"Current Comments"

ISI's Atlas of Science May Help Students in Choice of Career in Science

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The sight of buffalo streaming across the frontier prairies of 19th century America inspired many a poet. It inspired also not long ago the metaphoric advertisement of Merrill Lynch's being bullish on America. If Americans are not as bullish on Wall Street as brokers would like them to be, they sure are bullish on graduate education. As Arnold Grobman points out in a *Science* editorial,[1] students are stampeding into graduate schools. Paradoxically, the recession has caused this partial prosperity in education. Increased enrollments have resulted from the large number of students who want an edge in the competition for jobs. Many students are taking extra degrees--in business administration, law, etc.

Rather than a stampede of cattle over the prairie, one might more realistically imagine a picture of cowboys and Indians running helter-skelter in overlapping circles. Students are saying, "I want to grow with a growing field!" But they don't know how to go about finding 'where the action is.'[2,3]

Most university professors are abysmally indifferent to vocational needs and opportunities, except perhaps in academe itself. The average professor just ain't interested. He's totally committed. Except in special cases of brilliant persons with very open minds and highly mobile talents, the student is unlikely to get useful vocational guidance from his professor. And by the time he or she has done a Ph.D., the die has been cast.

Henry Menard has confirmed that students get little vocational guidance from professors.[4] He talked with students in diverse arts and sciences departments on several campuses. And even if faculty occasionally do advise students, they rarely help place them in jobs. I think the student deserves such advice, and where possible, such help.

Menard suggests a method for selecting a field which could be used by graduate students seeking a career in science. What he's really saying is that there is a need for a service that will help one choose a promising specialty and determine its future potential. The service would be based on use of data obtained from citation analysis. Growth-decay data, together with immediacy data,[5] would be used. It's really not necessary for the student to use the method Menard suggests and research the business himself 'by hand'. *ISI's Journal Citation Reports*™ (*JCR*™) already provides these chronological data.

At ISI® we have been doing extensive work that goes even further. With support from the National Science Foundation, Dr. Henry Small is directing a research project entitled, "Mapping of Scientific Specialties." Using well-known clustering methods in combination with co-citation analysis,[6] we expect to create a map or an 'atlas' of science. Manipulating ISI's *Science Citation Index*® (*SCI*®) magnetic tapes, we are able to identify and graphically display science as it is at any given time.[7] More than a thousand main clusters have been extracted for the years 1970-1973. Using title-word information, we have named each cluster, that is, we have named each region on the map.

We have data on the age distribution of highly co-cited papers as well as information showing the movement of specialties over time. Once we have determined the milestone papers of a cluster, we can see whether the same pairs of papers continue to be cited or whether new highly-cited papers enter the picture. By examining the average age of the highly cited

