firm an insight into the life and thought of a foreign scientific community. If this staff is brought occasionally into the U. S. and made to feel like welcome associates, rather than direct dependents, of the American enterprise, they can give valuable guidance in assessing important research trends in their country, and even predicting important break-throughs before they occur.

The American Cyanamid Company established such an institute in Geneva, Switzerland, in 1959. Its laboratories house some 50 scientific workers exclusively engaged in fundamental research. The institute's scientific directors., comprising English, German, Swiss and Danish subjects, have been exceptionally well accepted in European scientific and academic circles. Significant scientific contributions in theoretical organic and inorganic chemistry, molecular orbital theory, and the physics of the solid state, have begun to issue from that laboratory. It is really too early to say whether the Cyanamid European Research Institute will also prove of some value as a means of communication with the European scientific world, particularly since we have made no effort to utilize the institute or its staff in that manner. Indeed, it is not our intention to make such an effort, except as it may occur naturally in the frequent scientific interchange between our institute's scientists and their counterparts in our domestic laboratories.

The Role of the International Union of Pure and Applied Chemistry*

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It has been said many times that science knows no national boundaries. If proof were needed the history of chemistry has much to offer by way of evidence. Papers in the early journals of chemistry were not submitted only by citizens of the country in which the journal was published. They were just as likely to come from abroad. Further, there has always been that important supplement to the published literature of chemistry—personal correspondence between investigators in different countries.

But such means as these fall far short of meeting the full needs of communication. It is the purpose of this symposium to explore some of the other means for promoting world-wide exchange of information in the field of chemistry. My assignment is to describe the ways by which the International Union of Pure and Applied Chemistry contributes to international communication in its area of science.

The Union, commonly known by its English initials as IUPAC, was organized in 1920 as the successor to the International Association of Chemical Societies. The predecessor body was formed prior to the first World War and was composed of about fifteen national chemical societies, all in Europe. In Europe few if any chemical societies are as broadly representative of the whole field of chemistry as is the American Chemical Society in the United States. It became apparent to the chemical leaders of the time who were interested in promoting international communication that the adhering bodies of an international organization that was to be truly representative should, each in its own country, represent the whole field of chemistry and chemical technology. Such representation was provided for in the statutes of the new Union. Thus, in the United States, the Division of Chemistry and Chemical Technology of the National Research Council became the adhering body. Although the American Chemical Society, through its divisional structure, and in other ways, has very successfully integrated most of the organizational interests of chemists in the United States, there are several specialized societies, all of which find a common meeting ground in the National Research Council's Division of Chemistry and Chemical Technology. In Great Britian it is the British National Committee for Chemistry that is the adhering body, in Canada, the Division of Chemistry of the National Research Council, and in France, the Comité National de la Chimie. Because of this basic principle of operating through broadly representative national bodies the Union has a network of communication with chemists throughout the world that is potentially very effective. I shall have something to say later of the extent to which the effectiveness has been and, hopefully, can be realized.

The Union's devices for international communication are broadly divided into two kinds—international congresses and symposia, and the commissions. I feel certain that chemists in the United States know more about the former than the latter. The usefulness of international congresses of chemistry was recognized by chemists before there was a formal organization to sponsor them. The first such congress was held at Brussels in 1894, under the sponsorship of the Belgian Association of Sugar Refining Chemists. The second was held in Paris in 1896, and succeeding ones in Vienna (1898), Paris (1900), Berlin (1903), Rome (1906), and London(1909). The last congress held before the first World War was in New York, in 1912, with 4400 chemists participating. Nearly 800 papers were presented in a program divided into 23 sections. This may well have been the largest congress ever held in proportion to the number of chemists available to attend one. The proceedings of the 1912 Congress, in 29 volumes with a total of 7500 pages, made an impressive contribution to the literature of chemistry and provided an

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interesting picture of the state of our science a half century ago.

Although world congresses of chemistry, since IUPAC was founded, have been held under the auspices of that agency, together with many international chemical meetings of smaller scope, the Union does not plan, organize, or manage such meetings. The Union's human and monetary resources are far too small for such enterprises. The organization and management of congresses are the responsibility of the host country (which was Canada in 1961). The Union's sponsorship tends to set high standards for the papers presented. Judicious selection of host countries helps to provide good geographical distribution of the meetings, and an orderly sequence of programs devoted to various subjects in the field of chemistry and chemical technology.

