. Among these the biophysical research group in chemistry is undoubtedly foremost. All staff members in this area hold joint appointments in biochemistry. Similarly, the biophysics group in the Department of Physiology and Biophysics in the School of Life Sciences has close ties with biochemistry. Professor Gregorio Weber from biochemistry holds a joint appointment in biophysics and serves as a senior advisor to that group. The Department of Microbiology likewise shares common research and teaching interests with the Department of Biochemistry. The basic medical sciences program developing on this campus has provided a new staff position in biochemistry, and similarly offers a source of staff and students who have biochemical interests. The College of Agriculture has several interests in the biochemical area; Dr. James Robinson, Assistant Professor of Biochemistry in the Department of Dairy Science holds a joint appointment in biochemistry.
4. Major objectives

The department has the responsibility for teaching all formal undergraduate and graduate courses in biochemistry on the Urbana-Champaign campus. This means that most of our teaching both at the undergraduate and graduate level is devoted to giving basic biochemical instruction to students enrolled in many different curricula. For example it is quite common for premedical students on this campus to complete a lecture and laboratory course in biochemistry prior to their entrance into medical school. Likewise, many of the advanced courses offered in the School of Life Sciences require a beginning biochemistry lecture and laboratory course as a prerequisite. Similarly, graduate students in the College of Agriculture routinely take biochemistry as a minor area. Thus, in addition to managing our own undergraduate and graduate program, we have a considerable burden of service-type teaching. The major objective of our program, however, is to prepare students for teaching and research in biochemistry and related life-science areas.

5. Criteria for the attainment of objectives

The undergraduate program can be judged on the basis of placement of our undergraduate majors in professional and graduate schools. With respect to the graduate student program, the placement of our graduate students in professional careers would serve as an excellent criterion for measuring our success.

6. Educational role of program

See response to question 4.

7. Innovation and change

An important example of innovation which has occurred in our program during the past five years is the establishment of the Department of Biochemistry as a separate unit and the initiation of an undergraduate major in biochemistry. The interaction of biochemistry with the new School of Basic Medical Sciences on this campus is another example of innovation and change. Also, the development of strong cooperative research programs between biochemistry and physics has been a recent development. Biochemistry has participated in the establishment of a neurosciences program on this campus.

8. Classification of program

It is very dangerous to attempt to classify programs in rapidly advancing field as to whether they are devoted to long-range basic problems or to more applied research. For example, the work in the field of antibiotics in the late 1930's and early 1940's started as a long-range basic program of research; however, the dramatic success of penicillin as an applied problem obviously led to an immediate change in the lives of most of the people on earth. At the present time, it would appear that current basic research in biochemistry and molecular
biology may likewise contribute to a revolution in the health field in terms of cancer therapy and in terms of treatment of heart disease. However, as is the case with all basic research, it is impossible to predict the timing or even the precise nature of the discoveries which will eventually contribute toward these goals.

9. National ranking

Our graduate program was ranked in the latest ACE report as 15th in the nation. In the previous Carter study (1966), the program ranked 10th. I believe that during the two years since the latest report, biochemistry has probably regained its earlier 10th place standing. The recent report was based on data gathered just after we had undergone a major loss of senior faculty. In a two year period, 1965-67, we lost four senior faculty members to other high quality institutions. Professor Carl Westling left to become Head of Biochemistry at the University of Iowa. Professors Hastings, Rutter and Wold accepted full professorships at Harvard, University of Washington and Minnesota, respectively. Those losses have now been compensated by the appointments of vigorous young staff members at the assistant professor level.

A measure of the esteem which the department holds on the national scene is the fact that it has one of the largest training grants in the United States for the training of graduate students. The National Institutes of Health currently supports approximately 1,000 graduate students in biochemistry departments at fifty institutions via training grants. Our training grant provides for 38 trainees. This is twice the average support given to the high quality institutions selected for such grants.

10. Major problems

(1) The quality of our space does not compare to that of other major institutions. With the exception of Harvard, every institution which ranks above or equivalent to Illinois in the last ACE report occupies relatively new spacious laboratories which were built or enlarged during the 1960's. Total space at Illinois, barely adequate for current faculty and student needs, does not have room for expansion. Likewise, the quality of much of our space is poor. Roger Adams Laboratory, which was built just after World War II, suffers from poor design. Some experimentation such as sterile work with tissue culture is almost impossible to do because of air leaks around windows.

(2) Lack of expertise in the area of animal cell biology on this campus hinders the development of research in a new and exciting field related to developmental biochemistry in animal cells and in animal cell circus research.

(3) A third major problem is communication with the new School of Basic Medical Sciences. Current administration in the Medical School is not committed to the same standards of excellence in research that characterizes biochemistry's attitude.
11. **Some Remedies**

Hopefully the need for new instructional space in biochemistry could be provided by internal rearrangements within the School of Chemical Sciences. It would appear that not all laboratory space for instructional needs in the School is maximally utilized. The problems arising from the interaction of the Biochemistry Department with the new School of Basic Medical Sciences have been discussed, sometimes heatedly, within the Basic Medical Sciences program and hopefully those problems can be resolved within that structure. If this proves to be impossible, I suggest that the entire program and structure of that School be reviewed at the campus and university levels.

12. **Evaluation of Teaching**

The quality of our formal course programs is constantly reviewed through five devices. Comments and evaluations in the Advisor have been routinely gathered and studied, the student affiliate of the local ACS does a yearly survey of biochemistry courses and our beginning laboratory course is monitored each semester by a detailed questionnaire which is completed by most of the students in the course. Biochemistry courses have been included in the survey of courses made by departing seniors. We routinely receive feedback on our courses from our own students via their research advisors and from students in other departments, quite often through departmental heads. It should be noted at this point that biochemistry offerings commonly receive rave notices in all these reviews. Biochemistry 355 is the only laboratory course which has been listed by departing seniors as one of their most rewarding undergraduate experiences.

13. **Training in Instructional Methods**

Instructional methods for teaching assistants in biochemistry involve a one week orientation program for new graduate students. This orientation program has operated now for a three year sequence. Teaching assistants are also provided instruction in lecturing techniques through the use of practice sessions which are recorded on TV tape for playback and review.

14. **Unmet Demand for Instruction**

Yes, there is a demand for instruction which has not been met. In our advanced laboratory course, Biochemistry 452, we routinely limit enrollment in this course because limitations are placed on class size by the instrumentation available for teaching the course. We are rapidly approaching the time in both of our beginning laboratory courses, Biochemistry 355 and 356, where the student demand will surpass our facilities. We can only accommodate 100 students per semester in both of these beginning laboratory courses. We routinely reach the 100 student limit in the fall semester of each year; however, only recently have we approached the 100 number for Biochemistry 355 in the spring semester. Biochemistry 350, our beginning lecture course which is offered three times a year, has approximately 700 students enrolled per year. We also have a need for advanced topics courses for our graduate majors; however, we have been unable to provide this course on a routine basis because of lack of teaching personnel.
15. Guidance and counseling of majors

Undergraduate advising in biochemistry is performed by a staff committee under the direction of Dr. John Clark. At the present time the total number of majors is sufficiently small so that a reasonably close relationship can be established between a student and the advisor. In addition, most undergraduate majors also do a thesis project during their senior. In this way, they are brought in close contact with graduate students and a senior staff member. Biochemistry has been extremely successful in placing undergraduate majors in high quality graduate programs at other institutions.

The head of the department serves as the advisor for all graduate students in biochemistry up to the point where they select a thesis supervisor. At this point, the thesis supervisor becomes the major advisor for the graduate student. In general, the thesis supervisor accepts the responsibility for placement of the student after completing the Ph.D. degree requirements. Contacts with industrial companies are largely maintained through the services of the Placement Office of the School. (See School report.) A high proportion of Ph.D. graduates in biochemistry enter postdoctoral training programs elsewhere. These are usually negotiated on an individual basis with the prospective employer.

16. Charting progress of students

All graduate majors in biochemistry are reviewed each semester to chart the progress of their work toward the M.S. and Ph.D. degrees. Students with a 4.0 or lower average are carefully watched. Graduate students in order to qualify for entrance into the Ph.D. degree program must successfully pass a cumulative exam program (must pass six before failing seven exams) and must pass a research qualifying examination 18 to 24 months after their entrance into graduate school.

17. Procedures and factors for promotion, tenure and salary

Recommendations for salary increases are based on the judgement of the department head. Procedures for recommendations for promotion and tenure were described in section 2.

18. Faculty lost

Dr. George J. Schroepfer, Jr., resigned as Professor of Biochemistry to move to Rice Institute, Houston Texas to become Professor and Head of Biochemistry. Professor Schroepfer had a strong desire to organize and develop a new biochemistry program which he was given an opportunity to do at Rice. Personal reasons were also involved in his change of location. We consider the loss of Professor Schroepfer to be serious, but we believe that we can recruit a top flight replacement.

19. Measures of cost effectiveness

One measure of cost effectiveness is to compare the space and faculty-staff positions available in our program with those at institutions of comparable size and quality. Table I compares the space for our program with the allocations at the University of California, Berkeley, the University of Wisconsin and Michigan State University. The University of Illinois ranks below both California and Wisconsin in the latest ACE report, Berkeley ranked second and Wisconsin ranked fifth. Michigan
State ranked 28th in the report. Table II compares the staff size and the ratio of students to staff at these institutions. These comparisons suggest that the Illinois program is equivalent to California, Wisconsin and Michigan State, yet it is produced with approximately 1/2 of the resources available to those programs. The ratio of total students in the university to biochemistry staff is particularly noteworthy. The ratio of total student population to staff at Illinois is approximately twice that for the other three institutions.

Table I. Comparison of Assigned Space (sq. ft.)

<table>
<thead>
<tr>
<th>Institution</th>
<th>Research and Office Space</th>
<th>Teaching and other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>U. of California, Berkeley</td>
<td>45,000</td>
<td>10,000</td>
<td>55,000</td>
</tr>
<tr>
<td>U. of Wisconsin</td>
<td>55,541</td>
<td>28,000</td>
<td>83,541</td>
</tr>
<tr>
<td>Michigan State University</td>
<td>68,000</td>
<td>17,500</td>
<td>85,500</td>
</tr>
<tr>
<td>U. of Illinois</td>
<td>20,707</td>
<td>8,621</td>
<td>29,331</td>
</tr>
</tbody>
</table>

Table II. Comparison of Student Staff Ratios

<table>
<thead>
<tr>
<th>Institution</th>
<th>Academic Staff</th>
<th>Graduate Students</th>
<th>Ratio GS/AS</th>
<th>Total Enrollment</th>
<th>Ratio TE/AS</th>
</tr>
</thead>
<tbody>
<tr>
<td>U. of California, Berkeley</td>
<td>18</td>
<td>80</td>
<td>4.5</td>
<td>27,500</td>
<td>1530</td>
</tr>
<tr>
<td>U. of Wisconsin</td>
<td>29</td>
<td>100</td>
<td>3.5</td>
<td>36,000</td>
<td>1240</td>
</tr>
<tr>
<td>Michigan State University</td>
<td>27</td>
<td>65</td>
<td>2.4</td>
<td>40,000</td>
<td>1430</td>
</tr>
<tr>
<td>U. of Illinois</td>
<td>12</td>
<td>69</td>
<td>5.8</td>
<td>33,000</td>
<td>2750</td>
</tr>
</tbody>
</table>

20. Comments
None at present.

21. Evaluation timetable
Yes, we are prepared for an immediate COPE Study.

Submitted by: L. P. Fager
Head of Department
RESOURCE OUTLINE

FY 1972-73 (Estimates)

SCHOOL OF CHEMICAL SCIENCES

Department of Biochemistry (32-85)

PART I -- RESOURCE OUTLINE

<table>
<thead>
<tr>
<th>FTE Academic Staff</th>
<th>Related $</th>
<th>FTE Nonacademic Staff</th>
<th>Related $</th>
<th>Wages $</th>
<th>Expense $</th>
<th>Equipment $</th>
<th>Total $</th>
</tr>
</thead>
<tbody>
<tr>
<td>State Funds</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.77</td>
<td>300,400</td>
<td>6.00</td>
<td>36,900</td>
<td>4,800</td>
<td>33,800</td>
<td>--</td>
<td>384,900</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Institutional Funds (CRR)¹</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.25</td>
<td>8,500</td>
<td>0.50</td>
<td>2,900</td>
<td>1,000</td>
<td>11,400</td>
<td>41,900</td>
<td>65,700</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grants and Contracts²</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>46.75</td>
<td>364,600</td>
<td>6.61</td>
<td>62,300</td>
<td>16,200</td>
<td>291,300</td>
<td>97,400</td>
<td>831,800</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals - All Sources of Funds</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>66.77</td>
<td>673,500</td>
<td>13.11</td>
<td>111,100</td>
<td>22,000</td>
<td>336,500</td>
<td>139,300</td>
<td>1,282,400</td>
</tr>
</tbody>
</table>

¹ This includes grants from the Research Board and University Fellowships.
² Direct costs only; indirect costs average an additional 24%.

PART II -- ESTIMATED BREAKDOWN BY PROGRAM

There are two programs sponsored by the department, the undergraduate major and the graduate program, the latter offering the MS and PhD degrees. In addition, the department teaches several service courses at the 300 level; also a large fraction of the enrollments in its courses for undergraduate and graduate majors come from other departments. As a rough estimate, the costs assignable to the formal teaching program of the department (excluding Biochemistry 499) are about half of the state funds, i.e. $192,000 which is 15% of the grand total.

11/1/72
PROGRAM REVIEW QUESTIONNAIRE

Fall, 1972

SCHOOL OF CHEMICAL SCIENCES

Department of Chemical Engineering

1. Structural outline of unit

See response for the School as a Unit. Two programs are offered by the department, the undergraduate curriculum in chemical engineering and the graduate program, the latter offering M.S. and Ph.D. degrees. The fall 1972 enrollments total 156 in the undergraduate curriculum and 53 in the graduate program.

2. Operational structure

The department operates with a head. The head bears responsibility for setting policies and making operating decisions. Faculty input to the policies and decisions is substantial. A faculty meeting occurs regularly once per week, during lunch on Monday. Information is provided, discussions occur, and decisions are announced.

Each staff member is assigned to a number of departmental committees by the head, after consultation with the head. Some of these are one-man committees. The committees handle such things as registration, selection of scholarships, preparation of the Time Table, graduate student correspondence, and several dozen similar items of concern to all. The complete list of committee assignments is provided to all the staff. It is revised each year. Copies are available if desired.

