International Cooperation: The New ICSU Program on Critical Data

Harrison Brown

From that vast, amorphous body of knowledge known as scientific and technologic information, evaluated numerical data emerge as a definable and manageable aspect. It is recognized that the generation, evaluation, and dissemination of critically evaluated numerical reference data are an important part of the overall problem of science information because of the direct dependence of both technology and basic scientific research on reliable quantitative data. As increasingly accurate and precise information is required on increasing numbers of compounds, it is simply impractical for each nation alone to attempt to cope with the problem. Not only is the scope of the task too large; no one nation has the expert manpower or large financial resources required to abstract, appraise, compile, and disseminate all the data generated by scientists of the world and needed to fuel modern research and development. Since the membership of the International Council of Scientific Unions (ICSU) covers all disciplines in the basic natural sciences, with representation from the major science-producing nations of the world, it seems ideally suited to provide the necessary intellectual stimulation and the proper cooperative forum for a voluntary international coordination of efforts at compilation.

The interest of ICSU in critical data dates back to the early 1920's when its predecessor, the International Research Council, was an important sponsor of a project that resulted in publication of *The International Critical Tables of Numerical Data of Physics, Chemistry and Technology* in seven volumes between 1926 and 1930. It had been hoped that this would be a continuing effort, with the issuance of periodic supplements and revisions, but various factors converged to prevent this. Meanwhile, modest efforts at compilation were in progress in individual countries as the need for more up-to-date information accelerated. The ensuing war years interrupted or ended most of this work on compilation. Projects were soon begun again, however, although by the 1950's it was clearer than ever that the job of updating and expanding *International Critical Tables* from its original form would be an impossible task. Not only had science and technology expanded and new areas requiring quantitative data been discovered, but the degree of precision required for measurements in both science and industry had increased in many areas by at least an order of magnitude.

Compilation efforts continued, most notably in the United States through the coordinating efforts of the Office of Critical Tables of the National Academy of Sciences–National Research Council and later with funding and management provided by the National Standard Reference Data Program of the National Bureau of Standards; in Germany with the *Landolt-Bornstein Tabellen*, and in France with what was originally known as the *Tables Annuelles de Constantes et Données Numériques*. Other, more limited work on compilation was done in various countries as individual nations attempted to meet particular needs in limited areas for standard quantitative data. No country succeeded in meeting all its needs.

Establishment of CODATA

Early in 1964 the National Academy of Sciences–National Research Council, which had financial and editorial responsibility for the *International Critical Tables*, decided to approach ICSU again with the suggestion that the latter consider offering its services for voluntary coordination of the many individual efforts that existed or were contemplated; the basic purpose was to assure that data of high quality were readily available as a meaningful whole to all who desired them. The Council reacted favorably to the proposal and established a working group under my chairmanship to examine the suggestion in depth and to make recommendations for further action. Other members of the group were V. A. Kirillin (a Russian engineer), W. Klemm (a West German chemist and president of the International Union of Pure and Applied Chemistry), F. D. Rossini (an American chemist intimately associated with the original *International Critical Tables*), Sir Gordon Sutherland (a British physicist and a vice president of the International Union for Pure and Applied Physics), and Boris Vodar (a noted French high-pressure physicist).

The working group was asked to report back to the executive committee of ICSU in 1965; this it did by recommending that ICSU, as the leading international nongovernmental organization in the basic natural sciences, accept responsibility for coordination and improvement of various efforts at compilation in the relevant disciplines on a worldwide basis. The executive committee of the ICSU endorsed the report of the working group, and a series of final recommendations was prepared for submission to the general assembly of ICSU, meeting at Bombay, India, in January 1966. Full approval was received for the project with the appointment by the general assembly of a Committee on Data for Science and Technology (CODATA) (see box) to supply the necessary leadership in coordination of an international effort to improve compilations of critically selected numerical and other quantitatively expressed scientific data.

