THE MANAGEMENT OF SCIENTISTS - A STUDY OF THI MANAGEMENT INFLUENCE ON THE PRODUCTIVITY OF SCIENTISTS

Cyril O'Donnell

National Aeronautics and Space Administration
Washington, D. C.

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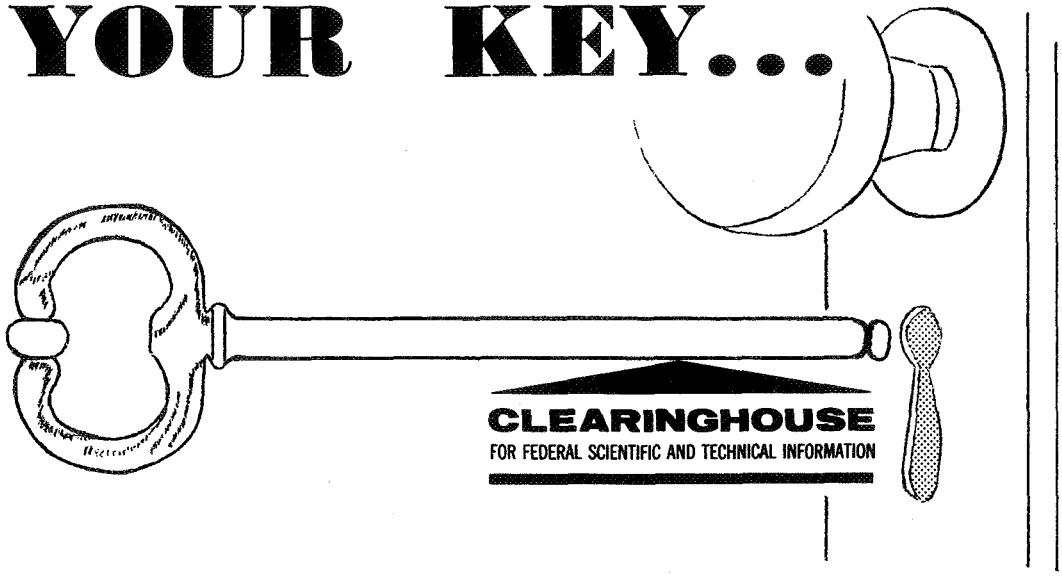

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Sponsored by the Division of Research of the Graduate School of Business Administration and the Institute of Geophysics and Planetary Physics, UCLA, and by the National Aeronautics and Space Administration

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PREFACE

Special problems relating to the management of scientists in industry came to the fore during World War II and have, to a considerable extent, been with us since. It is not that there were no scientists in industry prior to that time: indeed, there were a few older firms such as Bell Telephone, du Pont, Eastman Kodak, General Electric, Radio Corporation, and Westinghouse who were very comfortable with the scientists on their staffs. They had advanced considerably up the learning curve. There were other firms that utilized scientists in development activities, and these, of course, were managed much in the same way as engineers. But it was during World War II and in the interval years that large numbers of firms employed scientists for basic research for the first time. As is often regretfully true, businessmen leapt into the potential morass before they looked and trouble started for them at once. Managers did not recognize that their problems would be any different with scientists than with other subordinates. They continued to carry out their functions in the same way although not necessarily with skill, defining objectives, establishing control systems, appraising these men, and directing them closely. The result was surprising to both managers and scientists. The latter simply would not be managed this way.

This response reflected the scientists' attitude toward work, how they thought it should be approached and evaluated. Their attitude was a direct outgrowth of the depth of knowledge and the discipline of methodology taught to them during their university careers. Not understanding these matters, managers recoiled in

surprise at the response of scientists to enterprise techniques of work definition and control: managers certainly were hurt, and they reacted by withdrawing from almost any attempt to manage this new type of employee. Thus, over the last twenty years the process of managing scientists has been one of learn-as-you-go, although quite needlessly for much could have been learned from the experience of the pioneers. In addition, executives got very little help from management theorists. There have been some studies of this matter, but they have not singled out the basic scientist as distinguished from engineers, technicians, or nurses. The relative number of scientists who were engaged in research was always very small, and consequently the problems involved in managing them were not relatively significant in the operation of the total enterprise.

It was with this background in view that a proposal was made by the author to undertake a preliminary study of the management of scientists. A committee of businessmen-scientists assisted in guiding the study. Its function was to aid in the problem of identifying the scientist and/locating him. This was no easy matter. It was finally determined that to qualify as a scientist a person should be spending a significant part of his time in original intellectual effort leading to the discovery of new knowledge or truths. This formulation was selected in order to include the laboratory managers who carry on their own research and the scientists who are required to travel, to negotiate research proposals with customers and act as internal consultants to other parts of the enterprise: it specifically eliminates all engineers, technicians, and those scientists who are primarily engaged in applied science.

