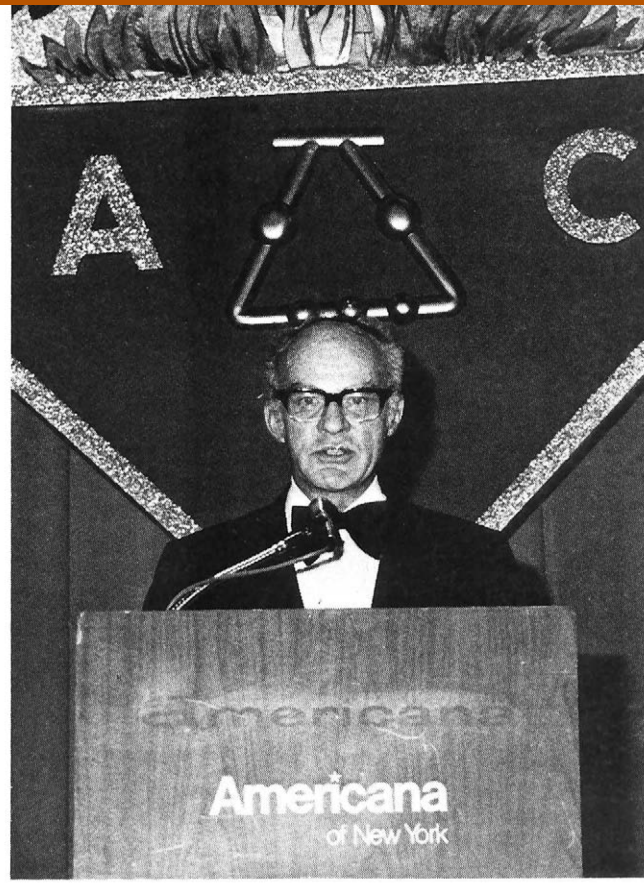
CHEMISTRY IN INTERNATIONAL AFFAIRS

George S. Hammond



George S. Hammond, Priestley Medalist

I now spend half of my life as foreign secretary of the National Academy of Sciences dealing with some international aspects of science and technology. Since the other half of my professional existence finds me still operative as a professor of chemistry, I sometimes try to put the two activities together, at least in my own head. I would like to share some of those thoughts with you even though my attempted synthesis has not yet produced a high yield of profound new conclusions.

There is an ambivalence, characteristic of any kind of large-scale scientific activity, that appears in especially troublesome form in international activities. This problem derives from the questions of motivation for doing and disseminating science, and for public support of those activities. The problem can be illustrated within a single country such as our own. The very rapid buildup of the general scientific effort in the U.S. in the quarter century following World War II and the slackening of the growth rate to nearly zero in the past few years is well known and somewhat painful to many of us. Misunderstanding and mismatching of motivation have contributed to the unhealthy rates of both acceleration and deceleration. The general public, and most importantly their political representatives, supported rapid scientific growth because they perceived possible great gains from the new technologies that would derive from the new science. Paramount among these goals were overwhelming superiority in military technology and anticipated progress in the field of human health. Actually the technical yield in both those fields has been close to sensational. However, in the field of armaments the development of incredibly destructive new weaponry has brought paranoia rather than security because we do not have a monopoly on the developments, and because our faith in the wisdom of the leaders who will determine when and where the weapons will be used has been shaken. Major accomplishments in the medical field, such as development of effective oral contraceptives and chemotherapeutic relief of some of the worst suffering that accompanies mental disorder, are now either taken for granted or questioned as being less clearly beneficial than they seemed but a few years ago.

We scientists have done a certain amount of waffling and have created our own version of the general dilemma. There is some comfort and inspiration from the notion that acquisition of any new knowledge is a gain for humanity and that no one can predict which new knowledge will impinge directly on the lives of many people. This concept becomes less sustaining when the public threatens to decrease or take away support of our work. We are forced to stop and realize that: 1) there is more new science to be done than can conceivably be supported, 2) there must be inequalities in the prospective yields of both knowledge and technical implication in various scientific researches, 3) there is challenge and *possibly* great satisfaction to be had in trying to deal directly with perceived problems of our society, and 4), because we are human, it is not possible to extirpate self-service from our motivation as completely as is done in idealistic and theoretical models of the scientific enterprise.

