

The Group Structures of Two Scientific Specialties:

A Comparative Study*

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Abstract

Using block modeling of data from a sociometric questionnaire, we analyze the patterns of social structure shown by authors of two highly cocited clusters of biological-science papers. Analysis of anecdotal data, background information, and data on citations support the findings from the block models. The density of contacts and the patterns of sociometric and citation data show that the authors of papers in the two cocitation clusters form distinct social groups. Each group has a center-periphery pattern with some differences that appear to reflect differences in the timing and spread of intellectual development within the groups.

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Scientific specialties are strategic research sites for studying the social and intellectual features of scientific change. Research on these changes was originally stimulated by the influential work of Kuhn (1962) and Price (1963), and many case studies have been published (Griffith and Mullins, 1972, summarize much of this research). Systematic comparative analyses are few, however (exceptions are Crane, 1972, and Mullins, 1973), largely because researchers have had no way to identify currently active specialty groups. Because they usually have high rates of in and out migration, include many individuals who consider their primary research interests to be outside the given specialty's research interests, and may dissolve while still quite young (Mullins, 1973), identifying specialties and discerning their boundaries and inter-
relations has been extremely difficult (Chubin, 1975, discusses various approaches to the task).

Small and Griffith (1974) have proposed that cocitation analysis is one possible way to identify specialties and discern their boundaries. Defining the strength of cocitation as the number of times two documents (either articles or books) are cited together in other documents, they argue that during a given time period, groups of documents with strong cocitation ties: (1) reflect the interests of publishing authors and (2) are probably critically important to work in existing specialties. By determining clusters of strongly cocited documents reported in the Science Citation Index (SCI), Small and Griffith attempted

to outline the structure of specialties in contemporary science.

Of course, formal equivalence between clusters of documents and active specialties does not necessarily exist. By examining patterns of word use in the titles of citing documents, Small and Griffith have shown only that the clusters are not merely random collections of disparate documents. The authors of the documents in the clusters have not necessarily been members of groups that show the social morphology of scientific specialties.

Sociologists of science have been skeptical of Small and Griffith's argument because no one has verified the relation between specialty-group membership and individual scientists' citation of documents (Mulkay, 1974). Indeed, Chubin (1975) suggests that cocitation analysis produces a scientific "specialty" that is only "the most visible slice of the literature--nothing more, nothing less." These objections, like Small and Griffith's argument, are a priori; they have not been evaluated empirically. In this paper we present sociometric data for two biomedical cocitation clusters and use block modeling (White et al., 1976) to assess the two positions.

DATA AND METHODS

We began our investigation with lists (provided by Small and Griffith) of highly cocited documents on two research topics: reverse transcriptase and Australia antigen. The documents on reverse transcriptase are associated with the discovery of an enzyme that can reverse the normal processes of information flow in cells. In 1970 two articles reported this discovery and a third replicated the findings. Additional

documents, with strong cocitation ties to these articles, formed a cluster that grew until 1973. In that year it merged with other clusters into a huge cluster of 329 documents associated with the general area of viral genetics. We chose for analysis 137 articles: the documents from 6 small clusters in 1971 that merged to form the 1972 cluster, and documents in the 1973 cluster that had been written by the authors of documents in the 1972 cluster.

The second cluster of papers shows strong cocitation ties with papers reporting the discovery of an antigen associated with type B viral hepatitis. Although these papers first appeared in 1966, intensive research exploiting the implications of the discovery was not reported until after 1969. Unlike the reverse transcriptase cluster, the Australia antigen cluster remained an independent cluster throughout 1970-1973. Therefore, we chose for analysis all documents included in the cluster in any of the four years--a total of 82.

For each cluster our next step was to list all first authors of documents, and any subsequent authors who appeared on more than one paper. Using this specification we obtained the names of 105 scientists for the reverse transcriptase cluster, and 65 scientists for the Australia antigen cluster.

For each scientist, we obtained sociometric data from two sources. The first was a questionnaire mailed to the individuals in each group asking them to report on nine types of sociometric ties with each of the other scientists on their list. The nine sociometric ties included three measures of awareness ("Have you ever heard of X?", "Do you follow the work of X?", "Do you know Y well?"), two indicators of teacher-student

relations ("Are you a teacher of X?", "Are you a student of X?") and four measures of collegueship ("Are you a colleague at the same institution with X?", "Have you ever been a co-worker with X?", "Are you presently a co-worker with X?", "Have you ever been a coauthor with X?"). We obtained completed questionnaires from 82% of the authors in the Australia antigen cluster, and 86% of the authors in the reverse transcriptase cluster. The questionnaires were mailed and collected during May-July 1975. The second source of sociometric data was the SCI. From it we obtained, for each year between 1967 and 1973, each author's citations of any document by all other authors in a given list.

