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Changes in Scientific Activities with Age

The life of an established scientist changes little over the years—unless he goes into administration.

Anne Roe

In the years 1947 to 1949 I studied a group of eminent research scientists (*1*). My reasons for seeking them out then were to find out if scientists differ in any consistent ways from nonscientists, or if different kinds of scientists differ consistently from each other, and to find out why they became scientists rather than something else.

In 1962 and 1963 I interviewed these same men again. I was concerned to learn what changes had taken place in the nature or amount of their scientific work, in the pattern of their lives generally, and in their opinions about such things as the nature and management of research activities (*2*).

The highlights of the earlier study can be reviewed briefly. There were 64 men in the group, 20 in the biological sciences, 22 in the physical sciences, and 22 in the social sciences. They were selected by their peers for the excellence of their scientific contributions. At that time their average age was 48, all of them were married, and most of them had children. Five were from Jewish homes, one was from a home of free-thinkers, and the rest had Protestant backgrounds. Just over half of them had fathers who were in professional occupations; none were sons of unskilled laborers, and none were from very wealthy, aristocratic families.

There were some characteristic patterns in their early histories. Most of the social scientists were socially active from an early age. Most of the others were rather shy, socially late-maturing boys, with strong hobbies and noticeable persistence in them. With the exception of some of the experimental physicists, all of them were voracious, if unselective, readers throughout their childhoods. More of the natural scientists regarded their fathers with great respect but felt somewhat distant from them. More of the social scientists had had strong conflicts in the family.

These scientists are of extraordinarily high intelligence. On a verbal test, their median was about equivalent to an IQ of 166, with the lowest about 121. That seems to be about a minimum IQ for a research scientist; higher levels are no drawback, but above that level other aspects of the person's nature or endowment may become more important. Perhaps the most influential of these other aspects is motivation—the degree to which the individual's work is important to him. All of these men are, and have always been, so immersed in their work that other considerations play much smaller roles (*3*). They give a picture of hard-working, driven, and devoted men, but they are these by choice. For the most part they spend their time doing what they want to do, and they always have. It is this and the respect of their peers that repays them, for their financial rewards are far from commensurate with the contributions they make to society.

Of the 64 men originally studied, 54 are still living; two of the biologists, three of the physicists, one of the psychologists, and four of the anthropologists have died. Some of the 54 had retired, some had moved to other institutions, but I was able to see all but two, who were in Europe at the time. From one of these I received a long report. Most of the interviews were tape-recorded.

Their present ages are from 47 to 73. There are 17 over 65, and 11 of these are biologists. The age difference is of more significance now than it was 15 years ago, because of the retirement issue.

Many scientists move about from one institution to another and stay for varying periods in various places, but, aside from wartime assignments and visiting professorships, 16 of these men (ten of them physical scientists) have stayed at one institution. Two biologists have been at seven different institutions, and one biologist and one social scientist, at six.

Honors

Many honors have come to these men, in addition to the visiting professorships and lectures, which are in themselves honorific. The most obvious are medals, prizes and awards, honor-

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Table 1. Medals, prizes, and awards received by the 54 scientists of the study.

Category	No. in category	No. with no such awards	Range per person	Average		No. of different awards within category
				For group	For those receiving awards	
Biologists	18	6	0–11	2.88	4.33	38
Physicists	19	8	0– 9	2.26	3.91	38
Social scientists	17	6	0– 3	1.06	1.63	5*

* This number includes one award from a scientific organization in a field not connected with psychology in the usual sense.

Table 2. Honorary degrees received by the 54 scientists.

Category	No. in category	No. with no honorary degree	Range per person	Average	
				For group	For those receiving awards
Biologists	18	5	0–11	3.35	4.92
Physicists	19	3	0–16	2.94	3.50
Social scientists	17	11	0– 2	0.40	1.16

Table 3. Society memberships of the 54 scientists.

Category	No. in category	National Academy of Sciences	American Philosophical Society
Biologists	18	17	14
Physicists	19	14	11
Social scientists	17	13	8

ary degrees, and membership in certain societies. Tables 1–3 give the data for this group as of July 1963. More honors have accrued to some of them since then.