This is all well known and adequately discussed within the country. I recall the national situation because I see a close relationship to some of the complications that occur in the international science scene. That there are problems is signaled by the fact that the largest and most important international scientific association is the International Union of *Pure & Applied* Chemistry. It is worthwhile to ask why we must have IUPAC rather than simply IUC as it was earlier. At the extremes it is fairly easy to identify activities as being either "pure" or "applied"—if one is willing to accept as pure anything that is clearly not applied. However, in chemistry the borderline between the pure and applied is very fuzzy. There are remarkable similarities in style in the work of many of the pure and applied people; supposedly pure chemists may be caught speculating about possible implications of their research and even guiding their work accordingly; and people whose conditions of employment are such that they should be labeled as "applied" often do experiments designed primarily to satisfy their own curiosity or because the work might lead to publication in a reputable chemical journal. Why, then, do we include the two adjectives in the name of our international union?

I think the reasons are rather complex. Before World War II active participation in IUC was limited almost entirely to a rather small number of North American and European chemists. The change of name is related to an effort to become more universal in appeal. Although I am only vaguely familiar with the discussions of the time, it is reasonable that the extended appeal was both to inactive groups of chemists in the already active nations and to all chemists in other nations. The latter group would have included Japan, which was setting out on its remarkable program of industrial development, and many developing countries where ambitions that would soon lead to many national development programs were stirring. I gather that some of the people who worked out the change of name regarded explicit inclusion of applied chemistry as a liberalizing action. I would not disagree with that view but believe that we probably should look at the present state of affairs with the intent to learn whether the change in name has been accompanied by substantial change in function and accomplishment.

IUPAC has certainly become much larger than IUC was, but this growth might be related only to the growth of chemistry as a whole. New sections having "applied" titles have been added and are, I gather, at least moderately successful. However, the chemists of the world do not flock to IUPAC meetings to learn the newest breakthroughs in commercial applications of chemistry. Instead IUPAC conferences appear to be convenient places to share the fundamental chemistry that has been unearthed incidental to the pursuit of applied programs. The meetings provide a way to exploit the pure chemical tailings left from strip mining for applications. I do not wish to denigrate the action; it is a sensible way of adding to the store of available information.

There does remain the fact that a large amount of information remains proprietary and is not freely communicated. The result is much the same irrespective of whether the proprietary control is exercised by a government or by a corporation in a free market system. Even the international patent system does not lead to full disclosure of chemical results for a variety of reasons. Some countries do not adhere to the patent conventions. Patents are a kind of game in which people strive for maximum protection in return for minimum disclosure. We probably all have had difficulties in repetition of procedures reported in patents, presumably because the disclosure is incomplete rather than dishonest. We also know that a skillfully prepared patent seeks to cover by implication and association cases that never have been tried at all.

As has been pointed out by many people, and especially strongly by Derek de Solla Price, there are categorical differences between science on the one hand and technology on the other. The differences may have something to do with the inherent nature of the physical universe but they derive more from the ways in which people conduct their affairs. Science is variously referred to as the study of natural laws or the accumulated knowledge derived from that study. *Use* of scientific knowledge is *sometimes* referred to as "science" as, for example, when we speak of medical science. Technology involves the use of scientific observations, intuition, and sometimes experimental engineering to make something or to provide a service that is needed and/or desired by people. By these criteria the manufacture of automobiles is clearly technology. It also seems to me that administration of chemotherapeutic drugs also could, by the same criteria, be called technology, but when I have done so on occasion the idea is received as a kind of blasphemy.

I regard these nuances of language and the thoughts and feelings behind them as important. We usually hold that the body of knowledge and insight that we call science is universal, since we have only one universe available to us for study. The paradigm of the singularity of valid scientific fact leads to the recognition that the same facts need not be rediscovered within each of the national boundaries. A modest amount of overlap is desirable because of the fallibility of human observation but a scientific fact is not altered by being British, Chinese, or Brazilian. I conclude therefore that chemists, and other scientists, are correct in forming international unions to help in worldwide dissemination of the results of their work along with other ancillary functions such as settling upon accepted standards of measurement, nomenclature, and the like.

The politicians of the world also participate actively in some aspects of international science and technology. Nearly all bilateral and multilateral accords, such as the Helsinki resolution of 1975, include strong statements of intent to implement vigorous programs of exchange and mutual development in science and technology. On the whole, the results have been disappointing. Logically, chemistry and chemical technology might expect to be featured items in exchange programs so we can learn something about the general situation by looking at what happens in chemistry.

