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STUDIES IN SCIENTIFIC COLLABORATION PART III. PROFESSIONALIZATION AND THE NATURAL HISTORY OF MODERN SCIENTIFIC CO-AUTHORSHIP

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A review of selected parameters of the growth of scientific collaboration over the last century provides further confirmation of the dependency of teamwork on the increasing professionalization of science. Analysis reveals significant inaccuracies in current views of the recency and prevalence of collaborative research, and affords a more correct picture of twentieth century developments. A change in the growth rate of the practice of scientific collaboration at about the time of World War I, and indications of associations of teamwork with financial support and research publication in leading journals are discussed. Characteristics of the natural history of scientific collaboration signify that collaboration reflects relationships of dependency within a hierarchically stratified professional community, and serves as a means of professional mobility. As such, it continues to fulfil its original functions.

Introduction

In previous articles we have shown that both theoretically and historically scientific co-authorship is best and most comprehensively viewed as a reaction to the process of professionalization.[1] In this essay we extend that treatment to the present, by reviewing the natural history of scientific collaboration over the past century.

What follows constitutes the first integrated account of the recent past of scientific co-authorship, and should help to correct several misconceptions currently in vogue. In particular, it demonstrates that reports of co-authorship's prevalence are exaggerated, and derive from an erroneous statistical methodology untutored by sociological or historical acuity. In addition, the universal misperception that co-authorship is a twentieth century phenomenon is shown to derive from a change in its rate of growth, coincident with increased financial support of science. This, together with other data indicating the sensitivity of co-authorship's practice to financial support, further exemplifies the theory regarding it as a response to professionalization, and emphasizes the nature of co-authorship as an acknowledgement of dependency, financial or intellectual, within a hierarchical social system of science.

The later 19th century

The spread of professionalization to both England and Germany during the latter decades of the nineteenth century presents yet another case in which collaboration is directly related to the development of professionalization.

While the scientific communities of England and especially Germany grew more professionalized, that of France declined. Compared with its status during beginning decades of the nineteenth century the French scientific elite had lost considerable professional autonomy. BEN-DAVID attributes this decline in professional status to the elite's dependence on "the vicissitudes of politics" and the establishment's "organizational rigidity." According to BEN-DAVID, both of these factors derived from an overly centralized bureaucratic organization. Far more than in other countries, the leaders of French science were dependent on "passing political constellations"[2] and consequently occupied unstable positions as the ultimate sources of recognition and support. CROSLAND, who disagrees with BEN-DAVID's analysis but shares his conclusion about the decline of French science, places the blame on the neglect of the primary and secondary educational systems because of overattention to the universities and other institutions of more immediate effect. Although they produced a second generation of highly productive scientists, the French elite neglected to provide the inputs for succeeding generations. Consequently, French science gave up its lead to the scientific communities of Germany and England. Analysis of the snowball sample supports CROSLAND's argument. Included in the second generation of collaborators were young scientists, like Liebig, who used their training in France to great advantage in their own countries where they were a first generation of professional scientists.[3]

Data from the snowball sample indicate that the French share of collaborative research decreases over time as the English and German shares increase (see Table 1).

By the end of the nineteenth century, Germany had become the world's scientific leader, and the professionalization of science had proceeded quite far in England. Overall statistics for this period again show that by that time too, collaborative activity was more evenly divided among the major research producing countries (see Table 2). Germany had disproportionately increased its share of teamwork with respect to its share of research. Simultaneously the French share declined.

Table 1
Cumulative percentage of collaborative papers produced by the sample group, by nationality of authors, by time

Period	Nationality					
	French	German	English	Swedish	Other	Total
1800–09	87	2	–	6	5	100
1800–19	81	6	2	8	3	100
1800–29	75	12	4	5	6	102*
1800–39	70	16	8	3	3	100
1800–49	70	15	10	3	2	100
1800–59	69	14	9	3	5	100
1800–63	68	14	10	3	5	100

*Figures add to more than 100% because of rounding upwards.

