The Free Flow of Information: A Utopia? Ways To Improve Scientific and Technological Information and Its International Exchange†

REINER LUCKENBACH

Beilstein Institute for Literature of Organic Chemistry, Varrentrappstrasse 40–42, D-6000 Frankfurt/Main 90, West Germany

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Chemistry, which is a large and well-developed area of science with comprehensive bibliographic and data collections, has been taken as a representative example on which to base a discussion of the importance and accessibility of reliable scientific and technological information and some of the major problems and challenges, together with possible solutions, associated with the collection, evaluation, and distribution of such information. The topics treated are the flood of information; avoiding data overkill by evaluation, concentration, and improvement of data quality; information consciousness and costs related to it; trends in chemical information; political (international), technical, economic, and legal aspects of information; and ways in which to improve the international exchange of information.

IMPORTANCE AND AVAILABILITY OF SCIENTIFIC AND TECHNOLOGICAL INFORMATION

Nowadays more and more people, particularly those engaged in the field of science and technology, are beginning to value the growing importance of the "production factor" information, which must undoubtedly be given equal consideration along with such other production factors as raw materials, real estate, manpower, machines, capital, and energy. High-quality factual information provides mankind with tremendous profits. It helps one to avoid pitfalls, not to draw wrong conclusions, not to "reinvent the wheel" but serves, instead, to direct men, machines, investment, and energy in the right direction, i.e., to concentrate on important subjects in an evolutionary manner.

This is in particular true of chemistry, which is a scientific discipline with an enormous output of, and demand for, data. Moreover, chemistry has traditionally had extensive documentation and information services whose excellence has enabled them to attain a prominent position—if not the leadership—within the field of science and technology information.

That a bad decision based on false, incomplete, or a lack of information, especially in the area of chemistry, can, in extreme cases, have incalculable effects does not need to be emphasized here. Every chemist carrying out an information search bears the heavy responsibility of ensuring that the result is as complete and accurate as possible so as to minimize the risk of a disastrous decision being made. If we perform this duty properly, we are making one of the best possible contributions to chemistry at a time when it is suffering from many attacks, some of which are justified but most of which are not.

The picture just sketched is calculated to put the importance and availability of chemical information—and scientific and technological information in general—into proper perspective. Information users are becoming more and more aware that the provision of reliable information is just as important in the service of chemistry as the expansion of information by, for example, the publication of the 125th ester of benzoic acid.

CHEMICAL INFORMATION: PROBLEMS AND CHALLENGES

As chemistry, among all branches of science and technology, plays a prominent—if not the leading—role, it seems justifiable, for the rest of this paper, to concentrate mainly on problems, challenges, and perspectives of information in the area of chemistry. Most of the aspects of information discussed here certainly have a significance that extends beyond the field of chemistry; hence, most of the statements and conclusions drawn here, with due modifications to detail, are also applicable to other branches of science and technology.

The Flood of Information. The process of communication between scientists—one of the fundamental requirements for all intellectual work—is influenced to an increasing extent these days by the ever greater flood of data and information. This can become an intolerable burden for the individual scientist, who finds it less and less possible to select relevant data from the mass of information reaching him. How did this situation come about?

In 1880, the number of known chemical compounds was less than 20 000, and it was still possible, then, for the individual scientist to cope with the amount of information published in the primary literature sources.

Even so, 50 years earlier, in 1830, the abstracting journal *Pharmazeutisches Central Blatt* was launched, which was later renamed *Chemisch-Pharmazeutisches Centralblatt* and finally, in 1856, *Chemisches Zentralblatt*. This abstracting journal, together with the *Gmelin Handbook of Inorganic Chemistry*, founded in 1817, and *Beilstein's Handbook of Organic Chemistry*, available since 1881, formed the basis of the documentation of chemistry in Germany, the country which at that time practically dominated both chemistry and its documentation throughout the world. The enormous output from German universities and research laboratories that contributed to the explosive development of chemistry therefore made German for decades the most influential language in the field of chemical information, a position that has, however, since been taken over by English, in this area, as in practically all other areas, of science.