It is noteworthy that the social scientists have received many fewer honors than the others, although they are as highly selected a group. Table 1 shows, for example, that there were 38 different medals, prizes, and awards given to the biologists, a number of men in the group having received the same award at different times. For the physicists there were 37 awards, but for anthropologists and psychologists, considered together under the heading "social scientists," only four different honors were available. In addition, some subjects in all groups received the Presidential Certificate of Merit for contributions to the war effort, but this is the only award common to all fields.

The situation with regard to honorary degrees (Table 2) is even more striking: only six of the social scientists have received any honorary degrees.

Membership in the National Academy of Sciences and in the American Philosophical Society is also commoner among the natural scientists (Table 3). Psychologists in these two societies have always been selected almost entirely from the "experimentalists" (who now constitute a relatively small percentage of the American Psychological Association), and under present election procedures this imbalance is likely to continue indefinitely. It is somewhat surprising to find the psychologists in the American Philosophical Society no more broadly representative of the profession, since this society has members from the arts and humanities as well as the sciences.

These differences are interesting and somewhat curious. It is, of course, true that receipt of any of these honors tends to lead to the receipt of others, for it adds to the general visibility of the recipient. Also, the older sciences have undoubtedly accumulated a stock of medals and prizes, which continue indefinitely, but the differences in honorary degrees and in society memberships cannot be explained in this way.

Retirement

Retirement policies vary from institution to institution, but for most of these men retirement from teaching or administration comes earlier than retirement from research. Few retire before the required age, which may be anywhere between 65 and 70 and seems to be usually earlier in private than in state-supported institutions. However, there are special appointments which are unlimited, and there is an occasional institution without a retirement policy (this often means without a good pension plan).

I encountered no one who did not have, or did not expect to have, the privilege of retaining office space, and frequently laboratory space, if he remained in the same city after retirement. There *are* problems with regard to assistance, and one major lack is secretarial assistance. This can be serious for many of those whose correspondence has become very heavy over the years. Retired scientists who wish research grants seem to have no difficulty in securing them.

In general, the scientists' working habits have changed very little in 15 years, and they show very few signs of "disengagement"—at most, they go to fewer meetings and no longer work nights.

Nine of the biologists have formally retired, but one of these is continuing as a research professor, having retired at 66 from administration and teaching only, and another has continued research on a half-time appointment since retiring at 67. One retired from one university at 65 and has just retired from another at 70; he has given up experimental work but continues writing and working on data from other biologists. Three others retired at 67, and two at 68. All of them continue to be active, although in different ways. One, in the 7 years since his retirement, has divided his time about equally between work in a research institution and society administration. One has been involved in administrative and consultative activities with research foundations and professional associations. After retirement another spent a year and a half in administration in a different science and is now working actively on his own research, with adequate grants. One, who has never had teaching or administrative duties, is continuing in his laboratory, with no noticeable change in his activities.

Among the physical scientists only two (both experimentalists) have formally retired, one of them twice, at 65 and 70 from different institutions. He is continuing a full-time program of writing and lecturing. The other

retired at 67 after devoting many years to full-time administration. He still retains an office at his university and has begun some experimental work again, but he spends the greater part of his time in maintaining an active consulting practice in his specialty. Another physicist, in his fifties, has made an unusual arrangement with his company to serve as a consultant 1 or 2 days a week, but he has otherwise retired.

Only two of the social scientists have formally retired. One psychologist retired at 65, but is continuing on a half-time appointment until he is 70. He devotes about a fourth of his time to teaching and the rest to research, and his productivity is at an all-time high. The other retired several years ago at 66, but, here again, there has been no noticeable change in his activities. He had not been engaged in either teaching or administration and continues his research as before, although the output in terms of number of papers has been steadily decreasing for some years.

One anthropologist will retire shortly, at 70. His teaching load is still a very heavy one, but he expects, after retirement, to spend 1 year giving a seminar at another institution and to devote the rest of his time to writing. He has done little research for some time, but has continued writing.

Research Support

The sources of funds which have been available to these men for the support of research throughout their professional lives are given in Table 4. This list may not be complete. Occasionally one of them would remember other (usually minor) sources after we had moved on to different questions, and there may be still other sources that they did not remember. Presumably these are few and not major ones. No source is listed individually in Table 4 if it was named by only three scientists. Subgroups of the physical scientists (theoretical and experimental physicists) and of the social scientists (psychologists and anthropologists) are listed separately, since their patterns of support are very different. Research requirements for theoretical physicists may be only paper and pencil or blackboard and chalk, and it is only in this group that there are men who have had no research funds whatever; there are a few more who have had very limited funds, or funds for a very few projects.