Research in chemistry has flourished during the past 30 years as judged by the volume of published material, the credibility of published results, and the depth of incursion into areas of exploration that were barely conceivable only a few years ago. There also has been considerable progress in commercial chemistry, although I have the feeling that the action has been less spectacular than might have been anticipated. There certainly have been remarkable advances in pharmaceutical chemistry. However, in the areas where chemical industries have experienced the greatest growth—synthetic fibers, films, elastomers, and plastics—the greatest progress has been in development of petrochemicals as a principal raw material and in clever engineering of the ways in which synthetic polymers are fabricated. Many new polymers have been produced and remarkably sophisticated chemistry has gone into their development. The new polymers have had some impact but their overall success has been limited by the fact that the old polymers, such as nylon, urea-formaldehyde, and acrylonitrile-butadiene-styrene elastomer, were and still are very good polymers. It may well be that important new commercial chemistry of the solid state will develop in the near future and the chemistry of environmental preservation seems destined to become an increasingly important area of commercial chemistry.

Pardon my minor digression. My real intent is to examine the contribution of international exchange and cooperation to the recent action. The existence of an international chemical literature has certainly been a powerful influence. Consider what has happened to *Chemical Abstracts.* It has clearly become *the* comprehensive guide to the world's chemical literature, an interesting kind of international collaboration. The publication also has grown so large that it is really used only for specialized literature search. The kind of regular monitoring of the literature that I once attempted, albeit with limited success, by regular reading of the organic and physical sections of *CA* is now done by way of publications such as *Annual Reviews* of *X, Y,* and *Z* or *Advances in P, D, & Q.* Other exemplary publications of this kind are *Accounts of Chemical Research* and *Angewandte Chemie.* The fact that *Angewandte Chemie* is published in an English language edition illustrates the extent to which an important kind of human activity, the precious gift of verbalization, has been shaped to meet the needs of international science.

When I look at the mechanisms for international dissemination of chemical information, I am appalled by their haphazard character. Sheer volume has made abstracts become archival and monolithic. The selective extract literature is invaluable, but disorganized and variable in quality. Some is published by chemical organizations such as the American Chemical Society and the Chemical Society of London; most is provided by entrepreneurial private publishers.

Irrespective of the merits of the specific vehicles for dissemination of chemical information that I have mentioned above, they have the common characteristic of being provincially located in and oriented towards the affluent "free market" countries. To varying extents the countries with controlled economies avail themselves of our abstract and review literature by appropriation or purchase. The countries of the West do the same in reverse on no organized basis. In fact, I believe that there may have been a decrease in the volume and quality of the chemical literature translated from Russian to English in recent years. A cruel result of our capricious system for interaction is that we end up extracting a greater financial toll for scientific information transfer from some of the poorer East European countries, such as Poland and Yugoslavia, than from our principal political protagonists, the people of the Soviet Union and the People's Republic of China.

We see much evidence that scientific sharing becomes a crude and simple extension of big power politics. The U.S. and the Soviet Union go through poorly orchestrated minuets designed to develop cooperative scientific programs. I do not know many facts, but I do have the impression that the Apollo-Soyuz experiments in recent years did not give a very high yield of either new science or new technology. Even if this is true, I am not greatly disturbed by the fact because the political and psychological gains were substantial. What does bother me is that people seem too ready to accept the notion that political gain is all that can be expected from any East-West collaborative effort in the science-technology area. It is as though the introduction of some obvious political motivation destroys scientific motivation, or at least makes people become lazy in that area. Such action is antithetical to some of my own pragmatic instincts. It makes common sense to try to get as much as possible in the way of science out of each of these activities.