General congresses of chemistry, such as the Union formerly arranged at four-year intervals, now would attract an attendance so large as to tax the facilities of the largest cities. The last general congress was that in New York in 1951. Since then limited congresses have been held at two-year intervals. Stockholm was the host city in 1953, Zurich in 1955, Paris in 1957, Munich in 1959, and Montreal in 1961. The Munich Congress featured inorganic chemistry but included several symposia on special topics in biochemistry and applied chemistry. The one held in Montreal in 1961 was devoted to physical and analytical chemistry, together with some phases of applied chemistry.

It is no longer the practice to publish the proceedings of an international congress. Instead authors of papers are free to publish them in journals of their own choice. This eases greatly the burden of organizing a congress and undoubtedly eliminates a substantial amount of duplicate publication that would occur otherwise. The change also suggests that the chief purpose of such meetings is to promote personal communication among scientists from different countries—not merely to provide another means of publication.

Under the ever-accelerating tempo of chemical research, certain areas of work generate such intense interest as to cause requests to the Union to organize and to provide partial financial support for international symposia on many special topics. In the current year the following international symposia and conferences will be sponsored or co-sponsored:

- Feigl Anniversary Symposium, Birmingham (England), April
- Conference on Coordination Chemistry, Stockholm, June
- Symposium on Organic Chemistry, Brussels, June (75th Anniversary of the Belgian Chemical Society)
- Conference on Spectroscopy, University of Maryland, June
- Symposium on Chemistry of Natural Products, Prague, August
- Symposium on Molecular Structure and Spectroscopy, Tokyo, September
- Symposium on Pharmaceutical Chemistry, Florence, September

All but the first- and last-named of these meetings will receive modest financial support from the Union, in amounts ranging from $2000 to $4000.

Good communication in any field depends upon a mutual understanding of the language used. For communication in the field of chemistry to have minimum handicaps it is desirable that there be a common language for as many as possible of the concepts, symbols and quantities that are peculiar and essential to chemistry. Among these basic elements of the language of chemistry are the names of the elements, their symbols, the names of compounds, and the names or symbols of fundamental constants. Many of us recall that a certain element was once called glucinum in most of Europe but beryllium in this country, whereas another was known abroad as niobium but over here as columbium. I do not recall that we had any particular difficulty in remembering the duplicate names, but ever since 1949, when the IUPAC commission on inorganic nomenclature recommended a compromise agreement on beryllium and niobium, the new generation of chemists has been able to use the available memory cells for information more important than the alternative names for these elements. This is, of course, only a trivial example of the advantages of standardized nomenclature. Standardizing the methods of naming compounds is a more important matter. Here there is urgent need for a common language, because the possibilities of variation are so much more extensive. In the field of nomenclature we owe what basic uniformity there has been mainly to the fact that, for a considerable time, Europe, in particular Germany and France, was the homeland of chemistry. Teachers and research workers from the rest of the world went there to get their training, and thus learned what may be called the mother tongue of the science. This is no longer true. We can no longer count on an Alfred Werner for the nomenclature of coordination compounds or an Emil Fischer for the nomenclature of carbohydrates and their numberless derivatives.

Obviously, in standardizing the nomenclature of existing compounds and in devising rules for naming compounds as yet undiscovered, there should be the widest possible representation of persons having the requisite interest and competence. This the three nomenclature commissions of IUPAC, dealing respectively with inorganic, organic, and biochemical compounds, have attempted to provide. The operating machinery of the Union makes it possible for persons of suitable interests and qualifications to be appointed to these commissions. Of the ten or so titular members of a commission, there are seldom more than one from a single country. Further, when a nomenclature commission reaches the stage of tentative agreement the preliminary report is circulated for comment to all the member countries represented in the Union. Thus, for example, the Commission on Inorganic Nomenclature circulated, in 1953, a set of tentative rules with the request that criticism and suggestions for improvement be returned. During the next four years, the commission held annual meetings of several day's duration. This very considerable effort to refine and improve the tentative rules resulted, in 1957, in the submission to the Council of the Union, of the "Definitive Rules of Inorganic Nomenclature," which were thereupon widely published.

Most of us would agree, I think, that organic and biochemical compounds present more complex problems of nomenclature than do inorganic compounds, but progress has been made here also. The Commission on Organic

Nomenclature has published a set of definitive rules for hydrocarbons and fundamental hetero-cyclic systems. The Biochemical group has submitted definitive rules for steroids and tentative rules for certain other classes of compounds. Even with the publication of definitive rules, the work on nomenclature is not finished, since there are always extensions to be made for new types of compounds. For such international standardization of the fundamental language of chemistry it is obvious that continuity of operation is as necessary as is broadly representative participation. Both aspects of a successful effort require a formally organized international body. This is the place in the world of chemistry that IUPAC is designed to occupy.