Graduate student input to the decision-making process is through the departmental Graduate Student Advisory Committee. This group consists of all third-year graduate students plus the department head. The meetings occur at about six-week intervals.

Undergraduate student input to the decision-making process is through the Student Chapter of the American Institute of Chemical Engineers. A faculty advisor attends the meetings and serves as liaison between the undergraduates and the faculty.

3. Relation to other programs

Chemistry is related to chemical engineering in that the students in the chemical engineering B.S. program take thirty hours of chemistry. Math and physics are related as service departments to a lesser degree. Some fields of interest in chemical engineering are multidisciplinary. Graduate research and courses in fluid mechanics occur in chemical engineering and also in mechanical engineering; automatic control occurs in chemical engineering and in electrical
engineering. In no case are the viewpoints identical nor the courses the same. In the courses there is a small but definite crossover of students from the various departments.

With one exception, there are no students or staff in common. The exception is Professor H. G. Drickamer. He holds a joint appointment in chemical engineering and in chemistry. He directs graduate theses for majors in chemical engineering, physical chemistry, and in physics. He utilizes space in chemical engineering and in the Material Research Laboratory.

4. Major objectives

The major objective of chemical engineering is to operate a graduate program of outstanding quality, one which is recognized and admired nationally and internationally. This demands a high quality undergraduate program as explained in items 5 and 6. Although education and research are paramount, significant contributions in the service category are encouraged. The major long-range goal is to achieve a rating of first in the American Council on Education rankings of graduate programs in chemical engineering.

5. Criteria for attainment of objectives

An appreciable number of criteria are valid to evaluate the degree to which chemical engineering has reached its objectives: (1) the ACE rankings, (2) the number of awards and prizes received by the faculty, (3) the success in recruiting first-rate faculty members from outside schools (Internal recruitment often is a sign of weakness, not strength), (4) the success in recruiting first-rate graduate students from other U.S. schools (Substantial internal recruitment of graduate students and substantial recruitment of non-citizens are signs of weakness), (5) the frequency of attempts by good schools to hire our faculty, (6) the success of our alumni, that is the number who have risen into positions of distinction, (7) the number of refereed publications by our staff, (8) the number of invited talks by our staff, (9) offices held by our staff in professional organizations, and (10) other criteria which are a function of the national and international reputation of the department.

6. Educational role of program

Our role in undergraduate education is to produce B.S. recipients who are avidly sought by industry and by graduate schools. This means that these students must be of high intelligence and must receive a thorough, modern education. Our role in graduate education is to produce M.S. and Ph.D. graduates who carry out research that has an impact in the field of chemical engineering and who are avidly sought by industry and by universities to fill staff positions.

The B.S. education is vital. Those B.S. recipients who go to graduate work in other good schools are "ambassadors" affecting our reputation and our success in recruiting graduate students from those schools. Those B.S. recipients who go
into industry affect the esteem of industry for this department and thereby
influence the job market for future graduates. We cannot minimize our strong
efforts to provide an undergraduate program of excellent quality.

Our Ph.D. education is of prime importance. We award an average of ten
Ph.D. degrees per year. In quantity, we rank usually about third or fourth
in the nation; in 1969-70, we ranked second in quantity. Industry and other
universities look to us as a key supplier of Ph.D.s. We accept this role.

7. Innovation and change

Our undergraduate and graduate programs are not static. Within the last
five years the undergraduate curriculum has undergone a reduction in the num-
ber of hours required, from 136 to 130, the addition of a new introductory
course to be taught at the freshman level, the revision of a number of courses,
and the elimination of our old "Engineering Option" and "Physical Science Option."
The new elective arrangement permits a student to obtain a background in
relevant fields such as bioengineering, medical engineering, environmental
engineering, and energy utilization.

Currently planned is a further reduction in the total hours, an easing of
the foreign language requirement, and an expansion in the electives.

At the graduate level, three new courses have been added in order to
formalize our long-standing usage of research-group seminars and individual
study. The foreign language requirement for the Ph.D. was reduced from two
languages to one. Grading of our seminars was changed from letter grades to
Pass-Fail.

8. Classification of program

Our program definitely is a mix of long-range basic problems of research
and problems the solution of which will lead to rapid changes in industry.
We prefer to have both approaches.

9. National ranking

Chemical engineering ranks sixth (of 130 schools) in the last ACE report.
This is an improvement from eighth place in the previous ACE report. The
present four full professors have been the recipients of fourteen major awards
from national professional societies. The present nine staff members published
44 refereed papers last year, an average of 4.9 per man which far exceed that
of any other chemical engineering department.

The staff and alumni have been shown in a study by the University of
Wisconsin, Milwaukee, to have a high ranking. A study "Institutional Origins
of Eminent Chemical Engineers," published in Chemtech, January 1972, by B. R.
Siebring and M. E. Schaff, defined an eminent chemical engineer as one who received a major prize or award or had been designated as distinguished by "thousands of reputable scientists who themselves did the choosing." Of 130 schools, the University of Illinois ranked first in baccalaureate origins for eminent chemical engineers (Table 4 of the reprint which is attached as Appendix B). The University of Illinois ranks fifth in doctoral origins for eminent chemical engineers (Table 1 of the article).

10. Major problems

(1) A major problem is that Southern Illinois University and also Chicago Circle desire to add chemical engineering to their degree offerings. Inasmuch as we have been graduating approximately thirty B.S. and ten Ph.D. recipients per year, we would be damaged if a serious dilution were to take place. We are able to handle more than the numbers listed, but no additional supply of well-qualified applicants is visible. Already in the United States, 130 departments of chemical engineering exist. This is too many, and some of the departments have ridiculously low enrollments. The establishment of additional departments in Illinois not only is unwarranted but also would be much more costly than expansion of the existing program.

(2) The admissions requirements in Liberal Arts and Sciences consist at present of one set of requirements for all departments including chemical engineering. Our admission requirements should match those of the Engineering College, not those of Liberal Arts and Sciences. At present we are losing prospective students to engineering.

(3) The use of instructional units to influence the size of a department's faculty, space, and budget has led to an increase in in-house course offerings on this campus and a decrease in outside offerings. A number of departments now teach their own mathematics, chemistry, physics, and chemical engineering among others. This weakens the service departments. Chemical engineering has resisted the temptation to teach its own non-chemical engineering courses, but we do not like to see the service departments weakened by migration of instructional units.

(4) The stress on this campus too often is on quantity rather than quality. A small department based on high quality finds difficulty in obtaining adequate recognition of its quality. Budget cuts tend to be across the board. Fellowships tend to be awarded in proportion to enrollment. Funds for operating expenses or non-recurring costs tend to be based on size. An identification of quality and rewards based on relative quality are needed.

11. Some remedies

(1) New degrees or new curriculum options anywhere in the system of state-supported universities should not be permitted until evidence is submitted from the departments already in existence to show whether or not the duplication is justified.
(2) The College of Liberal Arts and Sciences should have a multiple set of admissions requirements, not just one set. The admissions requirements for chemical engineering should be the same as for the College of Engineering.

(3) A university-wide requirement should be set requiring every undergraduate and graduate curriculum to have a minimum number of courses from outside departments.

(4) The evaluation of quality is the toughest of all. This Program Review Questionnaire is a good start.

12. Evaluation of teaching

(1) Questionnaires are used to assess the quality of teaching in our undergraduate and graduate courses. Copies are available upon request. One is used for lecture-quiz courses, and one is for the laboratory courses. These are filled in, anonymously, by the students during the last week of each semester. The results are examined by the department head and by the instructor in charge. In addition, during the first year of employment of a new staff member he gives a complete set of assignments, quizzes, and exams to the department head. These are discussed when advisable.

(2) The graduate teaching assistants ordinarily grade homework, short quizzes, and hour exams in lecture-quiz courses. The instructor in charge examines the grading. The teaching assistants in our laboratories consult with the students concerning the experiments and grade the lab reports. The instructor in charge examines the report grading. At the end of each semester, the instructor in charge records a grade for each of his teaching assistants and transmits it through the department head to the director of the School. (See item 12 of School report.)

13. Training in instructional methods

Our teaching assistants do not deliver lectures (except in very rare cases). Their training in paper grading, report grading, and laboratory conferences is by individual instruction from the instructor in charge.

A new faculty member is given private advice concerning his courses from the prior instructor. In addition, innumerable discussions of teaching methods, successes, and disappointments, take place during our weekly staff meetings.

14. Unmet demand for instruction

Now and then the department receives requests for night courses or extension courses. The demand is from workers in industry in Tuscola, Decatur, and Danville, who wish to obtain graduate degrees. However, the number of such potential students is much too small and their locations too far away to warrant such courses. In addition, our department is not large and would be strained to furnish the manpower for such instruction.
15. **Guidance and counseling of majors**

A mailing is sent to all undergraduates prior to registration stating any changes in courses or curriculum. The names and locations of advisors are listed in the letter and the registration (or pre-registration) dates are given. A file folder is maintained for every student. This contains his academic records and a check-off form showing his progress toward the degree. The advisors consult these records frequently. The records are kept up to date by graduate assistants. A personal record containing the student's photograph, honors, and awards is maintained also. Seniors receive an additional mailing inviting them to the office of the department head to discuss job interviews or applications for graduate work. Records are kept showing the jobs and addresses of our students after graduation. The Student Chapter of the American Institute of Chemical Engineers holds eight or nine meetings per year. Some of these are used to provide additional guidance and counseling both on a formal and informal basis.

A unique relationship exists between the graduate students and their thesis advisors. This a master-and-apprentice relationship. An enormous amount of guidance and counseling of graduate students takes place through the informal daily contacts. Records of undergraduate and graduate schooling, copies of appointments, application forms, letters of recommendation, and photographs are maintained for graduate students. Their jobs and addresses are maintained up to date after graduation.

The operation of the School of Chemical Sciences Placement Office is described in the report the School as a Unit and in the 1971-72 report of the Placement Office itself (see Appendix A). This office is a highly efficient and successful agency through which our students secure permanent employment.

16. **Charting progress of students**

For over 25 years detailed records have been maintained for all our undergraduates and graduates as described in item 15. Each semester a list of all our undergraduates is prepared, showing names, class standing, and grade point averages. It is thus possible for any of our staff to determine easily the progress of any student toward his degree.

The seniors are advised toward job placement by the department head as explained in item 15. The graduate students are advised by their thesis supervisors.

After our students become alumni, their addresses and jobs are recorded in our files and kept up to date. Published items in the "People" section of Chemical Engineering Progress and Chemistry and Engineering News are examined regularly, and changes in employment are noted. Whenever an alumnus visits our office, we have him sign our register book, bringing his address and employment up to date.
Our records show that during the last ten years, 275 B.S. degrees were awarded. Of these students, 115 went to 38 graduate schools; 158 took positions in industry, government, or the military; and two are unemployed. The ten-year production of M.S. degrees was 153, of whom 109 went on toward the Ph.D., 44 accepted jobs or the military, and zero are unemployed. The ten-year production of Ph.D. degrees was 98, of whom twelve took academic positions, 85 accepted industrial, government, or military positions, and one (a non-citizen) is unemployed. The names and locations for all these can be produced from our records.

17. Procedures and factors for promotion, tenure, and salary

A curriculum vita is maintained for each faculty member above the rank of instructor. At least once each year, each vita is brought up to date by the staff members upon request of the department head. These show courses taught, committee duties, papers published, invited talks, offices held, meetings attended, and other items related to teaching, service, and research. The younger staff members are informed by the head that they are in competition with young staff of similar age at other highly rated schools and that their future depends on how well they match or exceed the performance of that group of peers. Thus the staff include in the curriculum vitae all possible evidence of success in teaching, service, and research.

The Chemical Engineering Promotions Committee is very important in chemical engineering. It is composed of all the full professors. Each fall this committee has a series of meetings to study the curriculum vitae, ask for additional information, and seek opinions from outside experts. This committee finally provides recommendations to the head concerning promotions, tenure, and termination of appointments. Fortunately, this has been a cooperative group, and all recommendations during recent years have been with no strong dissent. This committee also states an opinion of relative progress for each of the younger staff.

The Executive Committee of the School of which the head of chemical engineering is a member, then considers all recommendations for promotion, tenure, or termination in the School of Chemical Sciences. The curriculum vitae are again examined at this second level before recommendations are forwarded to the Dean of Liberal Arts and Sciences. (See comments on this item in the School report.)

Salaries are recommended to the director of the School by the head of chemical engineering. For the younger staff members, the head decides on salary recommendations which in his opinion reflect the feelings of the Chemical Engineering Promotions Committee. For the full professors, the recommended salary changes reflect the opinion of the head as to their relative merit. On occasion, further salary adjustments are agreed on jointly by the department head and the director of the School.
18. Faculty lost in last five years

Professor J. A. Quinn resigned in February, 1971 to accept a professorship at the University of Pennsylvania. This was a serious loss to the University of Illinois. The reason for his resignation was a personal one involving family health, and there was no possible way to prevent this loss. Previously, we had successfully warded off offers to Dr. Quinn from Cornell, Stanford, Pennsylvania State University, University of Rochester, University of Cincinnati, Drexel Institute of Technology, Rutgers University, and Clarkson.

Also during the last five years, attempts to "raid" our staff for its most productive members were counteracted successfully. Dr. C. A. Eckert was sought during this time by Yale, Oklahoma State, University of Kentucky, and University of California, Davis. Dr. R. A. Schmitz was sought by the University of Connecticut, Clarkson College, and the University of Michigan (for headship). Dr. T. J. Hanratty was sought by Carnegie-Mellon University (headship), University of Rochester, Clarkson College (headship), University of Florida, University of Syracuse, and Virginia Polytechnic Institute. Dr. J. W. Westwater was sought by the University of Oklahoma (deanship), Sacramento State College (deanship), and Clarkson College (provost). It is difficult to think of a stronger evidence of staff quality than this number of attempts, with a staff of nine persons.

19. Measures of cost effectiveness

Inasmuch as the University is expected to carry out teaching, research, and service, the cost of those items should be determined. The cost of teaching can be computed as so much per B.S., per M.S., and per Ph.D. degree awarded. This requires a weighting system such as one M.S. is worth two B.S., and one Ph.D. is worth four B.S. (or with some other weighting factors). This system is preferable to the use of instructional units. The use of instructional units leads to distortions in curricula as departments divert instructional units away from service departments into their own departments. The use of instructional units tend to reward departments which keep their students in school for abnormally long times.