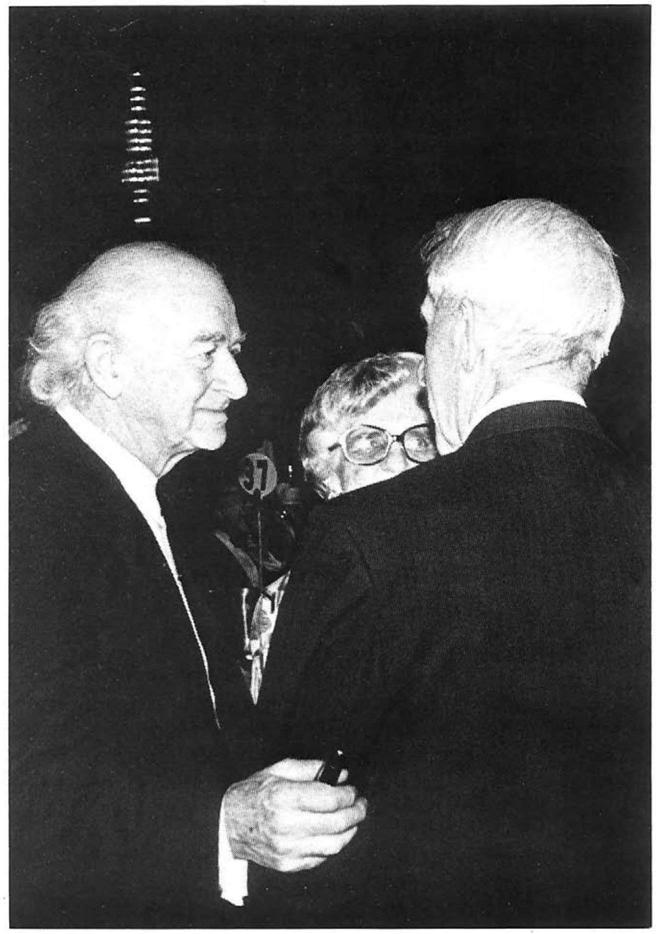
At the present time we are engaged in a large number of bilateral programs with the Soviet Union, and, at least on the books, we have bilaterals in various stages of development with a number of other countries. Many problems have developed including those which accompany any attempt to mesh complicated and very different bureaucracies. One hears disquieting commentary on the actual workings of programs that have been put in place. One of the most successful of the programs with the Soviet Union is said to have been the cooperative research in catalysis for which the American Chemical Society has responsibility but participants in even this most successful activity tell that their work is fraught with difficulties.

In other countries where the U.S. held substantial amounts of nonconvertible domestic currency the money was made available for collaborative work in science and engineering under Public Law 480. In the limited number of cases where I have information the results have not been good. There was a sudden infusion of substantial amounts of money with some special strings attached. The work of solving bureaucratic problems was great and may have exhausted the responsible officials to the point where they were not up to doing the exceptional job of choosing projects that were really needed to make such programs a success. Perhaps the task could not have been done anyway. At any rate the outcome has been discouraging. In some cases the programs are credited with producing results although those results are so like what was coming from the involved laboratories anyway that it is hard to know exactly what was the effect of the PL 480 money. In other cases, especially in research where field work is important, such as some kinds of biology and earth science, early results have been promising but the projects now may die of starvation because of the lack of any follow-on support funds.

The final area of international science about which I will comment is the interaction between the industrially developed nations and the less-developed countries. 25 years ago there was a kind of hazy optimism abroad that held that the less-developed countries could close the gap between themselves and the affluent nations by importing and developing high technology. For various reasons technology transfer did not occur easily just because it was wanted. Technology is regarded as proprietary either by national governments or by private corporations; technology of the kind most sought is highly capital intensive; when high technology is introduced into less-developed countries, massive stresses often are created within the receiving society. The job is difficult and many wonder if there is any conceivable way of coming even close to the targeted goals.

Transfer of science to the less-developed countries is not necessarily easy, but is easier than technology transfer. The U.S. and other scientifically advanced nations have contributed in various ways to development of science, with chemistry being accorded special attention, in these countries. Some of this has occurred through the international unions. Private foundations, such as the Rockefeller and Ford Foundations, have invested a good deal of effort and money in helping to build scientific education in developing countries. UNESCO, despite its political problems, has done some sound things in this direction and the World Bank by way of long-term, nearly interest-free loans has made considerable investment in the development of science education. The U.S. government has maintained some programatic work in the area. Although funding has been sparse, the National Science Foundation has been active in the field. USAID has made some contribution, although the AID program has in my opinion been weak in science and technology.

What have the consequences been? The results viewed as science qua science have been mixed. There are plenty of examples of poor planning and even corruption in the use of funds. The number of NMR machines lying around the world still in the original shipping crates is depressing and representative of a problem. However, the volume of useful scientific publication from developing nations is increasing and surely international assistance is partly responsible. Unfortunately, it also is true that the fraction of the total scientific publication coming from the poor nations has decreased; not surprisingly the rich have found it easier and more efficient to help themselves than to help the poor.



Linus Pauling greets old friends during awards dinner

It is also clear that science education in the less-developed countries has been strongly influenced by this country, Canada, and Europe. I do not see this as an unmitigated blessing because we are exporting a system of chemical education that I and others do not regard as ideal even in this country. However, there has been a good deal of international discussion of chemical education, especially during the past half-dozen years, and useful changes, although painfully slow, are occurring and have a genuine international flavor.