Table 2
National origins of collaboration: 1884–1900

Country	Percent share of all scientific papers	Percent share of collaborative scientific papers
Germany	33	39
France	24	18
Great Britain & U.S.A.	30	30

Data from 2% count of volumes XIII–XIX, Royal Society Catalogue of Scientific Papers. Nationality determined by language of original paper.

These are significant variations and are precisely what might be expected from a consideration of the state of their respective professional scientific establishments. Their share of the collaborative literature corresponds exactly to their relative states of professionalization.

Collaboration and the professionalization of science: tne 20th century

Analysis of twentieth century collaboration lends further support to our hypothesis that collaboration is a reponse to effects of the professionalization of science. Indeed, it is during the twentieth century that the professionalization of science has had its greatest impact on the members of the scientific community. Within the last six or seven decades, science has become richer, more specialized, larger,

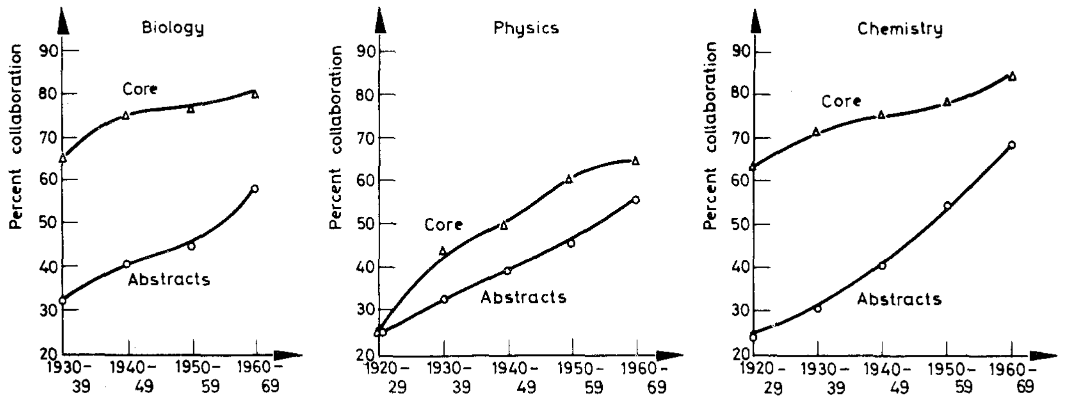

Fig. 1. Incidence of collaboration by decade for three sciences. Curves: – △ – incidence in "core" journals; – ○ – incidence in abstracting journals. Data for physics and chemistry "core" from H. *Zuckermann*, Nobel Laureates in the United States . . . , p. 94.
"Core" journals: Biology – American Journal of Physiology, Journal of Bacteriology; Physics – Physical Review, Journal of Chemical Physics; Chemistry – Journal of the American Chemical Society, Analytical Chemistry

more productive, more popular, more visible, and more influential than at any time during its past. It has also become more collaborative.

In her investigations of formal and informal collaboration, Diana CRANE found that formal collaboration in the twentieth century, as in the nineteenth century, increased visibility within the profession. In a similar vein, the Coles found that diffusion of the work of a co-author of low status occurs more rapidly when coupled with the name of a higher status scientist, "Authors of little or no scientific repute benefit from having high repute collaborators."[4] CRANE suggests that this increased visibility leads in turn to informal collaboration and hence, we must conclude, to increased access to information. As a result, collaboration enhances productivity, which correspondingly results in increased recognition (authority).[5]

If this is so, then we should find that collaborative publications of the twentieth century, like collaborations of the nineteenth century, are more visible than single-authored publications. Because the most visible articles are those appearing in the most eminent and prestigious "core" journals of science, collaboration should be disproportionately represented in those journals. That is, such journals should exhibit a greater frequency of collaborative articles than does the field of which they are the prime representatives.