The cost of research in chemical engineering can be based on the number of refereed publications during the year. Some scheme for expressing a paper as being equivalent to a certain number of B.S. degrees seems necessary. One thought would be to equate one paper to one Ph.D. degree (or four B.S. degrees).

I do not know how to evaluate the costs of service.

The funds used in calculating cost effectiveness should include the state budget only and should exclude all research grants.

The key issue, however, is the matter of quality. No department should be rewarded for turning out inferior students, nor should third-rate research be encouraged. Any scheme used to determine cost effectiveness must include the
matter of quality. A truly first-rate department should receive more operating funds per student and a lower teaching load per faculty. Hopefully a study such as this Program Review can be used to fix some score which expresses quality in a quantitative way. Then the budget, teaching loads, and space of a high-quality department should be adjusted so as to award its achievements and low-quality departments should be penalized.

20. Comments

None at this time.

21. Evaluation timetable

Chemical engineering has no objection to an in-depth evaluation in 1972-73 or any other time. See also comments in the report of the School.

Submitted by: J. W. Westwater
J. W. Westwater
Head of Department
RESOURCE OUTLINE

FY 1972-73 (Estimates)

SCHOOL OF CHEMICAL SCIENCES

Department of Chemical Engineering (32-38)

PART I -- RESOURCE OUTLINE

<table>
<thead>
<tr>
<th>FTE Academic Staff</th>
<th>FTE Nonacademic Staff</th>
<th>Related $</th>
<th>Wages $</th>
<th>Equipment $</th>
<th>Total $</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.33</td>
<td>13.30</td>
<td>206,700</td>
<td>13,300</td>
<td>4.00</td>
<td>257,100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.00</td>
<td>30,900</td>
<td>1,900</td>
<td>371,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>17,600</td>
<td></td>
<td>118,700</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>13,100</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>296,800</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>26,300</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>580,200</td>
</tr>
</tbody>
</table>

State Funds
Institutional Funds (CRR)¹
Grants and Contracts²
Totals - All Sources of Funds

---

¹This includes grants from the Research Board, and University Fellowships.
²Direct costs only; indirect costs average an additional 24%.

PART II -- ESTIMATED BREAKDOWN BY PROGRAM

There are two programs sponsored by the department, the undergraduate major and the graduate program, the latter offering the MS and PhD degrees. As a rough estimate, the costs assignable to the formal teaching program of the department (excluding Chemical Engineering 499) are about half of the state funds, i.e. $128,000 which is 24% of the grand total.

11/1/72
1. Structural outline of unit

The response for the School as a unit outlines the relatively complex structure of the Department of Chemistry. However, some repetition seems desirable here in order to indicate the manner in which this response for the department is structured.

The undergraduate S&L major and the professional curriculum in chemistry as well as the M.S. in the Teaching of Chemistry are the responsibility of the department as a whole, even though most of the courses are offered on a decentralized, area basis. Therefore, this response for the department, per se, will cover these programs. The graduate program, on the other hand, has several majors although they lead to the same degrees, an M.S. and/or Ph.D. in Chemistry.

Separate, partial responses (usually 3-9 and 14-16) are provided for the (graduate) programs in analytical, inorganic, organic and physical chemistry. The biophysical and chemical physics programs are very closely related to physical chemistry and are included therein. However, the budgetary data for each of these areas includes costs of the associated undergraduate courses as well as of the graduate programs.

Because of its size and central role in our service courses, a separate report is given for the General Chemistry Program. Also, our program in analytical chemistry has a major interaction with the campus-level Environmental Studies Program, so a separate report is included on that aspect of its operations.

Enrollments of majors in the various programs for Fall, 1972 are as follows:

<table>
<thead>
<tr>
<th>Program</th>
<th>Undergrad.</th>
<th>Graduate</th>
<th>Post-doc</th>
</tr>
</thead>
<tbody>
<tr>
<td>S&amp;L major and pre-professional</td>
<td>292</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specialized curriculum</td>
<td>151</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M.S. - Teaching of Chemistry</td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>M.S. &amp; Ph.D. programs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analytical</td>
<td></td>
<td>35</td>
<td>6</td>
</tr>
<tr>
<td>Biophysical</td>
<td></td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Inorganic</td>
<td></td>
<td>58</td>
<td>6</td>
</tr>
<tr>
<td>Organic</td>
<td></td>
<td>101</td>
<td>19</td>
</tr>
<tr>
<td>Physical</td>
<td></td>
<td>75</td>
<td>14</td>
</tr>
<tr>
<td>Unspecified</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Ph.D. in Chemical Physics</td>
<td></td>
<td>15</td>
<td></td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>443</strong></td>
<td><strong>294</strong></td>
<td><strong>45</strong></td>
</tr>
</tbody>
</table>
2. **Operational structure**

The executive officer of the department is a Head, who also serves, at present, as Director of the School. The department is operated by a blend of decentralized and centralized initiative and policy and decision making. For at least 40 years prior to 1967, the department had six divisions (including biochemistry and chemical engineering) each with a head appointed by the head of the department. Each division head was responsible for the full range of concerns ordinarily handled by a department head. This structure served very well until the early 60's when an increasing fraction of new developments occurred at the boundaries between the traditional areas (analytical, inorganic, organic, physical). Therefore, in 1967 these four divisions were combined into a Chemistry Division, which in 1970 became the Department of Chemistry.

Two major functions were and are centralized — the recruitment and evaluation of faculty, and the admissions and appointment of graduate students. These are now handled by standing committees, appointed by the head of the department, a Committee on Staff and a Committee on Graduate Admissions and Appointments. These committees recommend policies and specific actions to the Head, and the chairmen and committee members are largely responsible for the operations to implement the policies established.

There are several other departmental committees, including Courses and Curricula*, Faculty Grant-in Aids, General Chemistry*, Undergraduate Advising*, and Graduate Progress and Advising. Those marked by an asterisk have student members. Also, student input on issues not covered by standing committees is obtained via the School's Student Advisory Committee.

There continues to be a program head in each of the four areas, along with a Director of the General Chemistry Program. These individuals constitute a Budget and Operations Committee, each of whom is responsible for the following functions of that program: management of the operational budget, teaching assignments and performance of faculty and TAs, curricular review and developments (which go to the Courses and Curricula Committee), space assignments within the program, and "general housekeeping." Most of these functions are handled according to policies established or operational decisions made by meetings of the faculty involved. An associate head is responsible for overseeing many of these and other activities.

3. **Relation to other programs**

See comments under School as a Unit. Also, the programs most closely related to those of the Department of Chemistry are of course those in biochemistry and chemical engineering. The first two years or more of the chemistry in the undergraduate chemistry program is also taken by undergraduates in the other two departments, graduate students in chemistry will often minor in biochemistry, and graduate students in biochemistry or chemical engineering will often minor in chemistry (or an area thereof). Faculty in chemistry hold joint appointments with biochemistry (3) and chemical engineering (1).

In addition, recent years have witnessed increased participation of our faculty in the program of the Materials Research Laboratory, including major use of its facilities and space. At present, five of our faculty are participants, Professors Brown, Curtin, Flygare, Jonas, and Stucky.
4. Major objectives

In the broadest of terms, our primary objective is to provide educational opportunities in chemistry of the highest possible quality and effectiveness, responsive both to the needs of the individual students and to the interests of our society. Of equal, overlapping importance is to do truly first-rate research.

At the undergraduate level there are three more specific objectives, corresponding to the three large groups of students who take our courses. (1) Terminal and service courses for non-majors whose objectives require or encourage some college-level study of chemistry. (2) Major or minor programs of study for those who plan careers, such as medicine or biology, requiring an advanced command of chemistry. (3) Major, professionally-oriented programs for those planning careers in chemistry, especially for those who plan to continue their studies at the graduate level.

At the graduate level our primary objective is to aid in the best possible way, our most promising youth to develop into creative scientists, teachers and leaders in the various branches of chemistry. Moreover, we seek to have a faculty who themselves will be the most creative and productive chemists in the world, to uncover new knowledge and to achieve a deeper understanding of changes in the structure and properties of matter. Also, for non-majors, we seek to provide advanced level courses germane to their specialties.

These objectives are strongly supported within the department, usually in an implicit manner rather than explicitly. However, they are reviewed explicitly in periodic revisions of the various curricula or in connection with new curricula. Also, recent annual reports of the School have included explicit statements of these objectives.

5. Criteria for attainment of objectives

The broad range of our programs leads to a correspondingly large number of criteria for determining the extent to which the objectives are attained. An important criterion applicable to all of the programs is the subjective views of the students, preferably a few years after they've left the campus. Another is the placement record of the graduates and the level of their subsequent attainments.

At the graduate level, the ACE ranking of the department, or other national ratings of specific areas, is an important criterion as is the external recognition (prizes, awards, lectureships, professional offices) accorded to the faculty.

6. Educational role of program

The overwhelming majority of our objectives are educational in character, as stated in part 4. Therefore, the central role of our programs is the education and development of students in chemistry.
7. **Innovation and change**

(1) The restructuring of (what is now) the department so as to reduce its divisionalization, starting in 1967-68, is probably the most significant innovation affecting the department as a whole during the past five years. This is the change described in the first two paragraphs of part 2. It was no longer intellectually satisfying nor profitable in any other way for the (now) department to continue in an organization in which the divisions (analytical, inorganic, physical, and organic chemistry) operated as semi-autonomous units. Rather, the need was clear for increased interaction between faculty and students in the various areas.

(2) The style of conducting graduate research in chemistry has undergone a significant, cumulative change during the past five years. The instrumentation available to the chemists has become considerably more sophisticated and more expensive than previously. As a matter of deliberate policy to meet this development, centralized research facilities containing large numbers of very expensive instruments have been made an important feature of the School. Perhaps most notable are the molecular spectroscopy and mass spectrometry laboratories. These facilities serve the needs of all research personnel who have need for the services provided. Although the cost of the facilities is very high, they provide a large quantity of sophisticated information which has made possible increasingly complex and sophisticated chemical research. In terms of cost effectiveness, the centralization clearly has paid off. Moreover, there is no question that many problems are being solved today with these instruments much more quickly and inexpensively than would have been possible prior to five years ago. The fact that the total cost of the chemical research operation has increased must be taken in the context of the fact that a much larger volume of chemical research is being accomplished than previously.

(3) Many innovative changes have been made in the undergraduate and graduate instructional programs. One notable example is the new integrated undergraduate laboratory program, locally referred to as the "Core Lab Program." A description of this program written by Professor T. L. Brown, appeared recently as an article in The Journal of Chemical Education. A copy is attached as an Appendix, C.

(4) Another notable example of educational innovation for undergraduates relates to the increased use of the PLATO system. Professor S. G. Smith has achieved world-wide recognition for his imaginative use of the PLATO system in developing new learning materials for students in the undergraduate organic chemistry area, and comparable work has been carried out in relation to the freshman chemistry program.

Two important developments with department-wide implications are in progress: (a) Establishment of a Doctor of Arts in Chemistry program. This has been developed and submitted to the Graduate College, where it is now under review. (b) Further development and testing of PLATO IV lessons in our undergraduate
organic and general chemistry courses. Another major concern of the department is (c) the role and structure on the campus of the broad area of biophysics, biophysical chemistry, and molecular biology. The matter is now being studied by a committee appointed by Vice Chancellor Weir, with Gregorio Weber as chairman.

8. Classification of program

In general, the department is concerned mainly with long-range basic problems of research. However, it also deals with more applied studies which can and have contributed to rapid changes in aspects of our culture and environment.

9. National ranking

The graduate program (overall) of the department was rated 6th, out of about 180 Ph.D. granting programs in the country in the 1971 ACE evaluation by Roose and Anderson, the highest rating not near a coast, mountains or large urban center.

10. Five major problems

In general terms, these are the same as those cited under the report for the School as a Unit, namely quality of space, non-availability of improvement and operating funds, increased budgetary and administrative constraints, and decreased federal support of fellowships and traineeships.

Of these, quality of space is the most critical in some ways because the two oldest buildings of the School, Noyes Lab and Chemistry Annex are occupied by the department. This, coupled with the lack of building or remodeling funds necessitates our occupying substandard space for the foreseeable future. This may lead to losses of some of our most creative faculty and also seriously hurts our efforts to recruit faculty.

The cutbacks in fellowships and traineeships have fallen largely on this department. This has affected adversely its ability to recruit enough high quality graduate students to maintain an optimum size for all of its graduate programs, including graduate students to serve as TAs.

11. Some remedies

Unfortunately, most of the problems require additional funds for their amelioration. However, a more vigorous recruiting program might help the graduate student numbers.

12. Evaluation of teaching

See comments under this heading for the School as a Unit.

13. Training in instructional methods

See comments for the School as a Unit.
14. Unmet demand for instruction

There are no appreciable unmet demands for instruction within the department. Enrollment pressures in the undergraduate organic courses are causing some problems however. See report from that area for details.

15. Guidance and counseling of majors

Advising of undergraduate majors in the department is handled on a centralized basis. There is an advising office, actually half of the time of a full-time person in the General Chemistry office (conveniently located) which maintains records and handles the more routine inquiries. A faculty member (R. L. Belford) is in charge of the overall advising program. He is assisted by a group of 8-10 advisors, most of whom are junior faculty. The usual procedure is to assign a student entering one of our undergraduate programs to a corresponding advisor, who serves that student until he completes or otherwise leaves the program. Also, students have the option of changing their advisor.

Advising of graduate majors is handled on a decentralized basis. A faculty member is appointed by the department head to advise beginning students in each of the areas. The students choose (and change) their own areas; those with unspecified interests are advised by the associate head. The most obvious element of guidance and counseling in the early stages of the student's graduate career involves at first a careful assessment of his background and then of his progress in and suitability for continuing graduate work. This is done initially by the faculty member designated as advisor in the area of the student's interest. As an aid to this process, entering students are required to take a battery of four three-hour exams given in the four traditional areas (analytical, inorganic, organic, physical) shortly before registration. These exams are at the level of our undergraduate courses.

Students whose performance is (roughly) in the lower quartile of a given exam are required to take our corresponding 300-level course(s) in the area. Those in the third quartile are given an option, the course(s) being required as preparation if they plan to take advanced work here in the area. This procedure is designed to ease the adjustment of the entering students to our program.