Table 4. Sources of research support, during their professional lives, for the 54 scientists.

Source	Biologists	Physicists		Social scientists	
		Theoretical	Experimental	Psychologists	Anthropologists
None	2	7	0	0	0
Institution	6	0	4	4	4
Private	3	0	0	1	2
Ford, Rockefeller, Carnegie	8	2	1	8	0
NIH	4	0	1	9	0
NSF	7	0	2	7	1
AEC	4	0	4	1	0
Cancer, Polio, Heart foundations	4	1	0	0	0
Social Science Research Council, NRC, General Services Administration, American Philosophical Society	2	0	1	4	0
Office of Naval Research, Army, Air Force, NASA	0	1	5	11	1
Office of Education, Weather Bureau, Office of Vocational Rehabilitation, Office of Scientific Research and Development	0	0	1	5	0
Miscellaneous small foundations	5	1	5	5	2
Commercial	0	1	0	0	0

The few men who have had no support other than the funds of their own institutions are generally proud of this. At the other extreme, there are a few who have very large grants from several sources and are responsible for several large studies—usually, but not always, closely related ones.

Very few of the 54 scientists had really adequate funds before World War II, and indeed for many of them the kind of research they are doing now, especially that requiring large funds, was not even thought of then. In some instances this is obviously due to changes in the science itself. In others, because large research funds were extremely rare outside of purely research institutions, large programs were simply not designed. The change is very largely due to research support from the federal government.

There is unanimous testimony that, since the war, none of these men have lacked the funds they have needed, although a few have had to put in a great deal of time securing them. These last have been chiefly men who were developing new programs in rather underfunded institutions. Some quotations from their comments will illustrate how great the change has been.

"This is a small University and we had limited funds. Before the war we were terribly hard up for research money, and one reason we didn't go into high energy and nuclear physics work, which I wanted to do then, was because I didn't have the money. We have actually gone through about four stages, I think. When I first came here, they were just beginning to talk about research but didn't really make this very important, and while they didn't throw any roadblocks in your way, they didn't give much support or encouragement, and the kinds of equipment we had were mostly just what we needed for teaching the basics of the subject. Then a friend of the University gave us some money for fellowships. These were very choice fellowships for the time, better than any of the others, and as a result we got a lot of very good students. This made the department move better, and then we began to get better and better professors and more and more money, and now it's simply unbelievable how fast the department is growing. During the war, of course, we were doing a lot of contract work. Now we have mostly grants and now I can finance my work very nicely."

One of the psychologists was quite specific:

"Sources of research support varied from zero on any research on my early work to, I think, $100 at one university where we were doing some beginning research back in the early 1940's. The time I really felt cheated of research support was when I moved to another university. Before that, if you got $200 you were real lucky, but when I moved for a time I got turned down many times on many projects. Then I got the money from the university research fund, and then I finally began to get breakthroughs, thanks to the guy who

then was head of the Rockefeller Foundation. . . . We got a good-sized grant from them and that seemed to open the floodgates. . . . Since then I've had all I needed."

One of the biologists referred to the early period as "in the bad old days, by which I mean prior to the Second World War," and says: "I think that in the field of biology today any person who has a sensible suggestion about what he wants to work on can get the fiscal support that he needs to do it, and there is no need for any biologist or at least any semi-respectable biologist, to feel that he is pressured to work on some particular thing because there is money available for it. There is money available for anything."

Asked whether or not their own research plans had ever been altered because of the source of funds which might be available to them, the general reply was an unqualified "No." Most of the men said quite flatly that they had never made any changes in what they wanted to do in order to get funds for it, but a few did admit to some (minor) influence from the source of support or stated that they know that such things have occurred with other people.

Administration

One of the men said, "Well, it is a fact of life that most professors who rise in the world have to take on administrative posts." As Table 5 shows, this has happened to the majority of these men. There are some interesting differences among fields, however. None of the social scientists has become administrative head of an institution, although a number of men in both the other groups have. It is also clear that, of the group in this study, administrative duties have been undertaken more often by the experimental physicists than by the theoretical physicists.

