PROFESSIONAL RELATIONS BULLETIN

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DENNIS CHAMOT, *Editor*

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FROM THE EDITOR . . .

Report from St. Louis

Well, they did it to us again.

Faithful readers of DPR material will recall that we lost a Councilor recently. To recap, ACS Divisions are entitled to representation in the Council based upon numbers of members, with each Division allowed from one to four Councilors.

In the old days, every Division had two Councilors, regardless of size. We retained two when the current system was introduced, by virtue of the fact that our membership was just over the minimum required for two—500 members. Just last fall, the Council Policy Committee (CPC) raised the cut-off to 600; we were below that figure on the date of the official count (which was taken in July, 1983, before the new limit was determined), so we lost a Councilor.

With the help of a lot of dedicated members, we signed up enough new recruits to bring our membership up to well over 600 before December 31, 1983 (the newly established deadline for the official membership count to determine *1985* Council representation). So, the DPR Executive Committee met in St. Louis at the national ACS meeting last spring and confidently made plans to hold an election this year for the second Councilor we should be allotted for 1985. And then a funny thing happened, or actually, didn't happen.

As is the usual practice, CPC announced to the Council a minor change in the Local Section Divisor (which determines Councilor representation from Local Sections, again, based on membership). No mention was made of any Divisional changes, so we, of course, assumed that none were made. We were wrong. We learned that the minimum for two Councilors was raised yet again, from 600 to 700, just high enough to keep us from our second Councilor for another year. In spite of our highly sucessful membership activities, which brought us well above the recently set limit of 600, we were still short of 700.

As of the time of this writing, I have seen no detailed explanation as to how the new calculations were carried out, nor the basis for the new limits. There was certainly no excuse for not mentioning the new limits in the CPC report to Council, even if there were no changes in current representation—we expected to gain. In fact, three other Divisions gained or lost Councilors because of the change. Protests have already been filed, and we expect this action to be debated at the next national meeting in Philadelphia.

Stay tuned for the next exciting installment. In the meantime, go out and sign up a whole bunch of chemists. The only appropriate defense aginst this kind of nonsense is a large and active membership. As starters, let's try for 1,000. That's certainly not unreasonable for a Division as important as ours, out of total membership of 130,000!

Content

The bulk of this issue is devoted to some of the papers presented in St. Louis at the DPR symposium on chemist supply and demand. This interesting session was co-chaired by Mordecai Treblow and Jack Kay. We expect to publish additional papers in the next Bulletin.

I don't agree with everything each speaker said. You will each have your own opinions, too. But I think you will find a lot of interest on a extremely important subject.

Official DPR Election Returns

Chairman-elect:	
Phil Landis	66
Margil Wadley*	189
Dennis Chamot	1
Treasurer:	
Valery Kuck*	213
Dennis Chamot	1
Attila Pavlath	1
Mordecai Treblow	1
Member-at-large:	
Jo-Anne Jackson	54
Alan Nixon	81
Fred Owens*	153
Attila Pavlath*	189
*Bylaw Amendment:** *	
YES	239
NO	13

* = elected
**establishes Henry Hill Award

—Dennis Chamot

NEW DPR BOOK—Industrial-Academic Interfacing

A new book has recently been issued in the ACS symposium series. Based upon a DPR session at the Kansas City national meeting, the book focuses on the rewards, expectations, problems, needs, and new initiatives of the relationship between universities and industry. Key educators and corporate executives describe this interaction with regard to cooperative research, contracts, the transfer of technology, and the quest for improved education.

The list price of the book, *Industrial-Academic Interfacing,* edited by Dennis Runser, is $34.95. However, DPR members may order one copy at the substantially reduced price of $20.97. Use the coupon below for a discount copy.

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Mutually Beneficial Academic Consultantship for Industry
Lowell D. Miller

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G.G. Meisels

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University-Industry Cooperative Research: Expectations, Rewards, and Problems
Charles W. Gehrke and Robert W. Zumwalt

Interfacing with Academia: Some Corporate Approaches
Theodore E. Tabor

Recent National Science Board Studies in University-Industry Research Relationships
Carlos E. Kruytbosch

Academic and Corporate Values and Goals: Are They Really in Conflict?
Ronald E. Cape

Industrial-Academic Cooperation in Education
Peter E. Yankwich

Perspectives for the 80s on Academic-Industrial Relationships
Alan L. McClelland

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THE ACADEMIC ROLE IN THE SUPPLY OF CHEMISTS

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University of Pittsburgh
Pittsburgh, PA 15260

Introduction

The purpose of this paper is to address the issue of the role that universities should play in establishing a supply and demand equation for chemists. What is and what should be the academic role in determining the supply of chemists? My major emphasis will be on graduate programs and on those factors which relate to the supply of Ph.D. chemists. A steady supply of Ph.D.s is necessary for the continued growth and health of our national research establishment. During the recent economic downturn, and for the first time in history, there were large numbers of research Ph.D.s laid off, and the question legitimately arose as to whether or not we were overproducing Ph.D.s.