When the student has made arrangements with one of the faculty to act as his thesis research advisor, usually by the second semester, that person assumes the role of graduate program advisor, and works out with the student a suitable subsequent program of courses and study. The student's progress is charted by means of his course grade record, his performance on the written cumulative prelim examinations which are offered several times during the academic year, and by progress made in the beginnings of his thesis research efforts.

Job placement is handled by the School's Placement Office, as reported in Appendix A, the 1971-72 annual report of the office.
16. Charting progress of students

Much of this is handled as part of the advising and counseling procedures described above in part 15. In addition there are the semi-annual reviews of graduate student progress outlined under part 16 of the School as a Unit report. Our placement record is included in Appendix A.

17. Procedures and factors for promotion, tenure, and salary

The factors considered are the same as those employed at the School level, see part 17 of the School as a Unit report. The internal procedures of the department center on the Committee on Staff. It is charged with developing recommendations to the head of the department for promotion and salary. In the promotion and initial appointment review, it seeks the advice of the faculty in the area of the person under consideration. Customarily this consultation for promotions includes only those at a higher rank, while for initial appointments it includes those of the proposed rank as well.

18. Faculty lost

<table>
<thead>
<tr>
<th>Year</th>
<th>Name</th>
<th>Rank</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>1967-68</td>
<td>Baldwin, John E.</td>
<td>Assoc. Prof.</td>
<td>Univ. of Oregon, Professor</td>
</tr>
<tr>
<td></td>
<td>Denning, R. G.</td>
<td>Asst. Prof.</td>
<td>Oxford University, Lecturer</td>
</tr>
<tr>
<td></td>
<td>Todd, Lee J.</td>
<td>Asst. Prof.</td>
<td>Indiana Univ., Assoc. Prof.</td>
</tr>
<tr>
<td>1968-69</td>
<td>Goodisman, Jerry</td>
<td>Assoc. Prof.</td>
<td>Syracuse Univ. Asst. Prof.</td>
</tr>
<tr>
<td></td>
<td>Moeller, Therald</td>
<td>Prof.</td>
<td>Arizona State, Dept. Chairman</td>
</tr>
<tr>
<td>1969-70</td>
<td>Bloomfield, V. A.</td>
<td>Assoc. Prof.</td>
<td>Univ. of Minnesota, Assoc. Prof.</td>
</tr>
<tr>
<td></td>
<td>Juvet, Richard S.</td>
<td>Assoc. Prof.</td>
<td>Arizona State, Professor</td>
</tr>
<tr>
<td></td>
<td>Woody, Robert W.</td>
<td>Asst. Prof.</td>
<td>Arizona State, Assoc. Prof.</td>
</tr>
<tr>
<td>1970-71</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1971-72</td>
<td>Beattie, James K.</td>
<td>Assoc. Prof.</td>
<td>Univ. of Sidney, Australia</td>
</tr>
<tr>
<td></td>
<td>Teipel, John W.</td>
<td>Assoc. Prof.</td>
<td>Ortho Products Co., Research Chemist</td>
</tr>
</tbody>
</table>

Besides noting those whom we've lost, it's at least as important to list those whom we might have lost but haven't. Most of our top faculty have been sought very actively by other institutions but have elected to stay at Illinois because of our strong efforts to provide a superior environment for their teaching and research. Faculty in this category during the past five years include at least the following, most of whom have been propositioned more than once and some a half-dozen times or more: Bailer, Beak, Brown, Drago, Flygare, Gutowsky, Haight, Jonas, Laitinen, Leonard, Marcus, Martin, Rinehart and Yankwich.
19. **Measures of cost effectiveness**

Two aggregated measures may serve the purpose best: (1) cost in state dollars per degree granted and (2) cost in state dollars per instructional unit delivered. However, consideration must also be given to the quality of the degree recipients and of the instruction delivered.

20. **Comments**

See those given under the School as a Unit and School Shops and Services.

21. **Evaluation timetable**

See statement in report for the School as a Unit.

Submitted by: [Signature]

H. S. Gutovsky
Head of Department
RESOURCE OUTLINE
FY 1972-73 (Estimates)
SCHOOL OF CHEMICAL SCIENCES
Department of Chemistry (22-86)

PART I -- RESOURCE OUTLINE

<table>
<thead>
<tr>
<th>FTE</th>
<th>Academic Staff</th>
<th>Related $</th>
<th>FTE</th>
<th>Nonacademic Staff</th>
<th>Related $</th>
<th>Wages $</th>
<th>Expense $</th>
<th>Equipment $</th>
<th>Total $</th>
</tr>
</thead>
<tbody>
<tr>
<td>113.73</td>
<td>1,338,600</td>
<td>25.30</td>
<td>208,400</td>
<td>15,700</td>
<td>132,800</td>
<td>--</td>
<td>1,695,500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.70</td>
<td>60,200</td>
<td>0.50</td>
<td>2,300</td>
<td>3,100</td>
<td>27,900</td>
<td>128,900</td>
<td>222,400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>102.55</td>
<td>799,900</td>
<td>5.70</td>
<td>48,300</td>
<td>30,800</td>
<td>572,100</td>
<td>189,200</td>
<td>1,640,300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>225.98</td>
<td>2,198,700</td>
<td>31.50</td>
<td>259,000</td>
<td>49,600</td>
<td>732,800</td>
<td>318,100</td>
<td>3,558,200</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Analytical 12.6  $449,100
2. Biophysical 5.8  207,300
3. General 15.3  544,200
4. Inorganic 14.4  511,100
5. Organic 28.9  1,027,700
6. Physical 23.0  818,800

Totals 100.0  $3,558,200

1 This includes grants from the Research Board, and University Fellowships.
2 Direct costs only; indirect costs average an additional 24%. Direct support obtained via the Materials Research Lab is included here. Funds granted to chemistry but used for School facilities are listed under the School and excluded here.

PART II -- ESTIMATED BREAKDOWN BY PROGRAM

There are two ways in which the programs of the department can be described. One is in terms of the various degrees offered. These include the undergraduate major and the professional curriculum, an MS in the Teaching of Chemistry, the MS and PhD in Chemistry, the joint chemistry-physics program in Chemical Physics, and the very large amount of service teaching at virtually all levels. The second is in terms of the different areas of chemistry. The latter is the way in which our fiscal data are ordinarily organized and is the basis used in preparing the breakdown given below. The General Chemistry (freshman) program is entirely undergraduate instruction, all from state funds. As a rough estimate, the other costs assignable to the formal teaching program of the department (excluding Chemistry 499) are about half of the remaining state funds, i.e. $676,000 which, along with the $544,000 for the General Chemistry program, make up about 30% of the grand total. This does not include costs at the School level.

<table>
<thead>
<tr>
<th>% Share</th>
<th>$ Amount</th>
<th>% Share</th>
<th>$ Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Analytical</td>
<td>12.6</td>
<td>$449,100</td>
<td>4. Inorganic</td>
</tr>
<tr>
<td>2. Biophysical</td>
<td>5.8</td>
<td>207,300</td>
<td>5. Organic</td>
</tr>
<tr>
<td>3. General</td>
<td>15.3</td>
<td>544,200</td>
<td>6. Physical</td>
</tr>
</tbody>
</table>

Totals 100.0  $3,558,200

11/1/72
Only those questions are answered for which the circumstances differ from those given in the report for the department or for which the particular details augment the departmental report.

6. Educational role of program

In general these are the same as for the department. In more specific terms, Chem 229 and 329 provide basic preparation for students wishing a solid background in environmental chemistry, whether they be chemistry majors or students with other interests in the physical and/or biological sciences. Also, Chem 122 serves primarily as a service course for students in the life and health sciences who need to know the principles of analytical chemistry.

Chem 323, electronics and instrumentation serves both undergraduate and graduate students, mainly in chemistry but also in other departments and colleges. The other graduate courses Chem 421, 422, 424, 425 are primarily designed as a background for research in analytical chemistry, but they also serve a few students from other areas and/or departments.

7. Innovation and change

The most significant innovation fostered and aided by the analytical chemistry faculty and program is the development of a campus-wide Environmental Studies Program. This effort is described in detail in a separate report.

In addition, several important course changes have been made. Chem 229 has been developed and Chem 329 has been revised to provide instruction in environmental chemistry, as outlined in item 6 above. Chem 122 has recently been changed from a 5-hour to a 3-hour format, and revised to emphasize quantitative analysis relevant to life science students. Chem 323 has been further developed to emphasize digital electronics, automation, and computer interfacing with analytical instruments. Chem 322 has been revised to emphasize separation methods relevant to biochemistry and to modernize the approach to functional group analysis.

8. Classification of program

The environmental chemistry component of the program deals with shorter-range problems, the solution of which is of immediate concern to our society. The other aspects of the teaching and research program emphasize fundamentals and long-range basic problems.
9. National ranking

In a recent informal survey (Appendix D) of graduate analytical programs similar to the ACE study of graduate programs in general, Illinois rated fourth with Purdue, Wisconsin, and North Carolina being first, second, and third.

10. Five major problems

These in general are the same as described in the report on the School as a Unit, with the exception that the quality of the space available is high. (The program is located in the new addition of Adams Lab.) More specific problems are similar to (1) and (2) given under item 10 in the report on the Environmental Chemistry Program.

Three problems particular to the analytical program are the following:

(1) Several items of major equipment, such as ESCA, electron microprobe, scanning electron microscopy, X-ray fluorescence, most of which can be shared with other SCS areas or departments, are needed.

(2) A space shortage probably will become acute with the increasing demand for graduate education in analytical and environmental chemistry.

(3) There should be renewed emphasis on training of advanced teaching assistants. Analytical chemistry has greater emphasis on advanced lab than any other area of chemistry. Our past individual efforts have not been continued during the past few years, due to lack of support.

11. Some remedies

Although many of the problems require additional funds some, such as the shortage of space, can be met at least in part by internal adjustments within the department or School.

14. Unmet demand for instruction

See response under Environmental Chemistry report.

21. Evaluation timetable

Our staff is in such a state of flux that it would be better to postpone an in-depth study until a greater degree of stability is attained.

Submitted by: H. A. Laitinen
Professor of Chemistry
3. Relation to other programs

Inorganic chemistry is most closely related in both an historical and intellectual sense to the other areas which define the field of chemistry, e.g., organic, physical, and analytical chemistry, biochemistry, and chemical engineering. It forms an important element in the general field of materials science, and as such is related to research activity in the Materials Research Laboratory. Several of the faculty with a strong element of inorganic research interest have, or have had, affiliation with the Materials Research Laboratory (Bailar, Belford, Brown, Stucky).

In general, inorganic chemistry relates to physics, chemical physics and physical chemistry in the sense that it serves as a source of new materials, and of methodology with respect to their preparation. It relates on the other hand to the more applied sciences by serving as a source of fundamental information about the chemical behavior of materials which may play an important role in these applied sciences. As an example, an understanding of the chemical behavior of the metallic elements is essential to an understanding of the mechanism by which metal ions are taken up by plants.

Many of the substances of greatest interest at present as environmental pollutants are inorganic, and an understanding of their inorganic chemistry is essential to an understanding of their distribution in nature, i.e., in plants, water bodies, animals, etc. Similarly, the inorganic chemistry of many of these contaminants is an essential feature of their detection and quantitative estimation. Inevitably, therefore, inorganic chemistry finds a place in interdisciplinary activities aimed at understanding and controlling distribution of pollutant materials in the environment.

Geochemistry and cosmochemistry are important sub-fields within the larger field of geophysical sciences. The understanding of atmospheric chemical processes, an essential aspect of the science of aeronomy, involves both inorganic chemistry and techniques and methodologies which are commonly ascribed to modern physical-chemical approaches to gas-phase kinetics.
In addition to the above-named disciplines, inorganic chemistry often appears in an important role in several other areas of applied science such as soil chemistry, plant physiology, dairy science, food science and food technology, and, of course, biochemistry.

4. Major objectives

With the understanding that the two are not entirely separable, it is nevertheless possible to distinguish between research goals on the one hand and other objectives and goals on the other. With respect to the first, the long-range goals of the research programs in inorganic-organometallic chemistry are to uncover new knowledge, develop new concepts and methodologies in the broad areas of inorganic and organometallic chemistry, and to exploit these in achieving a deeper understanding of the major fundamental processes involved in the various areas of applied science in which inorganic and organometallic chemistry play a role. Such objectives and goals are not of course explicitly stated; they are embodied implicitly in the activities of the faculty, postdoctoral research associates and graduate students working in the area. These research activities are designed to provide training for postdoctoral research associates and graduate students in inorganic and organometallic research. The objectives of this activity are to provide trained men and women for teaching and research positions in academic institutions, and for research and managerial positions in industrial and governmental organizations. Although the proportion has varied somewhat over the past several years, about two thirds of those receiving Ph.D. degrees find their way into teaching positions. Of these, perhaps half establish independent research programs; the other half are engaged mainly in teaching. Most of the remaining one third of those with a Ph.D. find employment in industrial laboratories, mostly in research activity.

5. Criteria for the attainment of objectives

The quantitative aspects of our objectives relate most obviously to the number of students graduated, and the number and types of positions they have filled. The inorganic program at Illinois has traditionally been one of the largest in the United States. Over the past few years, the size of this program, with respect to both faculty and the number of graduate students and postdoctoral research associates, has remained about constant. This has been the case in large measure because of the insistence upon very high standards. Some measure of the success of the inorganic program is given by the following data relating to the presently held positions by those receiving their Ph.D.s during the eleven-year period 1961-1971 (inclusive):

- Faculty positions in Ph.D.-granting department: 43
- Industrial research position: 44
- College teaching: 45
- Governmental research laboratory: 7
- Other: 7

Total Ph.D.s granted: 146
These data show that a large fraction of our graduate students have been able to obtain positions in high quality institutions in the face of very competitive situations. Of those in the "Other" category, a couple have dropped from chemical activity altogether, and the others are employed in jobs in which their graduate training is not an essential component.

While specialization within the larger area of chemistry is not particularly encouraged for students at the undergraduate level, it might nevertheless be pointed out that many undergraduate students who decide to major in chemistry elect also to undertake a senior thesis project within the field of inorganic chemistry. Most of these students, if they go on to graduate school in chemistry, elect to work in the area of inorganic chemistry and eventually receive a Ph.D. in this area. Also, these students, of course, do their graduate work at another institution.

