The Institutionalization of Scientific Information: A Scientometric Model (ISI-S Model)

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ABSTRACT

A SCIENTOMETRIC MODEL (ISI-S model) is introduced for describing the institutionalization process of scientific information. The central concept of ISI-S is that the scientific information published may develop with time through permanent evaluation and modification processes toward a cognitive consensus of distinguished authors of the respective scientific field or discipline. ISI-S describes the information and knowledge systems of science as a global network of interdependent information and knowledge clusters that are dynamically changing by their content and size. ISI-S assumes sets of information with short- or long-term impact and information integrated into the basic scientific knowledge or common knowledge. The type of the information sources (e.g., lecture, journal paper, review, monograph, book, textbook, lexicon) and the length of the impact are related to the grade of institutionalization. References are considered as proofs of manifested impact. The relative and absolute development of scientific knowledge seems to be slower than the increase of the number of publications.

MODELS OF THE GROWTH OF SCIENCE

According to the information model of science suggested by Nalimov & Mulchenko (1969) one can assume that scientific research is an organized information generating system and that science is a system of organized knowledge. Scientific research is fed with information as input for generating information as output that is new (original) or restructured knowledge compared to the input.

The growth of science is preferably described in the literature by models based on the *cumulative growth of publications.* In each model the cumula-

tive number of publications in a given year depends on the number of publications in the starting year, the rate of growth, and the length of the time period elapsed (Gilbert, 1978; Wolfram, Chu, & Lu, 1990).

The *linear model* calculates with constant increases during equal time periods. Rescher (1978) suggested, for example, a linear growth function for the first-rate publications. The *exponential model* predicts an exponential increase of publications without limits to growth (e.g., Price, 1963; Egghe, 2000; Gupta & Karisiddappa, 2000). The logistic growth takes into account that scientific research is not a closed system and physical, economic, intellectual, etc. limitations occur that may bring about an upper limit to the growth (e.g., Price, 1963; Egghe & Rao, 1992; Gupta, Praveen, & Karisiddappa, 1997).

The application of cumulative numbers of publications for describing the development of science is, however, inappropriate, since the method does not take into account *the aging of information*. The concept, "cumulative number of papers," would indicate that all information previously published was relevant (regarding currency or recency) in the year of the study. This cannot be valid, considering, for example, the decreasing percentage shares of references with years referenced in Science Citation Index or Journal Citation Reports (SCI or JCR) for any journal.

Several authors (e.g., Egghe & Rao, 1992; Egghe, 2000) try to describe the development of science with the assumption of exponential increase of publications and exponential decrease of the relevant information. Theoretically, the model may be correct but practically, the synchrony between the opposing trends cannot be justified for any period.

Rescher (1978) tackled the "Rousseau law," suggesting "that the historical situation has been one of a constant progress of science as a *cognitive discipline* notwithstanding its *exponential* growth as a productive *enterprise*" (p. 111).

The calculation of the annual increase and subsequent aging of publications may give only an approximation to the growth of scientific knowledge in different fields of the natural sciences. Science works with great redundancy; there are numerous parallel papers, and several results already published are republished as original works (Price, 1963; Merton, 1968).

Menard (1971) investigated the publication development of chemistry, geology, and physics. The number of papers in physics increased linearly up to 1914 and then showed an exponential growth. The number of publications on chemistry was found to increase exponentially from the beginning of this century. Menard found very fast development in some hot fields, such as particle physics, where the annual rate was 15 percent in the 1950s and 60s. Menard distinguished three types of subfields: Stable fields, which increase linearly or exponentially at very slow rates; fast, exponentially growing fields; and cyclic fields, with stable and fast growth periods alternating. In support of Menard's results, Vinkler (2000) found that the

mean publication growth (i.e., mean annual number of publications) of different scientific fields *strongly depends on the time period selected.* For example, for Chemical Abstracts, a 6 percent mean annual increase was calculated between 1962–1979, and only one percent from 1980–1992, whereas 4 percent was observed between 1993–1999. Consequently, one may conclude that *there is no general law "governing" the publication growth* of disciplines for longer periods. The (cumulative) increase (or decrease) in the annual number of publications depends on several factors within and without science. The time/number of publications functions may be valid only for the period studied and have no predictive power.