The greatest problem that I see in the role of chemistry and other sciences in international development is that there is confusion and disappointment as to what really is to be accomplished by building scientific research and education in the poorer nations. The immediate needs in, and strong demands from, those nations are for industrial and agricultural technology. A principal justification for building indigenous scientific establishments is the notion that industrialization can occur only in a society where there is a strong scientific community. U.S. scientists have contributed to this paradigm despite the fact that our own history partially contradicts the notion. Our country was becoming highly industrialized, by the standards of the time, at the close of the last century. Even though ACS was born in 1876, the scientific establishment in this country was still relatively feeble in 1900 and any person aspiring to do significant chemical research went off to Europe to get a proper education. The U.S. imported machines and people from Europe and paid by exporting food and promising the immigrants a more affluent life in a rich, underpopulated land.

If we learn from our own history, we realize that the conditions of our development do not exist in many of the nations which now struggle to advance. We also realize that the sacrifice required to build a strong science establishment in such countries may not be justified in terms of rapid impact on development, at least as it is commonly visualized. The prospects can appear rather grim, a circumstance that is reflected in the

Herman F. Mark (extreme right) flanks other awardees at the awards dinner

political stance of the 77-plus nations in the United Nations.

If we stop and think soberly, I believe that we can see ways in which chemical science can continue to thrive as an international activity and to contribute small, but genuinely important, elements to the relations between nations. We have not been doing badly, just not very well; and we will do better if we examine more carefully what we do and *why*.

I am strongly in favor of selective development of collaborative research involving scientists from different nations. Incidentally, I also favor more collaboration among scientists in the same nation and even in the same university, but that is the subject of another lecture. I believe that in seeking areas where collaboration will be worthwhile we have to pay a lot more attention than has been common to the question of complementary contribution by the partners. Two people who will contribute the same skills and understanding may enjoy working together but they may not really accomplish any more than if they worked independently and read each other's papers. When this is the case the extra costs of international cooperation do not seem justified. However, when people can bring different skills and other resources into play the results may be very worthwhile. An example of an international program having some of these qualities is found at the International Center for Insect Physiology & Entomology (ICIPE) located in Nairobi, Kenya. Natural products chemists and entomologists from North America, Europe, and Japan are eager to work with ICIPE because they gain an entrée to tropical insect problems that have vastly richer range than those of the temperate zones. The same is true of the wonderfully rich field of tropical forest products. If we think creatively, I believe that we will find far more that can be contributed to mutual scientific enterprises with other countries, both rich and poor, than has been commonly recognized.

I also believe that international development of chemical and other scientific education continues to be a worthy cause. However, I do believe that we should be far less didactic in our approaches because we do not ourselves have a satisfactorily dynamic system and because direct transplantation of our system may be incompatible with the receiving culture. Here again I believe there is remarkable opportunity for real international cooperation. For example, Americans like to keep playing with new forms of visual aids to education, even though we know that the techniques are a long way from perfected. I suggest that we would do well to work with people from other cultures in these efforts and that the added insights concerning perceptual impact might help create products vastly more useful for everyone. I have an ambition, which I probably never will fulfill, to coauthor a textbook with a colleague whose native tongue is not English. It would be challenging to work out the chemistry with such a person and to see the book being created simultaneously in two languages. I could go on with other examples but time will not permit me to do so.

The reception prior to the awards dinner attracted a big crowd

There is before the American Chemical Society a problem of grave import. If we regard the future of international pure and applied chemistry with optimism, this implies that people should work at it creatively and that the work will require some financial support. I believe that the creative people are available in our own and other countries although not every volunteer will meet the criteria. I am unfortunately pessimistic about the support prospects. The U.S. government seems to be reducing even the minimum programs that it has sponsored directly and in some cases is showing curious dedication to maintaining program forms cast in concrete. For reasons that are well known, highly political, and emotionally acceptable to many Americans, the U.S. has suspended its dues payments to UNESCO, which may deal a death blow to an agency that, despite its problems, has been an important agent for international science. As I have said before, the many bilateral agreements in science and technology are in trouble because they are hard to work out effectively and because many are entirely unfunded. I do not think that our foreign policy is prepared to deal with the present situation in international science and technology and I hope that members of this society will press for a more expansive action. After all, we received Joseph Priestley and many other scientists and engineers from Europe. We now have sent back science and technology, probably to the mutual benefit of the countries involved. At this time we need to both pay careful attention to these old lines of communication and to continue to reach out to those 80% of the world's people who seek to somehow seize the brass ring of technological advantage. □