6. Educational role of program

The answer to this question, as it applies to the education and development of graduate students, is self-evident on the basis of the answers provided above. The program provides an essential element of guidance and training in development of the capability of independent research activity on the part of a young man or woman who aspires to obtain the Ph.D. degree. The advice and guidance is provided mainly by the thesis director. Additional training elements include the program of graduate courses offered by the faculty of inorganic-organometallic chemistry, and the seminar program in this area.

With respect to undergraduate students, inorganic chemistry is involved in the teaching of general chemistry in the sense that several of the faculty and many of the inorganic graduate students teach in this program. In addition, inorganic chemistry is taught as an advanced undergraduate level course which is commonly taken by students majoring in chemistry, as well as students from other areas. An advanced undergraduate inorganic laboratory course is offered as an elective laboratory in the chemistry curriculum program. Senior undergraduate thesis research may be carried out in inorganic chemistry. Inorganic chemistry thus serves to provide an essential and important element in the undergraduate training of students in the chemistry curriculum, and as a resource for students in other areas desiring an acquaintance with inorganic chemistry.

7. Innovation and change

Many of the changes which have occurred in the inorganic-organometallic program in the past five years have been of an evolutionary nature, and thus the individual, incremental changes do not of themselves seem to be very striking. The overall effect, however, is of a rather dramatic change in the nature and style of graduate training. One of the most important changes has been a broadening in the scope of the course offerings. The most recent offerings include organometallic chemistry, kinetics and mechanisms of inorganic reactions and theoretical aspects of inorganic chemistry. While an individual graduate student is not required to take all of these courses (the course requirements for individual students have in fact been reduced), the overall effect has been to develop a much less rigid and formal style, and to encourage interest in a broader range of chemistry.
We have seen the beginnings also during the past five years of increased interest in "interdisciplinary" activity, in the sense that research activity has begun to turn increasingly toward problems which have implications for other areas of science such as biochemistry and atmospheric sciences. The interface between inorganic-organometallic and biochemistry has been of particular interest, and quite close ties have developed. Indeed, one of the more promising possibilities for the future is course offerings jointly taught by members of the inorganic-organometallic group and faculty from other units, in which the relationships between inorganic and organometallic chemistry and the other areas are more fully explored and exploited. Plans are underway to offer a course in the next year or so in "Inorganic Biochemistry."

In addition, a seminar program centered on bioinorganic chemistry is planned. The possibility exists of joint appointments at some time in the future between biochemistry and inorganic areas. Professor Brown has recently developed a research interest in the area of aeronomy, and it is anticipated that interactions with the faculty in the department of electrical engineering (Professors Bowhill and Sechrist) will develop over the next few years.

8. Classification of program

It is evident that the style and character of the inorganic-organometallic program deals with long-range basic research. Nevertheless, the path from academic research to its appearance in the industrial market place, such as in the methodology of pollution control, is relatively short. The impact of science and technology on our culture and the environment is cumulative; it is difficult to single a particular invention or technical development as, in itself, creating a major impact. For example, the development of a low-pressure process for the production of polyethylene is certainly one of the most important economic-industrial chemical achievements of the last two decades. This process was developed in European academic research laboratories, and quickly found its way into the industrial economy. The result of this is that polyethylene is a ubiquitous feature of our environment. And yet, is it possible to say that it has made a major impact on our culture or environment? One would be more likely to argue that chemical technology as a whole, by providing a host of new materials, and by drastically changing economic factors in the synthetic versus natural product competition, has made a major impact, because it has provided a material basis for changes in life style.

One does not normally find chemists working on solutions to particular societal problems, although chemists might, for example, seek solutions to a particular environmental pollution problem. Such activities in the normal course of things do not generally involve fundamental research, but rather involve application of an already established body of knowledge to the solution of a particular problem. As such, activities of this kind do not easily fit within the framework of academic research. Nevertheless, it is a fact that the proliferation of new catalytic systems and the availability of low-cost processes for the production of many new types of synthetic organic materials has provided the basis for a major change in the materials situation, and that changes are felt in every aspect of contemporary life.
9. National ranking

We are not aware of any formal evaluations of inorganic-organometallic chemical programs within the various degree-granting institutions in the United States. Nevertheless, there are several reasons for asserting that the program at Illinois ranks among the top few in the United States. The research programs of the inorganic-organometallic faculty have consistently been well-funded by federal agencies such as NSF, NIH, the Air Force Office of Scientific Research, etc. The faculty have also received several of the major awards which might accrue to members of the academic chemical profession in general and to inorganic and organometallic chemists in particular.

For example, Professor Bailar has been awarded the Distinguished Service Award in Inorganic Chemistry, the Priestley Medal of the American Chemical Society, and several other high awards. Professors Drago and Brown have received the Texas Instrument Award of the American Chemical Society in recognition of research accomplishment in inorganic chemistry. Professors Beattie and Brown have been Alfred P. Sloan Research fellows.

Ph.D. and postdoctoral research associate alumni of the inorganic-organometallic area have consistently been able to compete for high-quality positions in academic institutions, as described above. Despite the recent decline in interest in the pursuit of graduate work in chemistry, occasioned by a temporary dislocation in the job market, we continue to receive interest on the part of very high-quality students in pursuit of graduate training in inorganic-organometallic chemistry.

Submitted by: T. L. Brown
Professor of Chemistry
Only those questions are answered for which the circumstances differ from those given in the report for the department or for which the particular details augment the departmental report.

3. Relation to other programs

A number of other programs on campus are closely related to organic chemistry, especially by means of collaborative research projects. One of our staff (Curtin) has a joint appointment in the Materials Research Laboratory. Collaborative research undertaken in the past or under present investigation include joint projects with the Department of Physiology (Katzenellenbogen), Entomology (Katzenellenbogen), Plant Pathology (Rinehart), Dairy Science (Rinehart), Microbiology (Rinehart), Biochemistry (Leonard and Rinehart). Within our department, organic staff members have carried out joint research projects with chemists in the biophysical, inorganic and physical areas. Some of our staff members (Leonard, Paul, Rinehart) have joint listings in the biophysical and analytical areas.

Teaching interests are also shared with some of the other departments: Professor Smith has made a major contribution to the teaching of chemistry through the PLATO program, in association with the Computer-based Education Research Lab; Professors Katzenellenbogen and Rinehart have taught courses in Veterinary Pharmacology.

4. Major objectives

The major objectives of organic chemistry are shared with the other areas of the department. In particular, we seek to maintain and enhance our national reputation for excellence in research and superior training of professional chemists. At the same time we seek to continue to provide stimulating instruction to students, non-majors as well as majors, in organic courses designed to reflect the current state of the art.

5. Criteria for attainment of objectives

Criteria by which our efforts in research can be evaluated should include national evaluations, such as the ACE report, publications in recognized journals, research awards to the staff, invited lectures by staff members, job offers to staff members, service as consultants to government and industry, and elective or appointed positions to national offices in the American Chemical Society. Our training of professional chemists can be measured by placement of graduating students in superior positions and attraction of first class students to our graduate program. Evaluation of the teaching function can best be made in the long run by teaching awards to the staff and by the productivity and status of our graduates. In the short run, evaluations can be gleaned from such student evaluations as those carried out by the Advisor, the Student Affiliates of the American Chemical Society, and the Office of Instructional Resources.
6. Educational role of program

The organic program has traditionally had the largest number of students pursuing graduate studies in the department; thus, the organic staff assumes a major role in the teaching of graduate students within the department. Organic graduate courses are taken by students from many other departments as well, including Biochemistry, Plant Pathology, Microbiology, and Dairy Science. On the undergraduate level, organic courses serve not only to train professional chemists but also serve exceptionally large numbers of other students. Chemistry 131, 134 and 336A are largely designed to teach the large numbers of premedical, predental, and preveterinary medical students on our campus, as well as biology students. However, increasing numbers of these students (especially the premedical students) are taking courses designed for chemistry majors—Chemistry 136, 181, and 337.

The organic staff also has made a major commitment in the past five years to the teaching of general chemistry. Professors Beak and Coates have taught Chemistry 102, Professors Rinehart and Katzenellenbogen have been involved in designing and revising the television version of Chemistry 102 and have prepared and delivered television lectures in that course. Professor Leonard is developing Chemistry 103, a terminal general chemistry course for non-majors, which will be offered for the first time next spring.

7. Innovation and change

A number of innovations have been made during the past five years in both the teaching and research functions. At the undergraduate level, a major innovation was introduction of the core laboratory program, which aims to give chemistry majors a common background in laboratory chemistry. This lab program supersedes the previously compartmentalized organic, physical, inorganic, analytical laboratories. (See Appendix C.)

Also, as noted above, much of the revision and innovation in general chemistry has been aided materially by organic faculty. This includes the development and revision of televised general chemistry (Chemistry 102) and the development of the new terminal course (Chemistry 103), primarily for agriculture and biology students. In response to student suggestions, the intermediate organic course, Chemistry 336 has been split into two sections, reflecting the interests of its clientele toward the biological or the physical side of organic chemistry. Other innovations at the undergraduate level include establishment of tutorial clinics, available to students in all organic courses but especially valuable in the larger courses, and of optional discussion sessions in some of the larger courses.

At the graduate level, replacement of written preliminary examinations by the cumulative exam system has now been joined by the replacement of an oral preliminary examination by a written paper on the research carried out to that point by the student. This paper provides an effective evaluation of a student's progress toward the Ph.D., which is a research degree. Evaluation of the research facet of a student's progress is provided also at the end of the first year by a first-year paper on his research.
Although it is outside the formal teaching function of the department, note should be made of the Wednesday Night at the Lab (Relevant Chemistry) lectures, to which the organic staff has made a major contribution. These lectures are designed for the general public but have attracted students in chemistry courses as well.

Innovations in research have involved largely the acquisition of superior research instrumentation, notably in nuclear magnetic resonance and mass spectrometry. These instruments have been purchased with research grants, some to organic staff.

8. Classification of program

Although our program is geared more toward the solution of long-range basic problems, a testimony to the practical applications of the research may be found, for example, in several patents applied for by the University or granted to it resulting from the research of organic staff members.

9. National ranking

No formal comparison of the organic chemistry program here with organic programs at other institutions is available. One can note individual recognition which reflect the stature of the organic staff. Professors Leonard and Curtin are members of the National Academy of Sciences, Professors Martin and Rinehart have recently served on the National Executive Committee of the Organic Division of the American Chemical Society, Rinehart ran unsuccessfully for Chairman of that Division. Professors Leonard and Martin have been invited to speak recently or will speak soon at the biennial national symposium held by the Organic Division of the American Chemical Society.

10. Major problems

(1) Diminished or static operating funds in a period when the size of organic courses is increasing rapidly. This makes it much more difficult to innovate, since many of the desirable major innovations center around changes in laboratory courses and the use of PLATO programs, both of which are initially expensive.

(2) The geographical division of the department. Isolation from major components of the department such as the Chemistry Library, the departmental office, the Mass Spectrometry Laboratory--provides energy barriers to an effective program. It is also significant that recent trends are toward interactions with groups in Roger Adams Laboratory (especially biochemists) rather than toward groups in Noyes Laboratory (physical, inorganic chemists).

(3) Static faculty size. Only one retirement can be foreseen within the next ten years and the remaining nine tenured faculty can be expected to grow old gracefully together. Yet we need innovative young faculty to provide fresh infusions of outside air.

(4) Difficulty in maintaining continued national recognition and visibility--the "Illinois (Adams-Marvel-Fusion) image."

(5) Difficulty in recruitment of first class graduate students.
11. **Some remedies**

Problems (1) and (2) in part 10, can be relieved by increased funds.

Problem (3) can be addressed either by expanding the organic staff or by turnover of present staff.

Problem (4) might be attacked by more actively supporting organic faculty for awards or positions of responsibility in national organizations. Also, it might be helpful if the organic staff sought greater recognition through lectures elsewhere, or via publications.

Problem (5) can probably best be met via approaches to solving Problem (4).

12. **Evaluation of teaching**

Note is taken of the formal evaluations by the Advisor, the Student Affiliates, and the Office of Instructional Resources. In addition, students in courses are encouraged to discuss any problems of communication with their instructors.

13. **Training in instructional methods**

See department and School reports. Rotation of course teaching assignments among the organic faculty on a regular (2-3 year) basis encourages regular introduction of new material and methods.

14. **Unmet demand for instruction**

Chemistry 131 has become very large and the class now fits only into rooms not originally designed as lecture halls. This is a particular problem in the examination process. Chemistry 134 is very near the absolute capacity of that laboratory (467 N.L.). Moreover, the lab has inadequate desk space, aisle space, hoods and ventilation.

15. **Guidance and counseling of majors**

See department report. Undergraduates who enroll in senior research (Chemistry 290) develop a close relationship with their research advisors, who often provide considerable additional input to their career decisions. The same close relationship holds between our graduate students and their Ph.D. advisors.

It should be noted that our alumni who are dissatisfied with their current status (unemployed or with unsatisfying jobs) very often avail themselves of the continuing services of the School's Placement Office. Other students in departments on campus also use the office, which maintains a roster of students looking for part-time or full-time jobs locally.

Submitted by: K. L. Rinehart
Professor of Chemistry
PROGRAM REVIEW QUESTIONNAIRE

Fall, 1972

SCHOOL OF CHEMICAL SCIENCES

Department of Chemistry - Physical Program

Only those questions are answered for which the circumstances differ from those given in the report for the department or for which the particular details augment the departmental report.

3. Relation to other programs

The physical chemistry program has strong interests in common with all of the areas and departments of the school, inorganic, organic, analytical, biochemistry and chemical engineering, and also with parts of physics, the Materials Research Lab, nuclear engineering and computer science. It has both students and staff in common with most of these areas. As to similarity of courses, this is most appreciable in the cases of physics and inorganic chemistry.

5. Criteria for attainment of objectives

A number of criteria are suitable for this purpose, including the ACE rating of graduate programs, awards to staff, employment statistics, and alumni achievement as manifested in awards and advancement to responsible positions.

7. Innovation and change

Although there have been no dramatic particular developments there have been a sizeable number and variety of changes which, in aggregate, have had substantial impact upon the quality and direction of our program. At the graduate level, for example, faculty have been added who have strong interests in molecular beams and statistical mechanics, areas not previously covered by the program.

There has been continued revision and evolution of our courses, especially those related to biophysical chemistry. Perhaps the most important curricular change is development of the core lab program (see department report and Appendix C), which incorporates what was previously a physical chemistry laboratory course—a development in which the faculty of this program had a large hand.