Several attempts have been made to describe the development of science with nonscientometric models (Kuhn, 1962; Goffman & Warren, 1980; Crane, 1972; Mulkay, Gilbert, & Woolgar, 1975; Mullins, 1973). Gupta & Karisiddappa (2000) distinguished four developmental phases where cognitive content, methodology, type of publications, social structure, and institutionalization of the scientific research is characteristically different. According to this model, the information in the first phase is published primarily in "innovative" documents and reprints, in the second phase in papers, in the third phase in specific journals and textbooks, and in the fourth phase in journal bibliographies. The main institutional frameworks of emerging disciplines are as follows: Informal (nonorganized) stage, small symposia, congresses and formal meetings, university departments.

GROWTH OF THE LITERATURE CHARACTERIZED BY THE RELATIVE PUBLICATION GROWTH INDEX

For describing the publication growth of science, one may borrow an analogue from physics: The velocity of moving bodies is equal to the length of distance covered during a time unit. In scientometrics we may select one year as the time unit and the number of journal papers as the distance. Consequently, the annual number of journal papers published in a specific field of science may be accepted as *Publication Velocity* (PV) of the respective field (Vinkler, 2000).

For characterizing the *relative growth* of the scientific literature during a time period, the *mean Relative Publication Growth,* RPG(t) index has been introduced (Vinkler, 2000). The RPG(t) index relates *the number of publications issued in a given year to that published during a preceding time period* selected (t). The length of the preceding period (termed as relevance period) may preferably refer to two, five, ten, or twenty years. The length of period *t* may be assumed as the *maximum age of recent, relevant* (RR) papers. RR papers are the publications that may contain all the *information required for generating new information.* It may be assumed that papers referenced in scientific papers at a given time may contain such information.

The number of publications referenced during a period of seventeen to thirty years were followed in Chemical Abstracts (CA), Inspec Section A

(I), Psychological Abstracts (PA), Biological Abstracts (BA), Science Citation Index (SCI), and Mathematical Abstracts (MA). A relevance period of two years was applied. The RPG(2) indices were found as follows: CA (1962–1993), 0.53; I (1980–1998), 0.52; BA (1964–1993), 0.53; SCI (1980–1998), 0.52; PA (1960–1979), 0.56; MA (1952–1990), 0.55 (the time periods studied are given in brackets). It may be easily concluded that the RPG(2) values refer to an average *yearly percentage increase* of about 4, 3, 4, 3, 8, and 7 percent, respectively (Vinkler, 2002). The Pearson's correlation coefficients characterizing the annual increase of papers in time were found significant, positive, and relatively high (> 0.92) for all cases. In contrast to this, the trends of the yearly RPG(t) values gave controversial patterns. In some cases, they were significant but negative; in other cases, they were not significant.

From the RPG(t) values calculated for the different disciplines the following conclusions may be drawn:

• The RPG(t) values depend on the length of the relevance period (t) selected; greater *t* values result in lower RPG(t) data;
• The greater the annual percentage increase of publications, the smaller the ratios between RPG(2)/RPG(5)/RPG(10);
• RPG(t) values calculated with similar t-data are similar for the different disciplines;
• The mean RPG(2, 5, 10) values are higher than the theoretically calculated ones (0.50, 0.20, 0.10, respectively), meaning that there is an increase in the relevant information production within the time periods studied;
• The very low standard deviation values may indicate relatively constant RPG(t) values for the time periods studied.

Latter findings indicate that *the increase of the recent, relevant body of scientific information is slower than that of the total information.*

For lower aggregation levels, the data referring to RPG(2) and (yearly percentage increase) between 1970–1998 were found as follows: Applied chemistry and technology, 0.533 (4.22 percent); biochemistry, 0.529 (4.05 percent); physical and analytical chemistry, 0.520 (2.94 percent); macromolecular chemistry, 0.525 (2.89 percent); organic chemistry, 0.505 (0.46 percent). For comparison, RPG(t) values were calculated for some fast developing topics, such as AIDS research, fullerenes, nanostructures, composites, antisense nucleotides, etc. The respective RPG(t) values were found to be *significantly higher* than those for whole disciplines (Vinkler, 2002).