Fig. 1 depicts, by decade, the frequency of collaborative articles for selected American core journals in biology, chemistry, and physics, and the associated abs-

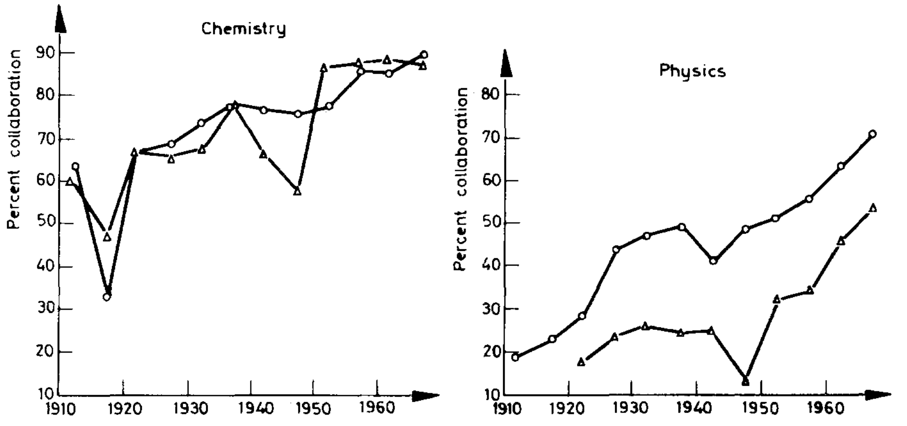

Fig. 2. Incidence of collaboration in European "core" journals in chemistry and physics. "Core" journals: Chemistry – ○ – Journal of the Chemical Society, – △ – Chemische Berichte; Physics – ○ – Proceedings of the Royal Society, A., – △ – Zeitschrift für Physik

tracting journals for these fields. The abstracting journals are used here because they should be the most representative index of research work in a given scientific area. As Fig. 1 shows, the most prestigious journals in a given scientific area contain a disproportionate number of collaborative papers relative to the abstracting journal associated with the area.

In addition to scientific papers, abstracting journals also contain books, texts, monographs, and patents. On the average, these tend to be less collaborative than papers.[6] One might argue that this would affect the statistics in Fig. 1 because the abstracting journals would naturally contain a lower percentage of collaborative work than the journals which contain only papers. However, such an objection does not hold: the number of papers in abstracting journals so outnumber the nonpaper works, that the latter's effect on the statistics is negligible.

ZUCKERMAN, who has already noted the difference between core and abstracting journals in chemistry, has suggested that this may reflect a difference between science in the United States and science elsewhere.[7] One would not expect this to be so on intellectual grounds, for modern science demands roughly equivalent training and specialization of scientists of all nationalities in order for them to compete at the supranational research front. Fig. 2 depicts the results of a limited investigation of British and German "core" journals in physics and chemistry. The incidence of teamwork in these journals is both above and below the average for their American counterparts. The percentages for chemistry appear virtually indistinguishable from those of American core journals; those for physics are mixed, with one journal considerably below the average for abstracts.[8] However, these data lead us to an important conclusion that the statistics of collaborative research are very sensitive to the journals selected for data collection. The closer one gets to the central core, the greater the frequency of teamwork. For example, it is

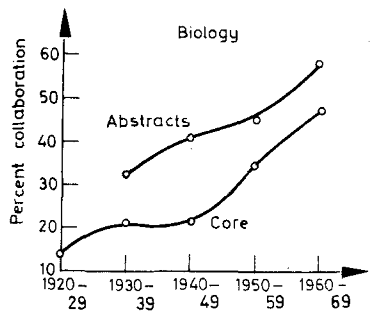

Fig. 3. Incidence of collaboration by decade in biology, in biological abstracts and in alternate "core" journals. Data for "core" journals: through 1950–59: H. *Zuckerman,* Nobel Laureates in the United States . . . , p. 94, 1960–69: averaged count for 1962 and 1967. "Core" journals: Journal of Morphology, Genetics, Biological Bulletin, Human Biology

quite possible to choose reputable U.S. journals as a "core" sample, and to obtain percentages of teamwork lower than that in the abstracts. Fig. 3 represents precisely that case for biology. The four well-known journals which were selected as "core" displayed a very low frequency of collaboration, a frequency well below that for biological abstracts.[9] The non-"core" status of these journals, indicated in the above statistics, was independently confirmed by citation data. None of these journals appears among the 13 most cited biological, biochemical, or biomedical journals for 1969.[10]

Nonetheless the data do leave open the possibility that research reported in prominent European journals may be less collaborative than that in U.S. journals. Thus they may partially account for the statistical difference between "core" and abstracting journals. But in view of our conclusions about collaboration in the nineteenth century, it seems more likely that such data reflect American predominance in science.

