interface

Information flow in analytical journals

Scientometric methods, based on the statistical evaluation of journal citations and references, are helping the analyst to achieve a better understanding of the interactions and relationships between the main communication channels in his field of research.

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In the world of science communication takes place through several formal and informal channels. The referred journal article is the accepted archival record of scientific progress and a measure of professional stature. Communication of scientific results is thus of vital concern to every chemist.

In previous articles we have discussed communication in activation analysis[1] and chemical literature[2]. Other authors have examined journal information flow in other fields[3–11]. Journal citations and references have been a primary tool in all these studies; the sources have been *Journal Citation Reports* and the *Citation Index*. These studies, though interesting in their own right, are not mere academic exercises: the increasing proliferation of journals, papers and costs has put a squeeze on both author and publisher. The author wants the largest and most appropriate audience for his paper; the publisher wants a quality publication, an informed readership, and a return on his investment. The results presented in this paper may be of some assistance to publishers, but it is primarily aimed at authors.

Scientometricians count journal citations in an effort to ascertain which articles are most influential. Such citations are best used where the sample is large and individual differences are averaged out. This is the case when one studies the flow of information between journals. In this article we use data from *Journal Citation Reports*[12] to describe information flow (on a macro scale) between two groups of journals and journals in other fields. The two groups of journals are then broken down into their components and the interactions between them described. Finally the interactions are compared with what one might expect to find assuming how journals cite themselves and each other. This exercise enables us to understand analytical chemistry as it is portrayed in its journals.

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TABLE I. The main broad-based analytical journals[13]

Journal	Rank according to Ref. 2	Source items published in 1978[12]	Impact factor for 1978[12]
Analytical Chemistry	2	564	3.06
Analytica Chimica Acta	3	364	1.40
Analusis	51	74	0.67
Analyst	14	165	1.67
Analytical Letters	18	108	1.24
Bunseki Kagaku	9	204	0.41
*Chemia Analityczna (Warsaw)**	11		
Fresenius' Zeitschrift für Analytische Chemie	6	275	0.93
Talanta	8	168	1.18
Zavodskaya Laboratoriya	10	330	0.12
Zhurnal Analiticheskoi Khimii	4	272	0.40

* Not included in the Journal Citation Reports.

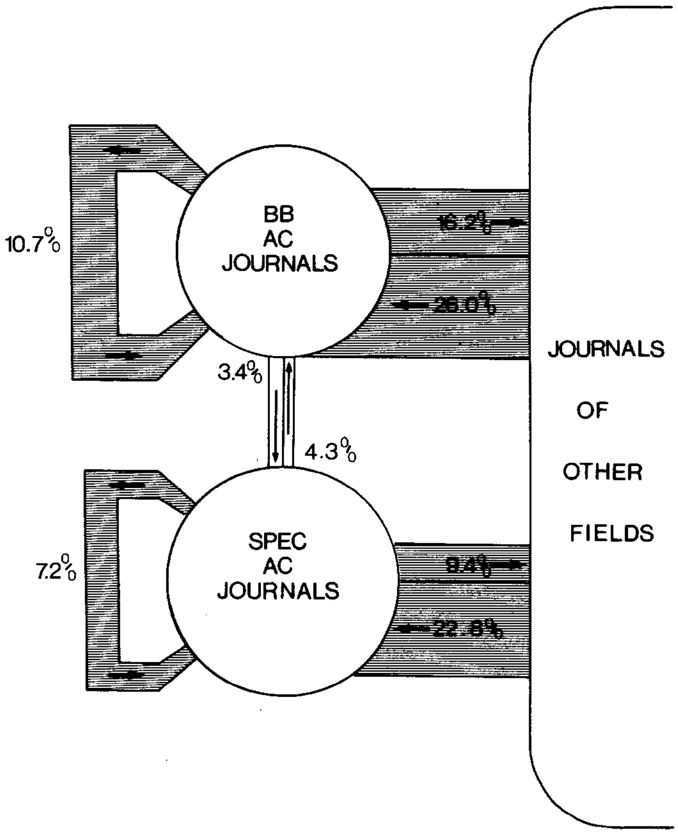

Fig. 1. The information flow in the group of the main broad-based and specialty analytical journals and in the journals of all other disciplines. Data are in percentages of the total information traffic.