Turning to organic chemistry, the rapid development of this discipline and its consequence, the mass of information produced, can be demonstrated with an impressive example: In the elucidation of the constitution of the naturally occurring compound strychnine, isolated in 1818 by Caventou and Pelletier, more than 270 publications appeared. Of these, 125 were published by Leuchs and his co-workers alone. It was not until 1945, however, that the final structural details were reported by an "outsider": Vlado Prelog, later a Nobel Prize winner, whose findings were confirmed in 1954 by another Nobel Prize winner, Robert Burns Woodward, in a 30-step synthesis of strychnine.

The rapid advances that have taken place in chemistry since 1880, in particular those in research and development in all its subdivisions in recent decades, have yielded a huge harvest

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of almost indigestible data. This problem can be amply demonstrated by considering, for example, the number of chemical compounds reported (about 8 million in 1987) or abstracts published (more than 11 million by the end of 1986).

At the moment, the growth of the chemical literature runs at about 500 000 publications containing about 300 000 new (!) compounds per year. There is no indication that this increase will either slow down or stop. For the next few decades, at least, we shall have to cope with a growing flood of chemical information. This implies that the burden for the information user will be increased, and the aim of retrieval of information with as little ballast as possible would be unrealizable if—besides the technical improvements in handling and retrieval of information and data—the possibility of avoiding data overkill by the evaluation and concentration of data were not available.

Avoiding Data Overkill: Evaluation, Concentration, Quality Improvement. Although many scientists today complain about the avalanche of information and see hardly any possibility of coping with it, very few of them ask themselves the obvious question: How can "unnecessary", superfluous, or useless data be avoided from the very beginning or at least—once they are published—be marked as unnecessary and excluded from those handbooks and factual databases aiming at the unequivocal presentation of hard facts?

Appeals to publish less have clearly gone unheeded. As a result, many scientists have adopted the practice of restricting their literature studies to cover only the latest information available at the time. This means that replicate publications, frequently containing already well-known material, have appeared, while valuable older information is often ignored.

How can this situation, intolerable in every respect, be improved? Is there a way out?

One, though not the only, possibility of avoiding an overload of false, unnecessary, trivial, or unwanted pieces of information is critical screening and data reduction in the processing of factual data. This process can be divided into seven steps:

(1) measurement, determination, calculation
(2) publication (primary)
(3) excerption
(4) systematization
(5) validation, evaluation
(6) concentration, reduction
(7) publication (secondary)

Steps 3–7 can be carried out recurrently with different emphasis and specialization.

It seems obvious that it should be possible to dam the tremendous flood of information, to a certain extent at least, in steps 1–3 and 6. In order to verify this, the seven steps, listed above, will now be examined more closely.

Step 1: *Measurement, Determination, Calculation.* Scientists carrying out experiments, calculations, and/or measurements should confront themselves, or be confronted with, the questions as to whether (1) the problem being tackled is really relevant to scientific discipline and hence of interest to the scientific community and (2) as a consequence, there is a necessity and justification to carry out their data-producing studies, which will, inevitably, contribute to the flood of information.

Without doubt, by far the greatest amount of effective "data reduction" can be achieved by eliminating, from the start, research that will not yield data of sufficiently high caliber to justify the work put into obtaining it.

It goes without saying that the main problem of data reduction in this first step is how, to the best of one's knowledge, to determine the importance of any given piece of scientific work before it is carried out and to distinguish between necessary and unnecessary research work. However, this obvious difficulty should not deter anybody from trying to discriminate; to misquote an English proverb: "It is better to have tried and failed than not to have tried at all".

