

Current Comments®

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The Encyclopedic *ISI Atlas of Science* Launches Three New Sections: *Biochemistry, Immunology, and* *Animal & Plant Sciences*

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In 1988 ISI® is releasing three new sections of the *ISI Atlas of Science*®. These sections—*Biochemistry, Immunology, and Animal & Plant Sciences*—join the *Atlas's Pharmacology* section, which appeared last year. All these sections combine ISI's computer-aided citation analysis with the expert insights of leading scientists and researchers. This essay describes the process by which the surveys in the *Atlas* are generated. These surveys are designed to help readers keep abreast of current research activity, newly emerging areas, and the likely directions of future research. The library edition of the *Atlas* includes the yearly cumulation, containing all the surveys published during 1987 as well as a series of pertinent multidimensionally scaled cluster maps. The three new sections and the yearly cumulation represent the latest steps in the *Atlas's* continuing emergence as a comprehensive, encyclopedic guide to the scientific literature.

One year ago we announced and launched the new *ISI Atlas of Science*®,¹ which in its ultimate form will be a veritable encyclopedia of research activity. The first appearance of the *Atlas* in its new, revised format was the *Pharmacology* section. This was the first of the *Atlas's* 12 projected sections. As such, the *Pharmacology* section is the first of many steps in the building of a comprehensive work that will cover the whole of science, technology, and medicine. The *Atlas* constitutes a new and original form of scientific review. It offers a combination of computer-aided citation analysis and written surveys incorporating expert observations by leading scientists and researchers. We believe that this approach, combining objective citation data with the subjective insights of our authors, produces a uniquely comprehensive and usable addition to the review literature.

In 1988 the *Atlas* releases three new sections: *Biochemistry, Immunology, and Animal & Plant Sciences*. These sections, like the *Pharmacology* section, are designed to help readers keep abreast of the latest research activity, outstanding problems and questions, newly emerging areas, and likely

directions of future research. The surveys in the *Atlas* provide an invaluable source for researchers, educators, and students who wish to stay informed not only in their own fields but in related or adjacent areas as well.

Citation Analysis Produces a New Kind of Review

The *ISI Atlas of Science* represents a new form of review literature. One important distinction between the *Atlas* and other review series is the process by which the surveys in the *Atlas* are created. Whereas other review journals may depend on editorial policies that are generally subjective and usually nonsystematic, the *Atlas* derives from a highly systematic process. Rather than relying solely on the decisions of an editorial board to identify topics for coverage, we begin with ISI's unique cluster database and its algorithmically generated clusters of research fronts. These data provide us with a valuable starting point—an exceptionally objective means of approaching the science literature and pinpointing topics to be reviewed.

The process starts with co-citation analysis of ISI's vast database of articles and references from over 4,500 journals. Papers that are frequently cited together, or co-cited, may have key features in common, such as methods, theories, or results.

The first step is to identify what papers have been co-cited. This is done by a massive sorting of the citation indexes each year, which ranks the millions of cited items by frequency of citation. Once this is done we can determine which papers have been co-cited and at what strength.

To form clusters, we apply variable thresholds to pairs of cited documents. For this we use "citation strength," the proportion of their total citations that are co-citations.² Some pairs of papers are strongly linked, having been cited together many times. Most pairs, cited together only once, are weakly linked. At the lowest threshold of co-citation strength, virtually all published papers are linked together into one large cluster.

By gradually raising the threshold of co-citation coupling—that is, seeking a higher incidence of co-citation among papers—more manageable and meaningful clusters are brought into focus. Through a process of trial and error, we have set a somewhat arbitrary limit on the size of these clusters, confining them to a maximum of 60 co-cited "core" papers. It is these core papers, and the associated group of papers that collectively cite them during a given year, that make up ISI research-front clusters.

These clusters are reviewed by our staff editors, who identify the common subject matter or theme in the cluster's core and citing papers. Using a highly automated system, they provide each cluster with a name. These named clusters, developed entirely through numerical, computerized analysis of the scientific literature, form the basis for the *Atlas* structure each year.

Research-front analysis is a powerful tool with which to examine and give structure to the scientific literature. While not all clusters denote significant scientific progress, all represent some aspect of research activity. Furthermore, since they are created

by the citation behavior of scientists, clusters serve as what might be considered "opinion polls"—aggregated views about what papers are currently most important.