The findings mentioned are in accordance with the concept recently suggested by van Raan (2000): Science can be regarded as a dynamic integrative system where the development results from the growth of several subsystems with very different publication velocities.

The models based on the concept of the cumulative or relative publi-

cation growth of science, which calculate with the number of papers published yearly, can give a simplified picture only. The aim of the present paper, however, is to describe the development of science by a scientometric model that integrates the production, evaluation, modification, and aging processes of scientific information.

MAIN CATEGORIES AND GENERAL FEATURES OF THE INSTITUTIONALIZATION OF SCIENTIFIC INFORMATION, A SCIENTOMETRIC MODEL (ISI-S MODEL)

According to the central concept of the ISI-S model the scientific information disclosed may develop with time through various evaluation and modification processes toward a cognitive consensus of distinguished authors of a scientific field or discipline. The ISI-S model assumes permanent production, evaluation, and modification of scientific information. It describes the information and knowledge systems of science as a *global network of interdependent information and knowledge clusters* that are dynamically changing by their content and size. The content and size of the individual clusters are regulated by different assessment processes.

The definitions (below) and the categories (Table 1) of ISI-S suggested here should be regarded as approximations. The term "information" refers always to natural science information.

Information in scientific publications (e.g., papers, book chapters, conference lectures) is:

• Addressed to the respective scientific community;
• Reviewed by peers before publishing and revised by the authors, if necessary;
• Disclosed by generally accepted norms of scientific publication of the respective discipline.

Scientific publication is a means of *announcing priority* (Price, 1963; Garvey, 1979) and contains (or at least should contain) all the information required for *understanding and repeating* the results published (Vinkler, 1998).

The ISI-S model postulates five main information sets, which can partly overlap: Information in publications; information of short-term impact; information of long-term impact; basic scientific knowledge; and common scientific knowledge. The rank of the information clusters as mentioned represents the hierarchical grade of institutionalization (see below) of scientific information (Table 2 and Figure 1).

ISI-S postulates three main and several additional evaluation processes. The first process refers to *public access* of the information to be published, the second to the *relevancy* and *use of the information published*, and the third to its general acceptance as *part of the basic scientific knowledge* of a discipline (Figure 1).

Table 1. Survey of the Main Categories of the ISI-S MODEL.

Forms of Scientific Information by Disclosing	Classes of Information Disclosed by Relevancy	Types of Impact of Information Published	Terms of Impact of Information	Types of the Processes	Classes of Evaluators	Main Evaluation Forms
Non-published, submitted, published	Relevant, non-relevant (faulty or redundant), aged	Manifested, latent, lack of impact	Short, long, very long	Scientific research; publication; absorption, evaluation, use, and modification of information	Peers, relevant authors, distinguished authors	Acceptance or refuse of publications submitted, recension written on publications, citing or neglecting publications

Remark: For respective explanations, see the text.

Table 2. Institutionalization of Scientific Information: A Scientometric Model (ISI-S MODEL). The Main Evaluation Forms of Scientific Information and Proofs of Impact.

Source of Scientific Information Evaluated	Evaluators	Type of Impact	Public Proof of Impact	Preferred Source of the Citation Proving Impact
Lecture				
Submitted	Peers (relevant authors)		Acceptance and publication	
Published in full-length (in conference proceedings)	Relevant authors	STI LTI	Citation	Conference proceeding, abstract, journal paper, review, monograph, book
Published as abstract	Relevant authors	STI	(Citation)	(Abstract, proceeding)
Journal Paper				
Submitted	Peers (relevant authors)		Acceptance and publication	
Published	Relevant authors Distinguished authors	STI, LTI LTI, BSK	Citation Citation	Journal paper, review, monograph, book, university text book
Book, Monograph				
Submitted	Editors, peers (distinguished authors)		Acceptance and publication	
Published	Reviewers Relevant authors Distinguished authors	STI STI, LTI LTI, BSK	Recension Citation Citation	Journal, journal paper, review, monograph, book, specialized lexicon, general lexicon, university text book
Information in Computerized Data Banks	Relevant authors	STI, LTI	Citation	Journal paper