Most of those who are or have been administrative heads had been department chairmen, and sometimes deans, before reaching their latest positions. The amount of time required for administrative duties is extremely varied. A college president spends full time at it, but a museum director may not. There is full agreement, however, that any administrative position takes time away from research, and that the higher positions are likely to put an end to all research. The men who have gone from research to administration give different reasons for having done so. Very few of them have gone back to research.

Table 5. Administrative positions held now or previously by 53 of the 54 scientists. Numbers of individuals in the four categories: biologists, 18; theoretical physicists, 9; experimental physicists, 9; social scientists, 17. The data do not include wartime assignments but do include government posts held since World War II.

Position	Biologists	Physicists		Social scientists
		Theoretical	Experimental	
Department chairman	7	2	4	5
Director of laboratory or large research project	2	2	4	6
Dean	1	1	1	2
Administrative head of institution	4	2	4	0
Other	3	1	1	0

"I've served in three capacities here from bottom to top, and if I attached a priority to those, from the point of view of the worthwhileness, I'd put them in that order, with the teaching at the top. Once you go from Professor to Dean you never go back. I confess I enjoyed the Deanship, it was a confirmation that I could reach the top in the scholastic pursuits, but I had no desire for the higher office. I looked forward to a time when I could return to research, but a law of irreversibility applies. I left at the time I was on the ascent—I don't know how much longer it would have gone on."

"I saw a genuine opportunity in the Deanship to do two things: to bring in a senior person in the field and to expand this field at a time when one Foundation was dedicating itself very largely to behavioral sciences. I tried for a while to carry on with my research program, but this didn't work very well, and I presently gave it up but kept my foot in the door through teaching . . . but when a good opportunity came to get out of it I came back to the field."

"If I had to take the chairmanship again I probably would do the same thing because the added money that it brought meant that I could do things for my family that I couldn't otherwise do. . . . I think the problem really is that the rewards go to the administrator's job in any area, and as long as they do, I think many people will find themselves distracted this way."

"It soon became obvious that I couldn't do personal research and be a chairman. I found a good deal of satisfaction in demonstrating that I could do a good job as chairman. . . . I can't do research by delegation, I can't have ideas unless I am working with my hands. I think that if I had stuck to research, I could have continued to be productive for some time. On the other hand this particular field was being pursued effectively by young people with a new kind of training . . . sometimes it's a good idea to quit while you're ahead."

"The real reason for the change to management was that I had obviously passed the point of being able either through ability or time to continue any pretense of personal research effort. . . . In industry there's continual crying that they should let a research man make as much money as the administrator, but it's very impractical because the guy who determines your salary is an administrator and he isn't about to encourage a subordinate to get more money than he does. . . . These outfits have a lot of young, energetic, creative people, and they don't need patriarchs floating around and giving them advice. So I just decided . . . to cut things short."

Some reactions to the job of administration are of interest:

"Social life is the aspect of Dean's work that I miss more than anything else. I just don't come in contact with the faculty the way I used to. I was seeing them all the time and now I only see them if I happen to bump into them."

"I think administrative work tires you more than anything else. It's the need for making decisions involving human beings. You have to make decisions all the time on my job but I don't mind it nearly so much if people aren't involved. But even so, making decisions is one of the most exhausting things there is."

The two concluding comments give very different pictures, but the administrative duties of the first were those of a division chairman only, and of the second, those of the head of a very large institution.

"A few years ago, unfortunately, I became acting chairman of this Division and I spent half a day every day doing that. I did that for about a year and a half and I found out that I didn't want to be the chairman of anything. The thing that really made me stop and realize how horrible it was is that I found myself liking it. It was all this trivia. It's so wonderful being an administrator because you're busy all the time, and you don't have to think. One day I was going around the laboratory deciding where to put new stuff . . . I found myself liking it, so I quit."

"There's a lot of snobbishness and hypocrisy about administration. I have listened to some of my colleagues from time to time through the years talk about the importance of research and scientific work and that everything else is sort of sordid materialism. Many of these people will go on through their lives producing pedestrian papers on matters that are really of no importance and glorifying this as the research enterprise. If you go into administration you must believe that this is a creative activity in itself and that your purpose is something more than keeping your desk clean. You are a moderator and an arbiter and you try to deal equitably with a lot of different people, but you've also got to have ideas and you've got to persuade people that your ideas are important, and see them into reality. The problems in a position like mine are almost unbelievable in their diversity and importance. This is part of the excitement of it. In both research and administration the excitement and the elation is in the creative power. It's bringing things to pass. Perhaps it's more action than simple knowledge but it has a reward too. Now I think this is more exciting than research."