Step 2: *Publication* (*Primary*). The second filter that may remove irrelevant pieces of information is the primary publications, e.g., scientific journals, whose editors, on the basis of their own scientific knowledge, should be more stringent in rejecting papers whose content does not meet certain standards and hence do not merit publication. Not a few publications appearing today convey the impression that there would not have been the slightest loss to the scientific community had these papers not been published at all. It is becoming increasingly obvious that the total number of publications exceeds, by several orders of magnitude, the number containing truly significant scientific results.

This statement immediately raises the question of publication worthiness of scientific work in general, and increased efforts should be made to stem the flood of information where it becomes obvious: in the primary publication sources. One should, as a consequence, refrain from founding new journals, and the editors of existing ones should keep a sharp eye on the quality of contributions to be published—or rejected.

Step 3: *Excerption.* Step 3 offers the possibility of discarding false, outdated, or worthless data during the excerption of the primary literature. In order to avoid the loss of important information, this data extraction process has to be performed by scientists competent in the fields with which they are dealing.

Together with predefined excerption criteria, his/her own "scientific sense" allows the excerptor to competently judge the registration worthiness of information and data and, in doing so, to eliminate at this stage all superfluous data and resolve contradictory reports.

Step 4: *Systematization.* It is not for all disciplines of science that a logical, self-consistent, hierarchical system of ordering exists which allows the arrangement of the excerpted facts and figures in a structured manner. However, within the areas of organic and inorganic chemistry, respectively, the Beilstein system and the Gmelin system, both based on the structural features of chemical compounds, fulfill the needs of a systematic arrangement of chemical species.

Although, at first sight, the systematization of structures and related data does not directly lead to a further data reduction by itself, it is a necessary prerequisite for data evaluation in the next step.

Let us, therefore, as an example, summarize some important features of the Beilstein system of systematic classification of organic compounds.

The Beilstein system is based on the constitutional formula of the compound as the sole classifying feature and only takes account of the given structural properties (the morphology) of the compound; thus, the Beilstein system represents a one-dimensional, natural, hierarchical classification.

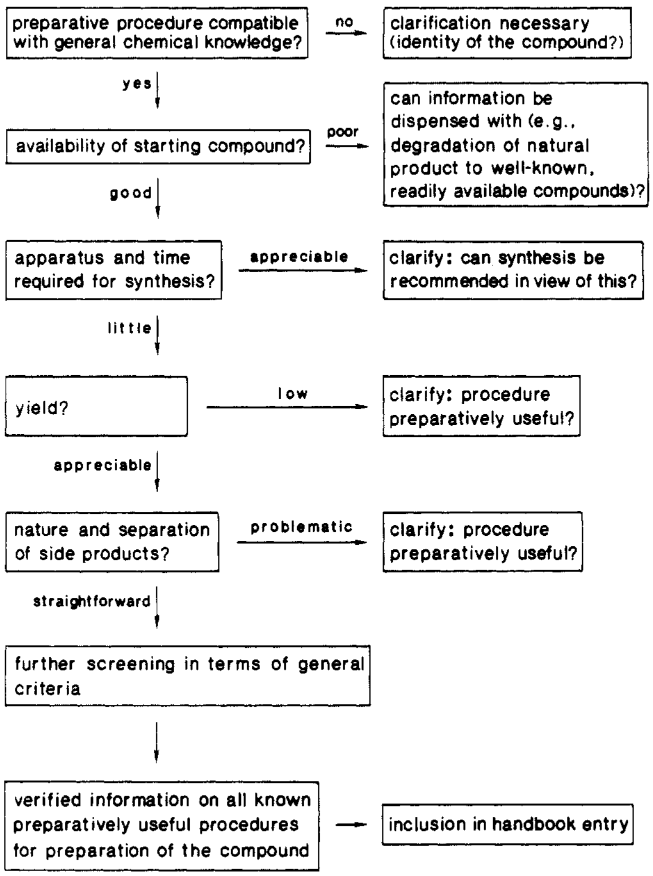
The principal classificatory criteria of this system can be summarized as (1) main division, i.e., acyclic, iso-(carbo-) cyclic, and heterocyclic (further subdivided according to the type and number of ring heteroatoms); (2) functional groups, i.e., no functional group, OH, C=O, COOH, NH_2, ...; (3) degree of saturation (C_nH_{2n-x} ...); (4) C number (total number of carbon atoms); (5) skeletal structure (unbranched, branched, ..., monocyclic, bicyclic, ...).

