Where is Chemical Information Science Going?†

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On March 22, 1977, Eugene Garfield was presented with the Herman Skolnik Award for ". . . outstanding and sustained service to chemical information". This article is his acceptance talk which he originally titled "For the Man Who Has Everything". Topics discussed include the prospects for chemical information science during the next 10 to 15 years, the changing role of the ACS Division of Chemical Information, and the growing importance of the critical review. Other subjects of discussion are the significance of *Current Contents* and the increasing acceptance of English as the international language of science.

Professor Robert K. Merton of Columbia University is a genius when it comes to naming social phenomena. Several years ago, in *Science*,[1] he created the term the "Matthew effect". I thought about this when I selected the title for my talk here today: "For the Man Who Has Everything". Merton's term is based on a quotation in the New Testament. In Matthew, Chapter 13, Verse 12, we find:

> "For whosoever hath, to him shall be given, and he shall have more abundance: but whosoever hath not, from him shall be taken away even that he hath."

Well, I suppose it is only natural that after receiving the ASIS Award of Merit—delivered and presented to me, ironically enough, by Dale Baker of *Chemical Abstracts*—the man who has everything should get an American Chemical Society award. I begin to wonder what the future has in store.

It is interesting that the very next verse in Matthew describes my feelings about the Establishment 25 years ago; by Establishment I mean *Chemical Abstracts*, the National Science Foundation, and other entrenched fortress mentalities:

> "Therefore speak I to them in parables: because they seeing see not; and hearing they hear not, neither do they understand."

Some of you may recall that two years ago in Philadelphia I was the luncheon speaker at the ACS Division of Chemical Information. There, I spoke about some seemingly unrelated topics, such as "The Entrepreneur as a Doctoral Candidate", in which I described the agony and the ecstasy of obtaining a Ph.D. in chemical linguistics.[2] So why have you asked me to come back so soon? Is it possible your awards committee figured as follows: If we give Garfield this award he will have nothing to say, having covered everything he could imagine last time?

When the subject of nothing to say comes up I always think of the story about the wedding of the librarian and the information scientist. When asked if anyone had any objection to their marriage, an ASIS member in the audience waved his hand and said, "I have no objection to the wedding but would anyone like to hear about my information retrieval system?" I suppose an ACS member would have proposed discussing a new method for manipulating connectivity tables.

As you can see, I was somewhat desperate for a topic. I've spoken to you so many times in the past and write so much in *Current Contents* and elsewhere that it is often difficult to be original. So, I wrote to Peter Sorter out of desperation and asked him to suggest a topic. Pete is concerned about the climate for chemical information science during the next five to ten years. He is also concerned about the role of the Division of Chemical Information and what its members can expect in the always uncertain future.

After all, there is good evidence that the rate of growth of chemical and scientific information has decreased in recent years. However, the absolute growth of scientific information each year is still substantial. Even if the literature were simply to grow at an arithmetic rate, the existing quantity of information is already so large that new methods of dealing with it are needed more than ever. If we needed *Beilstein* when the literature was "small" how do we manage without it or its equivalent when the literature is "large?" Thus, the need for information scientists is assured.

Certainly the need to extract chemical and physical data from the literature, as contrasted with bibliographic information, will increase. The new breed of chemical information specialists will not only have to be trained in information storage and retrieval but also in writing and digesting information—what is otherwise called reviewing. We are in the era of the critical review. I believed this when ISI launched the *Index to Scientific Reviews* (ISR). I believed it even more when we began including multiauthored books as source material for the *Science Citation Index* (SCI) this year and in *Current Book Contents* a few year ago.

Where are all the new chemical information specialists going to come from? Many of them will be people who start out in a career path in information science. But most will be Ph.D. chemists who will turn to information science as an alternative career in a tough job market. They will be no different than the many chemists who wound up as chemical marketing specialists back in the depression.