Members of the Committee include representatives of 11 interested international scientific unions that are currently members of ICSU, and representatives from the six leading nations involved in critical work on data: France, Germany, Japan, the United Kingdom, the United States, and the U.S.S.R. The role of the unions' representatives in the work of CODATA is a vital one. The international unions are one of the principal vehicles for recording and disseminating scientific information. Through appropriate com-

The author is professor of geochemistry at California Institute of Technology, Pasadena. This article is adapted from a paper read before the AAAS, 29 December 1966.

mittees and commissions, standardization and international accord are accomplished in such matters as values of atomic weights, values of the basic physical constants, standards of measurement, and symbols for physical quantities and the units in which they are expressed. Without standardization in such facets of scientific language, precise communication among scientists would be impossible and considerable confusion would result. In addition, several of the unions of ICSU, such as IUCr, IUPAC, and IUPAP, are engaged in the actual operation of substantial data-evaluation projects. The national representatives on CODATA were selected because of their knowledge of data-compilation efforts in their own countries as well as their basic familiarity with efforts in progress in other nations. It is expected that national representation on the Committee will expand as the scope of the ICSU project is widened. The members of the Committee agree that there is urgent need to increase the interchange and flow of the numerical data of science among the countries of the world; there is equally urgent need to share the task of evaluating and appraising newly produced data and putting them in forms useful to the world's scientific community.

The Committee's central office is housed by the National Academy of Sciences–National Research Council for the next 2 years. Sometime late in 1968 the office will be transferred to Europe. The central office of CODATA has been staffed internationally with Guy Waddington (National Academy of Sciences) as director (part time), Christoph Schaefer (Institut für Dokumentation, Frankfurt, Germany) as assistant director, Mrs. Simone Kyropoulos (French born but a U.S. citizen) as research assistant, and Miss Annegret Kundrat (recently employed by the International Atomic Energy Agency in Vienna) as administrative secretary.

INTERNATIONAL COUNCIL OF SCIENTIFIC UNIONS

Committee on Data for Science and Technology (CODATA)

MEMBERSHIP

Bureau

President:	Professor F. D. Rossini
Vice President:	Professor W. Klemm
Vice President:	Professor B. Vodar
Secretary-Treasurer:	Sir Gordon Sutherland

Union Representatives

International Astronomical Union (IAU)
International Union of Geodesy and Geophysics (IUGG)
International Union of Pure and Applied Chemistry (IUPAC)
International Scientific Radio Union (URSI)
International Union of Pure and Applied Physics (IUPAP)
International Geographical Union (IGU)
International Union of Crystallography (IUCr)
International Union of Theoretical and Applied Mechanics (IUTAM)
International Union of Physiological Sciences (IUPS)
International Union of Geological Sciences (IUGS)
International Union of Pure and Applied Biophysics (IUPAB)

National Representatives

France:	Professor B. Vodar
Germany:	Professor W. Klemm
Japan:	Professor M. Kotani
United Kingdom:	Sir Gordon Sutherland
United States:	Professor F. D. Rossini
U.S.S.R.:	Academician M. A. Styrikovich

Other ICSU Representation

ICSU Abstracting Board (IAB)
Federation of Astronomical and Geophysical Services (FAGS)

Purposes and Objectives of CODATA

Within its general purpose of promoting and encouraging the production and distribution of compendia and other forms of collections of critically selected numerical and other quantitatively expressed values of properties of substances important to science and technology, the Committee has established for itself the following specific goals: (i) increased awareness by all scientists of the importance of the problem, and, in particular, encouragement of young scientists to appreciate and participate in compilation work; (ii) improved status, salaries, working conditions, and facilities for compilers; (iii) realization that evaluation and publication of numerical and other quantitative data are inherently expensive and that subsidies from various sources may be required to promote both their production and fullest utilization; (iv) increased personal contact among workers in this area by encouragement and arrangement of periodic meetings of specialists in the various fields and of exchange visits between related compilation centers; and (v) encouragement of programs of precise experimental determination to close gaps in knowledge and to extend and complete compilations in important areas.

In order to establish a climate favorable to the success of these purposes, the Committee has delineated several particular tasks for its attention. Work has begun on preparation of a comprehensive "Request for information," to be sent to the various unions and appropriate national bodies to ascertain as completely as possible what work on evaluation and publication of numerical data is being carried on in each country, what other capabilities exist in each country, and what work is being sponsored by each of the scientific unions or other international groups. These surveys of countries will include identification of continuing numerical data centers and their pub-

lications, centers being formed, single or occasional books of tables of acceptable quality, and other relevant matters. The results of the surveys of nations and of union activities, capabilities, and needs will be reported in a "Survey and analysis" which will be distributed internationally. One of the most important features of the new ICSU project will be provision for continuity in various aspects of its work; toward this end, provision will be made for revised editions of the "Survey and analysis" to be issued periodically.