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TABLE II. Twelve specialty analytical journals

Journal	Rank according to Ref. 2	Source items published in 1978[12]	Impact factor for 1978[12]
Adv. Chromatogr.	> 50	9	2.41
Chromatographia	19	108	1.97
Int. J. Mass Spectrom.	> 50	110	1.61
J. Assoc. Off. Anal. Chem.	7	241	0.916
J. Chromatogr.	1	881	2.30
J. Chromatogr. Sci.	21	98	2.59
J. Radioanal. Chem.	13	305	0.685
J. Therm. Anal.	> 50	79	0.436
Microchem. J.	> 50	73	0.947
Mikrochim. Acta	16	133	0.697
Thermochim. Acta	> 50	160	0.718
X-Ray Spectrom.	41	37	1.12

Procedure

In our study we have divided the most cited analytical journals into two groups: (a) a group of 11 major broad-based (BB) journals (only 10 journals were used because one is not included in *Journal Citation Reports*); and (b) 12 analytical specialty (SAC) journals. Tables I and II list these journals and give some pertinent data concerning them.

Of course, many other journals publish papers on analytical chemistry or papers of interest and of use to analytical chemists. Such journals were included in this study if they gave or received more than 33 references or citations per year to or from one of the journals listed in Tables I and II. These non-analytical journals were classified into subfields according to Narin[14].

Information flow between analytical chemistry and other fields

Fig. 1 is graphical and shows the percent of total information flow. Feedback or recycling of information within each group is the sum of self- and cross-citations. Linking the two groups is a transfer process about half the size of recycling, but of about equal intensity in each direction. Note that both groups interchange heavily with journals of other fields; the large excess of imports over exports is an artifact caused by the padding of inflow by documents other than journals.

Fig. 2 shows the information flow map for chemistry subfields drawn from our BB journal database but including the SAC journals; Fig. 3 shows the information flow between analytical chemistry and other disciplines.

$$S_v = \sum_{i=1}^{N} P_i F_i \qquad (1)$$

The inflow and outflow data are expressed as a percentage of the total flow of analytical information in the field of chemistry. However, instead of using the number of items published by the journals as a measure in Figs 2 and 3, we have used a virtual size (S_v). To obtain S_v the number of published items was multiplied by the appropriate impact factor of the journal, then summed for the whole subfield where P_i is the number of published papers by journal i

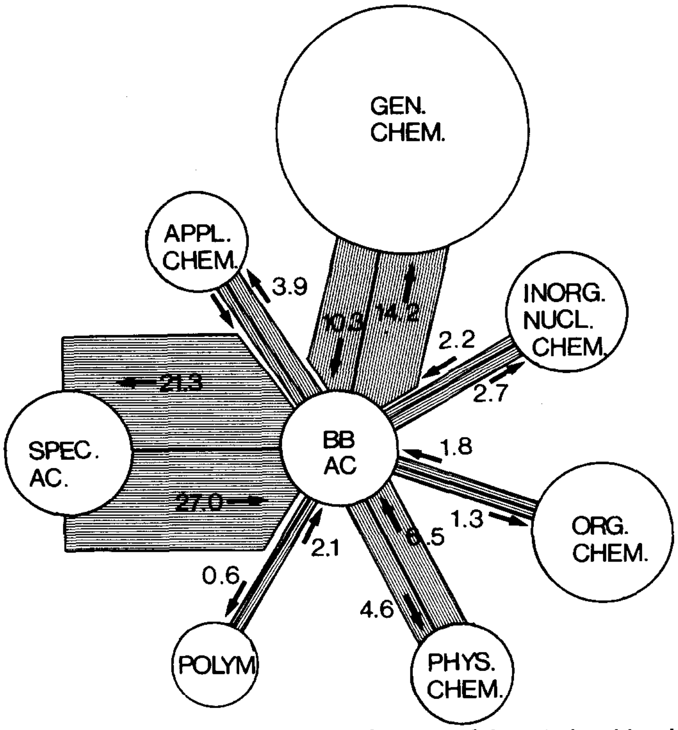

Fig. 2. The information flow between the group of the main broad-based analytical journals and the subfields of chemistry as percentages of the total analytical information flow in the field of chemistry. The area of circles representing subfields have an area proportional to the virtual size of subfields (Eq. (1)).

