portion of the molecule. Thus "phosphorus pentachloride" suffices for PCl_5 or P_2Cl_{10} for most purposes, but for designating the structure of the crystalline form, $[PCl_4]^+[PCl_6]^-$, "tetrachlorophosphonium(V) hexachlorophosphate(V)" is more accurate and more informative.

Furthermore, there are whole areas (such as isopoly and heteropoly acids) hardly touched on in the IUPAC Rules. Thus, while they are a much-needed start in the right direction, a great deal more remains to be done, as you shall see.

Procedures in the Development of Chemical Nomenclature*

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Language lives. As with all living things language is constantly changing for better or for worse. Because science must be exact and because scientific research is continuously turning up much new information, there is perhaps more need for growth in scientific language than in any other kind. In chemistry this need is extra strong because chemists need to discuss effectively hundreds of thousands of chemical compounds, including probably almost 100,000 new ones each year. Most of the newly prepared compounds are characterized by increasing complexity.

Individual investigators are continuously confronted with the need for good names for substances or phenomena on which new light has been thrown. In the earlier days names were coined with few or no guiding rules or other considerations with standardizing purpose. It is perhaps altogether natural that discoverers should have developed a feeling that they have the right to name their own children. This feeling of right or privilege is, no doubt, justified so long as it does not interfere with progress or what might be called the general good. In the earlier days there was a good deal more insistence on the exercise of this right than is true now, and this also is natural. The need for system has become overwhelmingly apparent with the growing quantity and complexity of information.

Editors, confronted with recording problems, have had a good deal of influence on nomenclature development and other efforts for good usage. They have had many struggles against rugged individualism. Abstract journal editors, confronted with the heaviest recording task, have had the advantage of not having to deal directly with individuals.

Nomenclature development has been both national and international. Since science is international, it is good to be able to say that there has been increasing emphasis on international efforts. The existence of the many national languages has been a handicap in the international efforts, but not an insurmountable one except for details.

Within nations the scientific societies, for chemistry at least, have long had standing nomenclature committees. On these committees the editors of the publications of the scientific societies have almost always been represented and so awareness of needs and general problems as well as good opportunity for applying rules worked out has been in the picture.

At first, the tendency was for one general committee, with various branches of chemistry represented on it, to undertake to solve nomenclature problems. Eventually, it was realized that there should be separate working committees consisting of groups of specialists for special fields or problems. Gradually, the role of the general society committee came to be one of stimulation, organization, general guidance, testing of proposals, and dissemination of information. I mean by these words that the general committees, while solving some problems of a more or less general nature themselves, have seen to it that specific problems received attention, have helped in the organization of working committees of specialists, have endeavored to help such committees, have made sure that the recommendations of the groups of specialists would fit in with the general nomenclature picture, and then have encouraged good usage by gaining official approval of the rules and by special efforts to get the information into the hands of users. They have gone further by pointing out bad usage to individuals, by urging good usage in key positions, as in those held by editors and teachers, and often by seeking international approval of rules standardized within a nation.

In the United States the American Chemical Society's Committee on Nomenclature, Spelling, and Pronunciation, organized in 1911 (there was an ACS Committee on Nomenclature and Notation as early as 1886), undertook perhaps too long to work alone. During the 1940's the need for special committees was met largely by the appointment of nomenclature committees within many of the divisions of the American Chemical Society. The Committee on Nomenclature of the Division of Organic Chemistry, under the leadership of Howard S. Nutting, became especially active and gradually built up special working committees for the organic field under its guidance. Now subcommittees of the divisional committees work out most of the rules on special subjects within the fields of the respective divisions.

When there has been overlapping interest, ACS divisions have not hesitated to appoint joint working committees. This has worked to good advantage.

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Many of the rules and recommendations of the American Chemical Society's general committee have, with little or no alteration, been made world-wide standards in chemistry by action of commissions of the International Union of Pure and Applied Chemistry.