Legend: STI = short term impact. LTI = long term impact. BSK = basic scientific knowledge.
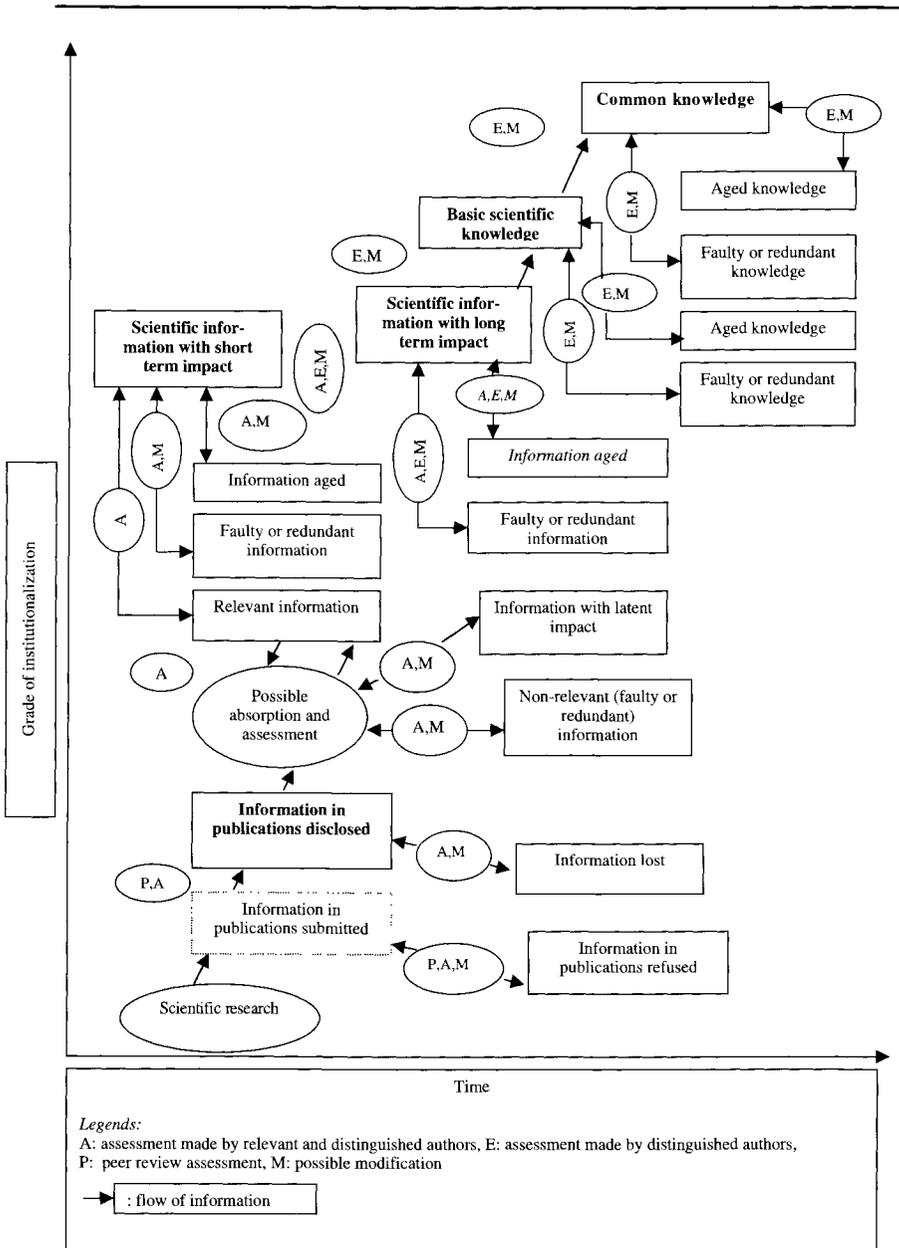Relevant authors may include distinguished authors as well.

Figure 1. Institutionalization of Scienometric Information. A Scienometric Model (ISI-S MODEL).