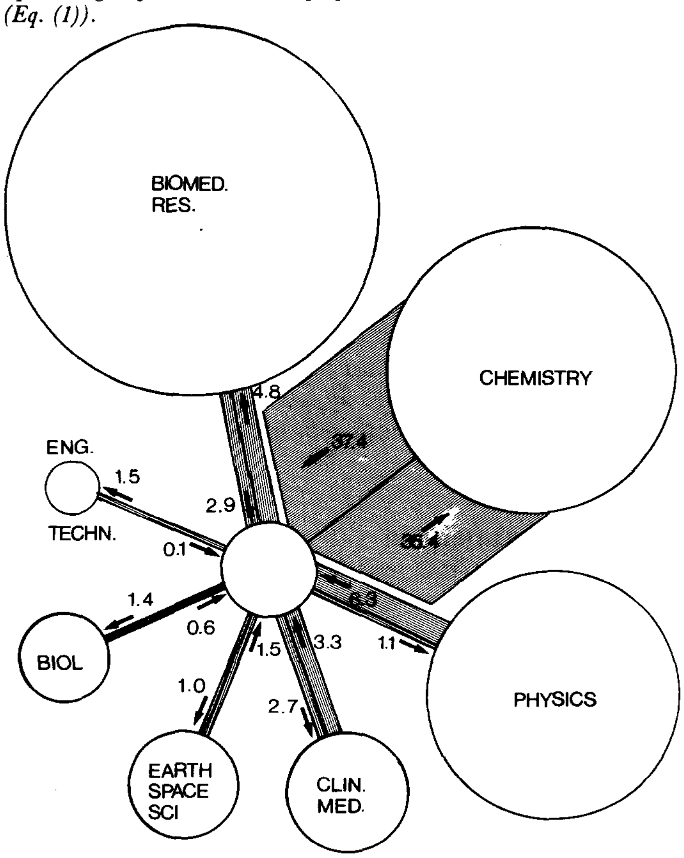

Fig. 3. The information flow between analytical chemistry and other fields of science as a percentage of the total flow of analytical information. The areas of the circles representing the fields are proportional to their virtual size (Eq. (1)).

in 1978, having an impact factor* F_i, and N is the number of journals in the subfield. The areas of the circles representing the subfields are proportional to their virtual size because the papers published appear as citations in an amount proportional to S_v.

From Fig. 2 one sees that the main information sources of analytical chemistry within chemistry as a whole are the specialty analytical and the general and physical chemistry journals. The rate of inflow and outflow differs for each subfield; for applied, general, inorganic and nuclear chemistry, analytical chemistry emits information, i.e., all these fields are drawing information from analytical chemistry.

From Fig. 3 one sees the main information sources of analytical chemistry. These appear to be physics, clinical medicine and the earth and space sciences; analytical chemistry absorbs information from all these disciplines.

Inter-relationship of analytical journals

If one arranges a group of journals in an $m \times m$ array, where an element c_{ij} indicates both the number of references that journal i gives to journal j, and the number of citations that journal j receives from journal i, a reference–citation matrix is obtained. Table III shows such a matrix for the BB journals and Table IV for the SAC journals. This transaction, or input–output matrix, shows the relationship of a journal to others in the group. For example the citation ratio for a journal can be a simple indicator of the journal's behavior within its group. This ratio is found by dividing the sum of the ith column by the sum of the ith row. If the citation ratio is greater than one the journal is an emitter or exporter of information; if less than one the journal is an absorber or importer of information. For example, within the BB group (Table III) *Analytical Chemistry* is seen to be an exporter (2159/2074 = 1.04); *Talanta* is an importer (696/836 = 0.83). Matrices such as those shown in Fig. 3 can be the starting point for more sophisticated analyses of information flow.