Systems of notation for organic compounds have been the subject of lively differences of opinion. In mentioning this topic I will only say that it would be desirable, if possible, to arrive at a single system that would achieve international acceptance. I believe that progress has been made toward this goal by one of the commissions of IUPAC.

Atomic weights constitute an important part of the fundamental language of chemistry. Knowledge of these constants makes it possible for chemistry to be a quantitative rather than a merely descriptive science. It is, therefore, important to know them as accurately as possible. But it is even more important for all chemists to use identical values. Otherwise confusion may result in the use of published molar- or gram-equivalent data as well as in commercial transactions.

The Commission on Atomic Weights is the oldest of the Union's commissions. Early in the 1900's the existing national committees on atomic weights were replaced by an International Commission sponsored jointly by several national chemical societies until the Union was founded in 1920. Ever since, the Commission has published periodically an "International Table of Atomic Weights" which has enjoyed universal acceptance among chemists. In 1930 the Commission recognized the fact that its scale, based on 16 as the atomic weight of oxygen, which consists of three isotopes, was not satisfactory for defining the atomic masses of individual nuclidic species. It therefore sanctioned Aston's adoption of what has come to be known as the physical scale, based on 16 as the atomic weight of oxygen-16 isotope. Several years ago the Commission recognized the disadvantages to chemists and physicists of having scales so nearly alike, and took the initiative in finding ways to solve the problem. These efforts culminated last year in the adoption of a new scale of atomic weights and nuclidic masses based on 12 as the atomic weight of carbon-12 isotope. Since this action was taken jointly with the International Union of Pure and Allied Physics it is to be hoped that the use of the former chemical and physical scales will be promptly abandoned in favor of the new unified scale. The well-established custom of publishing in many journals the periodic revisions of the International Table of Atomic Weights makes it almost certain that chemists will not hesitate to use the values based on the new scale. Since most, if not all, leading physicists concerned with nuclidic masses have indicated willingness to use the carbon-12 scale, it is likely that the period of transition from the two oxygen scales to the new unified scale will be short. If so, IUPAC and its counterpart IUPAP will have provided the means for interdisciplinary as well as international communication.

The field of chemical thermodynamics has provided an example of impediments to easy communication that can result from geographically localized use of symbols for the important quantities known as the Gibbs and Helmholtz energies. In Europe the symbol G was used for the former and F for the latter. In the United States F was used for the Gibbs quantity and A for the Helmholtz energy. Many hours were consumed by the Commission on Symbols and Terminology in the effort to resolve this problem. At the meeting of the Commission in 1959 agreement failed, but in 1961 a decision was made to recommend eliminating the symbol F, which had been used with two different meanings, to retain G for the Gibbs energy and to adopt a new symbol, A, for the Helmholtz energy. If these recommendations are generally followed, an important clarification of chemical notation will be accomplished. From this experience one can reasonably conclude that situations involving entrenched differences of opinion or practice are not likely to be resolved by correspondence but require across-the-table discussion among well intentioned people who realize the importance of standardizing the fundamental language of chemistry.

The exchange of information and ideas that is stimulated in the periodic meetings of commissions not infrequently leads to the organization of symposia on specialized topics. For example, in 1955, the Commission on Physico-Chemical Data and Standards took cognizance of an emerging technique for evaluating the purity of a substance by precise measurement of the slope of its freezing or melting curve. An international symposium held in Amsterdam in 1957 dealt with the many variations of the technique that had come into use. The principal conclusion was that an international experimental study should be made of systems of known composition. This has been done in a program in which 21 laboratories in six countries participated. A second symposium was held in 1961 to discuss the results. The proceedings of the symposium, when published, will provide a critical evaluation of the procedure. The international cooperation that took place will enhance the value of the study to the many users of this relatively new addition to physical methods for chemical analysis.

It should not be surprising that geochemists would make use of the channels of communication provided by IUPAC. The Commission on Geochemistry has sponsored a number of symposia and has undertaken the distribution of bibliographic material. Meeting places for symposia sometimes have been chosen to provide easy access to regions where profitable field trips could be made.

The Commission on High Temperatures and Refractories, after some years of inactivity, was reorganized in 1957 and held a symposium on High Temperature Chemistry in 1961. Another on "Properties and Applications of Plasma" is planned for 1963. This Commission also compiles and distributes bibliographic material. A "Bibliography on the High Temperature Chemistry and Physics of Materials in the Condensed State," prepared by eleven collaborators in various countries, has been issued quarterly since 1957. It covers the literature of thirteen countries and has a circulation of about 1700. A similar bibliography dealing with gases and with gas-condensed phase reactions was begun in 1961. These efforts provide excellent examples of the stimulating effect a small group, properly organized and sponsored, can have on international communication.