As mentioned in last year's essay on the *Pharmacology* section, examining the clusters allows us to highlight areas of activity and illuminate relationships between research fields that might otherwise be missed.¹ By looking at rapidly growing clusters or at changes in clusters from year to year, trends in research can be identified. For an additional discussion of ISI's activities in citation analysis research, see the recent essay by Henry Small, director, Corporate Research.³

Combining Cluster Data with Expert Insight

We use the clusters as the raw material for the *Atlas*. Clusters are first assigned into the 12 subject areas that will eventually be covered in the complete *Atlas*. The next step involves consultation with our advisory editors—panels of leading scientists in each of the *Atlas*'s main subject areas who assist us in organizing and compiling the various sections. We send pertinent cluster data to these advisory editors according to the editors' own defined interests.

Each outside editor is sent data on 3 to 20 clusters. For each cluster, we include the cluster name, a list of source (citing) documents, lists of frequently occurring source title words and source authors, and a list of "core" documents.

The editors nominate subject specialists qualified to write surveys for the *Atlas*. The editors also provide tentative titles for these surveys. The experts selected by the editors are then invited to become authors for the *Atlas*. With the cluster data as a guide, these authors write the research surveys for the various specialty areas.

Since we started publication of the *Pharmacology* section, we have learned a great deal about the process of creating critical reviews. Just how do these scientists use the cluster data in preparing their surveys? The clusters do provide the authors with a guide





	Atlas: Pharmacology. Experimental and clinical pharmacology, toxicology, carcinogenesis, mutagenesis, drug development, medicinal chemistry, pharmaceutical sciences.
	Atlas: Biochemistry. Biochemistry, molecular biology, microbiology, biophysics, molecular genetics, molecular physiology, other molecular-level biological subjects.
	Atlas: Immunology. Immunology, cell biology, cell-cell interactions, developmental biology, developmental genetics.
	Atlas: Animal & Plant Sciences. Agricultural and veterinary sciences, anatomy, physiology, plant science, aquatic biology, ecology, reproductive biology, endocrinology, entomology, environmental science, evolution, population genetics.

Figure 1: Subject areas covered in the four sections of the *ISI Atlas of Science*®.

to selecting key research to be included in their surveys. But we do not insist that they examine the subject areas solely in terms of the research-front data. Authors are free to make their own judgments and selections on which work to cite and discuss—and we have observed that they do so. We've noted that the "boundaries" of a subject area as delineated by a cluster do not always coincide exactly with the boundaries identified by the authors of the *Atlas* surveys. This is to be expected, as the cluster data reflect an averaging of the opinions of many scientists and do not necessarily reflect any one view.

Many authors of surveys in the *ISI Atlas of Science: Pharmacology* have told us how useful the cluster data are in helping them approach a subject area. As mentioned earlier, this represents one of the distinctive strengths of the *Atlas*—the combination of objective citation data with the subjective, expert insights of our authors.

The most recent issue of the *Pharmacology* section, incidentally, starts off with a survey covering "Chronobiology of melatonin," by Josephine Arendt, Department of Biochemistry, University of Surrey, UK.⁴ We recently devoted a two-part essay to chronobiology research.⁵

Three New Sections for 1988

In regard to the three new sections of the *Atlas*—*Immunology*, *Biochemistry*, and

Animal & Plant Sciences—the cluster data offer some interesting insights into these fields. Many of the largest clusters in our database, for instance, pertain to these areas—an indicator of the scope and intensity of activity in these disciplines. Our cluster data also provide an indication of the importance of methodology in these areas. We have remarked previously—for example, in our series on the top 1,000 papers in the *Science Citation Index*®, 1961-1982⁶—on the importance of methodology, technique, and instrumentation in driving scientific research.