Three additional observations should be made about these statistics. First, the discrepancy between the rates of collaboration obtained from core journals and those obtained from abstracting journals is hard to explain by appealing to any of the usual explanations for collaboration.[11]

Second, the core journal statistics are typical of those which commonly appear as measures of collaborative activity. Statistical studies of collaboration typically rely on an apparently efficient and appropriate adumbration of the literature rather than a complete count of the work in a given field for that would be a huge undertaking.

Counts are based upon a sample of a few "core" or eminent journals which might reasonably be expected to represent the normal organizational patterns of research. Such studies have indicated that, for science as a whole, collaboration has become the norm, accounting for nearly 70% of all investigation, and, in the case of chemistry, for 90% of all research. But in science, as in other social systems, the elite (which is overrepresented in core journals) is not the norm. As can be seen from Fig. 1 collaboration is not yet as typical for the general scientific community (viz., the abstract journals) as it is for the elite (viz., the core journals). It has only recently become the predominant form of research. Although frequent, collaboration has yet to reach such proportions that (extrapolating from the core journals) the end of the century will witness the virtual demise of the lone researcher.[12]

Third, it should now be clear why collaboration is viewed as a very recent phenomenon and a reponse to specialization. Extrapolation back from the statistics of Fig. 1 would place the origins of teamwork at the end of the nineteenth century, squarely in the period constituting the "triumph of specialization". But its origins, as we have shown, are much earlier. Consequently, the data indicate a significant change in the rate of growth of collaborative activity at the beginning of the twentieth century, rather than when collaboration originated.

Change in the growth rate of teamwork

Fig. 4 presents a more complete picture of the statistical growth of collaborative research.[13] During the nineteenth century teamwork exhibited a very slow and steady growth from about 2% of all research in 1800 to about 7% in 1900. However, for the first time at the beginning of the twentieth century, a significant upward change in the rate of growth occurred. By the beginning of World War I the growth rate had slowed down, but it was still increasing at an unprecedented rate. Since then collaborative research has continued to expand.

Some would argue that this change merely reflects a changing practice of acknowledgement of informal collaboration. Substantial variations in the formal determination of co-authorship do exist – both historically and currently, in and across fields.[14] Although the majority of papers are two-authored, increasing percentages of papers with more than two authors clearly reflect a trend toward greater recognition and inclusion of participants in research work. While rare, there are extreme cases of contributions to the literature signed by more than ten authors, or some with institutional names (the latter have received critical editorial comment).[15]

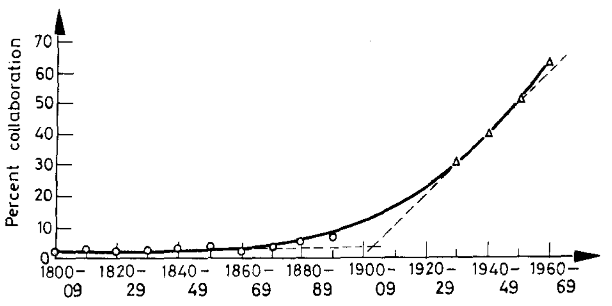

Fig. 4. Incidence of scientific collaboration in the nineteenth and twentieth centuries. Nineteenth century data (– ○ –): Royal Society Catalogue of Scientific Papers, 1800–1900. Twentieth century data (– △ –): weighted average of biological, chemical and physics abstracts

Although no existing studies have focussed on changing canons of permissibility regarding the inclusion of research assistants as co-authors, it is unlikely that any such changes occurred so suddently that they can account for the increased rate of growth.