When one speaks of the academic "role" in the supply and demand of chemists, this implies some sort of control over the supply by universities. If we are going to think about regulating the supply of chemists, we must think in terms of the possible mechanism that would be used. Several of these come to mind. First, some preset absolute number of graduate students could be admitted to graduate schools in the country (either by agreement or by fiat), and this would *de facto* regulate the number of Ph.D.s emerging. This type of system has been used by the medical schools for years to successfully limit the supply of physicians. Second, graduate schools could decide to control their input of graduate students in response to perceived needs for Ph.D.s five years hence. Third, we might encourage students to control their choice of careers based on the projected needs for Ph.D.s when they would finish their academic training. I would like to address how these ideas fit into the university picture and to judge them according to appropriate criteria.

Several important points relate to the academic role in the supply of chemists. First, there is the philosophical question concerning whether the universities *should* try to regulate the supply of chemists. Is this a reasonable role for the university to assume? Second, there is the *practical* question of, given that it is desirable for the universities to do this, is it possible for the universities to regulate the supply of chemists? We will look at both of these issues, because each is equally important.

A third and very relevant question has to do with whether we are addressing a real issue here or a fictitious one. That is, is there really a problem of an over supply of chemists or a potential over supply of chemists? Related to this, we must look at what factors actually regulate the supply of chemists coming from the universities. Another related issue is how well we have been doing producing chemists relative to the needs of their three prime employers: industry, government, and the universities. I also feel there are some lessons we can learn from the past, and perhaps we can make a reasonable prognosis for the future.

A fourth and very important point is that chemistry is a very heterogeneous discipline, and because of this heterogeneity, considerable variations can exist in the job market among subdisciplines. Frequently these variations are related to the area of graduate training. Also, we must recognize that 15% of the Ph.D.s produced over the next decade will take academic jobs; 85% will work for government and industry.

The supply-demand criteria for subdisciplines of chemistry can be illustrated by three examples. First, theoretical chemistry is an area which has never been in high demand. This has been because theoretical chemists find employment primarily in academe and represent a small fraction of that population. Therefore, one has had a small need and a small supply. Interestingly enough, it appears that this situation may now be changing because of the value of theoretical chemists to computer oriented enterprises. My second example is organic chemistry. This area has its ups and downs. Organic chemists represent the majority of chemists and, therefore, are the most susceptible to fluctuations in the job market. The third area I have selected is analytical chemistry where traditionally demand has exceeded supply. I will talk specifically about the situation with regard to analytical chemistry in an effort to reinforce some of the ideas I will present about the first three topics.

Philosophical Question

First, we must address the philosophical question: should the universities regulate supply of chemists? Even raising this question presumes a type of responsibility for the university that is inappropriate. The university has responsibilities to its students, it has responsibilities to the larger society, and in regard to chemists, it has a significant responsibility to the chemical industry, but these responsibilities are appropriately manifest in a very important and singular way.

The only role appropriate for the university with regard to chemistry is that of creating new knowledge and disseminating knowledge; the role of researcher and teacher. The roles the university should fulfill are the dual roles of teaching and research and nothing more. Students come to the university for an education. Hopefully, they will receive one while they are there. When they leave, they sever their ties with the university, except for a nostalgic attachment which plays a significant role in university fund raising efforts. We must recognize that the world does not owe a person a job simply because he has a Ph.D. He must be judged by what he offers to society and be awarded appropriately. University training only provides a base for employment. In a free society it is the responsibility of each student to select the area of study he will pursue at the university, and it is the responsiblity of this student to select his area of employment after he graduates. The university should be willing, and in fact is obligated, to advise students in selecting careers and to help them obtain employment. However, it is inappropriate for the university to attempt to manipulate students into or out of an area to match perceived job market needs. The university serves its job as advisor well. Most universities have excellent advising services and placement programs; in chemistry the major professor often plays a significant role in this regard for his own graduate students. This is what the university already does, and it should do nothing more.

Currently universities are retrenching from many programs which were initiated in the late 1960s and early 1970s. These programs were aimed at solving social and political problems. For some reason it was perceived by some that the university could solve the world's ills, and the role of social, political, and economic manipulator was appropriate for the university. This implied that the universities had the insight and the capacity to solve these problems. Most of us in the universities knew that this was utter nonsense, but the vocal minority prevailed for a while. The 1970s should have taught the universities something: society is not best served by the university playing the role of social activist. Social, political, and economic action programs are dinosaurs from another era that are best left to extinction. To try to initiate any kind of program that would match supply of students to meet a perceived demand would be a fallback to an era that is best forgotten. Universities should concentrate on their primary mission—that is, teaching and research. The above considerations argue against any attempt at regulation. We should avoid setting arbitrary limits. Such an action does not fit with the concept of a free university in a free society. Therefore, my conclusion is that it is philosophically indefensible for the universities to become involved in any attempt to regulate the supply of chemists.

Next, we should consider the practical question: even if it were philosophically defensible for the universities to regulate the supply of Ph.D. chemists, would such an effort be feasible? I believe such an effort would be faced with severe practical difficulties. What one is really trying to do by regulating the supply of Ph.D.s is to regulate a microeconomy, namely, to plan supply to match demand. To do this effectively one must be able to predict demand accurately at the time the supply process is initiated. To see the enormity of the difficulties involved in such a scheme we need only look at the history of regulated or planned economies: they simply don't work.