A kind of flow sheet of modern chemical nomenclature development would read somewhat as follows:

> From an idea or suggestion (made by an author, editor, committe member, anybody) to a subcommittee of specialists, to a divisional committee representing a branch of chemistry, to the ACS Committee on Nomenclature, Spelling, and Pronunciation (in a position to fit rulings into the general nomenclature picture and to gain official ACS approval), to the National Research Council, to the appropriate nomenclature commission of the International Union of Pure and Applied Chemistry.

There are, of course, variations in this flow, which is mentioned only as a typical example of procedure.

The official contact in America of the International Union of Pure and Applied Chemistry is the National Research Council. To facilitate the flow of nomenclature problems and tentative decisions from national consideration to international consideration, and *vice versa*, it was decided several years ago to organize a general Nomenclature Committee under the control of the National Research Council as well as various NRC subcommittees for branches of chemistry. It would be difficult to imagine too many active in nomenclature work. To facilitate cooperation, encourage consistency, and avoid work at cross purposes, it has been customary for the parallel ACS and NRC nomenclature committees to be made up in part of the same personnel. There has never been serious disagreement.

There is another kind of international cooperation in nomenclature work. The Chemical Society (London) and the American Chemical Society have long endeavored to work together as much as possible in nomenclature standardization. The two large, English-speaking nations which these chemical societies represent, with growing active cooperation in recent years, have often presented a common front in the efforts for international standardization in chemistry. English is the language most used by far in the recording of scientific information (over half of the world's chemical literature is recorded in the English language), which adds appropriateness to this special phase of international cooperation. Differences in languages do, of course, make for difficulties and variations in international standardization, as mentioned above, but that is a subject beyond the scope of this paper.

The members of nomenclature committees or commissions are, as a rule, rather widely scattered geographically. Frequent getting together for discussion of problems is usually impractical. Accordingly, much developmental work on nomenclature is done by correspondence. Meetings are held to good purpose from time to time, however, such meetings on a national scale most frequently occurring just before or during meetings of the responsible scientific societies. Special committee meetings, with travel subsidized sometimes, occur less frequently.

The members of the nomenclature commissions of the International Union of Pure and Applied Chemistry have a still tougher problem of gathering for meetings. The Union meets only biennially. The commission members work hard, however, and usually manage to hold special meetings. The IUPAC Commission on the Nomenclature of Organic Chemistry and the like commission for inorganic chemistry have a week-long meeting each year in addition to getting together during the week of each IUPAC meeting.

I believe that it would be well worthwhile for each of the larger branches of science to maintain some sort of full-time nomenclature board. The availability of good standard nomenclature kept up-to-date is essential for effective development in a science. Exact and clear communication among scientists is of paramount importance. I have been advocating the formation of such a board for chemistry, and a beginning has been made. In the office of the Chemical Abstracts Service two workers are devoting almost full time to nomenclature. In the National Research Council organization for more than volunteer help in chemical nomenclature development has been recognized as desirable, and it is understood that this is likely to be accomplished. The CA office, where the Chairman of the ACS nomenclature committee has always been located, has become a center for nomenclature information. Many thousands of copies of nomenclature pamphlets (30 different ones) are distributed annually. The staff members of an abstract journal for a science constitute that science's principal group of record keepers, and they have special responsibilities with reference to the development and use of good nomenclature.

Since procedure is my subject, I shall not go much further in this discussion, but would like very briefly to mention some of the general considerations which enter into the nomenclature development picture. I list these as (1) discoverer's rights, (2) logic, (3) etymology, (4) usage, (5) expediency, (6) recording requirements, as in indexes, (7) precedence, (8) teaching considerations, and (9) the frequent need for short names (trivial or generic) of substances commonly referred to verbally or in industry and trade.