The evaluations described in ISI-S result in a binary digit: Go or stop, that is, green light to the information to be published or having been published, or red light, which means rejection, ignorance, or disregard.

According to ISI-S, the *relevant information* refers to a part of information published that is found by any of the relevant authors (see below) to be relevant for any professional or social reason. Relevant information may be *absorbed* or *discarded* as faulty or redundant. The information absorbed may exert an *impact* of short or long term. Information that cannot pass the reference threshold (Vinkler, 1998) may exert a *latent effect* on respective authors. The information with potential influence may be transferred later to information with manifested impact. ISI-S considers references in scientific publications as proofs of impact on science or scientific research. Over longer periods, the information absorbed may progress into basic scientific knowledge. The "relevancy status" of the information in publications depends on several factors—for example, time elapsed between publication and the possible assessment, quality, topic, type of information.

Information evaluated by relevant authors (see below) may be proven nonrelevant, faulty, controversial, or redundant. Faulty results generally receive no or only some citations (Cole & Cole, 1968), whereas controversial information may obtain many citations, but only within a short period of time (e.g., "cold fusion" literature; see Bockris & Hodko, 1990). Through reevaluation processes the information types mentioned may later become relevant.

The aging of information is a very complex process (see Alvarez, Escalona, & Pulgarin, 2000). *Aged information* refers here to information that is completely replaced by new results. Any publication may be partly or completely aged after a shorter or longer period. A long-term *lack of references to publications referenced earlier* may serve as *proof of aging.*

The scientific information published or to be published may undergo modifications, which result in:

- Minor changes, that is, the essence of the publication remains relevant, only its form, validity, reliability conditions, etc. are changed;
- Major changes, that is, only the problem tackled or some details (e.g., methods, data, arguments, etc.) remain relevant;
- Complete aging, that is, the publication becomes nonrelevant.

Aging and modifications run parallel in opposite directions. Each modification of information is connected by *reassessment* and *disclosure of new publications.* The text referencing may reveal the modifications in the original (i.e., referenced) information suggested by the author referencing.

According to ISI-S, the impact of the scientific information published may be defined as *absorption and application* of pieces of knowledge in science in any form. It should be noted that the length of impact strongly

depends, for example, on the *discipline, type, topic,* and *quality* of information, and the *developmental grade* of the respective field.

Information of short-term impact refers here to the body of information that influences scientific research of a topic for a short term. Information of short-term impact very rapidly undergoes modifications. "Short term" in several natural science disciplines may refer to about five to ten years (Vinkler, 1999), during which time a majority of the papers becomes aged completely (i.e., not referenced any more). *Preferred sources* of information of short-term impact are conference lectures and journal papers. *Manifested proofs* of short-term impact information are references, preferably in journal papers and conference proceedings (Table 2).

Information of long-term impact refers to the body of information published that influences scientific research of a topic, field, or discipline for a long term. During this period the original information may undergo modifications. The information that has influence for a long period may represent an intermediate stage towards the status of basic scientific knowledge. The long-term impact period may cover ten to twenty years (Alvarez, Escalona, & Pulgarin, 2000), strongly depending on disciplines. *Preferred sources* of long-term information are reviews, monographs, and books. As *manifested proofs* of long-term impact, references preferably in secondary information sources (e.g., reviews, monographs, books) can be accepted (Table 2).

Basic scientific knowledge contains pieces of information that proved to be valid for a relatively very long period. It represents the incorporated, institutionalized, generally accepted body of information of a thematic unit (e.g., discipline, field, topic) that may have a fundamental influence on science and scientific research of the respective discipline, field, or topic for a relatively very long period. Basic scientific knowledge represents a part of the contemporary knowledge of mankind. Some of this knowledge is taught in university courses. *Cognitive consensus* of distinguished authors of broader thematic units is a necessary prerequisite for regarding information as basic knowledge. *Preferred channels* of basic scientific knowledge are secondary information sources, such as reviews, monographs, books, university textbooks, and special lexicons. *Manifested proofs* for this knowledge are references, preferably in the sources mentioned. Publications containing the original information accepted as basic knowledge are frequently not referred to directly. Referencing to names, initials, etc., or to reviews or books, is preferred (Table 2).