I would like to examine, in some detail, the practical problems of trying to regulate the output of Ph.D.s at some point in time by regulating the input at some previous time. This could be done either by self regulation on the part of the student (in response to propaganda) or by the university (control of input). A reasonable assumption would be that regulation of Ph.D. output would be in response to some economic indicator.

First, let's look at the student's time frame, for example, one who entered college in the Fall of 1974 in a bachelors program in chemistry and graduated with a B.S. in the Spring of 1978. If this student had elected to enter a Ph.D. program immediately after college, he would have entered graduate school in the Fall of 1978. Given the assumption that it would take 4.5 years to earn a Ph.D. (national average), he should have emerged from the Ph.D. program in the Summer of 1983. It is a reasonable assumption that the decision point for the student to attend graduate school would be sometime during his junior or senior year in college, around the Spring of 1977 or the Fall of 1978. It is important, therefore, to look at the scientific manpower projections and economic indicator at that time.

Projections of scientific manpower needs from the National Science Foundation indicated that the need for chemists will increase approximately at the rate of 5% per year. Therefore, taking 1974 as my base year with 1.00, the scientific manpower projections represent a monotonically increasing function. This indicates to the student (at any point in his career) that there will be an increasing need for Ph.D. chemists.

It is now interesting to look at a typical economic indicator for the same time period. The economic indicator I have used is Delta, which is the difference between the actual unemployment rate and the natural unemployment rate. Delta is only one of a number of economic indicators which can be used; I chose it simply because I had data available for the appropriate period. Others could be used but essentially show parallel behavior. The function Delta correlates with inflationary trends and gives an idea of how well in control or how out of control the economy is. The larger the value of Delta, the worse off the economy is. Therefore, in a time of decreasing Delta the economy appears to be healthy or in a time of increasing Delta the economy tends toward being out of control. If you look at the behavior of Delta during the student's undergraduate career, the inflationary indicator falls indicating the economy is pretty good. At the point where he had to make a career decision in 1977 or early 1978, one would receive a positive projection in scientific manpower requirement and a good economic indicator. On this basis, the student would probably be strongly encouraged to go to graduate school. However, during the time he is in graduate school (1978 to 1983), the economic indicator turns around completely. The scientific manpower projections have not changed, but the economy is getting worse. During the latter stages of graduate school, the economy is in fairly bad condition, and layoffs have begun to occur in the chemical industry. By the time the student is about to emerge in the Summor of '83 Delta is indicating some improvement in the economy, but none of this could have been predicted in the 1977-78 period.

The point to all of the above is the following: there was no way of predicting accurately in 1977 what the economy and manpower requirements would be in 1983! Anyone who could have made this accurate prediction should consider a career in weather predicting (evening TV news), or better, horse race betting; I am certain they could make a fortune. The short term economic cycle can vary significantly over the time frame of an individual student's career, and thus, any attempts to predict what exact employment needs will be more than a year in advance are unrealistic.

Therefore, I return to my original contention. The first priority for the university is the development and transfer of knowledge. The university should not and cannot regulate the supply of chemists. Supply will be related to long term needs, not to short term economic behavior. If the long term need is there, the short term fluctuations will be smoothed out.

Is There Really A Problem?

Next I would like to turn to the relevant question: is there really a problem of over supply of chemists? One way we might determine whether or not such a problem exists is to ask the question, "If short term economic behavior is unrelated to the supply of Ph.D. chemists, what are the major factors that influence the supply of chemists?" I submit that the most important factors which affect the supply of Ph.D. chemists are the factors which affect the supply of graduate students to the graduate schools. This is based on a simple assumption that those factors which affect the input to a process will indeed determine the output. I would like to deal in some detail with five factors which affect the supply of graduate students to university chemistry departments: undergraduate enrollment, faculty productivity, industrial fellowships, applicant pressure, and faculty research group needs.

My main thesis is that the number of graduate students in a given chemistry department is controlled directly by factors related to financial support. The ability to support graduate students will determine the number of students in a given department. The undergraduate enrollment of an institution will have a major effect, because the undergraduate enrollment largely determines the number of teaching assistants available to a department. Typically, teaching assistants will account for the support of about 35% of a department's graduate students. Faculty productivity in research is an important factor, because in the long run, it controls federal research funding, industrially sponsored research, some state supported research and instrumentation funds for a department. In short, faculty productivity in research is what determines a department's financial base and facilities for research. In a tyupical department, research funds will account for support of about 55% of the graduate students as research assistants and also will account for a large fraction of instrumentation funds to provide facilities that those students need. A third factor is fellowships which account for 10% of the graduate students supported in a typical department. The net sum of these three financial factors will determine how many graduate students any given department can support and thus how many Ph.D.s it will produce.

Applicant pressure from potential graduate students is a related effect. The quality of a group of applicants in a given year may influence a department to accept a few more students than it normally does. After all, we all like to have very good students. The economy may have an effect on this parameter, because if the job market for undergraduate chemists is poor, a higher fraction obtaining bachelors degrees will go to graduate school. This is probably the only place where performance of the economy has any significant effect on Ph.D. production; note, however, there is a time lag. Recruiting efforts of the faculty affect applicant pressure. In this day and age how hard the faculty gets out and recruits will definitely influence the quality and the size of the pool of potential graduate applicants. Another very important factor may be the actual needs of research groups within the faculty of a given department. This will largely determine the distribution among the subdivisions of chemistry, as well as the total input. I believe that every department is, in one way or another, sensitive to these needs.