The surveys in the *Biochemistry* section will address the methodological aspects of the field, as well as other aspects of research. The subjects covered include molecular biology, microbiology, biophysics, and other molecular-level biological subjects. Figure 1 is a chart showing the subject areas covered in the *Biochemistry* section as well as the other three sections of the *Atlas*. The surveys by the following authors are just a sampling of what the *Biochemistry* section will include: "In situ hybridization for viral gene detection," by J.K. McDougall; "Fibroblast growth factor," by D. Gospodarowicz; "Amyloid and Alzheimer's disease" by B.H. Anderton; "Biosynthesis of proteoglycans," by V.C. Hascall; "Protein kinase-C," by Y. Nishizuka; and "Use of flow-cytometric

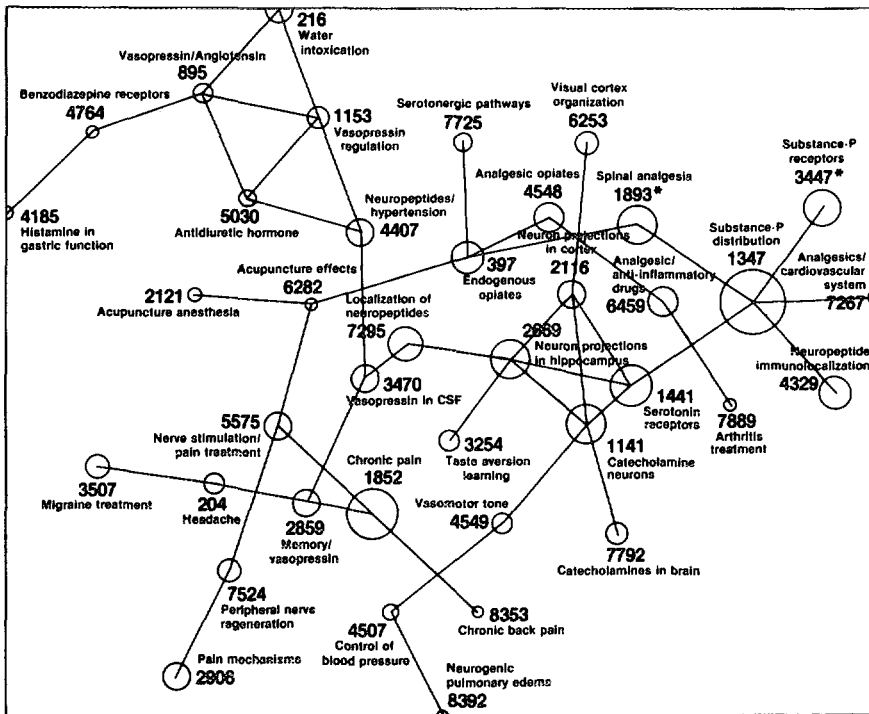


Figure 2: C2 cluster map of research fronts pertaining to neurophysiology. Asterisks (*) indicate clusters that are the subjects of reviews in the *ISI Atlas of Science®: Pharmacology (Volume 1)*.

DNA analysis in cancer programs," by B. Tribukait.

The *Immunology* section will cover cell biology, cell-cell interactions, developmental biology, and developmental genetics (again, see Figure 1 for a more complete list of subjects covered). Among the surveys in the *Immunology* section are "Drug development for AIDS," by S. Broder; "Interleukin in cancer immunotherapy," by P.D. Greenberg and S. Riddell; "Recombinant interferons," by S. Pestka; "Interferon and the common cold," by F.G. Hayden and S.J. Sperber; "Developmental regulation in dictyostelium," by W.F. Loomis; "Hepatitis-B vaccines," by A.J. Zuckerman; and "Cell kinetic studies of nervous system tumors," by T. Hoshino.

The *Animal & Plant Sciences* section will cover such subjects as agricultural and veterinary sciences, reproductive biology, entomology, environmental science, evolution, and population genetics. Surveys in this sec-

tion will include "Nitrogen uptake and plant growth," by A.J. Bloom; "Sterol metabolism in insects," by M.F. Feldlauer; "Cryopreservation of mammalian embryos," by D. Pomp; "Avian energetics and thermoregulation," by J. Williams; and "Effects of vertebrate predators on size and community structure of plankton," by P.J. Morin.