According to ISI-S *common scientific knowledge* is a part of the general and special knowledge of mankind originating entirely from basic scientific knowledge. *Preferred channels* of common scientific knowledge information are general lexicons, popular science books, and secondary and general school books. The aforementioned information sources refer preferably to monographs and books.

ISI-S assumes a *direct relation* between the *length of the impact* of information published and *the grade of institutionalization* (see below). The assumption mentioned involves the acceptance of ranking information by *institutionalization* grades.

ISI-S postulates three main categories of *evaluators* as follows:

- *Peers* deciding on the acceptance or rejection of the publications (or lectures) submitted;
- *"Relevant authors"* deciding on relevancy and application of the information published by their own individual professional and social viewpoints;
- *"Distinguished authors,"* who decide on relevancy by their individual viewpoints, but take into account worldwide professional (scientific) standards and interests of a whole thematic unit.

The assumed role of distinguished authors does not ignore the Ortega hypothesis, that is, to produce vast amounts of natural science data and to perform a great deal of experiments requires the activity of many researchers. But, each scientometric distribution (e.g., publication frequency or measure of citedness) reveals the Matthew effect of the first type (Merton, 1968)—that is, a few scientists publish very frequently and receive relatively many citations—and the second type (Vinkler, 1997)—that is, publishing in journals with a relatively high Garfield (impact) Factor) is a necessary but not sufficient requirement for attaining a Relative Subfield Citedness index higher than unity.

The assessment process of information performed *by relevant authors* refers to the activity of researchers (i.e., "relevant authors") working in similar fields as that of the publications to be assessed and surveying regularly pertinent information disclosed. The main goal of the assessment process is to keep abreast of the current literature and to survey previous information in order to obtain *recent, relevant knowledge.* The relevant authors are fellow scientists who potentially absorb, evaluate, and use information published and issue new publications themselves.

According to ISI-S, *distinguished authors* are those relevant authors who publish not only journal papers, but reviews, monographs, and books as well. They are editors or members of editorial boards, and they deliver invited and plenary lectures at international conferences on fields related to those of the publications to be assessed. The main goal of the *assessment process* performed by *distinguished authors* is to review and evaluate pieces of information disclosed that refer to a scientific topic, field, or discipline, and to *integrate* them into the relevant knowledge body. They play a decisive role in the evolution of science, *converting information into knowledge.*

The influence exerted by distinguished authors on scientific research and science must be much greater than that made by relevant authors. It may be stated further, that the impact of secondary information sources (e.g., reviews, monographs, and books) on the development of science is

significantly greater, on an average, than that of journal papers (see, e.g., the difference in the average numbers of citations obtained per item).

REFERENCING AS THE MAIN EVALUATION PROCESS TOWARD THE INCORPORATION AND INSTITUTIONALIZATION OF SCIENTIFIC INFORMATION

Considering the frequency and strength of scientific authors' motivations toward referencing, a model, the *Reference Threshold Model* (RTM), was established (Vinkler, 1998). Based on empirical data, it has been concluded that about 60–70 percent of total publications that might have exerted any impact (to any extent) on the publishing author, will be given in the reference list. It was found that the majority of references in scientific journal papers acknowledged the application of information in publications referred to. The motives for referencing may be divided into *professional* (i.e., scientific) and *connectional* (i.e., social) motivations. Connectional relevancy may refer, for example, to personal relations that may motivate the referencing attitude. Mean Normalized Reference Threshold values were found to be about *three times as high* for references made for connectional reasons as those made for professional goals. Therefore, it may be concluded that the referencing process is governed primarily by professional (i.e., scientific, information) factors, whereas nonprofessional reasons play a relatively negligible role. The main goal of referencing is *to provide readers with appropriate information* and *to document borderlines* between the results obtained by the researchers referenced and those of the authors referencing.

According to the central concept of ISI-S, evaluation of the information disclosed is performed by researchers working on the same field worldwide. The references in scientific publications may be regarded as manifested proofs of the impact of information. Atkinson (1984) suggests that the reference represents *"the smallest meaningful unit of bibliography"* (p. 109). Consequently, between the documents referencing and referenced, a *cognitive coupling* exists that is manifested by the bibliographic unit termed as reference.