Since we wanted to determine the extent to which social patterns among scientists reflect features of their intellectual products (see Griffith and Mullins, 1972), we searched for published reviews of the research reported in the papers and interviewed selected authors from each list of documents. This information was gathered between May 1975 and December 1975.

RESULTS

The Cognitive Developments

Both the published reviews and the interviews revealed that the documents in both clusters did, in fact, reflect important intellectual developments, and were not merely highly visible "slices" of scientific literature. The reviews and the interviews also showed important differences between the two areas. As we noted above, the original discovery of Australia antigen was reported in 1966. Immediately afterward, ambiguities about the source and nature of the antigen attracted the discoverers' attention. Indeed, for some time researchers believed

that a new mechanism of disease causation might be involved (Maugh, 1975, discusses developments in this research through 1975). Because of these difficulties, the development of a vaccine for hepatitis B occurred only recently (1975). Nevertheless, from 1966 on research was continuous (becoming more intense from 1969 on), and the original discoverers continued to do research on the topic.

Reverse transcriptase research has followed a different pattern (Culliton, 1971, reviews research up to 1971). In the middle 1960s, investigators had suggested the possibility that genetic information could be transferred from RNA to DNA, but convincing evidence of the transfer was not presented until 1970. This evidence was presented simultaneously by two groups working independently on somewhat different materials, and the investigators involved subsequently received Nobel Prizes for the research. After a flurry of activity devoted to specifying more precisely the exact mechanisms that transferred information from RNA to DNA, researchers have moved on to study related but somewhat different topics in oncology and viral genetics. Thus, unlike the research on Australia antigen, which has been fairly continuous since the middle 1960s, work on reverse transcriptase has declined since the early 1970s.

Clearly, then, the timing and structure of cocitations reflect actual differences in the cognitive development of the two research areas. We now consider whether the sociometric data indicate that the authors in each group have relationships that would be expected of either currently or recently existing scientific specialties. We focus on three separate but interrelated questions: To what extent do the

authors in each group show high levels of mutual awareness and relatively dense social contacts?; To what extent do the two groups of scientists exhibit social structures consistent with previous descriptions of social structure in scientific specialties?; And, to what extent do the two groups show patterns of growth and change consistent with our knowledge about their patterns of cognitive development?

Awareness and Social Contact

Since there are no previously established levels of awareness, teacher-student ties, and collegial ties that we can use as standards for deciding whether a given group of scientists is a scientific specialty, we compare our findings with those from previously published case studies. Table 1 shows the results for the three measures of

Table 1 about here

awareness. The figures are the proportions of the total possible links ($N^2 - N$) that respondents reported for each of the three measures. Thus the .745 for "ever heard of" among reverse transcriptase researchers shows that they formed nearly three-fourths of the 10,920 links possible among the 105 respondents from this group.¹ Brieger's (1976) results, from reanalysis of data on another biomedical specialty, are not strictly comparable to ours since, as indicated in the footnote to Table 1, he reported responses to a question about "unawareness" rather than "ever heard of"; also, he gave the proportion of "mutual contacts" rather than the proportion who knew each other well. Since "know well" very likely captures a higher level of awareness than is indexed by "mutual contact," the results show that levels of awareness in our two groups in our study are higher than the levels researchers studying

the neural control of food and water intake.

Crane (1972) described student-teacher and colleagueship ties in two specialties: One, in mathematics, concentrated on the theory of finite groups; the other, in rural sociology, concentrated on the diffusion of agricultural innovations. She computed "group connectivity scores" that took into account both direct ties between specialty members (e.g., the kind of ties reported in Table 1), and indirect ties for all numbers of steps (Crane, 1972:41-4 describes this technique). To obtain comparable figures for our two groups of scientists, we computed connectivity scores for four ties that are similar to hers. Table 2 shows three kinds of information for each tie: density of direct

Table 2 about here

contacts (as in Table 1) for our two groups, connectivity scores for our two groups, and connectivity scores reported by Crane for her two groups.