The *Atlas*—A Continuing Effort

As is the case with the *Pharmacology* section, these new sections of the *Atlas* will appear in four quarterly issues. This frequent publication schedule is another factor that distinguishes the *Atlas* from other review series, such as *Annual Reviews*. However, at the end of each year, a bound volume containing all the surveys published during the current year is issued. It also contains annual indexes and other reference materials. These hardbound volumes will serve as a

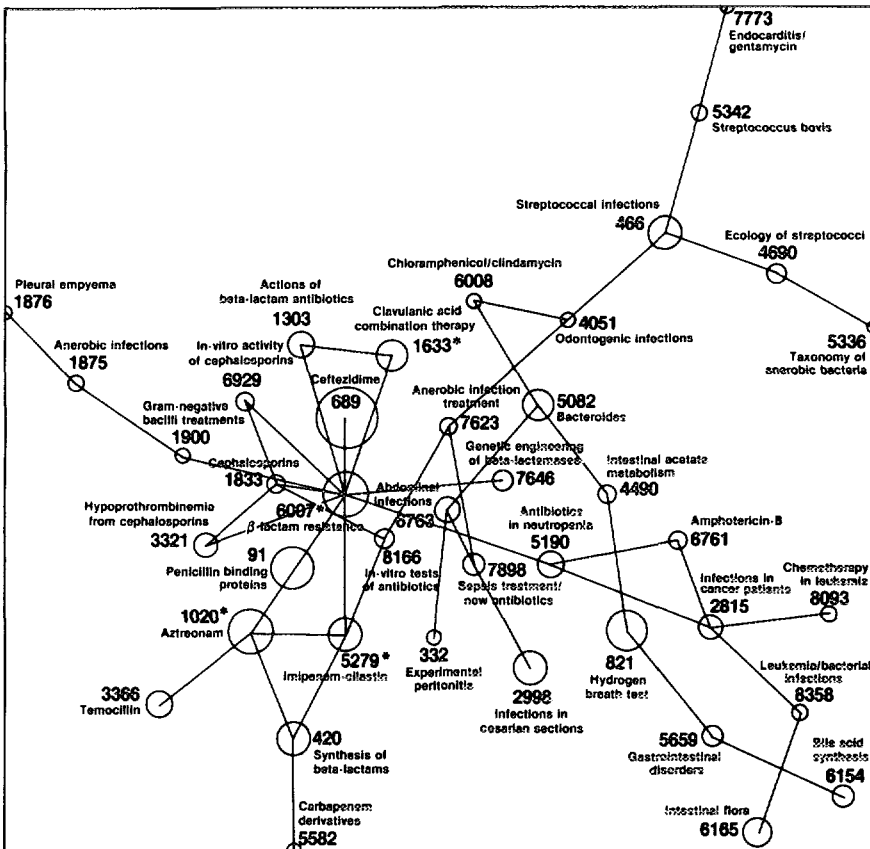


Figure 3: C2 cluster map of research fronts pertaining to antibiotics. Asterisks (*) indicate clusters that are the subjects of reviews in the *ISI Atlas of Science®: Pharmacology (Volume 1)*.

permanent, encyclopedic guide to research activity.

We will shortly be releasing the yearly cumulation for the *Pharmacology* section. In addition to the collected surveys published during 1987, the volume features a section on ISI's maps of science. These maps provide a visual representation of the structure and relationships of areas of scientific research. The section includes an explanation of how the maps are developed, as well as a discussion of the clustering procedures that allow us to examine scientific research activity at selected hierarchical levels.

The cumulation also includes a series of maps pertaining to the subject areas discussed in the *Pharmacology* section. These maps proceed from the higher, more general

level (C4)—representing larger groupings of subject areas in the physical, social, and life sciences—to the lower, more specific level (C2), representing clusters of individual research fronts. Two of the C2 maps from the *Pharmacology* cumulation are reproduced here: Figure 2 shows the citation links between research fronts pertaining to neurophysiology, while the map in Figure 3 shows the relationship between various research specialties in antibiotics.

As I've discussed, the *Atlas* offers a new kind of scientific review. The systematic selection process, combining citation analysis with the expert judgment of our editors, ensures comprehensive coverage of the most immediate, active research areas. The surveys themselves provide systematic, uni-

form coverage. And the *Atlas's* publication schedule provides timely review of the latest research areas.

With the *Pharmacology* section, and with the publication of the new *Immunology*, *Biochemistry*, and *Animal & Plant Sciences* sections, the *Atlas* now covers some of the largest and most active areas of science. But there is, of course, much more to cover. Subsequent sections of the *Atlas*, including

neurosciences, medicine, social sciences, chemistry, and physics and mathematics, will eventually encompass all areas of the scientific literature.

* * * * *

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