Therefore, I submit that the needs of each university's chemistry department for grduate students and its ability to support research programs are the major factors determining the number of students who come into that pipeline and emerge 4.5 years later from the same pipeline. Thus, the input is controlled by factors *largely unrelated to the job market.* I think we may conclude that the Ph.D. output of any chemistry department will be independent of job market demands at the time of input. In fact, if I wanted to select a single most significant factor affecting the supply of Ph.D. chemists in this country, I would say that it is federal research funding. The majority of graduate students in any department are supported by some kind of federal grant. Therefore, the availability (or unavailability) of federal research funds represents the most significant short term factor controlling Ph.D. production.

To determine whether a problem exists in the production of Ph.D. chemists, it is appropriate to ask the question, "How well have we been doing in producing Ph.D. chemists?" Figure 1 shows a plot of Ph.D. production as a function of time from 1968 to 1980. The data come from the National Science Foundation. There are three plots in this figure. The solid line at the top represents the total U.S. Ph.D. production over this time period; the dashed line in the middle represents the production of the top 78 schools according to the Roose-Andersen rating, and the dotted line at the bottom represents the top 37 schools according to the same rating.

The first thing to notice is that the chemistry Ph.D. production in the United States peaked in 1969 and has been declining ever since. In fact, in 1980, which is the last year for which I have figures, production had dropped 25% from the peak year. It is also interesting to note that these numbers are not corrected for the foreign student population which increased over this same time period.

An interesting point to observe in connection with Figure 1 is that the trend is independent of the quality (or at least of the perceived quality) of the institutions as measured by the Roose-Andersen ratings of graduate programs. The top 37 schools represent 21% of the universities in the United States; they produced 48% of the Ph.D.s and are responsible for 57% of the research expenditures in chemistry. The top 78 schools represent 45% of the schools, produced 76% of the Ph.D.s and are responsible for 75% of the research funds spent. Therefore, although we have a minority of schools producing the majority of Ph.D.s, the change in Ph.D. production seems to be unrelated to institutional quality. I submit that the data in Figure 1 demonstrate clearly that Ph.D. production is declining and that this fact argues against any over supply of chemists in the long run.

I think we can see that Ph.D. production is not sensitive to the peaks and valleys of the economy. There was an economic valley in 1970 but no peak or valley in this plot. My contention is that the decline in Ph.D. production began in '69 quite independent of the economic situation, reflecting a change in emphasis in many programs of the federal government. I believe we experience a relatively smooth time dependence of Ph.D. production, not reflecting the less-smooth behavior of the economy in general.

I believe one important point to consider is ways in which buffers can be created to help stabilize the Ph.D. talent pool during poor economic times, particularly when employment problems exist. One program which comes to mind as an effective buffer was the Petroleum Research Fund's program in the early 1970s which allocated a large fraction of PRF resources into post-doctoral support when the economy took a major downturn. This permitted putting the excess chemical manpower, representing new Ph.D. production, into a holding pattern until employment opportunities became available a few years later. This was an extremely foresighted program, and I think PRF deserves a great deal of credit for initiating it. It paid off well in stabilizing critical manpower needs, not to mention the human benefits affecting the futures of highly talented people. I feel that it would be far more productive for us to think in terms of these kinds of buffer programs than to think in terms of universities or anyone else attempting to control the supply of Ph.D. chemists.

What is my prognosis for the future? I believe the future of chemistry is bright. We must not make the same mistake made by many of our leading corporations, when they began to operate exclusively to achieve short term aims which turned out to be at the expense of long term goals.

Analytical Chemistry

I now come to my final point and that is to examine the job situation for Ph.D. analytical chemists in some detail. As indicated in the introduction, I have singled out analytical chemistry for special focus because it is an area of national concern, it is an area running contrary to the idea of a manpower shortage, and it is an area that in the recent past suffered from the intrusion of arbitrary decision making. The largest division of the ACS is Organic Chemistry with 6111 members and second is the Division of Analytical Chemistry with 5173 members. Polymer is third with 4972 members. About half of the ACS members affiliate with some division. Divisional membership relates directly to the interests of chemists, because belonging to a division of the ACS is purely voluntary. Therefore, if an individual associates with a division, it must reflect his professional interests. Using the above data one can readily conclude that 22% of the ACS members must regard themselves as organic chemists, 19% as analytical chemists, and 18% as polymer chemists, etc. Needless to say, analytical chemistry ranks high among the professional interests of ACS members. *(Editor's note: many ACS members join more than one division).*

On the basis of these figures, one might expect that Ph.D. output from chemistry departments in organic and analytical chemistry would be nearly equal. However, the Ph.D. output from a typical department would probably break down approximately as follows: 50% organic chemists, 25% physical chemists, 10% inorganic chemists, and 15% analytical chemists. Thus, the ratio or organic to analytical chemists overall is approximately 3.3 to 1, not in line with the divisional membership data. In the average university department one would have approximately 37 faculty. Distribution would be something like: 12 organic, 15 physical, 6 inorganic, and 4 analytical. Another interesting and related point is that whereas virtually all university departments have doctoral programs in organic, physical, and inorganic chemistry, of the top 37 departments only 21 have analytical programs, i.e., 16 do not. Furthermore, of the 16 that do not, about half of them used to but not longer do.