The first two ties, current collaboration and published collaboration, are measured in comparable fashions in our study and Crane's. In both cases the connectivity scores for our two groups of authors are substantially higher than those for Crane's two specialties. Indeed, in our two groups direct ties for these two relationships are as dense as all ties, both direct and indirect, in Crane's two specialties. In contrast, in our two groups the connectivity scores for "teacher of" are of sizes comparable to those shown for Crane's specialties. Thus, except for the mentorship relationship, the authors of our two clusters of papers exhibit denser patterns of contact than do the members of other scientific specialties that have been studied.

Social Structure

High levels of awareness, mentorship, and collegueship are evidence that our two groups of authors are members of scientific specialties. Further evidence is provided by the patterns of sociometric relations among these authors. Scientific specialties typically display a social structure that, for many social relationships, can be described as a "center-periphery" pattern (Brieger, 1976:128-129). The "center" is a subset of members who are recognized by others as being central to the specialty. These scientists are more productive than their peers, and among them are those who made the original discoveries which are the intellectual basis of research in the specialty. The central scientists usually have central locations in the specialty's pattern of information flow, and are important figures in its organizational as well as its intellectual development (Mullins, 1972, 1975; Crane, 1972:49-56). In contrast, peripheral members are less visible both to the core and to each other. They are usually linked to only one or a few members of the central group. In addition to central and peripheral members, some specialties include a group of "outsiders" who, although they have published research on the specialty's topic, show little awareness of core and peripheral members to whom, in turn, the outsiders are largely invisible. These scientists may show high levels of productivity and eminence in the larger discipline, but their primary research orientations are apparently outside the specialties studied (Brieger, 1975:131-2). To determine whether these general structural features were present among our groups of authors, we did a block model analysis of each group using the nine sociometric ties reported in the questionnaires. Block

model analysis (White et al., 1976) partitions the members of a population into mutually exclusive and exhaustive subsets (blocks). For each sociometric tie in the analysis, the members of each block have the same ties to members of other blocks.² Thus, for the ties in a given study, the members of a block are structurally equivalent (White et al., 1976:737-40).

We partitioned the two groups of authors by using a variation of the CONCOR hierarchical clustering algorithm (Brieger et al., 1975). In both instances a four-block partition provided a detailed picture of structure without excessive loss of statistical reliability from inadequate numbers of cases in the blocks. Figure 1 shows the successive

Figure 1 about here

partitions of the two groups. The roman numerals are labels for the blocks. *meaning?*

Table 3 shows the patterns for three levels of awareness, presented

Table 3 about here

as 4 x 4 matrices in which each matrix is a reduced form of the original, individual-level sociometric matrix. For example, for the Australia antigen (AA) authors we began with a 65 x 65 matrix showing ties for "ever heard of." We permuted the matrix to sort the authors into the four AA blocks shown in Figure 1. Thus, the 4 x 4 AA matrix for "ever heard of" (shown in Table 3) represents the structure of this type of awareness for the four blocks of structurally equivalent authors. The entries in the matrix are the densities of contact within and between the blocks. Specifically, the entry in cell i, j of this matrix is the number of times members of block i report that they have ever heard of

an author in block j , divided by the number of possible times such awareness could have been reported ($n_i \cdot n_j$ when $i=j$, $n_i^2 - n_i$ when $i \neq j$).

If a center-periphery structure exists among the blocks it will appear as strong ties within one or more core blocks, strong ties between a center block and its "follower" blocks (but not between these follower blocks themselves) and, perhaps, weak or nonexistent ties between some blocks and both center and follower blocks (outsider blocks). With proper arrangement of the blocks, this kind of structure would be reflected in high densities among the blocks at one of the two main-diagonal corners, with increasingly low densities becoming prominent as one moves toward the opposite, main-diagonal corner.

The results in Table 3 generally confirm the hypothesis that the two groups of authors conform to the center-periphery structure. The types of awareness shown in Table 3 range from the weak "ever heard of" to the strong "know well" and, as expected, the overall network densities fall off as one moves from the strong to the weak relationship. Within a given type of awareness, the densities decline fairly uniformly from the upper-left to the lower-right corner of the matrix. In all but three cases,³ the exceptions to the general pattern are small enough to be easily attributed to sampling variation and measurement unreliability. For each group block I is both most visible to the other blocks and more aware of the other blocks than they are of themselves. This pattern is repeated if we successively remove blocks I and II from consideration. Thus, the results show that in each specialty, the members of block I constitute the center of the group, and the members of blocks II through IV are increasingly peripheral. Unlike Brieger's

hunger and thirst specialty, however, there appears to be no outsider block in either of the two groups.