Recently, I wrote a proposal to Dean Harvey Brooks of Harvard University entitled "Alternatives to Research and Teaching for Unemployed Ph.D.'s".[3] Brooks is chairman of a presidential panel which is investigating the health of the nation's scientific endeavor.[4] I suggested that the oversupply of Ph.D's could be usefully directed into a new profession of scientific reviewing. The program would comprise postdoctoral training of no less than one year and could be established at selected information science departments. Preferably we would create new information science programs at every leading university. I hope to push these ideas further as the chairman-elect of Section T of the American Association for Advancement of Science (AAAS). I hope the ACS will evaluate this notion in the Division of Chemical Education and here in the Division of Chemical Information. I also hope that the National Science Foundation (NSF) will begin to pay

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serious attention to the proposal as originally outlined in the *Bulletin of the American Society for Information Science*.[5]

But what are the real prospects for scientific reviewers? The research in hard science fronts moves forward in quanta of 50 to 250 papers. In other fields, like descriptive biology, the number may be much larger. In any case, someone has to digest the information and present it in a synthesized, readable form. Keeping tabs on the literature, especially in rapidly growing fields, is a task which many laboratory investigators wish they could handle. For a variety of reasons—temperamental and otherwise—they usually cannot do this successfully. Scientific reviewing is thus an intellectual activity that is deeply appreciated. Its impact is reflected in the citation data we have compiled at ISI.

In December 1977 I published an article in *Nature*[6] which listed 80 different review journals that achieved an impact higher than two. Consider that only 300 scientific journals, out of the thousands published throughout the world, achieved a similar or higher impact. The average journal in our file had an impact score of 1.015. Impact tells us how often the average article was cited in the two years prior to the year under study. For example, *Chemical Reviews* had an impact of 8.1. Its articles for 1973 and 1974 were cited 530 times in 1975. And it ranked among the 50 most-cited journals of science, with 11,000 citations. We also know that review articles have a high immediacy. Some review journals are cited heavily within months of publication because, among other reasons, they become surrogates for the literature they digest. Thus, chemists can cite the previous research literature by a single reference to a review article. Incidentally, Angela Mazella at ISI is studying the characteristics of the review literature under an NSF grant.[7] Tony Woodward of ASLIB also has made some important contributions.[8]

Another way we have learned of the importance of review journals is through co-citation analysis. In these studies Henry Small and others have drawn cluster maps showing the most cited papers in certain specialties. Quite frequently, the papers that turn up in these co-citation maps are review papers.

All of this evidence indicates that chemists should not be reluctant to write reviews if they are interested in promoting their visibility among their peers. It is almost as good as being a journal editor—maybe better. In the past, people like Herman Skolnik realized, instinctively or otherwise, that another form of reviewing—section editing for CA—provided a similar visibility. I might point out that my proposal in no way denigrates the valuable service performed by such persons. Someone must agree with this—why else am I receiving the Skolnik award?

Our citation studies have shown that one must be careful to distinguish the various reasons why highly cited papers are heavily cited. The contribution of a reviewer is important, indeed essential to the progress of science. This view may or may not support the Ortega hypothesis.[9,10] But this is different from the importance and significance of breakthrough papers which report new phenomena or new theoretical insights—or the much maligned new methods. Recently we started a new feature in *Current Contents* called *Citation Classics*.[11] These autobiographical accounts of how and why certain highly cited papers were written have provided new insight into the role of new methods in science.

Of course reviews are not of uniform style. Many of them are speculative and stimulate needed research. In this connection, it is interesting how citation indexes and reviews are associated. The SCI was an outgrowth of my detailed analysis of review articles as suggested by Chauncey D. Leake. Later, Professor Joshua Lederberg mentioned the importance of citation indexes to help in his own review activities. He needed to know where and by whom his speculations (e.g., on exobiology) had been taken up by others. And review papers provide an important source for a posteriori indexing entries in the *Citation Index*. The average review article contains in excess of 150 references and provides an equal number of indexing terms in the SCI and ISR.

Many years ago in CC, I published a piece entitled "Who are the Information Scientists?".[12] I said then that in the future it would be more and more difficult to distinguish (ordinary) laboratory scientists from information specialists, as we then knew them. This is one of my few correct predictions. I think the evidence is quite clear. Today we have in the ACS not only a Division of Chemical Information, but also a Division of Computers in Chemistry. And it is not surprising that the programs of these two divisions overlap significantly. Nor is it any more surprising to find further overlap here in New Orleans. Consider the program in the Division of Physical Chemistry concerning computer analysis of reaction mechanisms.