8. Classification of program

Our program is geared primarily towards long-range basic problems of research.

9. National ranking

No ranking of the physical chemistry program is available. However, many of its faculty have received awards or national recognition of one sort or another.
Three (including Harry Drickamer—joint with chemical engineering) are members of the National Academy of Sciences and six have been awarded A. P. Sloan Research Fellowships. Indicators such as these place the program among the top handful or so in the country.

Submitted by: J. P. Hummel
Professor of Chemistry
3. Relation to other programs

This program is very largely a set of introductory courses required in a wide variety of curricula. It has much in common with freshman-level service courses in other experimental sciences such as biology, physics and even psychology. Because of its central character its students came from a wide range of sources, mainly engineering, agriculture, biology, and pre-professional programs.

4. Major objectives

The primary objective is to serve the needs of our clientele. These needs require us to provide:

(1) A solid foundation for future chemical scientists.
(2) An interesting, relevant course in chemical principles and knowledge for applied scientists and scientists in other fields.
(3) Teacher training for graduate chemists via their service as TAs.
(4) An effective system for the education of large numbers of students in chemical fundamentals, most of whom will not pursue chemical studies any further.

5. Criteria for attainment of objectives

Our objectives are relatively specific and each lends itself to correspondingly specific criteria. These are, respectively, as follows:

(1) Performance of chemistry majors as chemists. The level of interest in and quality of students in upper level courses in the department.
(2) Assessments by students in other fields of the worth of these courses to their intellectual and professional development or training, especially after they have graduated and applied their education for several years.
(3) Standing of departments in which our Ph.D.s teach.
(4) Degree of consultation with us and adoption of our methods by other institutions.
6. **Educational role of program**

As stated in item 4, the role of the program is entirely educational in character. Undergraduates gain basic insight into knowledge of the atomic and molecular world and how it is obtained, insight which is necessary to the sane management of the world’s matter. Graduate students receive training as TAs in the art of passing on their knowledge to the next generation, as well as firming up their own basic knowledge.

7. **Innovation and change**

There has been a great deal of experimentation and new developments in the program. The effective and efficient instruction of 2,500 to 3,000 students presents a formidable challenge, to which we have tried to respond.

In 1968 we introduced Chemistry 100, a two-hour remedial course for people having no high school chemistry. In this course we have developed the use of audio-tutorial techniques in chemistry teaching and experimented with open laboratories. The course has grown from 120 per year to about 700 for 1972-3.

Also, in 1968 we undertook the use of closed circuit television for lectures in the large Chem 101-2 service course, via videotapes. TV lectures to large audiences proved largely unsuccessful but in 1971, the availability of tape players and cassettes allowed us to reduce class size to about 24 students, with lecture material controlled by the teaching assistant. Tapes can now be interrupted at any time for questions and discussion. This format has been much more favorably received by both students and TAs. Current revision plans include the preparation of color tapes for all lecture material in the course. These developments have taken and require major efforts; more detailed reports are available.

In 1967, we broadened the content of the service course (Chem 101-102) to include organic chemistry. A further revision is now underway to create a course with greater appeal through emphasis on natural systems and materials and the need to manage the world’s matter. Much attention will be paid to the motivation of non-major students and the content will be adjusted to meet the needs of those who will take no further chemistry. To this end the second semester is being divided into:

- **Chem 102-B** - for students inclined toward biological sciences.
- **102-P** - for students inclined toward physical science.
- **103** - organic chemistry for agriculture students.

These courses will begin to appear in 1973 and 1974.

The Chemistry 107-8 laboratories, for chemical sciences majors, have been redesigned to give bonafide training in quantitative laboratory techniques. The laboratory now has been designated as separate courses Chem. 109-110.

A number of PLATO programs have been developed for general chemistry courses and intensified experimentation with PLATO IV is planned for the next few years.
8. **Classification of program**

   Does not apply.

9. **National ranking of program**

   Nothing specific is available. However, anecdotal comments from former TAs and staff members now at other institutions and also from visitors indicate that our program compares favorably with the better ones in the country.

10. **Major problems**

    Besides the general problems of the department, there are several peculiar to this program.

    (1) The main problem is size of program coupled with lack of motivation of students in the big service course. This brings up the question of worth for any innovation.

    (2) Laboratory facilities and equipment need a complete overhaul for the non-majors program.

    (3) The continuity of staff is inadequate for such a large operation. The intellectual level does not lend itself to frequent repetition of assignments by senior staff; TAs are transient.

11. **Some remedies**

    A means should be found to provide greater continuity in the senior faculty who teach in the program, and their number should be increased.

12. **Evaluation of teaching**

    For faculty, their teaching is evaluated by Advisor and other student ratings. (See School report) and also via general impressions gained through mutual discussions and observation of classroom performance.

    The evaluation of TAs is based on class visitation by faculty, formal discussion of teaching problems, and by student ratings.

20. **Comments**

    I'm very dubious about student evaluations - especially for beginning courses. Extreme students - A's and failures - especially the latter, are most prone to comment.

Submitted by:  
G. P. Haight, Jr.  
Program Director
PROGRAM REVIEW QUESTIONNAIRE

Fall, 1972

SCHOOL OF CHEMICAL SCIENCES

Department of Chemistry - Environmental Chemistry

1. Structural outline of unit

The School of Chemical Sciences has cooperated extensively in the campus-wide efforts to develop an Environmental Studies Program. These efforts on our part have included faculty and students from all three of our departments, for example John Wood in bio, John L. Hudson in chemical engineering, and D. F. S. Natusch and H. A. Laitinen from the analytical program in chemistry, among others. An overall report on the Environmental Studies Program (ESP) is being submitted by its director, B. B. Ewing. However, because of the strong interaction of ESP with our analytical chemistry program it seems desirable to comment separately on those aspects of the program which are of more immediate concern to chemistry, and which are not adequately covered in the other reports for it.

The part of ESP with which we are directly involved is the Metals Task Group, supported by a major RANN grant from NSF. (That support is not included in our financial data.) The Group is directed by Professor H. A. Laitinen, whose appointment is funded 1/2 time from the NSF grant. One of the analytical faculty, D. F. S. Natusch is a faculty participant in the task group. Two analytical graduate students are working in this task group and 11 others are working in other areas of environmental science, supported by grants not included in ESP.

2. Operational structure

See ESP report for overall structure. In the Metals Task Group, an interdisciplinary Coordinating Committee makes decisions concerning policies. H. A. Laitinen is chairman, with B. B. Ewing, R. L. Metcalf, Glenn Salisbury, John Pfeffer, J. B. Hanson, R. Boggess, and B. W. Carnow as members.

The research effort itself is administered by a Steering Committee composed of group leaders as follows: H. A. Laitinen (chairman), air-soil-water-plant continuum team; A. M. Hartley, analytical laboratory; B. B. Ewing, modeling team; G. L. Rolfe, general ecosystem team; F. A. Bazzaz, plant studies team; R. M. Forbes, animal studies team.

3. Relation to other programs

There are of course strong interactions and cooperative efforts with ESP on the one hand and the analytical chemistry program on the other, as well as with other areas in the School, such as biochemistry and chemical engineering.
4. **Major objectives**

The general objective is to develop a strong instructional and research program in environmental chemistry. It will serve to broaden the training of graduate and undergraduate students in our School and also to strengthen the foundations of the proposed Institute of Environmental Studies.

5. **Criteria for attainment of objectives**

See ESP and departmental reports.

6. **Educational role of program**

A substantial fraction of analytical chemistry graduate students, perhaps 25%, may be expected in the long run to elect thesis research in environmental science, as well as students majoring in other areas. At the present time, the involvement of H. A. Laitinen and D. F. S. Natusch in this program suggests that even a greater percentage may be thus involved. This is also of interest to undergraduate research students (Chemistry 290) of whom 2 to 3 have been involved in recent semesters. Chemistry 229 and 329 are courses specifically designed as a general introduction to environmental chemistry and for instruction in modern analytical methods as applied to environmental samples.

7. **Innovation and change**

The development of the program is itself the important innovation. Also, Chemistry 329, Instrumental Methods in Environmental Science, has been developed by D. F. S. Natusch during the past two years. Chemistry 229, Principles of Environmental Chemistry, is being offered for the first time in the Fall Semester, 1972. Another new course, Chemical Engineering 386, Introduction to Air Pollution, has been proposed by J. L. Hudson.

8. **Classification of program**

Environmental chemistry is geared to participate in interdisciplinary programs focussed on environmental problems of short and long range importance to society. University involvement in such societal problems are ideally of basic and long range character, but also such as to provide fundamental background for more practical, immediate studies by industry and government.

9. **National ranking**

Many universities are moving in the same direction, as regards the involvement of chemistry groups in environmental research. Although no formal surveys have been made, an informal inquiry made to about 50 universities in May, 1972, concerning recent trends in teaching analytical chemistry led to over 30 responses. Among the most striking trends reported was emphasis on environmental science and on clinical and biochemical analysis. From the number of invitations being received to participate in environmental conferences, it is apparent that our work in the environmental area is becoming recognized as being among the leading research efforts in the field.
10. **Five major problems**

   (1) **Support for basic research on new methodology** - Chemical analysis is recognized as essential to environmental science; but for the most part existing methodology is regarded as adequate, so support for basic research is relatively scarce as compared to funds for application of existing methods.

   (2) **Graduate faculty interested in environmental chemistry** - Student interest in environmental science at present exceeds the capability of our staff to handle it. This does not imply that additional staff members should be hired for this specific field, but that more staff members should devote a fraction of their research effort to the environmental field. There is still a serious overall lack of faculty to handle the demand for Ph.D. students in this field.

   (3) **Special facilities for environmental research** - Our central environmental analytical facility is well equipped only in two areas, atomic absorption spectrometry and anodic stripping voltammetry. A direct reading emission spectrograph, a GC-MS instrument, a pulse polarograph and several other pieces of equipment are needed. Special facilities for air sampling, aerosol generation, and chambers for controlled experimentation with plants and animals are required at other locations.

   (4) **More effective coordination with other work on campus** - The analytical chemistry subcommittee of the Advisory Committee on Environmental Studies, composed of H. A. Laitinen, chairman, A. M. Hartley, C. A. Evans (Materials Research Laboratory), N. S. Shimp (Illinois State Geological Survey) and S. Melsted (Agronomy Department), represents a beginning in this direction.

   (5) **More interdepartmental courses** - A few efforts, such as the joint seminar on chemical and biological effects of pollution by heavy metals given in 1971, have proved to be successful. A more permanent arrangement, presumably through the Institute of Environmental Studies, should be made to plan and offer such courses on a systematic basis.

11. **Some remedies**

   Referring to the responses to question 10, parts (1) and (3) require funds, primarily from external granting agencies for part (1) and from University resources, including CRR funds, for part (3). Parts 2, 4 and 5 require departmental cooperation and involvement of a greater number of staff members.

12. **Evaluation of teaching**

   See department report.

13. **Training in instructional methods**

   See department report.
14. **Unmet demand for instruction**

   See parts (2) and (5) under item 10.

21. **Evaluation timetable.**

   It appears preferable to postpone an in-depth study of the environmental program for 2-3 years to give time for the Institute of Environmental Studies to become properly organized and functioning.

   Submitted by: [Signature]

   H. A. Laitinen
   Professor of Chemistry
### Appendices to Program Review Questionnaire

<table>
<thead>
<tr>
<th>Appendix</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appendix A</td>
<td>Placement Office Report, SCS, 1971-72 (Not included in copies for internal distribution.)</td>
<td>1</td>
</tr>
</tbody>
</table>
Institutional origins of eminent chemical engineers

B. R. Siebring and M. E. Schaff

Earlier we identified the institutions at which eminent chemists received their undergraduate (1) and graduate (2) training. Here we present a similar study of both graduate and undergraduate education of eminent chemical engineers.

Doctoral training

We identified 198 chemical engineers as eminent. Of them, 147 had an earned doctorate granted as shown in Table 1. MIT and Michigan each provided the doctoral education of over ten percent of this group, while nine institutions (including MIT and Michigan) accounted for 56%.

In an attempt to ascertain shifts in doctoral training that had taken place with time, the doctoral origins of eminent chemical engineers were divided into two twenty-year periods (1920-1939 and 1940-1959). Although it was difficult to assign trends because of the small numbers, certain shifts in position were noteworthy. Wisconsin jumped from 7th position (shared with three other universities) in the twenties and thirties to first place with Michigan in the thirties and forties. Illinois also improved its position considerably between the two periods. MIT and Michigan were among the top three in both periods. Ohio State and Yale declined in relative standings.

Universities were classified in various ways to show the contributions of various groups of institutions. For example, nearly forty percent of the eminent chemical engineers received their doctorates at one of the "Big Ten" universities. The universities ranked as the top eleven in terms of quality of graduate faculty in 1966 by the American Council on Education (3) (essentially a compilation of the opinions of experts in the field) were the doctoral sources for better than 55% of the total. Universities in the North Central states provided the graduate education for more than 46% of the eminent chemical engineers, while universities located in the Northeastern states were the doctoral sources for 33%. The contributions from the Southern and Western states were 12% and 8%, respectively, but it was found that the Southern states have gradually increased their contributions at the expense of the Northeastern states.

When members of the National Academies (sciences and engineering) were considered as a group, doctoral training was found to be considerably more concentrated in a few institutions than when the complete group of eminent chemical engineers was considered. The leading doctoral sources of Academy members are in Table 2. We note that Michigan and MIT were doctoral sources for over 40% of this group.

In Table 3 institutions are ranked by the proportion of

Professor Siebring, who holds two baccalaureates—Macalester and University of Minnesota—has an M.S. from the University of Minnesota, and a Ph.D. from Syracuse University. He has been associated with various branches of the University of Wisconsin since 1936. His four texts are in basic chemistry, while his other publications concentrate on the education of scientists.

Ms. Schaff is a lecturer in chemistry at the Milwaukee campus of the University of Wisconsin. Her baccalaureate training was received at Heidelberg College, Ohio, and she holds a Master’s degree from Miami of Ohio. She has been coauthor of several of Professor Siebring's texts, and has also published on educational topics in general.
doctors graduates in chemical engineering, 1940-59, who achieved eminence. This list includes only institutions that had two or more doctoral graduates who later qualified as eminent. The number of doctorates in chemical engineering granted by each institution was obtained from the National Research Council (7). In some cases the ranks in this Table are based on small numbers, and positions could fluctuate considerably on the basis of the eminence of one individual. However, an index of productivity of this sort has an advantage over the rankings presented in Tables 1 and 2 in that this ranking would not necessarily be favored by a large total output of doctorates in chemical engineering.