Table 4 shows the densities for five types of social contact. In

Table 4 about here

general, the results are consistent with those in Table 3. For example, in both RT and AA the members of block I are more likely to have taught members of other blocks than are members of any other block. The other four types of contact repeat the center-periphery pattern. Overall, these results are consistent with previous theories of mentorship and information-flow patterns in scientific specialties (Mullins, 1975). The major exceptions to the center-periphery pattern in Table 4 appear to explain some of the deviations from this pattern in Table 3 (see note 3). In particular, members of AA block III show a high degree of contact with each other, a finding that is consistent with the AA block III's high density of "know well" ties (Table 3). In contrast, AA block II shows surprisingly low densities of contact with block III and IV, and this finding may account for the fairly low densities of ties for "ever heard of" and "know well" between AA block II and AA blocks III and IV (Table 3).

Thus far our inferences about center and peripheral groups have been based solely on the sociometric patterns of awareness and contact. By themselves, the sociometric results do not necessarily prove that these two groups of authors exhibit the social structure of a scientific specialty. Therefore, we will now show that the blocks identified above as central blocks (I in AA and RT) do indeed consist of the highly productive and eminent scientists specified in our earlier

discussion of a scientific specialty's typical social structure.

Preliminary evidence is the fact that in each group, block I scientists wrote the original discovery papers. More complete evidence is presented in Table 5, which shows the block-specific means for six

Table 5 about here

variables that reflect status differentials among the blocks in each group. The results are consistent with the patterns of awareness and contact shown above. For example, RT's block I authors have had the most professional experience and exceed the members of the other blocks on all of the other performance measures. RT's blocks II through IV show no consistent ordering on professional experience but do show a consistent hierarchical ordering on the five performance measures. The AA authors show no clear pattern for professional experience and papers published, but they do show the expected hierarchy for the more recent performance measures (funding received, and 1970 and 1973 citations). Thus, for both groups data on status measures generally confirm the inferences drawn from the block-model analysis.

Patterns of Change

Thus far our analysis has been based on cross-sectional sociometric data. The data are fully consistent with the hypothesis that the two groups of authors of highly cocited documents constitute scientific specialties. Now we analyze longitudinal data on patterns of citations to all documents, including the highly cocited papers, among the authors of each cluster. In this analysis we emphasize the fit between changes over time in patterns of citations and what we know about the cognitive development of the two specialties.

Table 6 shows citation patterns for both groups for four periods

Table 6 about here

during 1967-1973. These four periods were determined by examining the density levels and patterns for all of the years and then combining consecutive years that showed strong similarity. Two results for AA in Table 6 are especially noteworthy. First, there are substantial changes in overall density. Beginning with fairly low densities during 1967 and 1968, there are substantial increases in 1969 and 1970. The high densities in 1970 are maintained until 1973, when they begin dropping off. Second, there are changes in the pattern of citations over the period, and these changes occur precisely when the density changes. During the earliest period block I is cited slightly more than any other block, but all blocks show intrablock citation densities higher than any of the interblock densities. This pattern begins to change in 1969, when a center-periphery pattern begins to emerge and is quite strong during the 1970-1972 period. In 1973, the pattern begins to weaken.

These two changes conform fairly closely to the intellectual development of the specialty as discussed earlier. Intensive research in the area did not develop until the late 60's and early 70's. When it did develop, the group of authors who had made the original discoveries in 1966 constituted a clearly bounded central group. This group maintains its position after 1972, but as work in the area became less intense, citation densities among the entire group of authors declined.

Similar results are shown for RT authors. The citation densities are at relatively low levels from 1967-1969, and then increase to a peak in 1971, the year following the publication of the discovery papers.

Then a decline in the citation densities occurs in 1972-1973. Once again, the earliest period shows a pattern wherein block I receives more citations than the other blocks, but intrablock citation densities are generally higher than interblock densities. This pattern gives way to a center-periphery pattern as citation densities increase, but tends to emerge again when the densities decline (1972-1973). The chief difference between the citation results shown for the two groups of authors is the more sustained period during which high citation densities and the center-periphery pattern are maintained in Australia antigen.