Application of the Beilstein system as an ordering system for organic chemical compounds brings with it at least three decisive advantages:

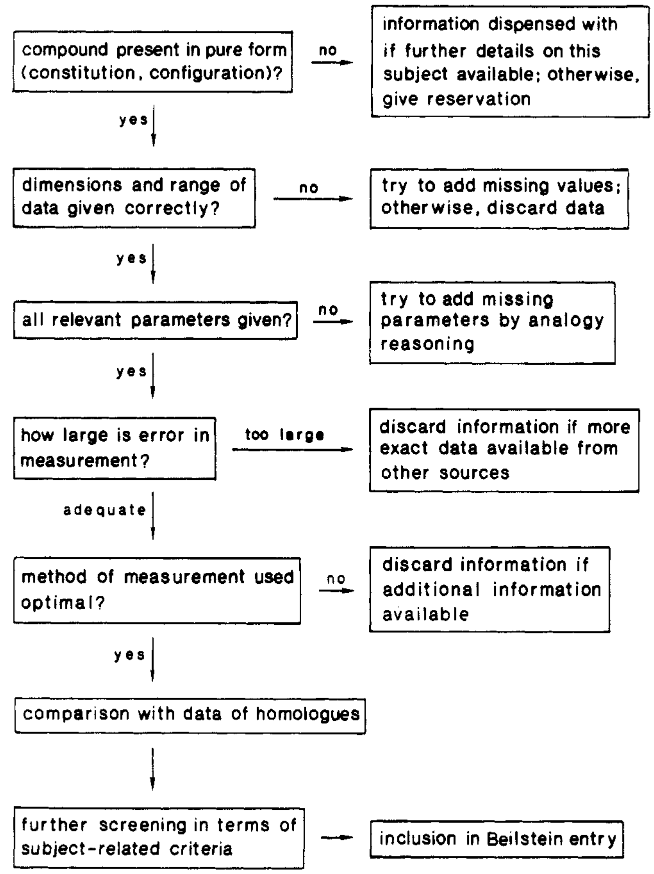
• Every compound (i.e., every structural formula) is assigned a unique place in the Beilstein handbook.

• Every compound can be retrieved from the Beilstein handbook without use of indexes or nomenclature.

Scheme I. Critical Screening and Assessment of Information on the Preparation of a Compound (As Applied to the *Beilstein Handbook*)



Scheme II. Critical Screening and Assessment of Information on the Physical Data of a Compound (As Applied to the *Beilstein Handbook*)



• Chemically related compounds are brought into close proximity by the system, thus enabling the Beilstein user to find, quickly, "chemical relatives" (homologues, analogues) of every compound searched for—"similarity search".

As a consequence of the features already mentioned, the Beilstein system frequently facilitates the critical evaluation of data in step 5.

Step 5: *Validation, Evaluation.* Leaving aside the "production costs" of obtaining data in the first step, step 5, that is, validation, evaluation, critical screening, and plausibility checking, is by far the most expensive one within the data cycle, as it requires a specialized scientist to perform these very demanding and important tasks.

In this connection, "critical screening" means the competent judgment of information with respect to its validity (i.e., its compatibility with the generally accepted state of the art and with analogous attributes), its novelty, and its overall scientific importance.

It goes without saying that today, in the computer age, numerous help programs facilitate this task. Nevertheless, the competent scientist is indispensable, as it is his/her qualified evaluation that finally leads to the inclusion, or rejection, of given data.

On the basis of his/her scientific expertise, he/she is, for example, able to filter out multiple publications with the same content, well-known results, and trivial findings; take into account corrections to earlier findings; transfer corrections to similar cases; recognize and, where possible, clarify conflicting data on a given subject; and correlate individual results with analogous cases and reveal errors.