The trivial or short-name problem in chemistry is a special one. Much can be said in favor of the use of systematic, descriptive names for chemical compounds, but such names do often become long and difficultly pronounceable. There is legitimate need for a considerable number of short names for various purposes. The springing up of many of the names of this kind has been haphazard, but in recent years there has been increasing effort to control the coining of trivial names. The effort has been to try to select or approve names which are not misleading or objectionable for some other reason. The American Medical Association objects to names for drugs which suggest clinical use and the ACS objects to names which break standard chemical nomenclature rules as to endings and the like. There are national groups now which undertake to control trivial names and recommend generic names for pesticides and for food additives, for example.

One of the problems confronting nomenclature workers has to do with publication. Should nomenclature proposals be published as such for the sake of the widest possible consideration or should publication await official approval of proposals with or without modification? There is always a risk that published proposals will be accepted for more or less general use before standardization can be effected, which is not good for the scientific record

when the proposals fail to gain approval. On the other hand, the widest possible consideration of proposals is desirable. Committee members often need the opinions of others. This question has never been settled and perhaps never will be. It is very desirable for proposed nomenclature (as contrasted with accepted nomenclature) to be regarded as tentative and used with discretion. Sometimes the interval between proposal and official action is rather long. This is not always avoidable.

Even approved nomenclature rules are often published as tentative for a year or so to give potential users an opportunity to discover and report objections. This is healthy practice.

Nomenclature development is not easy. The hard work required takes much time, study, criticism, correlation, and original thinking, and it calls for a truly comprehensive knowledge of the scientific field involved as well as of word structure. The widest possible nomenclature picture often needs to be kept in mind for the sake of consistency. It is wise to keep branches of chemistry from developing nomenclature systems out of step with each other as to general planning whenever the good of the whole of chemistry is better served by a consideration of the needs of all.

Once official agreement on nomenclature rules has been reached the widest possible distribution of the information is desirable. Then all scientists have an opportunity to help, not only in the good cause of nomenclature development, but also in the development of affected scientific fields through the use of the most effective scientific language. Is it not a duty to try to use standard nomenclature?

Inorganic–Organic Nomenclature

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Some of the overlapping areas between inorganic and organic chemistry and their nomenclatures have been no-man's land and some have been both men's land, without any real truce, although it is increasingly recognized that there is no fundamental distinction between these branches of chemistry that have been separated by historical developments. With the rapid growth of organometallic chemistry and the quickly disappearing border between the two disciplines, it is the purpose of this paper to examine the nomenclature systems used in inorganic and organic chemistry, to look at the similarities and differences in the two systems, and to point out some of the problems arising as the result of these differences.

When we compare organic and inorganic nomenclature some of the basic differences between organic and inorganic chemistry must be kept in mind:

1. Inorganic chemistry is concerned with many elements, while organic chemistry is basically concerned with just one element, carbon.
2. Inorganic chemistry deals with oxidation states.
3. Different types of bonding are much more frequently encountered in inorganic chemistry.
4. Structures with alternating atoms (that is bonding between different kinds of atoms) occur more often in inorganic molecules.
5. Organic chemists were concerned at an earlier stage with structure—inorganic chemists only more recently. Thus, some inorganic compounds of silicon, germanium, and boron analogous in formula to organic compounds were at one time given organic-sounding names like disilicoethane, germanoethane, and boroethane.

An encouraging development is the increasing cooperation between inorganic and organic nomenclature committees. In the International Union of Pure and Applied Chemistry (IUPAC), at least in recent years, there has often been an organic observer at meetings of the Commission on Nomenclature of Inorganic Chemistry, and *vice versa*. In 1959 at Munich, the two commissions set up a joint subcommission consisting of an equal number of members from each to study the whole field of nomenclature of organometallic compounds. The subcommission consisted of four, and later three, members each from the organic and inorganic commissions. In the American Chemical Society there has been good cooperation between inorganic and organic nomenclature committees in some cases, while in others more would have been highly desirable; fortunately, there is promise of better cooperation in the future.

Reports of special nomenclature subcommittees under the Division of Organic Chemistry of the American Chemical Society, dealing in some cases in part with inorganic as well as organic compounds, are those published on silicon,[1] fluorine and other halogens,[2] and

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