Expectation analysis

Inspection of the matrices in Tables III and IV reveals an interesting anomaly: most journals cite themselves much more frequently than would be expected. (Self-citations are shown in the diagonal terms.) Such self-citation may well represent a different emphasis, philosophy or policy from that employed by an author citing articles from other journals. For example, an author preparing a paper for submission to journal A might include peripheral references from previous papers published in that journal so as to indicate that his paper was important to the journal and followed a tradition of such papers.

In attempting to interpret such a citation matrix one would like to be able to 'normalize' (or correct) this anomalous behavior. Price[15] and Price and Burke[16] have devised a procedure to replace the diagonal terms by those that would be there if each journal referenced itself as it referenced others. Price's method consists of treating the matrix as if each element is a product of the corresponding row and column coefficients assuming the diagonal terms are unknown. For a simple 4×4 matrix this would appear as:

	Column			
Row	e	f	g	h
A	.	af	ag	ah
B	be	.	bg	bh
C	ce	cf	.	ch
D	de	df	dg	.

If the matrix operations given in equation 2 are performed one can obtain the value of each diagonal term, e_{nn}. This value is the 'corrected' or expected self-citation for each journal assuming it cites itself as it cites others.

$$e_{nn} = \frac{\left(\prod_{\substack{i \\ i=n}}^{m} c_{nk}\right)^{\frac{1}{m-2}} \left(\prod_{\substack{j \\ j\neq n}}^{m} c_{jn}\right)^{\frac{1}{m-2}}}{\left(\prod_{j=1}^{m} \prod_{\substack{k=1 \\ k\neq j}}^{m} c_{jk}\right)^{\frac{1}{(m-1)(m-2)}}} \tag{2}$$

However, when one looks at a matrix such as that in Table III one is hard pressed to see anything beyond a lot of numbers. Price[17] has proposed a procedure to 'pick out order and disorder in both rows and columns'.

$$e_{ij} = \frac{c_{ij} \sum_i \sum_j c^*_{ij}}{\sum_j c^*_{ij} \sum_i c^*_{ij}} \tag{3}$$

where the asterisk shows that the row and column sums should be formed with the new diagonals.

The results of this exercise are two expectation values for each journal pair, e_{ij} and e_{ji}. If one averages these expectation pairs one ends up with a symmetrical expectation matrix.

Using Table III as an example, we calculated an expectation matrix as follows. The cited sum and citing sum values given in this table exclude the diagonal. To each of these values we added the previously determined and expected self-citation (diagonal) values. A grand total $\sum_i \sum_j c^*_{ij}$ was obtained — this being the sum of either citing or cited values. If each entry c_{ij} is now multiplied by the grand total, $\sum_i \sum_j c^*_{ij}$ and divided by the appropriate row and column totals, $\sum_{j} {}^*_{ij}$.

Using this method we obtained the values shown in Table V, i.e. the symmetrical expectation matrix for the BB journals. What can we conclude from it?

* The impact factor[12] is a measure of the frequency with which the 'average cited article' in a journal has been cited in a particular year. It is basically a ratio between the number of citations and citable items published. Thus, the 1978 impact factor of journal X would be calculated by dividing the number of all the Science Citation Index source journals' 1980 citations of articles journal X published in 1978 and 1979 by the total number of source items it published in 1976 and 1977.

TABLE III. Cross-citing of broad-based analytical chemistry journals in the year 1978

References from	Citations to 1	2	3	4	5	6	7	8	9	10	Cited sum
1 *Anal. Chem.*	[3107]	578	46	229	160	151	216	276	126	292	2074
2 *Anal. Chim. Acta*	698	[541]	9	179	49	36	90	170	12	37	1280
3 *Analusis*	103	37	[33]	24	12	< 6	8	34	< 6	< 10	240
4 *Analyst*	349	162	< 3	[235]	31	13	45	66	7	48	724
5 *Anal. Lett.*	118	41	< 3	16	[34]	< 6	9	14	< 6	< 10	223
6 *Bunseki Kagaku*	200	74	< 3	34	6	[< 6]	21	50	< 6	9	403
7 *Fresenius Z. Anal. Chem.*	281	95	< 3	46	14	13	[344]	41	< 6	9	508
8 *Talanta*	247	147	10	100	16	74	87	[239]	37	118	836
9 *Zavod. Lab.*	27	11	< 3	7	< 6	< 6	6	8	[190]	76	150
10 *Zh. Anal. Khim.*	136	55	< 3	23	< 6	8	33	37	113	[429]	414
Citing sum	2159	1200	83	658	300	313	515	696	319	609	

