Last week's essay presented a biographical account of Shiyali Ramamrita Ranganathan, the father of Indian library science.[1] This week's essay will attempt to evaluate his contribution to library science, and discuss some parallels between his work and co-citation clustering. At the end of the essay, you'll find an appendix that describes his classification system, Colon Classification.

Any evaluation of Ranganathan's work must consider both his impact on Indian *and* on international library science. That Ranganathan made an enormous contribution to Indian library science is indisputable. An article by Mohinder Singh, Regional Research Laboratory, Bhuboneswar, Orissa, India, singles out the year 1925, when Ranganathan joined the library profession, as the advent of an important new era in Indian library science.[2] Before Ranganathan's time, he notes, libraries were simple book repositories, open access was unheard of, and the average librarian worked for little pay under poor conditions. No Indian university offered any library science certificate, diploma, or degree. It was Ranganathan who spearheaded the movement to professionalize librarianship and to expand the Indian library system. It was he who propelled Indian librarianship into the twentieth century.

Ranganathan's contribution to international library science, although significant, is more difficult to determine. Colon Classification, for example, is rarely used in libraries in the Western world.[3,4] Even in India, where Ranganathan's ideas have had tremendous impact, use of Colon Classification is not as widespread as might be expected.[3,5] In American library science schools, Colon Classification is usually covered only briefly. One study[6] found that of 48 schools accredited by the American Library Association (ALA), 73 percent (35 schools) include facet theory in their curricula (see appendix for an explanation of facet classification). But of these, only 20 percent (seven schools) cover it in any depth. And although 50 percent of the schools include Colon Classification in their curricula, only about eight percent (two schools) conduct any practice exercises in it. A related study[7] indicates that Dewey Decimal Classification is the dominant system in the US, being taught in all ALA-accredited schools. The Library of Congress system is a close second. Next comes the Universal Decimal Classification system, taught in just over half the schools. Colon Classification, in fourth place, is also taught in just over half the schools. Although, according to this study, the number of schools in which Colon Classification is covered seems to be increasing, coverage is cursory.

Ranganathan's international contribution is measured, however, not in the actual application of Colon Classification, but in its influence on classification and indexing theory. According to the *ALA World Encyclopedia of Library and Information Services*, Colon Classifica-

Figure 1: Portrait of S.R. Ranganathan included in the ISI* mural "Cathedral of Man."

System of Ordering commissioned by UNESCO and promoted by the International Federation for Documentation (FID) allows the combination of subject subdivisions according to faceted classification principles.[5]

A partial indicator of Ranganathan's international impact is the number of citations to his work in *Science Citation Index*＊ (*SCI*＊) and *Social Sciences Citation Index*＊ (*SSCI*＊). Over 400 publications cited his work over a 20-year period. *Prolegomena to Library Classification*,[12] his comprehensive work on classification theory, is his most-cited publication. But, for a number of reasons, these citations are only a fraction of what a thorough search would establish. Not-the least of these reasons is that our coverage of the field in the early days of *SCI* and *SSCI* was rather selective and limited. Still, when compared to other library notables, it is remarkable how often Ranganathan's work is cited. Indeed, when I began my recent talk at the Madras University library, I was moved to tell the audience that Ranganathan is to library science what Einstein is to physics. Considering the many honors Ranganathan received, examination of his citation record only confirms the widespread subjective impression of his impact. We acknowledged Ranganathan's contributions several years ago when we included his portrait in the mural at ISI＊ entitled "Cathedral of Man."[13] (See Figure 1.)