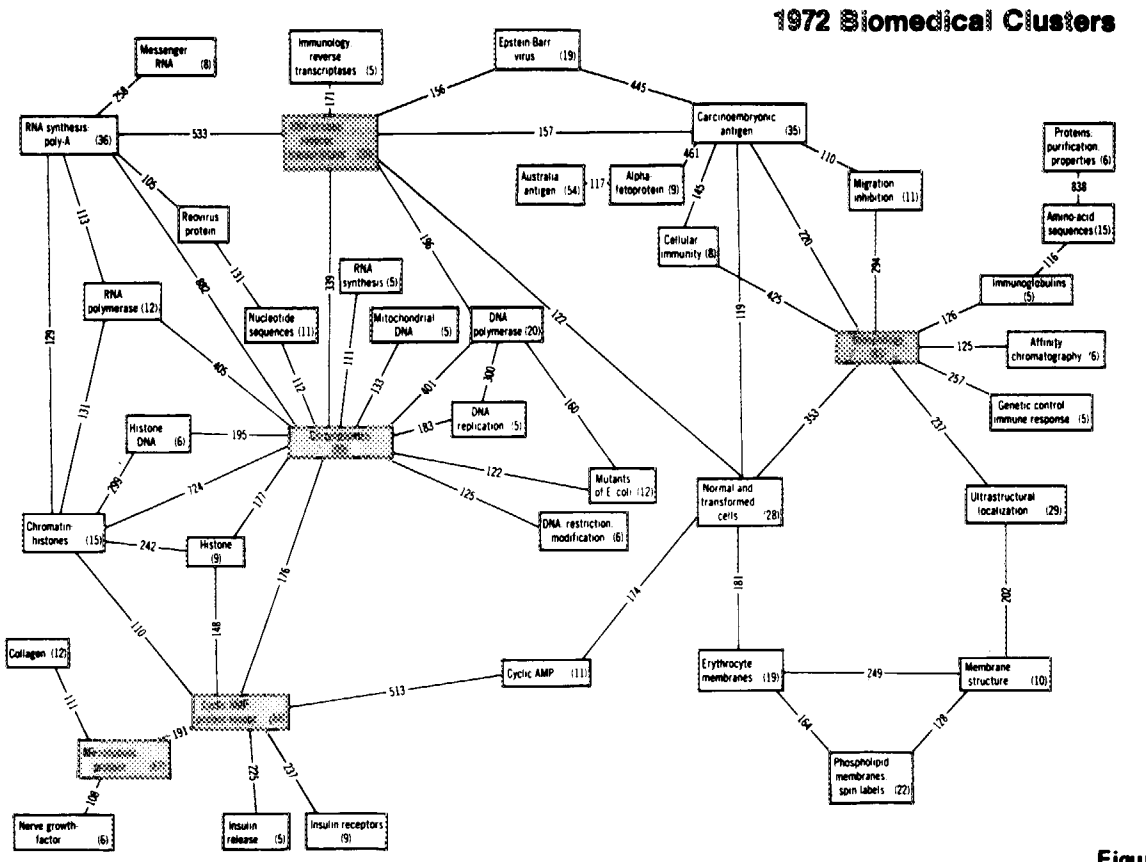
1972 Biomedical Clusters
Messenger RNA (8)
Immunology reverse transcriptases (5)
Epstein-Barr virus (19)
RNA synthesis-poly-A (36)
Carcinoembryonic antigen (35)
Proteins, purification properties (6)
Australia antigen (54)
Alpha-fetoprotein (9)
Migration inhibition (11)
Amino-acid sequences (15)
Reovirus protein
Cellular immunity (8)
RNA synthesis (5)
RNA polymerase (12)
Immunoglobulins (5)
Nucleotide sequences (11)
Mitochondrial DNA (5)
DNA polymerase (20)
Affinity chromatography (6)
Genetic control immune response (5)
DNA replication (5)
Histone DNA (6)
Mutants of E coli (12)
Normal and transformed cells (28)
Ultrastructural localization (29)
Chromatin-histones (15)
Histone (9)
DNA restriction modification (6)
Collagen (12)
Cyclic AMP (11)
Erythrocyte membranes (19)
Membrane structure (10)
Phospholipid membranes spin labels (22)
Nerve growth-factor (6)
Insulin release (5)
Insulin receptors (9)

Figure 1.