TABLE IV. Cross-citing of specialty analytical chemistry journals in the year 1978

References from	Citations to 1	2	3	4	5	6	7	8	9	10	11	12	Cited sum
1 *Adv. Chromatogr.*	[6]	< 6	< 6	< 6	64	< 6	< 6	< 3	< 4	< 6	< 6	< 3	116
2 *Chromatographia*	10	[150]	< 6	12	332	82	< 6	< 3	< 4	< 6	< 6	< 3	470
3 *Int. J. Mass Spectrom.*	< 2	< 6	[216]	< 6	10	< 6	< 6	< 3	< 4	< 6	< 6	< 3	58
4 *J. Assoc. Off. Anal. Chem.*	< 2	7	< 6	[519]	90	30	< 6	< 3	< 4	< 6	< 6	< 3	163
5 *J. Chromatogr.*	39	273	< 6	163	[3262]	526	< 6	< 3	15	22	< 6	< 3	1062
6 *J. Chromatogr. Sci.*	19	38	< 6	26	223	[147]	< 6	< 3	< 4	< 6	< 6	< 3	340
7 *J. Radioanal. Chem.*	< 2	< 6	< 6	< 6	30	< 6	[341]	< 3	5	20	< 6	14	104
8 *J. Therm. Anal.*	< 2	< 6	< 6	< 6	< 17	< 6	< 6	[63]	< 4	< 6	47	< 3	109
9 *Microchem. J.*	< 2	< 6	< 6	< 6	16	< 6	< 6	< 3	[54]	24	< 6	< 3	84
10 *Mikrochim. Acta*	< 2	6	10	< 6	45	10	11	< 3	25	[103]	< 6	< 3	127
11 *Thermochim. Acta*	< 2	< 6	< 6	< 6	< 17	< 6	< 6	76	< 4	< 6	[261]	< 3	138
12 *X-Ray Spectrom.*	< 2	< 6	< 6	< 6	< 17	< 6	< 6	< 3	< 4	< 6	< 6	[45]	68
Citing sum	84	366	70	249	861	690	71	106	77	114	107	44	

Data unavailable for *Anal. Chem., Anal. Chim. Acta Comp., J. Gas Chromatogr., J. Liq. Chromatogr., P. Anal. Div. Chem Soc., Zh. Prikl. Spektrosk., Chim. Anal. Paris*

TABLE V. Symmetrized expectation matrix for the main broad-based analytical journals

	1	2	3	4	5	6	7	8	9	10
1 *Anal. Chem.*	[1.9]	1.03	1.13	0.90	1.21	1.11	1.20	0.70	0.66	0.90
2 *Anal. Chim. Acta*		[2.4]	0.82	1.44	1.06	0.91	1.09	1.14	0.34	0.58
3 *Analusis*			[14.4]	0.83	1.42	0.73	0.57	1.34	1.37	0.65
4 *Analyst*				[3.8]	1.03	0.75	1.03	1.14	0.41	0.77
5 *Anal. Lett.*					[4.4]	0.57	0.71	0.59	0.93	0.51
6 *Bunseki Kagaku*						[ ]	0.76	1.76	0.74	0.40
7 *Fresenius' Z. Anal. Chem.*							[10.9]	1.20	0.48	0.74
8 *Talanta*								[2.8]	0.83	1.35
9 *Zavod. Lab.*									[34.4]	7.08
10 *Zh. Anal. Khim.*										[13.8]

$\bar{e} = 1.04$
S.D. = 0.97

First, looking along the diagonal, we note that most journals cite themselves a lot – notably the Russian and German journals. Only *Anal. Chem., Anal. Chim. Acta,* and *Talanta* manage to stay below a value of three.