I was particularly pleased to honor Ranganathan's memory by giving the Ranganathan lectures. I've felt a special kinship with the man ever since I heard a fellow student lecture on Colon Classification at Columbia University, New York, in 1953. At a time when documentation was a dirty word, I had joined forces with several other radicals at Columbia to form the Documentation Club. Although none of the faculty attended, at one of our meetings a member of the club named Gupta gave a

tion, in spite of its infrequent use, has had a major impact on library classification, affecting all existing or newly revised schemes except the Library of Congress system.[5] One author even suggests that the Library of Congress system is showing an increasing use of synthesis, which is the combining of notation symbols to create a class number, as in faceted classification.[4] Also, over the past few decades, many specialized faceted classification schemes have been developed by the members of the Classification Research Group, London, England.[8,9] Similar developments based on faceted classification principles include the natural language subject heading system of the British Technology Index and Thesaurofacet. Preserved Context Index System (PRECIS), the indexing system devised by Derek W. Austin for use with the British National Bibliography, also owes much to Ranganathan's influence.[10,11] Of the few generalized classification schemes developed in recent years, the USSR's Bibliothecal-Bibliographic Classification scheme has a faceted component, while the Broad

beautiful description of Ranganathan's system.

Unfortunately, for very practical reasons, Ranganathan had to compromise in constructing his system. The limited topics he chose for his system's classification schedules were not enduring ones. For example, there was no way Ranganathan could anticipate that such broad subjects as biochemistry would not be adequate to cover the growth of molecular biology information.

Regardless of the shortcomings of his system, it must be emphasized that Ranganathan's work anticipated the need for an automatic self-generating system of classification, of which co-citation clustering based on citation indexing is one important example. Indeed, one might consider each citation as a "facet" of the document citing it, because each citation represents a subject addressed in the document. These facets may be considered linked by implicit colons. For example, a document could be described as: 78JBC456:77PNAS1234:51JBC234:12JICS456:49SCI567. At the next hierarchical level of description, one could substitute for each of these citation facets the research front number we assign to documents through co-citation clustering. Each of these numbers represents a class of core papers identified by co-citation clustering. No doubt one could even determine Ranganathan's fundamental categories of personality, matter, energy, space, or time for each cited document, and organize the research front numbers by his facet formula.

As an automatic classification system, co-citation clustering answers Ranganathan's objections to the inflexible enumerative systems by allowing prompt identification of new research topics. Being completely algorithmic, co-citation clustering automatically reflects new directions in research, without depending on the "eventual" recognition of change in scientific terminology.

I must admit, I'd always thought of Ranganathan in terms of book classification and not in terms of indexing journal literature. But the arbitrary distinction between indexing and classification is based only on the tradition that articles are indexed, but books are classified or cataloged. This separation by form is, however, alien to scientists. At ISI, we index both journals and articles as well as multiauthor books. We also index cited articles, books, patents, or whatever may be cited. Furthermore, Ranganathan's formulation of the term *depth classification* (the symbolic representation of minute units of information), his involvement in the FID, and his founding of the Documentation Research and Training Centre all reflect his active interest in the documentation of journal articles.

In addition to co-citation clustering, more automatic classification systems will undoubtedly follow as computers make it possible to immediately expand and modify a classification schedule to accommodate new books and papers added to a collection. That will be one of the prime advantages of the electronically stored library. It is this responsiveness of computerized systems that's made it possible for us to produce a new *Index to Research Fronts* for our *Index to Scientific Reviews*™ and other data bases each year.[14] In the future, we expect to make such an index available for any time period desired. In this way, I like to think that we at ISI have fulfilled some ideas that are implicit, if not articulated, in Ranganathan's work. And I'm happy to acknowledge the debt that all workers in classification and indexing owe this revolutionary thinker.

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Colon Classification

The Colon Classification system, like enumerative classification systems, divides the universe of knowledge into a number of main classes, such as agriculture, philosophy, and literature. Dewey Decimal Classification, for example, has ten main classes, labeled zero through nine. The Colon Classification system has 42 main classes, most labeled with one or two letters of the alphabet. A few are labeled with numbers or Greek letters. (See Table 1.) But Colon Classification, rather than simply dividing the.main classes into a series of subordinate classes, as most systems do, subdivides each main class by particular characteristics into facets. The facets, which are labeled in the Colon Classification system by Arabic numbers, are then combined to make subordinate classes as needed. For example, literature may be divided by the characteristic "language" into the facet of language, including English, German, and French. It may also be divided by "form" which yields the facet of form, including poetry, drama, and fiction.