One can argue that it is primarily the impact of the computer that has accelerated the transition of the laboratory chemist into the information chemist. Sociological and behavioral changes of this kind are not easy to measure. However, in addition to computer conciousness I believe the average working scientist today is far more information conscious than his counterpart 25 years ago.

We used to have long discussions about the presumed importance of information retrieval. Many argued it was a waste of time and actually stifled creativity. The research administrator who encourages his staff to ignore the literature today does so at his organization's economic peril. One doesn't hear the old song about the literature discouraging creativity quite so often anymore, but the melody lingers on. The evidence is clear that our most creative scientists are those who use and help create the literature that others would like to avoid. At one time scientists had a legitimate excuse to ignore the literature. But today they have a large variety of mechanisms to help them keep up. It is now much easier to avoid the worst possible kind of duplication so prevalent just 20 years ago. I don't know how often one can cite examples of unwitting duplication of effort. It would be interesting for NSF to support a repetition of John Martyn's survey to see if the situation has improved or deteriorated.[13]

I think by now I should have made Pete Sorter happy. He can count on being employable for at least another ten years. Even Herman Skolnik won't be replaced by a computer, and somehow *Chemical Abstracts* will survive the synopsis journals designed to eliminate secondary services. With your future secure, and without stirring up any emotions, I've managed to get this far without really saying too much. But let me pursue my theme, "For the Man Who Has Everything", a little further.

In publishing *Citation Classics* we have learned from many authors that their most cited work is not necessarily the work they consider to be their most significant contributions. Sometimes we pay tribute to those accomplishments which have a certain intellectual elegance. But they are not necessarily those that have had the greatest social or scientific impact. In my opinion, that is why the method paper is regarded in less esteem than it ought to be. Let me carry this notion a bit further in a more personal way. There is a certain irony in my receipt of the Skolnik award when you consider the interesting paper Herman published concerning milestones in chemical information science.[14] In his very comprehensive review of milestones since 1943, he most graciously mentioned *Index Chemicus*, *Rotaform Index*, and *Science Citation Index*. I use the word "graciously" because Herman has never really used any of these tools in his shop but respects them as intellectual achievements.

However, it is most significant to me that Herman *didn't* mention *Current Contents*, which I am sure he also never uses. Nevertheless, thousands of scientists throughout the world, who couldn't care less about information science, consider *Current Contents* a milestone of far greater significance than *Index Chemicus* or SCI. You see, my friends, beauty is in the eyes of the beholder. CC is a methodology so simple that I have never been able to publish a paper about it.

But it was as editor and publisher of *Current Contents* that I was invited three years ago to publish an article in the French equivalent of *Scientific American—La Recherche*. The editor of that journal knew how important *Current Contents* had been in calling his new journal to the attention of the world scientific community. He also knew my views on English as the "lingua franca" of science.[15] So I published an article in *La Recherche* entitled "Is French Science Too Provincial?".[16] For those of you who don't have time to read it in French, the English version of this article was published in *Current Contents*.[17] In this article I provide rather conclusive data showing that French language journals today have very little impact on international science. Even more interesting, I showed that even French scientists do not cite French journals very much.

The data confirmed what a large number of French scientists knew better than I: the quality of the French scientific press had declined significantly in the past three decades. The publication of this article sent reverberations throughout the French scientific community. My article prompted a critical response from no less than a former Prime Minister of France.[18] I didn't realize at the time that a large number of French language journals receive government subsidies. Possibly as a response to my article, and as a result of subsequent deliberations, the French National Center for Scientific Research (CNRS), the equivalent to NSF, decided to launch a new journal in chemistry called *Nouveau Journal de Chimie*. Although the new journal is published primarily in English, it is understandable that CNRS was not so bold as to give this journal an English title.