Here is a list of some of the prerequisites for a successful and dependable critical screening without loss of important information: a highly qualified scientific editor; systematic classification of the material to be judged; established working procedures; and scientific assistance (library, foreign language translations, etc).

Some of the criteria checked during the critical screening and data evaluation procedure are the following: material correctness of information (consistency with current general scientific principles); depth of information; completeness of information (are all relevant details and parameters given?); objectives of the publication; accessibility of (primary) information (type of journal, language, date); and origin of the information (caution!).

The practical application of these and other selection criteria to processing, for example, the Beilstein handbook entries, is outlined in Schemes I and II.

Step 6: *Concentration, Reduction.* As a direct result of the data evaluation in the preceding step, a considerable data reduction—without any loss of important information—is now achieved in step 6.

Without any doubt the extent of data compression may vary from discipline to discipline and—within any given discipline—from branch to branch.

Table I provides some random examples, taken from the *Beilstein Handbook* production process, of the extent to which data reduction without loss of information is possible. The examples listed in this table demonstrate impressively that, apart from step 1, the combination of steps 5 and 6, i.e., the evaluation and—as a result of this—the concentration of data, has by far the largest effect in the elimination of redundant information.

The advantages and benefits of this kind of data processing for the user are obvious: improved confidence in the accuracy of the tested data; a diminished risk of false conclusions and nonoptimal experimental planning as a result of inexact literature results; a reduction of "ballast" in literature searches through a concentration on dependable data; intensive intellectual reexamination of selected data is unnecessary—greater

Table I. Extent of Information Reduction by Critical Screening (Examples Taken from the *Beilstein Handbook*)

	compound (Beilstein citation)		
	ternatin (E V 18/5, 660)	griseofulvic acid (E V 18/5, 148)	fustin (E V 18/5, 211)
no. of citations during 1960–1979			
in *Beilstein* (*a*)	5	9	8
in *Chemical Abstracts* (*b*)	9	26	49
eliminated during Beilstein processing since			
contents already contained in earlier *Beilstein* series	—	—	6
duplicate publication	2	2	4
data are given in more detail in other publications	4	16	33
reduction $\{b/(a-c)\}$ achieved in *Beilstein*	3:1	3:1	8:1
no. of citations only to be found in *Beilstein* (c)	2	1	2

time saving; a guarantee that no relevant information is lost; and promotion of further innovations due to the cross-referencing of published information.

It should be evident that the concentration and selection of the highest quality primary information by means of a science-based, and intelligently carried out, evaluation program requires very high personnel and financial commitments.

Step 7: *Publication* (*Secondary*). In step 7 the concentrated data are now republished, i.e., offered to the scientific community in a condensed form in printed and/or machine-readable formats. This concentrate now comprises only a fraction of the original amount of data and has thus gained considerably in clarity, systematic arrangement, and—most important—quality of the data.

The data may now enter the "data circle" again at step 3, recurrently under certain circumstances, if, for example, individual information users extract these secondary data collections with respect to selected information bits relevant to their special field of interest.

In concluding this section, one has to admit that the difficulties, already mentioned, inherent in this procedure should not be underestimated. These difficulties, however, should not prevent us from undertaking reasonable efforts to restrict the vast amount of data as far as possible.

In the field of chemistry, this challenge has been successfully accepted for more than a century by the large handbooks, *Beilstein* and *Gmelin*, as is acknowledged by the users of these information systems.

Now that we have the grains of knowledge that have survived our intellectual sifting, we must next carry out some "consumer education".

Information Consciousness vs Information-Cost Consciousness. In recent years, high-quality factual information has gained considerably both in importance and in the attention it receives within the scientific community. It is evident that in the area of chemistry information consciousness, that is, the recognition of the great importance of information as a production factor, has grown. Unfortunately, the same cannot, as yet, be said for the cost consciousness of information users, i.e., the realization that information costs money and with it the unavoidable economic fact that the more comprehensive and more reliable the information the more it is going to cost. "Bigger budgets buy better information"—a fact of life well-known to law- and tax-enforcement authorities!