In general, the longitudinal results for the two groups of authors correspond fairly closely to the cognitive development of each area as discussed earlier. Both groups show the same general changes in citation densities and patterns, and these changes occur at the expected points in time. Furthermore, the chief difference between the two groups is consistent with the fact that research on reverse transcriptase itself occurred during a shorter period of time than research on Australia antigen.

It should be noted that the decline in citation densities and the weakening of the center-periphery pattern shown in the most recent periods for both groups cannot be attributed to a decline in the scientific activity of their members. Table 7 shows that scientists

Table 7 about here

in our study have continued to publish at the rates they did during the peak years in the early 1970s. Furthermore, although the members of each group cite each other less than during the peak years, they have received increasing numbers of references from the scientific community

as a whole. These results suggest that with the passage of time the scientists in each group have turned their attentions to other research topics, and this kind of shift among the central figures in a scientific specialty has been suggested as the modal pattern of (specialty decline) (Mullins, 1975; Mulkay, 1975). In summary, the results shown by the longitudinal citation data for the two groups of authors provide further corroboration for the conclusion that they do in fact constitute scientific specialties.

CONCLUSIONS

In this paper we have examined various features of the social structure exhibited by the authors of two clusters of highly cocited papers. We have found that both groups are dense social networks and that they show patterns of social ties which are consistent with previous accounts of the social structure of scientific specialties. In addition, changes over time in the citation flows among the authors in each group are consistent with our knowledge of the cognitive development of the two research areas. Finally, differences between the two groups, such as the different times of peak activity and the difference in citation densities during these periods, are also consistent with our knowledge about the cognitive development of the two areas.

On the basis of these results we conclude that the highly cocited papers were produced by scientists who were, when the papers were written, members of scientific specialties. Thus, we believe that the use of cocitation analysis to identify scientific specialties provides a promising tool for the comparative analysis of specialty growth and

development. Two directions of inquiry seem promising. First, more detailed analyses of the social structures of groups such as those studied here should be carried out. The consistency in the relationships among blocks across different types of social contact suggests the existence of coherent role relationships, and the algebra of these relationships (Boorman and White, 1976) needs explication. Second, it is clear that the kinds of specialties identified by cocitation analysis are not necessarily equivalent to some of the entities discussed in previous work on scientific specialties. The two groups examined in this paper, for example, fit neither the model of the "revolutionary specialty" (Griffith and Mullins, 1972) or the model of the "institutionalized specialty" (Mullins, 1974). Instead, they bear a strong resemblance to the kind of entity discussed by Mulkay (1975). Further investigation of the differences among these types of specialties and, more important, the processes by which one type is transformed into another, is clearly in order. The study of groups identified by cocitation analysis is a promising avenue for such work.

Footnotes

¹We have included in the analysis those who did not return questionnaires because they were recipients of "choices" from those who did return questionnaires. Since the nonrespondents obviously reported no ties with the respondents, our results underestimate the true densities of ties for our groups. Nevertheless (see below), our densities exceed those reported in previous studies, even data that also exclude nonrespondents (Brieger, 1976).

²For Australia antigen, block III shows unexpectedly high intra-block awareness for "ever heard of" and "know well." Block II shows relatively low densities of awareness of blocks III and IV for these two relationships. For reverse transcriptase, the authors in block II show low densities of awareness of blocks III and IV for "ever heard of."

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Table 1. Overall Network Densities for Three Measures of Awareness,
by Specialty Area

Level of Awareness	<u>Specialty Area</u>		
	<u>Reverse Transcriptase</u>	<u>Australia Antigen</u>	<u>Neural Control* of Food and Water Intake</u>
1. "Ever heard of"	.74	.84	.47**
2. "Follow the work of"	.40	.35	--
3. "Know well"	.15	.16	--
4. "Mutual contact"	--	--	.07
N	105	65	107

proportion of total possible links

N²-N

* Source: Brieger (1976:119-122).