REFERENCES, EVALUATIONS, AND INSTITUTIONALIZATION

According to ISI-S, publications not cited during longer time periods may be regarded as aged, nonrelevant, or of latent impact. Pendlebury (qtd. in Hamilton, 1991) found that the ratio of papers not referenced in a five-year period after publication strongly depends on discipline, and it ranges, for example, in chemistry, from 18.6 percent (in organic chemistry) to 78.0 percent (in applied chemistry). Bourke & Butler (1996) reported that 15.0 percent of the papers published in natural science journals in 1976–1980 were not cited at all between 1980–1988 and only 14.1 percent received more than twenty-five citations. The ratios mentioned (and not mentioned here) indicate that scientific research works with great redundancy and

produces a great number of publications with no or very low impact. Consequently, we must build blocks into ISI-S containing *information with latent impact* and *nonrelevant* and *aged* information at each stage of the process toward incorporation (Figure 1).

As is well known, reviews, monographs, and books contain more references than journal papers. The average citedness of these items exceeds that of papers. Bourke & Butler (1996) reported average data as follows: 64.3 (citations per book) and 13.7 (citations per paper).

A survey of journal papers of twenty eminent Hungarian chemists showed that *papers cited by both journal papers and books* obtained, on an average, 3.55 times more citations than those cited exclusively by journal papers. This example also points to the importance of books in the institutionalization process of information (see Table 1).

Most of the references *in journal papers* in natural sciences (Earle & Vickery, 1969: 82.0 percent; Singh & Arunachalam, 1991: 90.8 percent; Bourke & Butler, 1996: 62.9 percent) were found *to refer to journal papers.*

1,756 references (from Barton & Ollis, 1979; Sykes, 1994; and Brown & Grushka, 1998) were selected randomly. The ratios of references referring to journal papers, reviews, books, and reports or data banks were found: 90.47; 2.73; 6.39; and 0.41 percent, respectively.

From *Römpps Chemie-Lexikon* (1981) 606 references were selected randomly, of which 89.4 percent refer to books or monographs and only 10.6 percent to journal papers.

From the *Dictionary of the History of Science* (1981) 176 references were selected randomly and classified as journal papers and books. The former class represents only 7.95 percent, whilst the latter 92.05 percent.

Several university textbooks were reviewed. Most of the books contain *no direct references* to the respective publications but do give the "Relevant Literature" under which different numbers of references are listed. In the textbook *Organic Chemistry* (K. Lempert, Budapest, Mûszaki Könyvkiadó, 1976, in Hungarian), for example, 268 references are given, 34.3 percent of which refers to books and monographs and 65.7 percent to journal papers.

The above findings (and others not given here) indicate that the *institutionalization process of information proceeds* from journal papers through reviews, monographs, and books to professional and general lexicons. The rank of the publications mentioned is consistent with the lifetime of information.

Merton (1968, p. 462) writes on the *"institutionalization of evaluative judgements"* in science. In his view, evaluation systems play a very important role in any field of the society; for example, critics in art, supervisors in industry, coaches in sports, etc. The *referee system* of scientific journals involves the systematic use of judges to assess the acceptability of manuscripts submitted for publication. Garvey (1979) characterizes the role of the peer

review system as a *formal assessment* system that critically examines the papers against the standard set by the current state of knowledge in a discipline. Garvey (1979) writes about the process of institutionalization of scientific information in publications as follows: "Between the time an article is published and the time it is cited in another article a great deal of digesting, interpreting, and evaluating of its content takes place which serves to integrate the 'new' information in that article into the existing body of scientific information. This is all part of the continuous filtering and integrating which synthesizes scientific information into knowledge" (p. 93). Garvey & Griffith (1971) stress the importance of the evaluative steps in citing and reviewing published research and the synthesis in reviews and books as establishing the knowledge base of disciplines.