The Commission on Thermodynamics and Thermochemistry has an effective program of standardization of techniques of experimental thermochemistry and has published two volumes of a series dealing with this subject. This Commission also publishes the Bulletin of Thermodynamics and Thermochemistry, which will run about 1000 pages this year. Through symposia it has been highly successful in promoting personal acquaintance among the world's leaders in this field of science.

The illustrations I have given of commission activities have been chosen partly on the basis of their importance but partly also on the basis of my greater familiarity with them than with some others. Time would not permit giving even a brief account of each of the commissions not yet mentioned. However, the appended list of all the commissions now in being will serve to show the diversity of interest and activities. The listing will also show the organization of the Union in the six sections of Analytical, Applied, Biological, Inorganic, Organic, and Physical Chemistry. Each of these sections has a section committee whose duties are not only to give oversight to the operations of the commissions but to deal with matters that go beyond the scope of interest of the commissions.

LIST OF IUPAC COMMISSIONS

Analytical Chemistry: Analytical Reactions, Microchemical Techniques, Nomenclature, Spectrochemical and other Optical Procedures, Electrochemical Data, Equilibrium Data

Applied Chemistry: Food Division; Trace Elements in Food, Food Additives, Fermentation Division; Determination of Fusel Oil, Characterization and Evaluation of Dried Yeasts.

Biological Chemistry: Nomenclature, Proteins, Clinical Chemistry

Inorganic Chemistry: Atomic Weights, Nomenclature, High Temperatures and Refractories, Geochemistry

Organic Chemistry: Nomenclature; Codification, Ciphering and Punched Card Techniques

Physical Chemistry: Symbols and Terminology, Chemical Thermodynamics, Electrochemistry, Macromolecules, Physicochemical Data and Standards, Molecular Structure and Spectroscopy, Applied Radiochemistry (Joint Commission with other Unions,

Some of the above listed commissions have subcommissions. The primary organization of the Section of Applied Chemistry is by divisions. In addition to the two divisions named, there are Divisions of Water, Sewage, and Industrial Wastes; Pulp, Paper and Board; Plastics and High Polymers; Pesticides; Organic Coatings; Oils and Fats; Toxicology and Industrial Hygiene.

Although the Union has a very important mission in international communication, both through the functioning of the commissions and through its sponsorship of international congresses and symposia, there have been limitations to its effectiveness in performing the mission. More than 25 years passed after its founding before the Union had any significant influence outside of Europe. This was not because it lacked distinguished leadership. Some of Europe's most eminent chemists served as the Union's presidents during the early years. There was always, of course, a lack of adequate financial resources. But the chief obstacle to international cooperation outside of Europe was the time required for travel from countries no farther away than the United States and Canada, not to speak of Australia and the Far East. Air travel has changed that. One no longer has to take two weeks or more to attend a two or three day meeting in Europe. United States representation on IUPAC Commissions before the second World War was almost entirely limited to persons who took holidays in Europe or who occasionally had some other business that could be fitted in with an IUPAC conference. It was only by accident that these representatives had any interest in or competence for the tasks IUPAC was concerned with. Today some fifty chemists in the United States are active members of IUPAC commissions. There is also representation from Australia, Egypt, India, Japan, and South America. The U. S. S. R. stood aloof during the Stalin regime but now participates substantially in the Union's business.

An important step toward increasing the usefulness of the Union was the establishment in 1959 of the Journal, "Pure and Applied Chemistry," as the official journal for the publication of scientific literature resulting from the work of the commissions, sections, and divisions. To date three volumes have appeared, in seven issues totalling about 1800 pages. Five of the issues contain papers presented at symposia. One provides a set of wave lengths for the calibration of infrared spectrometers, produced by the Commission on Molecular Structure and Spectroscopy. The seventh is a tabulation of Dissociation Constants of Organic Acids in Aqueous Solutions, sponsored by the Commission on Electrochemical Data. The journal is self-supporting.

The union has three principal sources of financial support; dues of member countries, voluntary contributions, and subventions of UNESCO funds. Dues are divided into several categories determined by the extent of chemical activity in the various countries. Currently the dues range from $450 to $10,000. UNESCO funds are channeled through the International Council of Scientific Unions. Their use is limited to other than administrative purposes. Other funds are used mainly for administrative costs and for partial reimbursement of commission members, section officers, and general officers.

There is now an active movement toward increasing the Union's financial resources so that desirable operations need not be restricted for this reason, at least to the extent that they have been in the past. These changes will not come instantly but only as and when the Union demonstrates that it can promote the science of chemistry in ways that complement those pursued by national chemical organizations in the various countries.