** This figure is the complement of that reported by Brieger for the proportion of "unaware" responses.

Table 2. Overall Network Densities and Connectivity Scores for Mentorship and Colleagueship Ties, by Specialty

	Connectivity Scores					
	Direct Ties					
	RT	AA	RT	AA	Theory ^a Of Finite Groups	Diffusion ^b of Agri- cultural Innovations
Current Collaboration	.014	.018	.046	.125	----	.010
Published Collaboration	.031	.043	.452	.394	.030	.022
Thesis Directors	----	----	----	----	.010	.028
Teacher Of	.006	.006	.019	.022	----	----
N	105	65	105	65	102 ^a	221 ^b

Note: RT = reverse transcriptase; AA = Australia antigen

^a Source: Crane (1972, 147-9).

^b Source: Crane (1972, 146-7).

Table 3. Four-Block Densities of Three Types of Awareness, for
Authors of Two Co-citation Clusters

Reverse Transcriptase				Australia Antigen			
				"Ever Heard Of"			
I	II	III	IV	I	II	III	IV
I .98	.91	.72	.62	I .99	.85	.86	.53
II .92	.78	.58	.36	II .96	.88	.66	.66
III .92	.78	.69	.57	III .91	.77	.83	.67
IV .83	.59	.47	.45	IV .89	.81	.73	.70
				"Follow Work"			
I	II	III	IV	I	II	III	IV
I .72	.53	.38	.26	I .51	.67	.58	.34
II .72	.55	.40	.23	II .40	.30	.21	.18
III .44	.30	.20	.11	III .36	.19	.19	.10
IV .42	.26	.17	.13	IV .27	.24	.13	.12
				"Know Well"			
I	II	III	IV	I	II	III	IV
I .52	.21	.11	.08	I .56	.26	.15	.08
II .22	.12	.12	.07	II .20	.09	.02	.04
III .11	.07	.04	.02	III .10	.04	.18	.01
IV .12	.03	.04	.04	IV .08	.08	.02	.02

Table 4. Four-Block Densities for Five Types of Contact

RT Authors					AA Authors				
Teacher of									
I	II	III	IV		I	II	III	IV	
I	.02	.01	.02	.01	I	.02	.01	.02	.01
II	.01	.00	.00	.00	II	.00	.00	.00	.00
III	.00	.00	.00	.00	III	.00	.00	.01	.00
IV	.00	.00	.00	.00	IV	.00	.00	.00	.00
Colleague at Same Institution									
I	II	III	IV		I	II	III	IV	
I	.08	.04	.03	.04	I	.05	.02	.08	.01
II	.03	.04	.01	.01	II	.00	.01	.00	.00
III	.01	.01	.01	.01	III	.09	.01	.17	.01
IV	.05	.01	.01	.03	IV	.00	.01	.00	.00
Ever a Co-worker									
I	II	III	IV		I	II	III	IV	
I	.07	.03	.03	.03	I	.12	.05	.07	.03
II	.04	.02	.02	.01	II	.02	.01	.00	.00
III	.02	.01	.01	.01	III	.04	.00	.10	.00
IV	.02	.01	.01	.02	IV	.01	.02	.01	.00

Table 4. continued

BT Authors					AA Authors				
					Co-worker Now				
	I	II	III	IV		I	II	III	IV
I	.03	.02	.01	.01	I	.07	.02	.04	.01
II	.03	.02	.01	.01	II	.01	.01	.00	.00
III	.00	.00	.00	.00	III	.02	.00	.03	.00
IV	.01	.00	.01	.00	IV	.01	.00	.00	.00
					Coauthor				
	I	II	III	IV		I	II	III	IV
I	.08	.04	.02	.03	I	.14	.05	.09	.02
II	.06	.04	.02	.01	II	.04	.04	.00	.01
III	.02	.01	.02	.01	III	.05	.00	.04	.01
IV	.03	.01	.02	.01	IV	.00	.02	.00	.00

Table 5. Block Specific Means for Status Measures

Block	Mean year of Ph.D.	Reverse Transcriptase				
		Research Funding ^a	Papers Published ^b	Citations Received		
				1967	1970	1973
I	58.1	633.2	56.0	49.2	66.2	87.9
II	63.6	158.5	26.0	12.3	25.8	60.2
III	61.5	84.0	25.6	14.5	21.8	39.8
IV	65.0	19.1	17.1	7.7	16.0	39.0

Block	Mean year of Ph.D.	Australia Antigen				
		Research Funding ^a	Papers Published ^b	Citations Received		
				1967	1970	1973
I	58.9	437.2	47.0	22.7	52.4	76.0
II	50.3	46.8	49.2	22.9	44.2	67.0
III	52.5	34.3	27.2	9.9	23.5	42.1
IV	58.6	5.8	31.4	14.3	19.9	31.9

^a Research grants and contracts for 1974 and 1975, in \$1000's.
Source: Smithsonian Scientific Information Exchange

^b Total papers published, 1967-73. Source: Science Citation Index.