On the basis of the information collected by the survey, CODATA will attempt to assess the needs of science and industry for additional compilations of evaluated data. The aim is to make those who are responsible for the actual production of compilations of data aware of the specific needs and requirements of the users of data. Costly delays in industrial work and in research investigations can often be avoided if the right type of data are easily available when needed.

The Committee will direct its attention to existing programs also in an effort to strengthen them if necessary and encourage coordination among them in order to maximize their effectiveness, minimize unintentional or undesirable overlap, and discover possible needs for new compilation programs. It is hoped that, as is appropriate, informal links can be established with governmental and intergovernmental groups, the unions, and their national adhering bodies that are involved with reference-data programs in various ways. The Committee hopes to perform a useful service by providing an opportunity for exchange of information among these groups, and by acting as a channel for communication and coordination between and among them. The desired type of stimulation and coordination is already becoming visible. The adhering organizations of several major countries have established national committees for CODATA, manning them with scientists of the highest caliber. Also a move is developing, in a very informal way, for governmental program managers, having funding responsibilities, to meet under the aegis of CODATA for exchange of views. Thus a very real fruit of the ICSU program will be the improvement of the organization within unions and countries that is bound to result when leaders in the planning field, from various countries, are able to put their feet under the same table. The Committee is also highly conscious that very important compilation work of high quality is conducted in private institutions and supported by nongovernmental funds; such work is to be strongly encouraged.

The quality and completeness of some existing compilations could also be enhanced if more experimental work were done in some areas. CODATA hopes to be able to identify these gaps in knowledge and promote research programs where they are needed.

Assisted by the international scientific unions, CODATA will encourage the use of nomenclature, symbols, and constants advocated by the responsible unions, and, when they are desirable, promote uniform editorial policy and procedures for the presentation of information. Compilations of data will achieve maximum usefulness only when they can be understood and employed by most people in widely varied situations. If the number of barriers across which information must be transferred can be reduced, communication will be greatly facilitated. Numerical data probably have the least number of barriers to cross within the science-information field, but it is still of the utmost importance that the selected reference values be clearly understood internationally.

Efforts will be made also to stimulate wider distribution of compilations of high quality. As a first step, the "Survey and analysis" of continuing projects for compilation of data, and related publications, will be distributed so that existing and ongoing projects will be widely advertised. Adequate indexing of substances and properties covered by all such compilations will be encouraged. The Committee will also consider and promote new methods for the preparation and dissemination of tables of numerical data. A special task force is now being established within the Committee to promote international communication and exchange of information on computer applications to the processing, storage, and retrieval of numerical data. Franz Alt of the National Bureau of Standards has accepted the chairmanship of this Task Group on Computer Aides. The use of computers is particularly applicable to this type of quantitative material, especially as the number and variety of reference data grow. The use of computers for data handling is certain to increase substantially in the next few years and will benefit the efficient storage, dissemination, and use of data. The International Computation Center, which is headquartered at Rome, has expressed interest in the work of CODATA and a desire to cooperate in particular projects in which their advice and assistance may be mutually useful.

The Committee hopes to convene meetings periodically to review its operations and to stimulate further activity in the field of critical data. Plans have been initiated for a conference in Western Europe in 1968, organized along the lines of the Gordon Research Conferences. The Committee will undertake sponsorship of the conference in cooperation with a suitable European organization. At meetings of this type the Committee expects to bring together those involved at various levels of work on compilation of data: for example, scientists who both generate and use numerical data could discuss their various needs and define priorities. The recommendations emerging from these discussions could benefit existing operational programs by periodically serving to sharpen their focus and scope. Moreover, those directly responsible for directing specific compilation efforts being undertaken by various nations would have an opportunity to outline their work for the benefit of other nations and to adjust their own programs, if necessary, in the light of their discussions. Another most important level of discussion would concern those actually evaluating and compiling evaluated reference data in selected related areas; they might usefully discuss agreed evaluation methods and formats for standard presentation of data and other such items that would make their compilations most useful on a worldwide basis.