Colon Classification contains both *basic subjects* and their facets, which contain *isolates.* A basic subject can stand alone, for example, "literature" in the subject "English literature." An isolate, in contrast, is a term that modifies a basic subject, such as the term "English." To create a class number, the basic subject is named first. The isolates follow ordered according to a *facet formula.* This formula states that every isolate in every facet is a manifestation of one of five fundamental categories: personality, matter, energy, space, and time. Personality is the distinguishing characteristic of a subject. Matter is the physical material of which a subject may be composed. Energy is any action that occurs with respect to the subject. Space is the geographic component or the location of a subject. And time is the period associated with a subject.

Thus, the basic subject "handicrafts" of the topic "19th-century woven wool Peruvian clothing handicrafts" would have the isolate from the personality facet, "clothing";

48

Table 1: The main classes of S.R. Ranganathan's Colon Classification system.

z	Generalia	HZ	Mining	O	Literature
1	Universe of Knowledge	I	Botany	P	Linguistics
2	Library Science	J	Agriculture	Q	Religion
3	Book Science	K	Zoology	R	Philosophy
4	Journalism	KZ	Animal Husbandry	S	Psychology
A	Natural Sciences	L	Medicine	Σ	Social Sciences
β	Mathematical Sciences	LZ	Pharmocognosy	T	Education
B	Mathematics	M	Useful Arts	U	Geography
Γ	Physical Sciences	Δ	Spiritual Experience and	V	History
C	Physics		Mysticism	W	Political Science
D	Engineering	μ	Humanities and Social	X	Economics
E	Chemistry		Sciences	Y	Sociology
F	Technology	ν	Humanities	YZ	Social Work
G	Biology	N	Fine Arts	Z	Law
H	Geology	NZ	Literature and Language		

from the matter facet, "wool"; from the energy facet, "woven"; from the space facet, "Peru"; and from the time facet, "19th century." Some topics have fewer than five fundamental categories. And some have more than one facet in a given fundamental category. Isolates are always arranged in order of decreasing concreteness, based on the fundamental categories. Personality is considered the most concrete and time the least concrete. The acronym PMEST helps the classifier remember the formula and its order.

To avoid confusion when combining several facet numbers, the classifier needs a device for stringing facets together. The *colon*, from which Colon Classification takes its name, was the first such device in the system. Later, Ranganathan introduced the comma, semicolon, period, inverted comma, and other punctuation marks. Each of these introduces a new fundamental category of facet, such as space or time.

How does a classifier go about synthesizing a class number? Suppose the book to be classified is entitled *The Management of Elementary Education in the United Kingdom in the 1950s.* For this topic, "education" is the basic subject facet. It is also one of the main classes and is indicated by a capital T. "Elementary" is the personality facet. It is indicated by the number 15. There is no matter facet for this topic. Therefore, a colon follows to introduce the energy facet "management," indicated by an eight. A period introduces the space facet, "United Kingdom," indicated by 56. The space facet is followed by an inverted comma, which always introduces time. In this case, the time facet is the 1950s, or N5. When we string together the letters, numbers, and punctuation marks, we obtain the class number T15:8.56'N5. This number will appear on the spine of the book.

Besides its greater flexibility in determining new subjects and subject numbers, Colon Classification improves on the enumerative systems in several other ways. One such improvement is the concept of *phases*. This allows the classifier to readily combine both main classes in a subject such as "mathematics for the biologist." Such a subject is considered "bi-phased" and Colon Classification supplies a specific notation to indicate this condition. However, single-class-number enumerative systems, which predominate in US libraries, tend to force the classifier to choose either "mathematics" or "biology" as the main subject.