Contrasted with the above, in chemistry departments where analytical programs exist, growth in analytical chemistry is exceeding that in any other area. On the average, I would guess about 25% of the graduate student population is analytical, as opposed to 11% of the faculty. Why then do we see a decrease in the number of departments offering analytical chemistry, an increase in student interest, and an inappropriately low number of faculty? This situation is largely the result of myopic misdirection which occured in university chemistry departments in the 1960s, which was aimed at phasing out analytical chemistry. This phaseout was done successfully at some institutions but not at all. However, the prevailing attitude toward analytical chemistry at that time retarded its growth in most university chemistry departments. This is not the appropriate place to go into the details about the whys and wherefores of this situation, but it does represent a perfect example of what can happen when forces attempt to arbitrarily direct the distribution of chemists in university programs. Those who would try to limit Ph.D. chemist production to some arbitrary means should take heed!

Dr. T. J. Logan of Procter & Gamble reported some interesting data and projections on the current shortage of analytical chemists at the August 1981 ACS Meeting, and subsequently at the Allerton Conference, which was held jointly between university and academic representatives to deal with the shortage of analytical chemists. I thought it would be well to look over some of the data which Logan presented. To start with, contrasted with the decline in chemistry Ph.D. production during the period 1970 to 1983, there is a distinct upward trend in the production of analytical chemists starting about 1973. The data show that the percentage of Ph.D.s represented by analytical chemists is increasing significantly, as well as the absolute numbers. The peak around 1971 in analytical Ph.D. production probably resulted from environmental interests (and can be considered an aberration), but the sharp upswing starting in 1973 is real and continuing.

Logan gave some information which is additional food for thought. He calculated the cumulative number of Ph.D.s in analytical chemistry awarded since 1942 and assumed that these are still currently practicing. For the period from 1975 to date, the number of analytical chemists has increased at the rate of about 7.2% of that cumulative total per year. He made the assumption that this level of Ph.D. production has just met the current demand for analytical chemists (every Ph.D. analytical chemist I know of has been able to obtain a job, so this is probably a valid assumption). Also assume that in the period 1980-1990 the demand for analytical chemists will continue to increase at a rate of 7.2% per year. Actually, I believe the demand for analytical chemists is not met by the annual production, so this is certainly a conservative estimate. By 1990, then, the number of Ph.D. analytical chemists needed will essentially double. Next, assume that the Ph.D.s produced in analytical chemistry represent 13.1% of all Ph.D.s and that that ratio will remain constant from 1980-90. The 13.1% figure represents the highest ratio in the last decade and a half. If one factors this into the projected supply of total Ph.D. chemists produced for the period 1980 to 1989, we will actually see a *decrease* in the number of analytical chemists produced each year. Data on the projected total number of U.S. Ph.D.s produced in this time should be very good—remember that students entering graduate school in the Fall of 1984 will graduate in the Summer of 1989. In 1989, according to Logan's projections, we will need 393 analytical chemists to meet the demand. In that same year we will produce 172, off by more than a factor of 2. The total projected Ph.D.s in chemistry in 1989 will be 1300. This means that to supply the 393 analytical chemists needed will require that 30.2% of all Ph.D.s given in that year be analytical chemists. In other words, the students who are now going into the pipeline are the ones who will have to make up the deficit. Although student interest in analytical chemistry continues to be strong, I see that the supply/demand statistics are strongly in favor of demand rather than supply. There is no shortage of analytical chemists, and there will be no shortage of analytical chemists for at least a decade to come.

Conclusions

My conclusions are relatively straightforward. First, it is neither philosophically desirable nor practically possible for the universities to regulate the supply of chemists to match demands. Second, even if it were philosophically desirable, valid economic indicators do not exist which justify such an attempt. Third, the major factors which contribute to the supply of chemists are largey unrelated to marketplace criteria. Intra-university and federal funding are the major factors affecting the supply of chemists and their distribution within subdisciplines of chemistry. Fourth, there is no problem with over supply of chemists. The long term prognosis for continued positive growth and need for chemists has been met over the last several decades, and there is every indication that this situation will continue in the near future. There may be short time periods of over supply, and it is better to spend our efforts thinking of potential short-term buffers than about long-range regulation. Fifth, my prognosis for the future is for a decreasing supply of chemists against an increasing demand. Analytical chemists are particularly in short supply, and the problem of finding Ph.D. analytical chemists in the future will probably become acute.

What is the appropriate role for the universities? The role of the universities is education and research. The academic system operates under the tacit assumption that there will be a need for Ph.D. chemists when they graduate. Although there may be short term aberations, in the long term I foresee this to be true. To make any attempt to monkey with the academic system as we now know it would be to court disaster.

TRAINING OF CHEMISTS FOR INDUSTRY

Madeleine M. Joullié
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Philadelphia, Pennsylvania

I want to thank the chair of this symposium for inviting me to be part of this distinguished group of speakers. So far, we have heard different views o the demand and supply of chemists and probably will hear many more.