A comparison of the rankings in this study to those of the American Council on Education shows considerable correlation in spite of the different time periods of the two investigations. The data for the A.C.E. investigation are primarily an evaluation of the departments as they were in the sixties. The data from Tables 1 and 2 cover several decades, and the data from Table 3 cover the forties and fifties. Of the top 11 departments in Table 1, seven are among the top 11 departments in the A.C.E. ranking of quality of graduate faculty. The correlation of Table 2 with the A.C.E. ranking of quality of graduate faculty is less pronounced. However, the correlation between Table 3 (proportion of doctoral graduates who achieved eminence) and A.C.E. ranking of quality of graduate faculty is more pronounced. Here seven of the top nine in Table 3 are also among the top nine in the A.C.E. ranking. Although there was considerable correlation between the rankings in this investigation and those of A.C.E., there was marked disagreement about several individual institutions. For example, Penn State ranked high in all three tables presented in this study, but the A.C.E. research ranked this institution as only "adequate plus" in terms of faculty quality and "acceptable plus" in terms of effectiveness of graduate program. Columbia also did better in the rankings presented here than in those of the A.C.E. study. On the other hand, California

<table>
<thead>
<tr>
<th>Institution</th>
<th>Number of eminent chemical engineers</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIT</td>
<td>19</td>
</tr>
<tr>
<td>Michigan</td>
<td>17</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>12</td>
</tr>
<tr>
<td>Minnesota</td>
<td>8</td>
</tr>
<tr>
<td>Illinois</td>
<td>7</td>
</tr>
<tr>
<td>Columbia</td>
<td>5</td>
</tr>
<tr>
<td>Ohio</td>
<td>5</td>
</tr>
<tr>
<td>Penn State</td>
<td>5</td>
</tr>
<tr>
<td>Yale</td>
<td>5</td>
</tr>
<tr>
<td>California Institute of Technology</td>
<td>4</td>
</tr>
<tr>
<td>Delaware</td>
<td>4</td>
</tr>
<tr>
<td>Princeton</td>
<td>4</td>
</tr>
<tr>
<td>Texas</td>
<td>4</td>
</tr>
<tr>
<td>California</td>
<td>3</td>
</tr>
<tr>
<td>Chicago</td>
<td>3</td>
</tr>
<tr>
<td>Johns Hopkins</td>
<td>3</td>
</tr>
<tr>
<td>Pittsburgh</td>
<td>3</td>
</tr>
<tr>
<td>Purdue</td>
<td>3</td>
</tr>
<tr>
<td>Illinois Institute of Technology</td>
<td>2</td>
</tr>
<tr>
<td>Iowa</td>
<td>2</td>
</tr>
<tr>
<td>Louisiana State</td>
<td>2</td>
</tr>
<tr>
<td>Northwestern</td>
<td>2</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>2</td>
</tr>
<tr>
<td>Rensselaer</td>
<td>2</td>
</tr>
<tr>
<td>Stanford</td>
<td>2</td>
</tr>
<tr>
<td>19 institutions</td>
<td>1 each</td>
</tr>
</tbody>
</table>
ranked higher in the A.C.E. study than in any of the rankings of this investigation. Probably these differences in individual institutions can be explained at least in part by changes in these departments with time.

**Baccalaureate training**

The top institutions as baccalaureate sources are listed in Table 4. The total number of institutions involved in the undergraduate education of this group of eminent chemical engineers was 79. Again, a relatively small number of institutions contributed a large share of these graduates. Illinois, the top-ranking institution, contributed better than 7% and the top three institutions contributed better than 20%. The top 23 institutions, less than one-third of the total group, provided the undergraduate education of more than 60% of the 198 eminent chemical engineers. Comparison of Table 4 with Table 1 reveals that on a total graduates basis the leading institutions in graduate training of eminent chemical engineers are also pretty much the leaders in undergraduate training. Georgia Institute of Technology is a prominent exception to this generalization. This institution did not grant the Ph.D. in chemical engineering until the fifties.

Members of the National Academies were again considered separately. The leading institutions as baccalaureate sources of eminent chemical engineers who became members of the national academies are listed in Table 5.

An attempt was made to compare institutions as baccalaureate origins of eminent chemical engineers, taking size of departments into account. Unfortunately there is little data on total graduates available for the years during which most eminent chemical engineers received their baccalaureates.

An alternate and possibly related index is the proportion of baccalaureate graduates from a given institution who later earned a Ph.D. in chemical engineering. The National Research Council has tabulated the baccalaureate origins of Ph.D.'s in chemical engineering since 1920 (5). In Table 6 institutions are ranked by the number of their graduates who achieved the Ph.D. in chemical engineering during 1965-70.

In Table 7 schools are ranked by the fraction of graduates (1961-66) who achieved the Ph.D. in chemical engineering (1965-70). Data on baccalaureate degrees were assembled by the National Research Council and the A.I.Ch.E. Only institutions who granted three or more baccalaureate degrees to individuals who received the doctorate in 1965-70 are included.

This same ratio was calculated for institutions that granted the Ph.D. in chemical engineering during this period and those that did not. Results were 11% and 7%, respectively. There was little difference in this ratio among geographical areas (11–9%).

**Who is an eminent chemical engineer?**

Some controversy may arise over the definition of an "eminent chemical engineer." Certainly no group can arrive at a definition satisfactory to everyone. Various professional organizations periodically recognize outstanding individuals by awards or other distinctions. Our list of eminent chemical engineers was compiled essentially from those who have been recognized in this manner.
Table 5. Baccalaureate sources of past and present chemical engineering members of The National Academy of Sciences or National Academy of Engineering

<table>
<thead>
<tr>
<th>Institution</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michigan</td>
<td>7</td>
</tr>
<tr>
<td>MIT</td>
<td>5</td>
</tr>
<tr>
<td>Penn State</td>
<td>3</td>
</tr>
<tr>
<td>Case Western Reserve</td>
<td>2</td>
</tr>
<tr>
<td>Columbia</td>
<td>2</td>
</tr>
<tr>
<td>Illinois</td>
<td>2</td>
</tr>
<tr>
<td>Purdue</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 6. Institutions ranked by number of their graduates who achieved the doctorate in chemical engineering during 1965-70

<table>
<thead>
<tr>
<th>Institution</th>
<th>Number of graduates who earned Ph.D.'s during 1965-70</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIT</td>
<td>77</td>
</tr>
<tr>
<td>The Cooper Union</td>
<td>52</td>
</tr>
<tr>
<td>City University of New York</td>
<td>46</td>
</tr>
<tr>
<td>Penn State</td>
<td>40</td>
</tr>
<tr>
<td>Michigan</td>
<td>39</td>
</tr>
<tr>
<td>California (Berkeley)</td>
<td>38</td>
</tr>
<tr>
<td>Cornell</td>
<td>38</td>
</tr>
<tr>
<td>Illinois</td>
<td>37</td>
</tr>
<tr>
<td>Rensselaer</td>
<td>36</td>
</tr>
<tr>
<td>Purdue</td>
<td>33</td>
</tr>
<tr>
<td>Louisiana State</td>
<td>32</td>
</tr>
<tr>
<td>Lehigh</td>
<td>31</td>
</tr>
<tr>
<td>Georgia Institute of Technology</td>
<td>29</td>
</tr>
<tr>
<td>Texas A&amp;M</td>
<td>29</td>
</tr>
<tr>
<td>Texas</td>
<td>29</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>29</td>
</tr>
<tr>
<td>Carnegie-Mellon</td>
<td>27</td>
</tr>
<tr>
<td>Illinois Institute of Technology</td>
<td>26</td>
</tr>
<tr>
<td>State University of Iowa</td>
<td>26</td>
</tr>
<tr>
<td>Notre Dame</td>
<td>26</td>
</tr>
<tr>
<td>Maryland</td>
<td>25</td>
</tr>
<tr>
<td>Polytechnic Institute of Brooklyn</td>
<td>25</td>
</tr>
<tr>
<td>Columbia</td>
<td>24</td>
</tr>
<tr>
<td>Newark College of Engineering</td>
<td>24</td>
</tr>
<tr>
<td>Rice</td>
<td>23</td>
</tr>
</tbody>
</table>

Science designated them as chemical engineers as described in number 1. These awards are sponsored by the American Society for Engineering Education.

5. All individuals whose biographies in Engineers of Distinction (6) described them as chemical engineers, either by indicated specialty, by degrees received, or by position, and who were recipients of recognized engineering awards.

6. Americans whose biographies in McGraw-Hill Modern Men of Science describe them as chemical engineers. The editors of this book describe in the preface those scientists whose biographies appear in these volumes as "... selected from among the recipients of many of the world's prizes in science awarded since 1940" (7).

7. Persons listed as distinguished chemical engineers in the first edition of Leaders in American Science. The editors of this volume characterized their Poll of Distinguished Scientists in the preface with the following words:

The purpose of our compilation is to list the opinions of the scientists themselves as to the most distinguished men and women in their own specialized fields. .. Again, this list of distinguished scientists is not of our own choosing; it is based on the choice of thousands of reputable scientists who themselves did the choosing (8).
8. All recipients of the following awards whose biographies in American Men of Science designated them as chemical engineers as described in number 1: all awards sponsored by the ACS, some of its Divisions and Sections when Section awards were not limited to a small geographical region. We included all recipients through 1969 and those announced through April 1970.

Certainly one could argue that there are eminent chemical engineers in addition to those who have been recipients of the distinctions listed above. On the other hand, we feel that the chemical engineers in the above categories are correctly classified as eminent.

As we found in our study of eminent chemists, many chemical engineer's names appeared several times. Some of them are Warren Kendall Lewis, Richard H. Wilhelm, Olaf Andreas Hougen, Carl F. Prutton, Manson Benedict, Edwin Gilliland, Harry G. Drickamer, Donald L. Katz, Robert L. Pigford, and Thomas K. Sherwood.

Other eminent chemical engineers selected at random from our list include L. E. Scriven, George Platt, John B. Robert, Frederick A. L. Holloway, John R. McWhirter, James Bliss Austin, Harold W. Fisher, Robert Curran, George Oliver Curme, and John J. McKetta.

Institutional origins of the eminent chemical engineers were procured from American Men of Science, Engineers of Distinction, and biographies appearing in Chemical & Engineering News and Chemical Engineering Progress.

As in previous studies, institutional names caused some difficulties because biographers did not always clearly distinguish between institutions such as Washington University and the University of Washington. However, only eight eminent chemical engineers had to be excluded because institutional origins could not be identified. Except in Tables 6 and 7, no distinction was made between University of California campuses, since the biographers did not always clearly identify a specific campus.

References
(4) Harmon, L. R., Director of Research, National Research Council, Office of Scientific Personnel, private communication.
(5) Harmon, L. R., private communication.
The Integrated Undergraduate Laboratory
Program at Illinois

Several years ago a committee in the Department of Chemistry, University of Illinois, was appointed to study the undergraduate chemistry laboratory offerings for students above freshman level, particularly for students majoring in chemistry and chemical engineering. After considerable study and debate, a committee chaired by Professor Peter Beak recommended the initiation of a Core Laboratory Program. In due course, a series of laboratory courses modeled upon the initial recommendations was formulated, and the laboratory sequence was first taught in 1968. It is satisfying to observe that the move to integrate undergraduate laboratory work has been gaining ground in the U.S. during the past few years. With the benefit of several years' experience, it seems worthwhile to take stock of the courses we offer, evaluate their effectiveness as a method of teaching students chemistry, and look toward possible improvements through continuing course development.

The undergraduate laboratory program at Illinois begins with a freshman year directed toward teaching the student quantitative laboratory technique. Some time may be devoted to qualitative inorganic analysis, depending upon the student's background, but the major emphasis is upon developing quantitative analytical techniques. Most of the experiments involve use of 0.1 mg sensitivity balances; instruments such as pH meters and spectrophotometers are used in a quantitative way. The experiments performed are designed to give students some appreciation of the characterization of materials, or to illustrate an important concept being developed concurrently in the lecture. As a general rule, however, no great effort is made to correlate activities in the laboratory with the particular lecture material the student may be learning at the same time. The laboratory time during the first year consists of 4 hr per week of lab and 1 hr per week of lab conference. The lab conference is used to discuss techniques, elaborate upon the principles involved in the experiments, and in general to assist the student to carry on his laboratory work with maximal understanding.

Following the freshman year, the student begins the Core laboratory sequence which consists of three laboratory courses.

In formulating the contents of the sequence, we took the view that the undergraduate laboratory experience should correspond as closely as possible to the contemporary activities of practicing chemists. This meant that the students would need access to relatively sophisticated instrumentation at an early stage in their laboratory development. As a further guiding principle, we took the view that the experiments should as much as possible involve the student in genuinely interesting chemistry. In many instances the experiments are based upon results reported in the recent chemical literature. A strong emphasis is placed on leading the student to see his laboratory work as a process of learning how to go about answering questions through experimentation. Our approach contrasts with the view that the undergraduate laboratory should be primarily a training in techniques. It will be evident from the discussion which follows that students in the Core lab program do receive instruction in many
important laboratory techniques, and have opportunities for using several instruments. The emphasis, however, is on the intellectual content of the experiments rather than on the techniques themselves. We felt we could not hope to bring the student to a point of reasonably high competence in the use of a large variety of laboratory techniques. Rather, we have sought in the Core Laboratory program to teach the student how to go about learning to use any appropriate laboratory tool, and apply it in solving a particular problem.

The first course, Structure and Synthesis(I), carries as prerequisite concurrent registration in the first semester of basic organic chemistry, and completion of the freshman laboratory program as described, or its equivalent. The emphasis in this first course, which meets for one lab conference and 4 hr of laboratory per week during a 15-week semester, is on techniques employed in the synthesis and characterization of substances. A list of typical experiments is given in Table 1. The experimental descriptions are designed to maximize the student's intellectual involvement with the experiment and to allow him as many options in his choice of experimental variables as possible. The ranges of optional procedures and synthetic routes is determined by the variety of standard taper glassware and other equipment available in the student's locker, and by the availability of the chemicals more commonly used in carrying out a particular experiment. For example, in the synthesis of n-butyl acetate the student is encouraged to devise his own synthetic, purification, and characterization procedure. His performance is evaluated as much on the basis of his achievement in design as on his manipulative skills. In fact this increase in responsibility seems to increase student motivation toward a careful mechanical performance.