International Cooperation: Conclusion

The internationalism of science is self-evident and for many years has enabled countries to work together in international collaborative research programs sponsored by other countries or by various international organizations. The problem of compiling scientific data is a part of this effort of the international community both because such compilations contain the fruits of research in all countries and because all countries need compilations for scientific and technological pursuits. As science develops, not only

is more precise information needed on existing knowledge; additional information is required on new scientific areas. The increase in scientific knowledge also necessitates a decentralized approach to the problem. The principle of cost-sharing and the need to locate experts in particular areas make international coordination in compilations of critically evaluated numerical data eminently feasible. International coordination avoids duplication of effort and, by setting up agreed standards of excellence, can often improve the quality of ongoing work. The result is often an upgrading of experimental work.

A recognized international plan also often makes it easier for national groups to obtain support for their work. While the sophistication necessary to produce data compilations of high quality in many large areas of science is found only in the major countries, it is recognized by ICSU and CODATA that smaller nations often excel in selected areas, in which they can make valuable contributions to the overall effort. Although the various national and international compilation projects and this particular ICSU endeavor have the same basic goal—production and dissemination of the highest-quality compilations of standard reference data—there is no danger of unnecessarily overlapping or duplicating areas of responsibility. The national or international operational programs are responsible for the funding and management of specific efforts, and obviously are not bound by international decisions by outside bodies. The international approach being undertaken by ICSU entails the provision of advice, stimulation, coordination, communications, standards, and assistance in the planned coverage of all areas.

I may note in conclusion that the initial success and enthusiasm surrounding this project have given hope for a related but much broader effort in the field of science information. By use of the CODATA experience as a model, a similar mode of operation is being contemplated with regard to a joint project that ICSU is undertaking with UNESCO. Working together, these two organizations hope to explore the feasibility of bringing about compatibility and voluntary coordination among the various components of systems of scientific information being planned or operating in various countries and various disciplines. Considerable attention is being given by many groups to the creation of systems for handling science information, but so far no concerted effort has been mounted to make systems compatible with one another so that information can be transferred between them. Systems barriers are being created between disciplines, languages, and differing computer technologies, and to some extent between nations. As each system evolves further, the difficulty of ensuring compatibility between them will increase. Therefore ICSU and UNESCO have agreed to study the feasibility of a worldwide system for science information; to this end they are preparing for the first of a series of meetings to outline the basic framework of the study. It is hoped that the experience gained from CODATA and the degree of cooperation that should result from present efforts will contribute to the success of this more complex and extensive project.

The National Standard Reference Data System

Edward L. Brady and Merrill B. Wallenstein

Improvement in the effectiveness of the nation's system for scientific and technical information is a matter of great popular concern these days. Much is being said and written about the flow of information from the generator to the user, and much is being done to try to speed the process. Taking the broadest possible approach, the President's Office of Science and Technology is examining all aspects of the problem (*1*).

The Chemical Abstracts Service of the American Chemical Society is in the midst of a long-range program designed to increase the retrievability of information within its concern (*2*). Similarly, the American Institute of Physics has embarked on a comprehensive study of means to make the world's output of information in physics more readily available to individual users (*3*); the Engineers Joint Council has a similar program (*4*). The Atomic Energy Commission, the Department of Defense, the National Aeronautics and Space Administration, and other major federal technical agencies are all increasing their efforts to improve the use of information generated within their programs.

These government activities are coordinated through the Federal Council for Science and Technology by means of its Committee on Scientific and Technical Information (COSATI), consisting of representatives of all government departments and independent agencies that have major technical-information programs. It was the initiative of COSATI and its parent council that led to establishment in 1963 of the National Standard Reference Data System, a federal interagency activity concerned with one aspect of the broad problem of scientific and technical information—improvement of access by the American technical community to compilations of critically evaluated data on the properties of substances.

Such compilations have been among the basic tools of scientists and engineers throughout the history of technology; each owns at least one handbook containing, among other useful information, table after table of data on the properties of the substances and systems that he deals with daily. Systematic compilations of data also contribute in a fundamental way to prog-

Dr. Brady heads the Office of Standard Reference Data, Institute for Basic Standards, National Bureau of Standards, Washington, D.C. Dr. Wallenstein is deputy director of the Institute for Basic Standards.