We all agree that there is a supply and demand of chemists but although we examine the factors that affect them, we rarely focus on the product, the chemist. Demand is seldom greater than the desirability of a product. Are schools producing a desirable product? If they are, in a country of this size and economy there should be a need for more scientists not less. Therefore, it is a pertinent question, although not necessarily a welcome one for educators such as myself, to ask whether we are producing scientists that are essential to the growth of our technology. Is our educational system missing something?

I would like to probe a little deeper into the factors that has effected graduate education, including the effects of federal policy although this topic has been addressed by other speakers.

I do not pretend to have the answers or even claim that my observations are of a general nature. I can only speak as an organic chemist and of things I have observed, but I would like to stimulate your thinking along different lines in search of solutions to equalize supply and demand of chemists.

I would like to address briefly the following topics:

1. Employment of chemists: producer-consumer relationship.
2. Involvement of industry in graduate education.
3. Present day graduate training:
    1. Influence of federal funding;
    2. Academic attitude towards industry.
4. Training emphasis.

The majority of students we train are likely to be employed by industry. Yet, over the years, the content, currency and relevance of the chemistry curricula have not related to the career goals of the students, thereby affecting their employment opportunities.

There has always been a gap between the expectations of industry and the judgement of the people who determine curricula and prepare students for employment. Within the past few years, this gap has widened considerably and the net result is that the demand and supply of chemists is not properly matched.

Academic scientists and industrial managers have a producer-consumer relationship which should require considerable interaction. The actual interaction, however, is insufficient.

The need for communication between academia and industry has been recognized by the governance structure of the ACS, and various efforts to increase industrial-academic interactions have been seen recently in the form of conferences on the subject, or establishment of academic-industrial groups to coordinate a wide spectrum of activities to bring academic and industrial chemists together.

Industrial and academic chemists must agree on the goals and purpose of a chemical education if they are to contribute to the growth and eminence of our nation in the scientific field. Close cooperation between the industrial and academic establishments is essential if we are to make major contributions in pure and applied science.

However, in spite of the recent extensive interest in promoting better communication between industry and academia, the level of interaction has been much lower than it should be, and possibly lower than several years ago. As a result, industry has had very little input in the training of the chemists.

Let me examine some of the factors that have influenced graduate chemical education in recent years.

The teaching of chemistry at any level has always been an expensive proposition. Laboratories require special facilities, costly materials, safety features, and adequate equipment. Over the years these costs have escalated. Topnotch instrumentation has become all important, and the rapid advances in this area often make expensive equipment obsolete in a short time. It is essentially impossible to offer a quality education in chemistry without appropriate funding.

Nevertheless, it has been difficult, if not impossible, to convince administrators that chemistry demands a larger portion of their budgets. As a result, the rising cost of chemical education has slowly changed the function of the chemistry faculty, as more and more schools are unable or unwilling to support their needs, especially with respect to the training of graduate students.

In recent years, the duties of a faculty member have changed from teaching and scholarly research to fund raising. It is now generally accepted that basic research, which is an essential part of our graduate program, must be supported by Federal funding.

When making tenure decisions, personnel committees consider teaching and scholarly work on the same level as "grantsmanship" or the candidate's ability to raise funds. Some committees even consider the ability to raise funds more important than scholarly work, although large number of publications are encouraged as they presumably will lead to renewal of funds since it is easier to count papers than to read them.

The least of these requirements is the actual teaching as measured by the acquisition of knowledge by students and their preparation for future accomplishments.

The need for funding graduate education from outside sources has many unfortunate consequences on our educational system. It has increased administrative burdens on faculty members. It has taken them away from teaching and scholarly work and caused them to sort of "subcontract" these important duties.

Possibly the worst consequence of all is that this system has encouraged the exploitation of graduate students and even postdoctoral fellows as simply "a pair of hands".

The pressure to finish proposed work that is being funded, leaves little time for pursuing other avenues or investigating new findings which may not be directly related to the project. There is no time for experimenting or for making mistakes. Yet both of these are an essential part of learning.

Perhaps more important, projects that are fundable, may not be particularly well suited for the training of graduate students because they are too narrow in scope. The system may produce chemists that are superb technicians in a rather specialized field but it is not apt to produce scientists.

The training of a scientist is a time requiring process during which a person is allowed to experiment, to make mistakes, to develop by reading and thinking, and to interact and communicate with other scientists. This is considered too time consuming.

Most faculty members view time as something which is best spent in producing results on which continued funding depends. They are paid to produce within the time allotted for a project, whether the time is realistic or not.

The funding may be renewed but the training of the graduate student may have suffered. The final product, a new Ph.D., will command a high salary in industry but may also fall short of the expectations an industrial manager is entitled to have. My previous comments do not necessarily mean that all federally funded research will cause schools to produce poorly trained graduate students but it does emphasize one very important point: federal funding is not concerned with the quality of training the supported research will provide. Therefore, is it really the best or only way to fund graduate education? If not, what is the best way? The answers to these questions are very important to the future of graduate education.

Assuming that our present system is indeed the best, I would like to bring up another problem. Although some faculty members are industrial consultants or have received support from industry, in general, academic people have little knowledge of what goes on in industrial laboratories. This ignorance has produced a poor attitude towards industrial research, and this attitude is passed on to the graduate students. Students expect to deal with the same type of problems they have been familiar with during their academic careers. Different types of problems will not be considered "science". This attitude has been extremely harmful.