The Nature of Research

In the course of discussing their own research it often happened that the scientists commented on the nature of research and the changes in science during their lifetimes. A sampling of their remarks is given here.

"I have given a lot of thought to the future of biology in general. It's undergoing a sort of log-phase extensional growth right now, and furthermore there are many more biologists and they're much smarter than I was when I was a graduate student. They know so much more. They have the shoulders of the people that worked in the bad old days to stand on. I think it's very probable that all of the aspects of what we now call molecular biology will be found out in 25 years and that so much will be found out in 10 that what's left won't be so interesting, so I may have to turn to still some other field."

"It was easier to do things in the old days because quantum mechanics was much newer—all virgin soil. Now it's terribly involved and complex and broad and diffuse. . . . It's a question of whether you can clear up your office quicker than the reprints arrive. Nobody can read all the publications. In the early 1920's when quantum mechanics was first breaking you needed a whispering campaign to learn what was happening it was happening so fast, but it's not happening quite so fast now."

"The students in this group would have been classified 20 years ago as theoretical physicists, although now they are classified as experimentalists. Now we have technicians to run the bubble chambers and handle the measuring equipment and the electronics and so now the graduate students, instead of spending their time running a milling machine or lathe or wiring up electrical chassis or blowing glass, as I did, have none of these skills at all. On the other hand they are exceedingly good at theoretical analysis of the experimental results and they're all very expert computer programmers. They are very good at statistical analysis—the kind of people that used to be in biology where you had a limited sample and you had to get out the most information from that limited population. We call them phenomenologists. I mean they're not really theoretical physicists in that they don't dream up new theories and propose new kinds of things, but they are able to understand the theories and to apply them and to think constructively in the field."

"An important thing is the influence that a discovery has on your colleagues throughout the world. You have to fight for these things sometimes. You can gain personal satisfaction in a discovery and I think that's probably the chief thing, but I think number two is the acceptance of a discovery by your colleagues and this doesn't come easily if it's really revolutionary. If it's against the thinking of the times then you've really got to go out and do a little talking."

Other comments illumine some aspects of the research life, particularly the involvement in all the details of his work of the man who does effective research and the need for long periods of uninterrupted time. (It seems to me quite probable that in this latter requirement can be found one of the reasons why so few women have done important scientific work.)

"Research never goes very well at any one time. The curious thing about it is that at any one time you are doing something very unimportant. I was cleaning off the contacts of a switch here yesterday. Now I have money enough to pay people to do this for me, but the trouble is if I don't do this I'm really not participating in the research and if I pay people to do it I get more and more out of it and pretty soon I've lost contact. I've seen this happen and if I don't go out and do the little trivial unimportant things I might as well sign off."

"Research has to be done by the person himself, and you don't train research workers the way you do technicians. You train them a little bit by letting them see a good example of how problems are solved—how to go at it. Real research is going to be out in new territory where technique won't be useful. So often when people have used techniques and have finished what the technique will do they stop, and then they have to quit research."

"What you hear so often is that agencies are supporting work for breakthroughs—if you give enough money then something wonderful will come out of it. But you get it through hard, careful, persistent work over a period of time, and just pouring a lot of money into it won't do it. This also means that with so much money the younger men buy their apparatus, they no longer do their own work, they get people to do some of it and that's bad, too. Because then you shape your work according to the instruments that are available instead of building up something that fits your particular case."

"When you are moving ahead in the field and trying to find your way you get tremendously concerned with your own set of variables, almost to the exclusion of others, and I think it's a precondition for doing thorough work."

There were many comments on the need for long stretches of time. These are typical:

"Some people can turn from one thing to another. My problem is to

get long stretches of consecutive time so that I can live with my research problem. I can't do this with hit-and-run tactics. Science doesn't get done that way."

"I couldn't do an administrative job and do research too, because to me research is always a 100-percent job. You've got to live it all the time. You think about it at night; you wake up in the morning and you're thinking about it; you can't wait to get there and do it. This isn't consistent with a bunch of interruptions. Teaching isn't so bad because you can, if you're fortunate, always teach them something related to your research, so you can tie the two together. In fact, I think it's a good distraction because you can't for too long get in the routine of nothing but research. Most pure research labs end up being a kind of 9-to-5 operation. Academic institutions are better for creative research people because they don't get into the routine. They have to fight for time and that's good. And they also have students to keep them from getting into that old rut."