A well-developed cost consciousness will be equally necessary, in the future information market, and the author will continue to plead for the free play of market forces and that the law of supply and demand, which has proved its worth in so many other areas, should also operate in this one as far as possible.

Look at the situation from the point of view of the information user, or better, the information buyer. He should be asking not only the justifiable, but often very restricted, question, "Can I afford this information?", but also, "Can I afford not to have this information?". This illustrates the Janus-like nature of information consciousness and information-cost consciousness, which are two faces of the same coin.

It is necessary for the information broker to point out the interdependence of these two concepts and for the information user to recognize and accept them. When this is achieved, we shall be a great deal further along the road to understanding what constitutes "cost-conscious attitude toward information".

Trends in Scientific and Technological Information (Especially Chemical Information). Apart from the topics already discussed, some of what appear to be the most important trends and tendencies within the field of chemical information deserve mention.

From Bibliographic to Factual Databases. First, there is the current, evermore noticeable, trend, on the part of the information user, toward the demand for hard, properly checked factual data in addition to pure bibliographic information. This is a predetermining factor for the next prominent trend.

Construction or Improvement of "Value-Added" Information Systems. Trends in this area include comprehensive databases of (organic) chemical reactions, synthesis design systems (existing examples are LHASA, SYNCHEM, SECS, CASP, EROS, CYCLOPS, CAMEO), and expert systems (knowledge-based systems).

The aim with expert systems is to achieve the ability to predict certain properties and data values and also to correlate structures and partial structures with particular chemical, physical, and pharmacological properties. For this purpose it is necessary to make use of computer graphics (molecular modeling), pattern recognition systems, and multivariate statistical methods (chemometrics).

These expert (knowledge-based) systems should have a wide knowledge base, i.e., comprehensive, properly checked data available in a well-structured form; the ability, by means of highly developed computer programs, to derive new knowledge from available information; user-oriented enquiry and dialogue facilities; the ability to evaluate its own information in a discriminating manner; and an application-oriented problem solving help facility.

Construction of Improved Methods and Instruments for More Effective Information Retrieval. This can be accomplished by using, for example, refined graphics-based structure/substructure searching with the inclusion of all stereochemical descriptors, generic structures, and "intelligent indexes" (e.g., SANDRA, a computer-based search program for the *Beilstein Handbook*).

Competition: *Printed Media vs Online Systems vs In-House Systems.* An as yet quiet struggle has already begun in the information world—a struggle between three participants, printed media, online databases, and in-house systems.

There are many indications that printed media will survive in the era of online databases, especially if the printed and the online formats of a given database are designed to be complementary and not competitive. Moreover, printed materials, when compared with online systems, have a number of advantages, for example, ease of browsing, ease of access, portability, etc.

On the other hand, more and more weighty opinions are being expressed predicting a considerable decline of the online scenario as soon as an advanced CD-ROM technology for large databases offers an improved way to provide information users with these databases as in-house systems. These can be accessed in a very comfortable manner without any external telecommunication networks and can even be expanded by using the institution's own (private) data files.

In addition to these four trends, which are important and relevant in relation to the factual content and instrumentation of information systems, there are other trends and problems in the areas of the politics, economics, technology, and legal aspects of scientific and technological information that are discussed in the next section.

Factors Preventing the Free Flow of Information: Political, Technical, Economic, and Legal Aspects. The great importance of information as a production factor has already been mentioned at the start of this essay. The politico-economic value of comprehensive, reliable information, especially in the areas of science and technology, is enormous if only because of the time and effort the user is spared.

Nevertheless, a series of problems remains with which each information user must, to a greater or lesser extent, come to terms.