A challenging but thus far neglected field of activities for the Union is the sponsoring of international meetings in countries in which chemical industry is still limited and needs encouragement to play its part in the strengthening of the local economies. We in the United States are well aware of the significance of chemistry to the national welfare and of the contributions to the development of chemistry that have been made by our well-organized and well-financed chemical societies. For us it is easy to imagine the stimulus that could be given to chemical development in outlying parts of the world by such means as well-planned symposia in fields of special national interest. The prestige given to such meetings by the sponsorship of IUPAC plus the subsidized attendance of a few well-chosen eminent specialists from Europe, Japan, the United States and Canada would give assurance of substantial benefits to the countries in which the meetings were held. Such activities by the Union, on a scale commensurate with the needs, would require resources far greater than the Union can command even if the contemplated increased rate of income is realized. There is evidence, however, that the Union is beginning to think in terms of a world-wide mission for the promotion of the science of chemistry, with all its attendant benefits to human welfare, rather than to limit itself to the interests of its constituent member countries.

SCANDOC—A Scandinavian Cooperation in Science-Tech Communication.

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The Scandinavian Documentation Center, SCANDOC, was established in Washington, D. C., in May of 1960. The purpose of SCANDOC is to assist the Scandinavian scientific and technical research councils and academies, as well as information services established by these organizations in the Scandinavian countries, in the fields of scientific and technical documentation and information activities. The activities of SCANDOC thus include the following: to locate and procure documents in science and technology upon request; to carry out or subcontract literature searches on request; and to follow developments in documentation and scientific information activities in the United States and Canada. These services are also open to Americans or Canadians who are interested in Scandinavian research. The activities of SCANDOC are limited to the fields of applied research and bordering fundamental research, exclusive of life sciences and medical research, and by the important consideration that SCANDOC shall not be used when the information or document can easily be obtained through conventional channels, such as the regular scientific press, bookstores, libraries, etc.

In general one may say that SCANDOC constitutes an unconventional channel for scientific communication between the Scandinavian countries and U. S. and Canada, with the prime objective of facilitating the exchange of scientific literature not easily obtainable through conventional channels.

It is hardly necessary to elaborate on the needs for an office of this kind: the mounting volume of Government Research reports, progress reports, conference papers, institute and foundation reports, thesis papers, pamphlets, brochures, exhibit material, etc. This activity of scientific documentation has in fact become the major activity of many scientific attachés, and the four Scandinavian countries Denmark, Finland, Norway and Sweden agreed that it was desirable to relieve the attachés of this work, and to economize and rationalize by centralizing this activity in one office.

The proposal for this venture in international scientific communication originated with the Scandinavian Council for Applied Research (SCAR). This organization is a common working secretariat for the research councils and academies for science and technology in Scandinavia, and has been instrumental in furthering Scandinavian cooperation in these fields. The plans for SCANDOC were worked out by the technical and scientific attachés and representatives of the four Scandinavian embassies in Washington on a request by the Scandinavian Council for Applied Research in 1958.

International cooperation in science and technology has long traditions in Scandinavia. The universal nature of science and the importance of direct communication between scientists was recognized quite early. The first organized Scandinavian Congress of Natural Sciences was held in Copenhagen in 1839. Since then across-the-border cooperation has been growing steadily both in magnitude and in scope. This development has, of course, two good reasons: (1) The problem of being small, which creates a need for cooperation, and (2) the closeness and similarities of the four countries, which make cooperation natural and easy.

All four countries are small in population: Sweden 7.5 million, Denmark 4.6, Finland 4.5, Norway 3.6 and Iceland 0.176 million inhabitants. Standard of living is high in all countries. A high standard of living is entirely dependent upon a well-developed and integrated economic and industrial system and an advanced and progressing technology. The problem of maintaining a technology in small nations averaging fewer than 5 million people, which must keep pace with the technology in the United States in the 1960's may seem an impossible task. The solution to the smallness problem is extensive cooperation. Together these five nations count more than 20 million people, that is about 2 million more than Canada. The countries cover an area about the size of Central Europe, that is, a little more than the six European Common Market countries (West Germany, France, Belgium, Netherlands, Luxemburg, and Italy) together.

It is interesting to note that this group of 20 million people, 0.7% of the worlds population, attracts 5.3% of the world's trade, produces one half of the chemical pulp entering world trade, controls 13% of the world's shipping and has the next highest income per capita in the world, surpassed only by the U. S. (1957-figures).

Professional manpower in science and technology is drawn from about 30 universities, institutes, and colleges granting professional degrees, all of recognized high standard, though inadequate in number and capacities.