Furthermore, a change in the practice of including assistants can scarcely explain the markedly different and consistent growth rates of teamwork in the nineteenth and twentieth centuries. If the increase were due to this alone, then the origin of "real" collaboration could be found by backwards extrapolation of the more recent statistics. This would place its roots in 1900, long after the practice had in fact begun.

Assuming that much of what is recognized as formal collaborative research would not have been in the past, and extrapolating forward from nineteenth century statistics, indicates that the incidence of strictly comparable contemporary collaboration ought to be about ten to fifteen percent of all research. However, it is highly unlikely that the remainder represents a wholly stylistic change rather than an actual increase. Indeed, change in the growth rate is probably related to both a change in the acknowledgement of teamwork, and an actual increase in its practice, To the extent that the growth of collaboration does reflect a change in acknowledging intellectual assistance, it reflects a change in the underlying social structure of science. How then are we to interpret the upswing in the incidence of scientific collaboration in the twentieth century?

The critical change in the growth rate of collaboration occurs simultaneously with critical changes in the support of science. It corresponds to those years in the early twentieth century, up to the time of World War I, in which both government and industry in Britain, France, Germany, and the United States began supporting science to a greater degree than they had. These years mark the birth and proliferation of research institutes, industrial laboratories, and private foundations which would heavily support science.[16] Of the various sciences assisted, chemistry, and particularly chemistry in Germany, was earliest and best supported.[17] Already by 1894 two-thirds of the world's chemical research came from Germany, and there were over 4000 trained chemists employed in German industry.[18] German chemistry, as one would expect from our hypothesis, led in the rapid growth of collaborative work. Consequently, it appears that the ability of the scientific elite to secure increased support for science in the early twentieth century constitutes the major factor responsible for the increase in the frequency of team research.

During the nineteenth century, financial support of science came only slowly and grudgingly, after much effort by the leaders of science. In England, it came rather more slowly than in Germany.[19] In America, "indifference to basic science" seemed characteristic; scientists resorted to various stratagems in order to obtain support, either public or private.[20] The slow and steady growth of the scientific community paralled the ability of the scientific elite to secure a steady but slow growth of financial support for scientific research.

The early twentieth century marks the beginning of a more successful era of public support of science. But scientists, claiming that fund-raising occupied too much of their attention, continued to be dissatisfied.[21] By the end of World War II, however, the situation had changed. The scientific establishment, having established its usefulness to the larger society, succeeded in laying claim to a greater proportion of society's resources. Since World War II, "each succeeding annual federal budget has surpassed its predecessor in funds for basic research; . . . no segment of American society has been accorded the degree of solitude or wish fulfillment that the federal government has lavished upon pure science . . . American science enjoys a combination of wealth and freedom unmatched in any nation."[22]

Having made "such a rapid advance from the deep poverty to great affluence, from academe's cloisters to Washington's high councils", the scientific elite continues in its search for greater support by skillfully using its earlier successes. "The denial of a grant is equated with the persecution of GALILEO; a harsh word from a knowing congressman, and the Cosmos Club simmers with talk of a new Dark Age.[23]

As we have noted, this increased support reflects social recognition of the utility of science. More importantly, such support is a validation and therefore a reinforcement of the structure of professional leadership. As society channels increasing resources to a professional elite, the elite, derives – through responsibility for its distribution – great authority within the profession. Therefore, increased support reinforces the hierarchical structure of the profession, which gives its leaders greater power and autonomy in their decisions regarding the disposition of these resources. Their authority is reflected in their ability to influence and direct policy regarding employment, education, grants, and the direction of research.

Those who are not in a position of leadership face an intensified problem of gaining access to both societal resources and, equally important, the intellectual resources of the scientific community. Access to these resources depends on recognition, which is enhanced by the increased visibility that collaboration can provide through both the literature and personal contact. Collaboration also seems to result in greater productivity, which offers another route to recognition. However, these findings should not be taken as evidence that collaboration has helped counteract the increased stratification in science caused by the growth of financial support. Rather, collaboration seems to have operated in the above manner within the limits imposed by the intensified stratification. That is, collaboration's effects are confined, more or less, to each level of the system. In this sense, it has helped to reinforce the increasing degree of stratification.