Huge amounts of information pass over the desks of each worker every day and must be recorded, dealt with, evaluated, filed, or acknowledged. It is becoming progressively more difficult for us to select from this dense jungle of information those data, facts, and opinions that we need and to consign the rest to our mental waste bin. Can we, however, in spite of receiving this indigestible mass of material, be sure that we are getting all the information that is important to us? Or are there considerations, be they political, technical, or financial, that deny us important knowledge, shut us off from important sources, or prevent us from having unhindered access to all the available subject information in our field?

Occasionally, attempts have been made (fortunately, so far in vain) to declare particular information "sensitive" on political or national grounds. We must continue to resist these restrictive efforts; otherwise, we can kiss goodbye the idea and practice of the free flow of scientific information about which we are all so very keen! From the outset we must, by rejecting one-sided, unwanted dependence on any one person, organization, or country, retain our right of unhindered access to complete information.

Incidentally, the phrase "free flow of information" is used here in the sense of "unimpeded" or "unhindered" and does not mean "free of charge"—we are selling information in what should be an open market free of embargoes and trade barriers.

The following discussion of eight factors or problem areas, selected from a much larger number, illustrates some other ways in which an unrestricted flow of scientific and technological information at the international level may be blocked.

Nonavailability or Nonaccessibility of Essential Services. These are information sources (e.g., databases, data collections), hardware, software, and international communication networks.

The nonavailability of a system essential for comprehensive information collection may be due to political, technical, or economic factors. The problem of the nonavailability of particular information because it has been declared sensitive on political or national grounds has already been mentioned, and we will assume that it can be regarded as settled.

Naturally, the lack of access to information resources can also result from the politically motivated banning of the import and export of hard- and software.

In all these cases, we are asked to balance the apparent, usually short-lived, advantages of a nationally held information lead on the one hand against the long-term negative aspects related to "internationalization", that is, the making of scientific and technological information freely available to the whole world, on the other. In any case, censorship is always damaging to the free flow of information on an international basis.

The importance of an international network with the goal of a rapid and comprehensive exchange of information has long been agreed upon. Nevertheless, it seems to the author that the description "international" should not be confined only to the accessibility of such a network but should broadly apply to the setting up of the network, its provision with databases, and its control. If the latter is not ensured at the international level, then the domination of one nation over an internationally accessible network could lead to an undesirable and unbearable monopoly—a monopoly that could then even extend its dominance to include the databases available over this network.

The possible lack of the previously mentioned instruments that are indispensable for optimum access to scientific and technological information may be due to political influences, as discussed before, or may be a technical problem caused by the nonexistence of the necessary infrastructure in certain countries, especially those counted today among the so-called developing countries.

While technical problems mainly affect electronic information services, both electronic and printed media are badly hit by financial difficulties. On top of this, financial problems, which frequently prevent a comprehensive supply of information, do not stop at political or economic borders, although some economic systems are plagued more by financial restrictions than others. Whenever the necessary means for the procurement of information are reduced, whether in universities or industry, the result is a deficit in information and data, a defect that makes itself felt at a later date when it is then only possible to recover with great financial difficulty, if at all.

Restrictions on the Movements of Individuals. The danger of the withholding of important information by declaring it sensitive is, unfortunately, not the only politically motivated method for suppressing the free flow of information. The practice, in many countries, of refusing or restricting entry and exit permission, the absurdity of which certainly requires no further discussion in this context, also often prevents the procurement, delivery, or exchange of information.

Language Problem. While practical solutions to most of the other problems mentioned here still have to be elaborated the solution to the language problem has already been found: Without any doubt, English has become the "lingua franca" of international communication in all branches of science, technology, and commerce.

Lack of Education in Information Resources. By this is meant the lack of attention paid in high schools, colleges, and universities to the practical aspects of all forms of finding, acquiring, and distributing information. Remedying this is a formidable but, nevertheless, essential part of the information revolution that is increasingly involving the practicing scientist. If this problem is not seriously addressed, the next generation of scientists will be cut off from, or unable to make use of, large amounts of information simply because they either do not know of its existence or have not mastered the techniques for accessing it, even though the technology for access is available to them.