Second, looking at the expectation values for pairs of journals we note some close and some distant relationships. The two Russian journals *Zavod. Lab.* and *Zh. Anal. Khim.* reference each other seven times more often than statistical estimates would predict. The Japanese journal, *Bunseki Kagaku,* has its closest relationship with *Talanta* ($e = 1.76$). *Bunseki Kagaku* also has the second most distant relationship of any journal – 0.40 with *Zh. Anal. Khim.* This is only slightly less frigid than that of *Anal. Chim. Acta* and *Zh. Anal. Khim* ($e = 0.34$). Other cool relations exist between *Zavod. Lab.* and both the *Analyst* and *Fresnius' Z. Anal. Chem.* (In Table V high values are underlined with a solid line, low ones with a broken line.)

Research interactivity

Pinski[18] has pointed out the necessity for size correction in making comparisons between journals of different sizes. One can, for example, compare the food intake and waste output of a Pekinese and Great Dane, but this ought to be done on a *per weight* basis. Using the procedure suggested by Pinski we have calculated a size-reduced (size independent) form of the citation matrix by dividing each element by the geometric mean of the corresponding diagonal elements. Thus, we have formed the matrix with elements:

$$r_{ij} = \frac{c_{ij}}{(c_{ii} \cdot c_{jj})^{1/2}} \quad (4)$$

giving diagonal elements equal to 1. A given journal k can be characterized by the referencing or inflow interactivity;

$$I_k^{(r)} = \frac{1}{m-1} \sum_{\substack{i=1 \\ j \neq k}}^{m} \frac{c_{ki}}{(c_{kk} \cdot c_{jj})^{1/2}} \quad (5)$$

the cited or outflow interactivity;

$$I_k^{(c)} = \frac{1}{m-1} \sum_{\substack{i=1 \\ i \neq k}}^{m} \frac{c_{ik}}{(c_{kk} \cdot c_{ii})^{1/2}} \quad (6)$$

and by the average interactivity;

$$I_k^{(av)} = 1/2(I_k^{(r)} + I_k^{(c)}) \quad (7)$$

These interactivity values are expressed as the average of an individual journal's interactivity with each of the other (m-1) units.

The ratio $\alpha' = I_k^{(c)}/I_k^{(r)}$ i.e., the outflow per inflow, is an influence related measure and may characterize a journal better than the citation ratio.

Interactivity calculations were made for both the BB group and the SAC journals. The ratio α' (outflow per inflow) was then calculated and compared with the citation ratio as found in the original matrix. These results are shown in Tables VI and VII. The α' appears in general to indicate a higher influence than the citation ratio, but overall the differences between values are not large. The only large discrepancies are in the citation ratios for *Zavod Lab.* and *J. Chromatogr. Sci.* (much higher than their α''s), and the citation ratio for *J. Radioanal. Chem.* (only 68% of its α' value). We find no obvious explanation for these differences.

TABLE VI. Interactivity values of main broad-based analytical journals

Rank according to influence	Journal	Citation ratio	Influence α'
	'Emitter' journals		
1	*Zavod. Lab.*	2.12	1.62
2	*Anal. Lett.*	1.23	1.42
3	*Zh. Anal. Khim.*	1.47	1.33
4	*Analyst*	0.91	1.29
5	*Fresenius' Z. Anal. Chem.*	1.01	1.29
6	*Anal. Chim. Acta*	0.94	1.22
7	*Anal. Chem.*	1.04	1.10
	'Absorber' journals		
8	*Bunseki Kagaku*	0.78	0.86
9	*Talanta*	0.83	0.76
10	*Analusis*	0.35	0.32
	Overall system interactivity: 0.292		