The problem seems to reduce to one of initial contact, thus we might ask in what ways scientists initially make contacts that lead to collaboration. In the early nineteenth century French scientific community, these initial contacts were usually between students (or assistants) at a high level and their professors, or within the informal Society of Arcueil. Those who managed to make such initial contacts often collaborated and were integrated into the elite. There is little evidence to suggest that the situation has changed. Scientists without any access to the elite seldom make it on their own, especially when greater resources are necessary for research. While lone scientists can and do publish, they are always at least one step behind the elite.

The importance of initial contact with the elite is supported by Diana CRANE's study of scientists at major and minor universities.[24] She suggests that the setting in which a scientist receives his training has more effect on his later productivity than the setting in which he works afterwards.

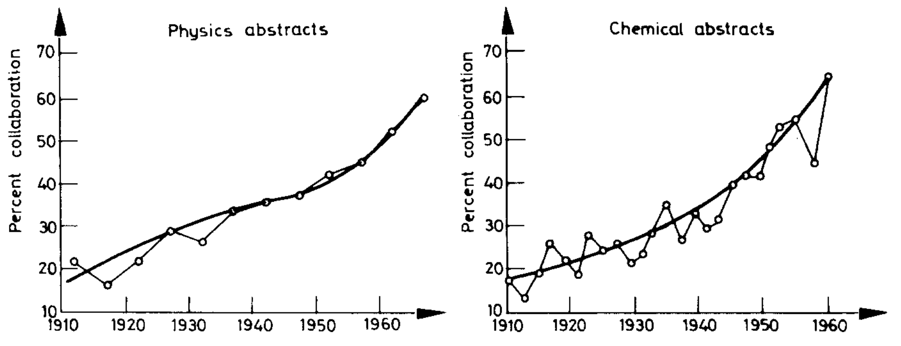

Fig. 5. Incidence of collaboration in physics and chemical abstracts. Chemical abstracts data: D. deS. *Price*, Little Science, Big Science, p. 88, Physics abstracts data: counts of years ending in 2 or 7

In a different way, data in Fig. 5, which depicts percentages of collaboration in twentieth century physics and chemistry for intervals shorter than decades offer additional support for our conclusions.

Since the scientific literature grows exponentially, one might expect the relative frequency of teamwork and individual work to be preserved during the two world wars.[25] However, during both wars and also during the Depression, the frequency of collaboration in relation to individual work decreased.[26] This decrease might be explained by the need for secrecy during conflict situations. However, during these periods both the input of new students to the universities and financial support for basic research decreased. In addition, the authority of the scientific elite was eroded; professional autonomy was forsaken in the interests of the larger society.

HIRSCH and SINGLETON indirectly suggest evidence for our conclusions by showing that there is "a relationship between financial support and multiple authorship."[27] Their study of articles published in two major sociology journals from 1936 to 1964 indicates that the more "establishment" (elite) publication, the American Sociological Review (ASR) exhibited a greater percentage of collaborative research than did Social Forces (SF) whose authors were less "establishment". The authors of articles in the ASR had more funding than did those who wrote for SF.[28]

Table 3 further suggests that in the context of a professional hierarchy, the degree of financial support is related to collaboration. To the extent that the number of authors per article is a measure of relative collaborative frequency. Table 3 indicates that the greatest degree of collaboration occurs in the best supported fields.[29] It is most frequent in the biomedical sciences, then gradually decreases, through chemistry and physics to technology and engineering. Mathematics, as is