Publications

There are various ways by which a scientist's output can be measured, but perhaps the easiest is to make some count of his publications. For 45 of the men interviewed, complete bibliographies were obtainable (*4*). The average yearly number of publications for these 45 ranges from 1.11 to 9.24, with an overall average of 4.20 per year. Peak production may come anywhere from the first to the ninth 5-year period after receipt of the doctorate, with modes in the second and sixth 5-year periods (so far as possible, allowance has been made for wartime activities). There is some, but not a consistent, tendency for straight research reports to diminish over time relative to other types of publication (books, chapters, symposium papers, and so on).

It appears from these records that there is clearly no justification for the sometimes expressed opinion that rapid advancement in the academic hierarchy will somehow reduce motivation to produce. Ten years after the doctorate most of these scientists were well up in that hierarchy, and their production was generally increasing.

But many of them do now notice changes in motivation and energy:

"My motivational system is narrowing. I'm not as charmed by giving speeches as I was once."

"I was already aware when we had that previous session that in my own case the originality or drive which leads to productivity in experimental research was slowing down. The work I did took a great deal of physical energy, and while as I got older I had more help, it still took daily attention and planning of a fairly arduous sort. After a while we had gotten to the end of what you could do in my field with the techniques I knew and I saw this coming. So I said to myself that since I had another talent I would quit doing experimental work and do something that I could do better than most."

"I have become considerably less productive. My main interest is the most advanced and difficult kind of mathematical physics, but for a long time I have not had the time or the energy to keep up with it enough to make any efforts of mine to publish in that direction any more than laughable."

"As you grow older you don't have patience or nervous strength to make long calculations in the way I did on my Ph.D. thesis. You have a certain amount of momentum and I hope to rewrite my book. That does not require quite the same creative energy as to plan a new research publication, but it requires a lot of energy at that. It takes a lot more effort to write a paper now, somehow or other."

Other kinds of changes are noted:

"I get along better with students than I used to, but I suspect it is because I'm not pushing as hard as I used to."

"I've become far less controversial. I can no longer think ideas as I used to be able to do. I now fall back more and more on mechanical ways of arranging materials and ideas. . . . There's a very, very clear-cut difference."

One of the scientists has quite a different sort of problem:

"You know this really is beginning to bother me—I'm having a hard time telling the difference between right and wrong. I always felt I really knew, and now especially for other people I just don't know whether they're doing right or wrong. The frameworks are so different from anything corresponding to the way I used to make judgments for myself, and then I used to make judgments about other people, too. But when I look at the different situations which they have faced and the different real situations in which they live, well, this is kind of upsetting. I've lost my sense of smell, my eyes are kind of feeble, my hearing is a little bit weak—when I can't tell right from wrong, I really had better retire, so it's got me worried."

Summary

Continuous study of the lives of eminent research scientists shows that, in spite of some changes, these men have continued to contribute at an extraordinarily high level. For most of them, their contributions are still in the scientific fields in which they attained eminence. Others may contribute more significantly now in administrative posts, in facilitating the work of other men. All are happy in their work, and none regrets his choice of occupation. Their rewards have been in terms of inner satisfactions and recognition from their peers.

References and Notes

1. Both the earlier study and the one reported here were supported by grants from the National Institute of Mental Health. A full account of the earlier study appears in A. Roe, *The Making of a Scientist* (Dodd Mead, New York, 1952); an Apollo edition appeared in 1961. A more complete report of the later study is given in A. Roe, "Scientists Revisited," *Harvard Studies in Career Development, No. 38*.
2. In addition I recorded material about the scientists' health, their children's occupational choices, their opinions of the effect of governmental support of research, and their opinions of women in science. I have also analyzed in some detail the nature and pattern of their publications. These data are reported in "Scientists Revisited," *Harvard Studies in Career Development, No. 38*, and in reports now in preparation. A brief paper on women in science will appear in the *Journal of Counseling Psychology*.
3. For a fuller account of the personality patterns of scientists, based on this and other research, see A. Roe, *Science* **134**, 456 (1961).
4. A detailed analysis of these bibliographies is in preparation.