The linguistic issue in France, as in Canada and Belgium, is politically sensitive. Having recommended the use of English by French scientists, I was falsely accused of cultural imperialism. In fact, I was trying to do a service to the French scientific community. It deserves better treatment for its efforts. Perhaps the most remarkable outcome of this incident is illustrated by the advertisement that appeared in a recent issue of *La Recherche*. Even if you don't read French, I think you will comprehend the simple message (see Figure 1).

Since *Nouveau Journal de Chimie* is probably a response to my article, this may be the first time in the history of science that a new journal was started in response to a challenge from an individual. I wouldn't be categorical about this claim because journals have been founded for a variety of reasons. It may well be that some other journal found its beginning in a similar way. At least it illustrates that an individual is not *entirely* powerless in this world. But we rarely have the opportunity to see the results of our efforts so directly and so quickly.

I have a feeling that something similar is going to happen in Italy. I recently prepared some similar data regarding Italian journals.[19] Subsequently, I participated in a conference of Italian Scientific Editors in Rome.[20] I would not be surprised if we see the establishment one day soon of a new *Italian Journal of Science* published in English on a prompt publication schedule. Consider that there are over 500 biomedical journals published in Italy, 95% of which are rarely consulted by anyone.

The importance of the role played by *Current Contents* in these transformations is indicated by the fact that the editor of *Nouveau Journal de Chimie* was quite upset that it was

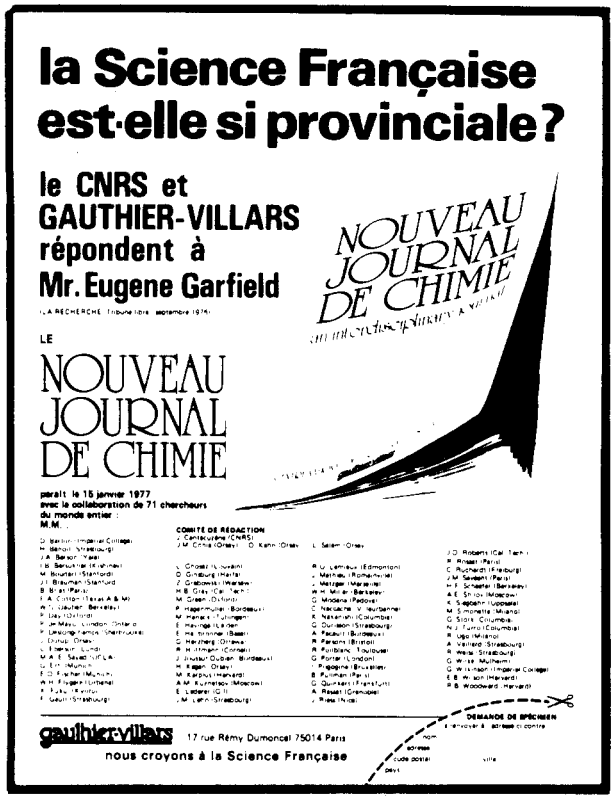

Figure 1. Advertisement announcing new French chemical journal with articles published in English.

not immediately covered in CC. He knows his journal will get immediate recognition from the French scientific community when it is listed in CC. It is an awesome responsibility to realize that so many newer journals are dependent upon CC for survival. It is also true that many of the most important journals of the world would survive quite well without us. But even for established publishers the difference of 5 to 10% in revenue or profit performance can make or break a journal. Consider that *Current Contents* is directly or indirectly responsible for 50 to 80% of the reprint requests received by many authors. Publishers often derive that needed extra margin of profit from the sale of reprints. The number of photocopies made in response to CC listings is miniscule when compared to reprint requests. For every tear sheet or photocopy we provide, 50 to 100 reprint requests are sent out by readers. In fact, we sell over 1,000,000 Request-A-Print® Cards per year! And now that a payment clearinghouse will be established, the real cost of photocopying will, I believe, provide greater incentives for using reprints.