Table 6. Citations Patterns Within Groups Documents, 1967-1973

<u>RT Citations</u>					<u>AA Citations</u>				
1967-69					1967-68				
I	II	III	IV		I	II	III	IV	
I	.04	.01	.00	.00	I	.03	.00	.01	.00
II	.01	.02	.00	.00	II	.01	.02	.00	.00
III	.01	.00	.01	.00	III	.02	.00	.03	.00
IV	.01	.00	.00	.01	IV	.00	.00	.00	.03
Density = .011					Density = .011				
1970					1969				
I	II	III	IV		I	II	III	IV	
I	.12	.03	.02	.02	I	.13	.05	.09	.01
II	.04	.02	.01	.01	II	.06	.05	.03	.01
III	.03	.01	.02	.01	III	.02	.01	.04	.00
IV	.01	.00	.00	.01	IV	.00	.00	.00	.02
Density = .030					Density = .042				
1971					1970-72				
I	II	III	IV		I	II	III	IV	
I	.17	.08	.05	.05	I	.26	.14	.11	.03
II	.10	.08	.05	.02	II	.14	.13	.05	.04
III	.05	.02	.03	.00	III	.05	.02	.06	.01
IV	.02	.01	.00	.01	IV	.08	.07	.04	.05
Density = .036					Density = .100				

Table 6. continued

<u>RT Citations</u>					<u>AA Citations</u>				
1972-73					1973				
I	II	III	IV		I	II	III	IV	
I	.09	.04	.02	.02	I	.19	.09	.06	.02
II	.04	.06	.02	.01	II	.07	.07	.02	.02
III	.02	.02	.02	.00	III	.04	.01	.04	.00
IV	.00	.00	.00	.01	IV	.01	.01	.00	.02
Density = .028					Density = .056				

Table 7. Rates of Paper Production by and Citation to Groups
Per Year

	<u>RT</u>		<u>AA</u>	
	<u>Citations</u>	<u>Total Papers</u>	<u>Citations</u>	<u>Total Papers</u>
1967	2580	1066	1207	471
1968	3088	1208	1297	532
1969	3166	1467	1671	696
1970	3881	1385	2478	738
1971	4672	1582	3035	902
1972	5308	1643	3557	1033
1973	6310	1889	3818	1092

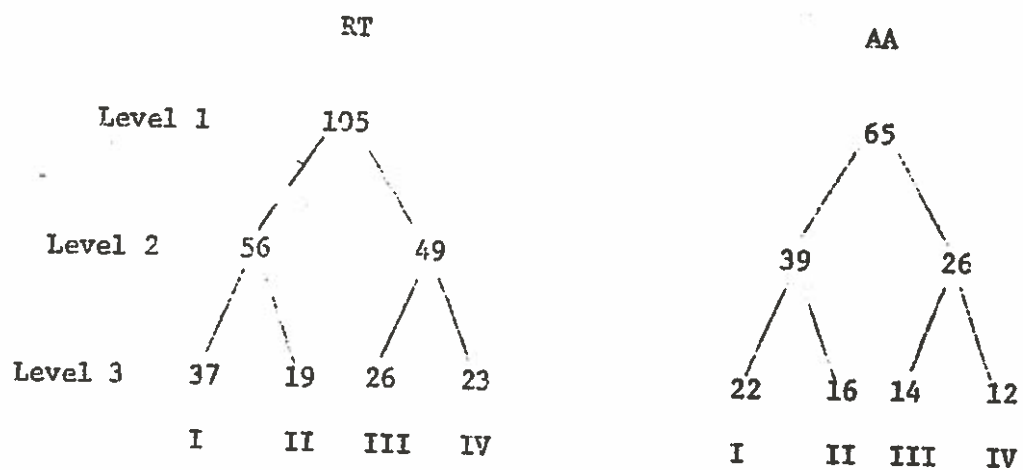


Figure 1. Successive Partitions of AA and RT Groups