Table 3
Multiple authorship by field of science

No. of Journals averaged	Subject	Authors/Article
14	Cardiovascular Systems	2.74
12	Cancer	2.49
15	Biochemistry	2.26
39	Medicine	2.16
14	Microbiology	2.15
26	Nucl. Sc. & Tech.	2.13
32	Chemistry	2.10
17	Polymer Science	2.06
25	Biology	2.02
39	Physics	1.97
9	Solid State Physics	1.94
21	Chemical Engineering	1.84
26	Metallurgy & Mining	1.82
27	Agriculture	1.74
23	Aerospace Sciences	1.68
21	Botany	1.66
21	Electronics	1.63
21	Astronomy	1.61
22	Material Sciences	1.57
20	Computers & Cybernetics	1.47
16	Engineering	1.39
12	Aeronautics	1.35
30	Mathematics	1.34
6	Education	1.30

Journals arranged by subjects according to the list headings in the SCI 1970 Guide and Journals Lists.

The number of authors in every journal is taken from the Computer Printout 1970 Source Journal Statistics. It is to be noted that the count has been substracted from the total number of articles in a Journal and do not affect the average.

well known, lies at the bottom of the sciences in collaboration, with astronomy next highest. It has long been a plaint of the astronomers that they are relatively undersupported.

Technology and engineering, areas which as "applied research" receive much greater financial support than the "basic" areas considered in this article, display markedly low collaboration. Furthermore, advancement in these areas does not primarily depend on professional evaluation, but on that of employers who both select problems and evaluate solutions in their own terms.[30]

Conclusion

During the twentieth century, the increasing propensity of scientists to collaborate has been a significant trend within the overall pattern of a mushrooming scientific establishment. The marked increase in the growth of collaboration during the past decades is intimately associated with changes in scientific organization which account for the amazing growth of science. But both collaboration and these changes in scientific organization have their roots in the professionalization of science. On the one hand, the changes that professionalization brought about in the scientific community of France, which influenced the growth of collaboration during the early nineteenth century, remain a factor in the contemporary organization of science. In fact, they are even more deeply imbedded in its structure. On the other hand, professionalization, by creating a scientific class which seeks to assure increasing societal support and to channel this support through a hierarchy of its own creation, has made possible increasing growth rates. In turn, this expansion has led to, and indeed necessitated new changes in scientific organization, such as deepening specialization and the invisible college. Collaboration, more than before, offers a way for individual scientists to increase their mobility within a growing array of subcommunities.

Notes and references

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   and Studies in Scientific Collaboration Part II, Scientific Co-authorship, Research Productivity and Visibility in the French Scientific Elite, 1799–1830; *Scientometrics,* 1 (1978) No.2, 133–149.
2. J. BEN-DAVID, *The Scientist's Role in Society,* Englewood Cliffs, N. J., Prentice-Hall, 1971, p. 107.
3. D. deB. BEAVER, R. ROSEN, Studies in Scientific Collaboration Part I, The Professional Origins of Scientific Co-authorship; *Scientometrics,* 1 (1978) No.1, 65–84.
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5. D. CRANE, Collaboration, Communication and Influence: A study of the Effects of Formal and Informal Collaboration among Scientists, mimeo, 1969, p. 1.
6. It may be of some interest to note, however, that of the patents cited in *Chemical Abstracts* for 1970, 40% were jointly held.
7. H. ZUCKERMAN, Nobel Laureates in the United States: A Sociological Study of Scientific Collaboration, unpublished Ph. D. dissertation, Columbia University, 1965, p. 80.
8. The percentage displayed by *Zeitschrift* may reflect either the shift of center of gravity of research to the U.S., or the possibility it isn't a core journal. Absent from these statistics are French journals, which we have not examined. Our theory, however, would lead us to predict that the relatively depressed state of science in France "in the age of the scientific state" would result in its best journals exhibiting a below average frequency of teamwork.