In closing, I not only want to thank you for this award, but also want to mention a few people who were very important in my professional life—especially here in the ACS. Though we never actually worked together, I met Jim Perry at the 1951 ACS meeting in New York. I think that was the Diamond Jubilee meeting. Somehow I walked in there and heard a few papers and knew that I was in the right place. I walked up to him and asked: "How does one get a job in this racket?" Later on he came to my house in the Bronx and ate my mother's cooking. Still later, he introduced me to Sanford V. Larkey at Johns Hopkins. Then, at the Welch Library, I met most of the leaders of the profession. This was a lucky opportunity for a young upstart. But most of the people I met had been upstarts at one time themselves; these included Ralph Shaw, Mort Taube, and Pete Luhn.

Through the Welch project I met E. J. Crane and Charles Bernier. At the CBCC I met Karl Heumann and Isaac Welt. I also first met Ted Herdgen in Baltimore. Later he hired me

as a consultant to Smith Kline & French Co. (now Smithkline Corp.) and became one of my closest friends; the first issue of *Index Chemicus* was dedicated to his memory. I was always encouraged by Madeline Berry, Hannah Friedenstein, Aaron Addelston, Al Gelberg, Bill Longenecker, and other Division members too numerous to mention. I was going to mention more names but as I reviewed some old correspondence, I realized how fallible my memory is. For example, if I were to name one member of the CNA I would have to name a dozen or more. But certainly Bill Wiswesser and Al Smith have played a key role in the development and use of WLN by ISI. So did Howard Bonnett.

As many of you know, the *Index Chemicus* was started with the support of approximately twelve drug companies. Joe Clark of Lederle, Bill Sullivan of Hoffmann-La Roche, and Alex Moore of Parke-Davis were especially helpful to me. Others who helped IC were Walt Southern of Abbott Labs, Howard Nutting of Dow, George McCarthy of Geigy, Charles Rice at Lilly, Evelyn Armstrong and Bob Harte at Merck, Rita Goodemote at Schering, Max Gordon at Smithkline, Doug Remsen at Squibb, Fred Bassett of Upjohn, Eliot Steinberg and Lee Starker at Warner-Lambert, and Ernie Hyde of Imperial Chemical Industries.

My own co-workers at ISI, including Gaby Revesz, Bonnie Lawlor, and Charlie Granito, have made it possible for some of these ideas to persevere in the face of tremendous odds. Not the least of my friends have come from the ranks of CA. I will not embarrass those who still work there by naming them. But for the man who has everything, it is perhaps most gratifying of all to have respected competitors as friends.

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On-Line Searching—Specialist Required†

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On-line searching has expanded into a complex specialty. Efficient use of computer-searchable files depends increasingly on the expertise of the information specialist whose skill in interviewing the client reflects a full understanding of the technical limitations of computer search systems and available databases. For the search, the specialist supplies experience in such areas as differences between on-line files and their hard-copy equivalents, the various indexing patterns of abstracting services, and the application of Boolean logic. The value of this expertise is illustrated here in terms of problems found in searching *Chemical Abstracts Condensates* relative to vocabulary, chemical nomenclature, search logic, and the search system used.

On-line bibliographic searching is alive and well. Today, on-line searching is a multi-million dollar per year business and is growing. It is estimated that 365 000 conversational terminals will be in operation by the end of 1977, as compared with 243 000 only three years ago.[1] Last year over 1 200 000 on-line searches were run. This number is expected to grow by 10 to 15% by the end of 1977.[2]

During the development and growth of on-line searching, the information specialist has played a key role by testing new systems and convincing the end user of their usefulness and value. But, in today's advanced systems, what part should and do the information specialists continue to play in on-line searching? How important is their skill in using the terminal to assure speed, reliability, and completeness at a minimum cost? To help determine these answers, we must review briefly how bibliographic data banks, the computer programs, and the interactive terminal systems to search them have developed.

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BATCH COMPUTER SEARCHING

By the late 1960s, refinements in computerized bibliographic information retrieval techniques opened the door to economical searching of many major data banks: *Chemical Abstracts*, ERIC, *Nuclear Science Abstracts*, NASA, *Biological Abstracts*, and others. During this period, governmental financial aid was supporting computerized information development groups at such organizations as Massachusetts Institute of

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