TABLE VII. Interactivity values of specialty analytical journals

Rank according to influence	Journal	Citation ratio	Influence α'
	'Emitter' journals		
1	*Int. J. Mass Spectrom.*	1.21	1.66
2	*J. Assoc. Off. Anal. Chem.*	1.53	1.66
3	*J. Chromatogr. Sci.*	2.03	1.28
4	*Mikrochim. Acta*	0.90	1.25
5	*Microchem. J.*	0.92	1.12
	In 'equilibrium'		
6	*J. Thermal. Anal.*	0.97	1.00
7	*J. Radional. Chem.*	0.68	1.00
8	*Thermochim. Acta*	0.78	1.00
	'Absorber' journals		
9	*J. Chromatogr.*	0.81	0.93
10	*X-Ray Spectrom.*	0.66	0.86
11	*Adv. Chromatogr.*	0.72	0.73
12	*Chromatographia*	0.78	0.73
	Overall system interactivity: 0.096		

It is interesting that the average system interactivity in the BB journals is about three times that of the SAC journals. Note also that the delineation between absorber and emitters is not nearly so clear for the specialty journals as it is for the BB's. However, as far as Pinski's method is concerned, it appears that making the correction for size only makes a difference in a few relationships, and these are, apparently, random.

Observations and conclusions

What have we observed in these studies and what useful conclusions can we draw for the practicing analytical chemist?

The social communication system of analytical chemistry is measured by its journal references. Some journals are apparently in close communication, while others are hardly on speaking terms. We have noted that the primary 'outside' sources of analytical information are to be found in journals concerned with chemistry and physics (certainly not an earth shaking observation). For chemistry the inflow and outflow are almost equal. However, the analyst contributes little to physics but borrows much; surprisingly, analytical chemistry is an exporter of information to biomedical research.

What is the practical value of all this? One could take the easy way out and dismiss practicality with '*ars gratia artis*'*. But we think there are some prescriptions and admonitions to be noted here.

For a very specialized paper aimed at a specialized audience, specialty journals are fine. But because of their limited relationship with other fields, they are not the place to publish a paper with implications for, say, the earth sciences or clinical medicine. This type of paper is better published in a broad based journal or in an earth science or clinical journal. Both of these options provide an excellent opportunity for interdisciplinary information exchange.

* Art for art's sake.

To build a reputation in a specialty field one should probably confine one's contributions to specialty journals, but one should be careful to choose one that is in communication (is cited) with other journals where similar papers appear. The impact factor of a journal is obviously an important determinant in journal selection.

The scientific literature contains numerous instances of 'buried treasure'; Mendel's papers are perhaps the classic example. Those who are interested in mining for undiscovered analytical ideas can see from Tables VI and VII which journals have been referenced (and thus, presumably, studied) least. The fact that physics contributes six times more information to analytical chemistry than it does to physics indicates another way of finding new methods and techniques.

Chemists in non-English speaking countries should closely examine the data concerning citations from non-English language journals. This and other similar observations hardly need further elaboration.

Finally, an admonition and caution: this study is a statistical one, and as such treats groups of journals, masses of papers, and thousands of citations. A paper, like an individual, is unique. Any author who uses these statistics to help him make a choice should always remember that he himself is not a number.

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trends

Thermal lens spectrophotometry

A thermal lens effect induced under laser irradiation is useful for the detection of very small absorptions. This forms the basis of a new technique which is becoming increasingly important as a tool for ultratrace analysis.

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Spectrophotometry has been widely used in the determination of many inorganic and organic species because of the availability of a variety of colorimetric reagents. However, the sensitivity of conventional spectrophotometry is not sufficient for ultratrace analysis. The signal in the conventional spectrophotometer is measured indirectly as the difference between the incident and the transmitted radiation, it is therefore difficult to improve the detection sensitivity of the apparatus. If one could measure the absorbed radiant energy directly by some spectrometric method, it would be possible to detect very small absorptions simply by increasing the power of the light source, as in the case of fluorimetry.

Historical development

In 1965 Gordon *et al.* found build-up and decay transients when a liquid cell was placed within a laser cavity of an He–Ne laser, and reported that the basic phenomenon was a lens effect produced by local heating along the laser beam[1]. As the intensity of the thermal lens effect is proportional to the absorbed radiant energy it provides a sensitive means of detecting very small absorptions when a strong exciting source is used. Most of the fundamental investigations in this field were done by physical chemists as analytical chemists showed little interest in the tech-

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