We should train our students to solve chemical problems. Whether solving a problem is considered "doing science" or not depends not on the problem but on the way it is approached. If our students cannot approach an industrial problem in a scientific manner, the fault rests with those who have trained them, not with industry.

The low opinion of industrial research by some academic people has hurt chemistry and chemical education in particular. We would all be better off if we recognized that all chemists are trained by the same schools. Whether they choose to pursue an academic or industrial career should not make any difference. If students are properly trained they can approach problems in a scientific manner and produce high quality work regardless of where they work.

Based on my previous observations, I believe that the training of future chemists is too important to be left to educators and the whims of the funding game. Furthermore, the involvement of both academic and industrial chemists in determining the future of chemical education would be advantageous for all concerned.

Many people believe that some suggestions for improving our graduate training will come from the Pimentel report. In my opinion such reports have in the past failed to improve the general chemical training. They have at best only produced more funding with little regard on how this funding would affect the students.

In closing, I will leave you with these thoughts: graduate education has suffered considerably during the last years. Time is running short if we are to overcome these losses. If we do not believe that quality training of chemists is an essential component of our society, the future of our country looks bleak indeed.

WOMEN AND MINORITIES IN CHEMISTRY

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I last discussed the subject of women and minorities in chemistry at an ACS meeting in September of 1978, and I thought it might be useful for me to look back at that paper and examine the progress made in the intervening five years. I am happy to report that there is some progress, and unhappy to report that in a number of ways, there isn't very much.

The first requirement for increasing the talent pool available to the chemical sciences is to increase the proportion of women and minorities coming out of the educational pipeline. Here the progress is dramatic, particularly for women.

Since 1970, the number of chemistry bachelor's degrees has dropped 2.3% but the number awarded to women rose 60%, increasing their proportion of baccalaureate awards from 18% to 30%. At the Ph.D. level, a drop of 31% in total degree awards between 1970 and 1982 contrasts with a 60% increase in the number of women earning Ph.D.s. Their proportion of chemistry doctorate awards has risen from 7.6% of the total to 16.2%. They were 37.5% of all full time U.S. graduate students in chemistry in 1983.

Although women are only 5 percent of all chemical engineers, they earned more than 20% of the baccalaureate degrees awarded in 1982, up from less than 1.3% in 1970. The percentage increase in total chemical engineering bachelor's degrees from 1970 to 1982 is 89%, but the increase for women is 2440%! Women are 26.6% of all full time U.S. undergraduates enrolled in chemical engineering, and 18.4% of full time U.S. graduate students.

Minorities are moving more slowly into the chemical sciences. They earned 7.6% of the bachelor's degrees in chemistry in 1982 and 5.1% of the doctorates. They were 8.9% of all full time U.S. graduate students in chemistry in 1983.

In chemical engineering, minorities earned 9% of the bachelor's degrees in 1982, with Asian Americans making up about half of that total. U.S. minority students are 12.3% of U.S. undergraduates enrolled full time in chemical engineering, and 10.7% of U.S. graduate students. The Census Bureau reports that minorities make up almost 10% of all chemical engineers and 15% of all chemists in 1980.

The good news, then, is that women and to a somewhat lesser extent, minority members, are preparing themselves to enter the chemical sciences community. Let's see how they are faring.

Women are about 12% of ACS members this year, up from 7% in 1973. New ACS recruits include 23% women. Minorities have advanced from 5.3% of ACS members in 1976 to 7.4% in 1982. In both cases, these proportions are somewhat lower than those indicated by the Census data.

It is disconcerting, however, to find that gains made by women in equalizing starting salaries earlier in the decade appear to be slipping away. As a proportion of dollar offers to men, those to women in 1983 are relatively lower than in any year since 1974 when these data from the College Placement Council were first reported by sex. The ACS Starting Salary survey for 1983 shows average offers to women bachelor's graduates to be only 94.5% of average offers to men, confirming the direction of the trend.

Given what we know about salaries of experienced chemical scientists, it is unlikely that these women will ever catch up to their male cohorts in salary. Examining salary data of doctorates in chemistry by sex and years since Ph.D. shows us that women fall farther and farther behind men as time goes by.

Salary differences by sex can result from a number of factors. Women are more likely than men to be employed in academic institutions where salaries are lower than in industry or government. Further, women in academic institutions are far more likely than men to be employed in those institutions that pay the lease—namely two and four year colleges. But even when these things are taken into account, together with age, years of experience, degree level and other salary determinants, there is still a large difference in salaries between apparently comparable men and women chemists—and indeed scientists in every field. This has always been true, and comes as no surprise. What most os us may find surprising is that after a decade and a half of affirmative action, women are farther behind their male peers than they were several years ago. How can this be so? The only answer that seems likely is that salary raises over the years have been awarded on a percentage basis, in an effort to match the percentage increases in the cost of living. This has significantly increased the dollar gap.

Salary is important not only for what it buys, but also because it symbolizes worth and power. If I seem to overstress the importance of women sharing some of that power in order to move ahead, let's look at an example of what happens when all power continues to vest in men. Let's look at employment in the academic chemistry departments that award doctorates.