INFORMATION PROCESSES IN THE ISI-S MODEL
TOWARD INCORPORATION

The processes in ISI-S toward institutionalization are summarized in Figure 1. The goal of scientific research is to generate scientific information that might develop into knowledge. Publication is an essential and inevitable part of scientific research; therefore, only information published or to be published is tackled by the ISI-S. The evaluation processes of possible (future) publications begin with submitting for publication. The publications submitted may be refused or accepted by some (limited number of) peers or reviewers and editor(s). The procedure is *formal* and *organized* and takes a relatively *short time.* The names of the reviewers are generally not disclosed. One of the most important features of the peer assessment system of journals is that, after reviewing the papers submitted, the respective authors may have the opportunity to survey their paper once again and make corrections, taking into account the suggestions made by the peers. If a publication is refused (several times by different journals), most of its information will be lost or significantly modified (see Figure 1). The information in publications accepted is given an opportunity to exert impact.

The *second main evaluation process* proceeds through researchers (both relevant and distinguished authors) working on similar fields as the publishing authors. These experts may form an invisible college. According to the calculation of the present author, each paper on a standard scientific topic of average size may arouse interest in about 50–200 readers (potentially citers), on an average. *Referencing* (i.e., citation) represents an *unofficial, nonorganized informal* (i.e., private) assessment process made by a nonlimited number of evaluators during nonlimited time periods as a result of which the respective paper figures in or is omitted from reference lists.

The information published may be absorbed by the research environment and can be assessed as *relevant* or *nonrelevant* (see Figure 1). Relevant information, may or may not exert *impact.* The impact exerted may be

manifested or *latent* (Table 1). The manifested impact may be of *short term, long term,* or *very long term* (*basic* scientific knowledge) (Figure 1).

The ISI-S model assumes *constant dynamic assessment processes;* that is, *nonrelevant* information may become relevant and that of *latent* impact may be transformed to information of *manifested* influence at any time through *reassessing processes.* The manifestation of the reassessment is proven, according to ISI-S, by *making references in new publications. Constant dynamic assessment processes* also refer to information once found to be relevant. In the course of time, aging of information takes place, which may bring about modifications or complete neglect. The *reactivation* of information (nonrelevant, relevant, or no impact), however, may rarely occur.

The *sources and authors of the referencing documents* are clearly distinguished by ISI-S. References made by *distinguished authors* writing reviews, books, or monographs, not only journal papers, are regarded as proofs for long-term and significant influence. *Greater numbers of references and longer terms of influence may be accepted as proofs for higher grades of institutionalization* (i.e., incorporation).

The *third main evaluation process,* performed preferably (or exclusively) by distinguished authors, implies information of long-term impact (see Figure 1). The information passed through the filter of distinguished authors may become *part of the basic scientific knowledge of a thematic unit.*

According to ISI-S, the highest degree of the institutionalization process is represented by the transfer from basic into *common scientific knowledge.* One may assume basic scientific knowledge to be the origin of information arriving at this level, exclusively.

CONCLUDING REMARKS

The scientific information institutionalized is controlled and verified several times and is generally accepted. It exerts influence over relatively very long terms. The changes of whole paradigms (Kuhn, 1962) or essential modifications of the scientific knowledge of a field or discipline may bring about changes in the respective part of the common scientific knowledge. The amount and type of knowledge in the set of basic scientific knowledge to be introduced in the set of common knowledge may depend on the developmental stage of both knowledge sets and the requirements, possibilities, and goals of the society in the given time period.

Figure 1 and Table 2 may give only an approximate picture of the functioning of the complex organism of the information and knowledge systems of science and scientific research governed by the different evaluation processes. The results obtained by the ISI-S model described here strongly supports Garvey's (1979) view: "The contrast between the rapid growth of science (in terms of manpower and *quantity* of information) and the slow processing of scientific information into scientific knowledge becomes

apparent" (p. 20). According to ISI-S, both the relative and absolute development of science seems to be slower than that indicated by the increase of the number of publications.

The results obtained by the ISI-S model many contribute to a better understanding of the information processes in science. ISI-S may also contribute to substantiate decisions on subscribing to journals by a library taking into account the Garfield (impact) Factor data of the journals. It may serve as proofs to understanding the importance of references-citations in assessing research results and converting information into knowledge.

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