9. Cf. H. ZUCKERMAN, *op. cit.*, p. 78, 79, 83, 94.
10. See E. GARFIELD, Citation Analysis as a Tool in Journal Evaluation, *Science*, 178 (3 Nov. 1972) 474, (Fig. 4).
11. See D. deB. BEAVER, R. ROSEN, Studies in Scientific Collaboration Part I, *Scientometrics*, 1 (1978) No.1, 65–84. (Table 1).
12. On this see D. deS. PRICE, *Little Science, Big Science*, New York, Columbia University Press, 1963, p. 88–89, and his Research on Research, in: D. L. ARM, (Ed.), *Journeys in Science: Small Steps–Great Strides*, Albuquerque, University of New Mexico Press, 1967, p. 5–6. See also H. ZUCKERMAN, *op. cit.*, p. 82, and B. L. CLARKE, Multiple Authorship Trends in Scientific Papers, *Science*, 143 (1964) 824.
13. For this figure, we are aware that the conflation of statistics from different sources represents a potential methodological difficulty,but are convinced that whatever degree of mismatching may exist is trivial. We have tried different weightings of the abstracting literature statistics, with virtually indistinguishable results. What is particularly interesting is the possibility that these data depict a logistic curve, already abundantly testified to in studies of the science of science; if so, the growth of collaboration is rapidly approaching its saturation limit.
14. H. ZUCKERMAN, *op. cit.*, p. 62.
15. Cf. H. ZUCKERMAN, *op. cit.*, p. 106–107; also I. H. PAGE, Some Perils of Authorship, *Science*, 144 (April 10, 1964), editorial.
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17. J. G. Crowther, *op. cit.*, p. 491–504, and D. S. L. CARDWELL, *op. cit.*, p. 134–137.
18. D. S. L. CARDWELL, *op. cit.*, p. 134.
19. D. S. L. CARDWELL, *op. cit.*, passim.
20. See, for example, R. SHRYOCK, American Indifference to Basic Science during the Nineteenth Century, *Archives Internationales d'Histoire des Sciences*, 28 (1948–49) 3–18; A. H. DUPREE, *op. cit.;* H. S. MILLER, *Dollars for Research.*
21. For the 1930's, see J. G. CROWTHER, *op. cit.;* for the 1950's and early 60's, see D. S. GREENBERG, *The Politics of Pure Science*, New York, New American Library, 1967.
22. D. S. GREENBERG, *op. cit.*, p. 288.
23. *Ibid.*
24. D. CRANE, Scientists at Major and Minor Universities: A Study of Productivity and Recognition, *American Sociological Review*, 30 (1965) 699–714.
25. D. deS. PRICE, *op. cit.*, p. 8.
26. The relative insulation of the U.S. from the locations of combat masks the effect for the abstracting journals particularly for World War I; the effect is most pronounced for the European journals counted directly.
27. W. HIRSCH, J. F. SINGLETON, Research Support, Multiple Authorship and Publication in Sociological Journals, 1936–1964, unpublished preprint, 1965, p. 1.

28. A. E. NUDELMAN, C. E. LANDERS, The Failure of 100 Divided by 3 to Equal $33^1/_3$, *The American Sociologist,* 7 (Nov. 1972) 9.
29. In Table 3, journals are arranged by subjects according to the list headings in the 1970 Guide to the *Science Citation Index* published by the Institute for Scientific Information, Philadelphia, Pa. The number of authors in every journal is taken from a printout of the 1970 *Science Citation Index* Tapes, which contains statistics of the number of articles published in the source journals processed in the *SCI.* It is to be noted that the count has been edited; anonymous articles have been subtracted from the total number of articles in the journal and do not affect the average. For permission to publish this table, grateful acknowledgement is due to the Institute for Scientific Information (ISI), and to Prof. D. deS. PRICE of Yale University, who first utilized this table, and kindly made it available to us. For further information about SCI, see E. GARFIELD, Science Citation Index, a New Concept in Indexing, *Science,* 144 (1964) 649–654.
30. For other distinctions between science and technology, see D. deS. PRICE, The Difference Between Science and Technology, published by the Thomas Alva Edison Foundation 1968; M. KRANZBERG, The Disunity of Science-Technology, *American Scientists,* 56 (Spring, 1968) 21–34, and N. W. STORER, *op. cit.,* p. 91–97.