Over the past 20 years, women have earned 9.5% of all chemistry Ph.D.s awarded by these universities. Over the past decade, that proportion is 11.5%. But although every U.S. research university admits women as graduate students in its chemistry department, appoints them as teaching assistants, employs them as skillful, responsible researchers, and eventually grants them Ph.D.s, they then "trivialize and waste" this investment by excluding them from their faculties.

The ACS Women Chemists committee, in six biennial surveys carried out by Sister Agnes Ann Green, found that in 1971, women made up only 1.5% of full time chemical faculties in the professorial ranks. By 1977 that proportion had risen to a magnificent 2.4% and in 1983, to 4.1%. Since 1970, only about 7% of new faculty hires have been women, compared to their far higher availability. Even in 1983, 44% of all university chemistry departments still have all-male faculties (down from 74% in 1971); and 18 schools employing 25 or more chemistry faculty members still include no women.

How does this continue to happen even when the law provides a penalty for institutions that fail to make a good faith effort to utilize appropriate numbers of women and minorities relative to their availability? Because the law has never been enforced. The penalty is withdrawal of their federal funding; but not a single institution has lost federal research funds because of its discriminatory practices.

Responsibility for selecting faculty members lies principally with present faculty members, who must make recommendations to the administration. When those faculties are essentially white and make, they appear likely to stay that way.

In biochemistry departments, although the proportion of women faculty is slightly larger, that proportion is lower in 1983 than in 1977, and 23% of the 136 departments surveyed have no women faculty. Are women available? We must assume so, since women have earned 20.9% of all biochemistry doctorates since 1960, and 23.1% since 1970.

Doctoral women are somewhat more likely than men to seek jobs in academe. I don't know the reason for this, but it can't be because they get better treatment there.

Even women who do find academic positions do not advance at the same rates as their male cohorts. Their opportunity for tenure is less than half of men's, and those who achieve tenure gain it only after a longer wait. They advance in rank more slowly than men, and their salaries lag consistently behind men from the same Ph.D. cohort.

Beyond data on degree awards and general participation in the working population, we have relatively little data by which to compare the advancement opportunities of minorities compared with majority males. However, our limited information indicates that minority women are treated first like women and then like minorities, providing a double barrier. ACS and other salary information indicates that minority women are slightly less than majority women, while minority men earn more than women of any race, but somewhat less than white men.

Women chemists are employed in the Federal government in approximately the proportions that they can be found in the available labor force—18.5%. Minority chemists are 13.7% of the federal workforce in this field. Even here, however, the salary difference between men and women exists. Women chemists in the federal government earn only 81.1% of the salaries that men earn.

Women are about 11% of all chemists in industry. Their salaries are lower than men's but we lack sufficient data to be sure why. They are under-represented in industry relative to their total availability, just as they are in academic institutions.

So it is not surprising to find that women are considerably more likely than men to be unemployed and seeking work. Particularly when demand is moderate relative to supply, women in chemistry as in other sciences find it harder to get a job. One way to see this is to examine unemployment rates of ACS members over several years. We could have utilized National Science Foundation data as well, since it shows the same thing. It is immediately notable that when the unemployment rate for men rises, even a little bit, the gap in unemployment rates between men and women widens further.

Perhaps this is because when RIFs occur, women get laid off before men who have more seniority. Perhaps it is because when there aren't enough jobs to go around, the people who have the jobs to award—almost always men—tend to favor their own sex. Perhaps it is because women are married, and thus not mobile (of course, men also have working wives). Or perhaps they aren't hired because they' single, and might get married and move away; because they have children or even because they don't have children. Oddly enough, there are studies which support each of these contentions as a significant explanation of the discrepancies in the treatment of men and women. Whatever the reason, women in the chemical sciences inevitably have higher unemployment rates than men.

To summarize the changes that have occurred in the status of women and minorities in the chemical profession over the past five years, we find that both women and minorities continue to make rapid strides in preparing themselves for such careers. However, at least for women, advancement still lags well behind that of men, whether in industry, academe or government. Women's salaries are less than men's even after accounting for years of experience, employment sector and degree level differences. Women have higher unemployment rates than men regardless of degree or experience level.

I hope you read Anne Briscoe's review of Vivian Gornick's book on women in science in the March 5 issue of **C & EN.** If not, I commend it to you. Anne points out that "the pattern of discrimination in chemistry is a national disgrace." She is right. All considerations of fairness aside, waste of a scarce commodity is always a disgrace.

Under-utilization of the talent represented in that 63% of the population that is not white and male is wasteful—a waste the nation cannot continue to afford.

SUPPLY AND DEMAND FOR CHEMICAL SCIENTISTS

Cosponsored by
Division of Professional Relations &
Board-Council Committee on Economic Status

Mordecai Treblow, Co-Chairman

This symposium was organized because many chemists believe that the supply—demand equation has fallen out of equilibrium.

In Pittsburgh a year ago we held a symposium on the same subject cosponsored with the Society for Analytical Chemists of Pittsburgh and the Spectroscopy Society of Pittsburgh (cosponsors of the Pittsburgh Conference).

Pittsburgh is unfortunately a good model for what some of us believe is a *shrinking* demand for chemists of all degrees. We have witnessed in the Pittsburgh area an apparent planned shrinkage of the chemical work force on the part of some of our major industries.

The papers presented above are three of those delivered in St. Louis in April of this year. Additional papers from the symposium will appear in the next issue of the *Bulletin.*