1973 Biomedical Clusters

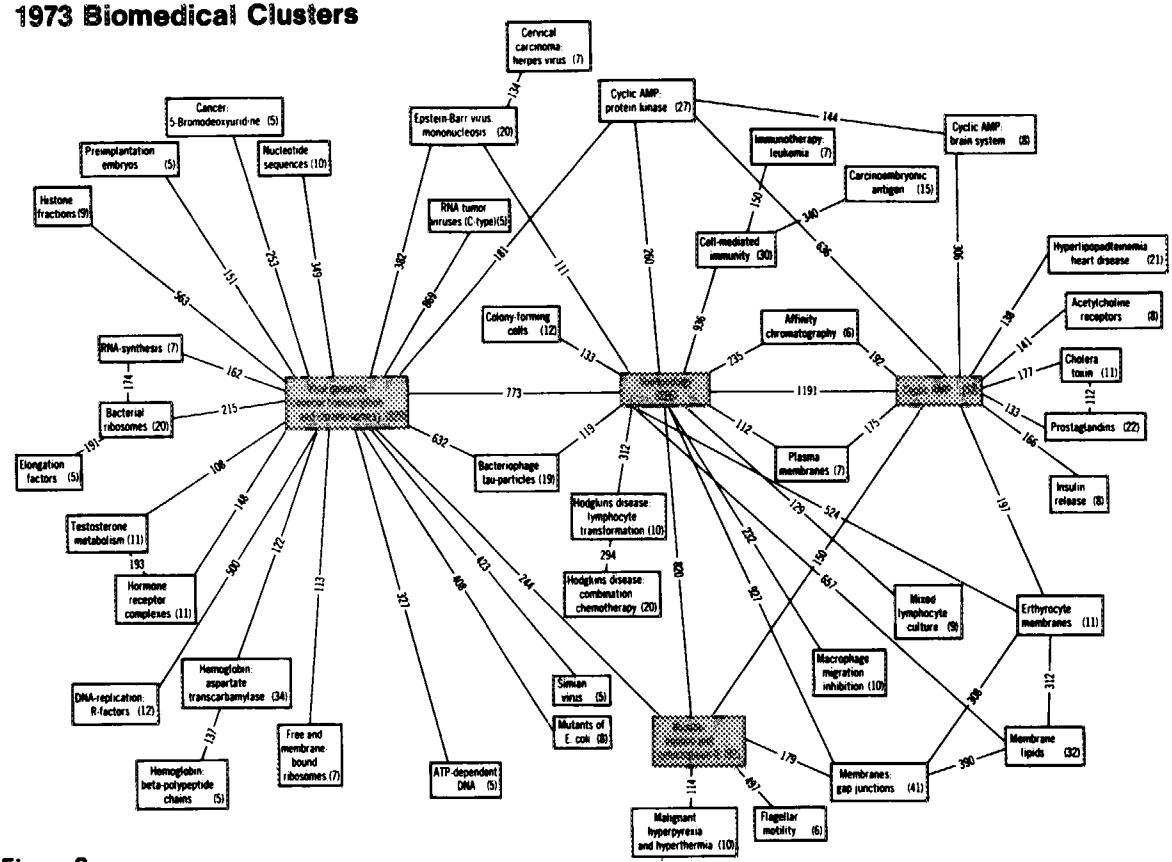

Figure 2.

papers which help reveal a cluster, it is possible to interpret the *rate of movement* of the specialty it represents. By interrelating the data for various specialties, we can create maps for each year which show not only the size of a particular specialty but also its proximity to other specialties. Thus in Figures 1 and 2,[8] one can see that the 'RNA viruses/reverse transcriptase' cluster and the 'chromosomes' cluster have largely coalesced into a subspecialty, while the 'immunology' cluster in Figure 1 has become a larger and more central cluster in Figure 2.

How would students use *ISI's Atlas of Science?* In some ways, the science counselor is like a travel agent. Here is a map of the world of science as it is today. Indeed, it seems to be mushrooming as compared with five years ago. Here is a place that is being explored by only a few people. It may provide an opportunity for an adventuresome person, even though the field is relatively stable. Menard cites the case of George Simpson, "a specialist in the very slowly growing subfield of vertebrate paleontology . . . [whose] countless honors in the forms of medals, prizes, and honorary degrees . . . show that the menace of the subfields can be overcome."[9] On the other hand, here are the areas where the grant funds seem to be going.

It is quite possible that our *Atlas* may oftentimes tell you the obvious. But how many times, for example, have you looked at a map of your own home state or country just to refresh your memory of the relationship between cities, towns, rivers, and roads. The new ISI *Atlas* may not tell you much if your town hasn't changed significantly in ten years or so, but even then it can be an exciting and informative experience to see an aerial photograph of your home town for the first time. Seeing the land below from a low-flying plane can provide insights never obtained in walking up and down the highways and by-ways.

Citation analysis will not solve the problems of inadequate support of basic research, or of inadequate direction in higher education. However, it will provide information to those who prefer to make career and research choices unrestricted by the understandably limited vision or imagination of a particular professor or institution. Citation analysis may in this way alter the future course of science, not by the puerile back-scratching of "You cite me and I'll cite you!", but rather by encouraging individual scientists to move in new directions where, at first, if they are only big fish in little ponds, they may become later big fish in big ponds. I suspect that the very small number of scholars who go on to achieve eminence will not need such assistance but it is also likely that they will be the first to recognize how to utilize and exploit fully the potential of citation analysis for this purpose.

1. **Grobman A B.** Students, careers and the recession. *Science* **187**(4176):495, 1975.
2. **Garfield E.** Where the action is, was, and will be--for first and secondary authors. *Current Contents®* (*CC®*) No. 11, 15 March 1972, p. 5-8.
3. ----------. Information, power, the *Science Citation Index. CC* No. 6, 9 February 1972, p. 5-6.
4. **Menard H W.** *Science: growth and change.* (Cambridge: Harvard University Press, 1971), p. 183-84.
5. **Garfield E.** Citation analysis as a tool in journal evaluation. *Science* **178**:471-79, 1972. Reprinted in: *CC* No. 6, 7 February 1973, p. 7-24.--The calculation and significance of a journal's *impact* and *immediacy* factors are explained in this basic article on citation analysis.
6. **Small H.** Co-citation in the scientific literature; a new measure of the relationship between two documents. *J. Amer. Soc. Inform. Sci.* **24**(4):265-69, 1973. Reprinted in: *CC* No. 7, 13 February 1974, p. 7-10.
7. **Small H & Griffith B C.** The structure of scientific literatures. I. Graphing specialties. *Science Studies* **4**: 17-40, 1974.
8. These figures are reproduced from: **Aaronson S.** The footnotes of science. *Mosaic* **6**(2):22-27, 1975. Reprinted in *CC* No. 22, 2 June 1975, p. 7-16.
9. **Menard**, p. 23.