Lack of (Globally Accepted) Standards. The lack of standards within the domains of hardware, software, and networks is another severe obstacle to unhindered worldwide access to information and its handling. Again, the developing countries obviously suffer most from either the nonexistence of, or the rapid changes in, standards.

Monopolism. The problem of monopolism has already been touched upon when one is dealing with the important role of international communication networks.

It should be self-evident that in the fields of databases, networks, hardware, and software any kind of monopoly would greatly hinder the free flow of information for which hopes are always so piously expressed.

Nonadherance to Copyright Agreements. That copyright protection is an integral part of information exchange should not need to be said. Protection by means of copyright is necessary and indispensable for the continued economic health, long-term existence, and international availability of an information system. Regrettably, many countries are not signatories of the international copyright convention and some that are are paying no more than lip service to its charter. Nevertheless, we should all agree that illegal copying and pirate printing are inappropriate and intolerable ways to overcome any financial difficulties placed in the way of acquisition of information through normal, economically determined channels. These unethical practices are unscrupulous and hostile and should be resisted with all the means at our disposal.

Domestic Taxes on Imported Information Instruments vs Subsidies for Domestic Information Services. These two politico-economic measures, which frequently operate at the same time in the domestic information market, obviously contribute to the financial problems previously mentioned and may sometimes be misused to impede the overall availability of all information sources required.

CONCLUSIONS, PERSPECTIVES, AND PROSPECTS

Having dealt with a few of the possible restrictions on the free flow of information, it is now appropriate to consider some of the necessary precautions and further steps we have to undertake to ensure, worldwide, availability, accessibility, and exchangeability of information in the future.

Ways in Which to Improve the International Exchange of Scientific and Technological Information. The following summary of developments necessary for the improvement of the international exchange of scientific and technological information is certainly far from being exhaustive but may nevertheless serve as a "directory" for future steps to be taken in order to reach the goals previously mentioned.

(1) Abolish and/or prevent, as far as possible, any kind of politically motivated restrictions with respect to the worldwide availability of information sources (databases, data collections), hardware, software, and international communication networks.

(2) Try to overcome any sort of technically and/or financially induced restrictions with respect to the availability of the four instruments mentioned under (1) above.

(3) Abolish any kind of restrictions with respect to the free movement of people.

(4) Improve education in information resources at all levels, especially in universities; educate people in how to deal effectively with all the instruments of scientific and technological information services.

(5) Create worldwide accepted standards in the information scenario (from publication formats to CD-ROM).

(6) Break existing, and avoid the implementation of new, monopolies in all areas of the information world and instead allow competition between different international database producers, vendors, hosts, etc.

(7) Acknowledge "fair trade" with respect to copyright protection; abolish illegal photocopying and pirate printing.

(8) Avoid unjustifiable surcharges (mark ups), which distort the competitive element of the free market, on nondomestic information sources and information instruments.

The Free Flow of Information: A Utopia? In this paper an attempt has been made to illustrate some of the difficult problems and some of the important and necessary tendencies in the area of scientific and technological information, with special emphasis on chemical information, in relation to both its content and its international accessibility.

Clearly, the realization of the aims inherent in these trends and demands is a job of truly gigantic proportions that requires an enormous expenditure of time, money, and brain power at the international level. However, it is an intellectually stimulating task of great value in its own right and, of course, of inestimable economic value to the community. As long as we are prepared to view these demands and aims as challenges to be accepted and overcome, we shall not be crushed by the existence and dominance of the gigantic masses of scientific and technological data.

Alongside the purely conceptual and factual problems, some of the nagging difficulties, the irritating obstructions, that may be placed in the way of unimpeded international exchange of scientific information have been indicated. It is particularly in this area, frequently dominated by politico-economic considerations, that we must make great efforts, based on equal status partnership, to cooperate in mastering these problems so that global free flow of information does not remain an unattainable Utopia.