In addition to the usual laboratory glassware, the student is provided with equipment for thin-layer chromatography. Instrumentation available includes 10 gas chromatographs, 8 infrared spectrometers, and 6 devices for rapid determination of melting point. The equipment is readily available to the student for his use at any time.

Enrollments in Course I are about 160 in the fall semester, 50-70 in the spring semester. Students are normally sectioned into groups of no more than 20, each section being provided with a graduate assistant. Two sections are together in the laboratory at each scheduled time in the fall semester, when enrollments are high. The lab conferences which meet once each week are conducted by a faculty member. In addition the senior faculty member in charge of the course spends considerable time in the laboratory in exercising general supervision of activities there.

The second course in the sequence, Dynamics, Structure and Physical Methods(II) carries as prerequisite concurrent registration in the first semester of Physical Chemistry lecture, and credit in the Structure and Synthesis course. About half the students take this second course in the semester immediately following the first. For the others there is a hiatus of one or two semesters, depending upon the student's background.

The emphasis in the second course in is on experimental measurements, particularly on evaluations of chemical equilibria and the rates of chemical reactions. On the one hand, the laboratory experiments are designed to illustrate important ideas involved in our present understanding of equilibrium and rates, and on the other, to acquaint the student with modern instrumental methods. The content of the course in its present form is outlined in Table 2. Course II meets for 4 hr of scheduled laboratory and one laboratory conference per week. Enrollments in Course II are normally about 75 (4 sections) in the fall semester and about 50 (3 sections) in the spring semester.

Students in Course II are grouped into sections of not more than 20 students. Only one section meets at any given time. The equipment available includes a 6 MHz nmr, four Beckman DB-G spectrophotometers with recorders, an Aminco model SPF-125 spectrophotometer, six polarimeters, several pH meters, and a 400-4000 cm⁻¹ range infrared spectrophotometer. This amount of equipment has proven adequate for a group of not more than twenty students provided that scheduling is arranged so that students do the experiments in varying orders. In part because of equip-

---

1 For students with adequate mathematics and physics preparation the first semester physical chemistry lecture course is taken concurrently with the second semester of organic chemistry lecture.

---

Table 1. Structure and Synthesis(I)

<table>
<thead>
<tr>
<th>Purification and Characterization</th>
<th>Melting Points; Unknown</th>
<th>Crystallization, Infrared Spectroscopy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolation of Caffeine: Extraction, Absorption Chromatography and Distillation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Synthesis</td>
<td>Aspirin</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ferrocene</td>
<td></td>
</tr>
<tr>
<td></td>
<td>n-Butyl Acetate: Shifting the Equilibrium; GLPC</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ester-Amide Hydrolysis; Experimental Design</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Resolution of Co(EN)₃⁺</td>
<td></td>
</tr>
<tr>
<td>Structure</td>
<td>Qualitative Analysis; Observations, Decisions and Deductive Logic</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Dynamics, Structure, and Physical Methods(II)

<table>
<thead>
<tr>
<th>Mutarotation of Glucose (Polarimeter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photochemical and Thermal Cis-Trans Interconversion of Azobenzene</td>
</tr>
<tr>
<td>Quenching and Spectroscopy</td>
</tr>
<tr>
<td>Catalysis of the 1,2-H₂O reaction by Mo(VI)</td>
</tr>
<tr>
<td>(a) Copper-Imidodiacetic Acid Equilibrium or</td>
</tr>
<tr>
<td>(b) Bis(ethylacetato) Copper-o-picoline equilibrium</td>
</tr>
<tr>
<td>Kinetic versus Thermodynamic Control of Reaction Product Evaluation of Solvent Effects on Keto-Enol Tautomerism using NMR</td>
</tr>
<tr>
<td>Electronics Measurements</td>
</tr>
</tbody>
</table>

Table 3. Chemical Fundamentals(III)

<table>
<thead>
<tr>
<th>Thermodynamic and Physical Properties of Matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lattice Energy of Argon</td>
</tr>
<tr>
<td>Heats of Solution</td>
</tr>
<tr>
<td>Dipole Moments</td>
</tr>
<tr>
<td>Magnetic Susceptibility</td>
</tr>
<tr>
<td>Velocity of Sound</td>
</tr>
<tr>
<td>Viscosity of Gases</td>
</tr>
<tr>
<td>Spectroscopic Properties of Matter</td>
</tr>
<tr>
<td>Microwave Spectroscopy</td>
</tr>
<tr>
<td>Vibration-Rotation Spectra of Diatomics</td>
</tr>
<tr>
<td>Infrared Spectra of Polyatomic Molecules</td>
</tr>
<tr>
<td>Electronic Spectra-Absorption and Emission</td>
</tr>
<tr>
<td>High Resolution Electron Spin Resonance Spectra</td>
</tr>
<tr>
<td>High Resolution NMR Spectroscopy—Spin-Spin Interactions; Chemical Shifts</td>
</tr>
<tr>
<td>Special Project (8-12 lab hr)</td>
</tr>
</tbody>
</table>

---

634 / Journal of Chemical Education
Because students have diverse goals, we have not felt it advisable to impose extensive formal laboratory requirements in the form of specific course requirements. While the total minimum required laboratory experience might be thought too light, we find that in practice most students do more than the minimum required laboratory work.

One of the most encouraging aspects of our revision of the traditional laboratory program has been the sustained interest on the part of the faculty in continuing development of the program. For example, a pilot project is presently underway in course I in the use of computer-assisted instruction using the PLATO system to teach basic laboratory techniques.

Evaluation of student performance in Core Laboratory courses varies with the individual faculty person in charge. In general, no written hourly or final examinations are given. Evaluations are thus based entirely on student performance in the laboratory, and upon graded reports. Factors such as degree of preparedness, proper maintenance of a laboratory notebook, laboratory technique, general aptitude in the learning of laboratory skills are all of importance. The laboratory reports receive significant attention, and are an important factor in the grade. In Course I the students are graded on the basis of observation and oral reports; in addition they submit products of synthetic experiments and results on unknowns. Written reports are required in Course II. The emphasis is on clarity, brevity, and thoughful analysis of the experimental results. In Course III the students make oral reports in which they present their results, calculations, and interpretations. The ensuing questioning and dialogue provide the instructor with ample opportunity to assess the quality of the student's experimental work, and his understanding of principles.

Student reaction to the Core Lab program has been very favorable. Laboratory courses have traditionally fared rather poorly in undergraduate student ratings, but the core lab courses receive ratings comparable to those for the more popular lecture courses. We have by no means arrived at the end of our search for an ideal undergraduate laboratory program, but the experience of the past three years convinces us we are on a reasonable course.

Acknowledgment

The core laboratory program has benefited from the contributions of many faculty members, most particularly of P. Beak, W. H. Flygare, J. Jonas, and J. T. Yardley III. Much of the instrumentation employed in the program was purchased with the aid of National Science Foundation Undergraduate Instructional Equipment Awards GY 4885 and GY 6721. We are grateful to The National Science Foundation for their assistancees, and hope that the very important Undergraduate Instructional Equipment Award program is continued.

Survey of Graduate Education in Analytical Chemistry

G. A. RECHNITZ

Department of Chemistry
State University of New York
Buffalo, N.Y. 14214

THE AMERICAN COUNCIL ON EDUCATION has conducted two studies (1, 2) to assess the quality of graduate education in chemistry and other disciplines. These studies make no attempt to assess subdisciplines such as analytical chemistry. Yet it would be interesting and, perhaps, helpful to have a measure of the quality and effectiveness of graduate education in analytical chemistry as an aid to future planning and a check on current efforts. Cram (3) has viewed the present situation in terms of a challenge to educational institutions.

The present survey was conducted along the lines of the Carter (1) report, using a questionnaire constructed with information from the 1969 edition of the American Chemical Society's "Directory of Graduate Research." The questionnaire listed in alphabetical order the 122 institutions which offer an analytical Ph.D. program according to the 1969 ACS Directory. This questionnaire was mailed to each individual identified as an analytical chemist in the Directory. Respondents were asked to indicate: "... which of the terms below best describes your judgment of the quality of graduate education in analytical chemistry at each institution listed?" with responses to be selected from "Distinguished," "Strong," "Good," "Adequate," "Marginal," and "Insufficient Information."

Replies were received from some 120 individuals representing approximately 40% of the analytical chemists listed in the ACS Directory. Results were tabulated according to the scoring system:

<table>
<thead>
<tr>
<th>Rating</th>
<th>No. of Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distinguished</td>
<td>5</td>
</tr>
<tr>
<td>Strong</td>
<td>4</td>
</tr>
<tr>
<td>Good</td>
<td>3</td>
</tr>
<tr>
<td>Adequate</td>
<td>2</td>
</tr>
<tr>
<td>Marginal</td>
<td>1</td>
</tr>
</tbody>
</table>

Replies were received from some 120 individuals representing approximately 40% of the analytical chemists listed in the ACS Directory. Results were tabulated according to the scoring system:

Table I. Summary of Survey Results: Institutions Ranked "Good" or Better

<table>
<thead>
<tr>
<th>Rank</th>
<th>Institution</th>
<th>Average Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Purdue</td>
<td>4.59</td>
</tr>
<tr>
<td>2</td>
<td>Wisconsin</td>
<td>4.54</td>
</tr>
<tr>
<td>3</td>
<td>North Carolina</td>
<td>4.44</td>
</tr>
<tr>
<td>4</td>
<td>Illinois</td>
<td>4.26</td>
</tr>
<tr>
<td>5</td>
<td>Iowa State</td>
<td>4.12</td>
</tr>
<tr>
<td>6</td>
<td>Cornell</td>
<td>4.00</td>
</tr>
<tr>
<td>7</td>
<td>SUNY, Buffalo</td>
<td>3.88</td>
</tr>
<tr>
<td>8</td>
<td>Michigan State</td>
<td>3.87</td>
</tr>
<tr>
<td>9</td>
<td>Indiana</td>
<td>3.80</td>
</tr>
<tr>
<td>10</td>
<td>Florida</td>
<td>3.77</td>
</tr>
<tr>
<td>11</td>
<td>Arizona</td>
<td>3.70</td>
</tr>
<tr>
<td>12</td>
<td>Massachusetts</td>
<td>3.69</td>
</tr>
<tr>
<td>13</td>
<td>Michigan</td>
<td>3.61</td>
</tr>
<tr>
<td>14</td>
<td>Kansas</td>
<td>3.58</td>
</tr>
<tr>
<td>15</td>
<td>Oregon State</td>
<td>3.56</td>
</tr>
<tr>
<td>16</td>
<td>Georgia</td>
<td>3.53</td>
</tr>
<tr>
<td>17</td>
<td>Louisiana State,</td>
<td>3.52</td>
</tr>
<tr>
<td></td>
<td>Baton Rouge</td>
<td></td>
</tr>
</tbody>
</table>

Institutions scoring above 3.50 in rank order:

<table>
<thead>
<tr>
<th>Institution</th>
<th>California at Los Angeles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>California at Riverside</td>
</tr>
<tr>
<td></td>
<td>Louisiana State, New Orleans</td>
</tr>
<tr>
<td></td>
<td>Minnesota</td>
</tr>
<tr>
<td></td>
<td>Texas, Austin</td>
</tr>
<tr>
<td></td>
<td>Wayne State</td>
</tr>
</tbody>
</table>

Institutions scoring 3.25-3.49 in alphabetical order:

<table>
<thead>
<tr>
<th>Institution</th>
<th>Cal. Tech.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Clarkson</td>
</tr>
<tr>
<td></td>
<td>Colorado State</td>
</tr>
<tr>
<td></td>
<td>Florida State</td>
</tr>
<tr>
<td></td>
<td>Iowa</td>
</tr>
<tr>
<td></td>
<td>Kansas State</td>
</tr>
<tr>
<td></td>
<td>Northwestern</td>
</tr>
<tr>
<td></td>
<td>Pennsylvania State</td>
</tr>
</tbody>
</table>

Institutions scoring 3.00-3.24 in alphabetical order:

1 Ranking should be regarded as tentative since survey was conducted from this institution.
Following the practice of the Carter (1) report, the principal results are presented (Table I) in three groups. The first group lists, in rank order, those institutions receiving average scores of 3.50 or higher. The second and third groupings list, in alphabetical order, those institutions with average scores in the ranges 3.25 to 3.49 and 3.00 to 3.24, respectively. All other institutions in the survey received average scores of less than 3.00 and are not listed. (Individuals at the institutions not listed in Table I but included in the survey may receive confidential information regarding their institution by writing to the author on official letterhead.) The results thus indicate that approximately one-fourth of the 122 institutions nominally offering an analytical Ph.D. program are judged "Good" or better by analytical chemists in fellow academic institutions. It would be interesting to know how the results of Table I compare with the judgment of analytical chemists in four-year colleges, industry, and government laboratories; such an investigation is beyond the scope of the present study, however.

Table II compares the results of the present survey with the rankings of the most recent American Council on Education study (2) for chemistry as a whole. Institutions with high overall ranking generally fare well in the analytical survey but strong analytical programs also are found in several less highly ranked institutions, and several institutions with high overall rank do not offer major analytical programs.

Table III indicates that the leading analytical programs are not distributed evenly geographically. A heavy concentration of institutions in the top category is found in the Midwest; however, several strong contenders appear to be arising in both the South and Northeast.

"Insufficient Information" responses for individual institutions ranged from zero to more than 80% of replies. As Table IV shows, the leading institutions also receive the smallest "Insufficient Information" response. As a result, none of the institutions listed in Table I received their high rankings as a consequence of a small number of averaging votes.

In addition to the formal questionnaires, a large number of letters, notes, and verbal comments were received in response to the survey. Several useful suggestions emerged from these comments—e.g., that the survey be repeated in three to five years; that an assessment be made of undergraduate education in analytical chemistry, as well; and, that evaluations of quality be solicited from alumni and employers of analytical chemists.

Furthermore, there appears to be a general consensus that the profession needs to define the nature of a superior analytical program, set the minimum standards of personnel for such a program, and encourage lagging institutions among the major universities to meet these standards. It is hoped that this survey will contribute in some small way toward these goals.

References

(3) S. F. Cram, Res./Develop. 21 (7), 16 (1970).