From the very first it was apparent that no statistical study could be made. No one knew how many scientists there were in the country or where they were. Everyone knew about universities in general but it is painfully clear that members of the professional staff in a scientific field are not all scientists. It was also clear that scientists were located in certain government research laboratories; in research institutions of a private nature; and in laboratories supported by business enterprises. The search for accuracy in identifying the scientist was too onerous for the modes study proposed. Consequently, it was determined to abandon a formal statistical approach and try to identify individual scientists in locations in Southern California with the hope that enough could be found whose collective views would provide a basis for tentative conclusions about their management.

To make the study more definitive, as well as quicker to accomplish, it was further decided to search for physical scientists employed in the laboratories of business enterprises. Furthermore, since this was a study to learn something about the special management problems involving scientists, it was important to gain the views not only of scientists but also of their own managers.

The alternative techniques available for securing this information included the extended personal interview and a questionnaire The former was a clear choice but would involve a great deal of time and it must be conducted by interviewers who understand both science and the managing process. The rarity and unavailability of people with these qualifications rendered the former tactic impractical. Reluctantly, the questionnaire route was taken with the intention that perhaps we could bring the participants together in a conference at a later date. This was happily achieved in December 1967.

The field work was conducted during the summer of 1966. A total of fifty-one scientists responded. They were employed in eleven laboratories. From a total of fifteen managers who completed the questionnaire there were nine who could be clearly associated with thirty-one respondent-scientists among their own subordinates. These nine represented seven of the eleven reporting laboratories.

Very few tables appear in this manuscript. Even though the reader is warned about the reliability of figures, he tends to give them weight. Furthermore, most of the questions were valued for their invitations to comment. I was looking for flavor, inferences, and viewpoints that are significant when related to the managing problem.

The cooperation received from individual scientists and

their managers has been of untold benefit to this study. I am especially grateful to them for the time they spent in responding to the questionnaire, and for the sacrifices many of them made to attend a seminar with me where we struggled manfully to cope with complex problems concerning the management of scientists. Some of this dialogue is reproduced at the end of each chapter so that the reader can understand the difficulties of generalization, of precision in language, and of understanding the manager's role within the laboratory.

This manuscript has benefited from the contributions of many people. Basic to all was the generous financing provided by NASA which is vitally interested in the productivity of scientists. The counsel of the original steering group comprised of Mr. E. M. Boykin, Vice President, Hughes Aircraft Company, Dr. Harper North, Vice President, Thompson Ramo Wooldridge, Inc., and Drs. Lewis Larmore and Herman Schneiderman of McDonnell-Douglas Corp. was most helpful at the time when the issues of definition, identification and discovery were still unsolved. General John W. Cave gave many hours of his time to aid in solving all of the problems concerned with the definition of the project and in pilot testing the field procedure. It was my original hope that he would co-author this manuscript and I regret that this has not been possible. I have an exceptionally deep feeling of gratitude for his contribution. Professor George A. Steiner, Director, Division of Research, Graduate School of Business Administration at UCLA provided the opportunity for me to undertake the original proposal and carried on with great skill the negotiations with NASA that eventually supported this effort. I am deeply grateful for his

kindness. For aid in the design of the questionnaire and in the conduct of the field work I am indebted to and proud of the work of John Burke, Richard Carter, Don McLaughlin, Michael Lockareff, Loren Raymond and Steven Westfall--all graduate students at UCLA at the time and on several of whom the Ph.D. degree has since been conferred. Finally, for their administrative support and clerical help a special note of thanks is due to Miss Mary McMurray and Miss Marilyn McElroy.

Cyril O'Donnell

Los Angeles
December 9, 1968

FOREWORD

DR. LIBBY: We are very pleased to be able to assist in the organization of this meeting. Some funds have come from the space program. Mr. James Webb has been concerned about the impact of this space program on the business community as a whole, and I think realistically so.

It seems to me that the problems of acquainting the community with science and scientists are important, and that your subject today is one important facet of the whole question of this interrelationship. I am very much impressed by the lack of scientific education in people of great authority, and the only thing one can do in the face of this is to try to bring them to know scientists and to have scientists advise them on scientific matters. So not only do you have the problem of the many scientists, but the problem of scientific management in general. Society has to have this because we are in deadly, serious competition with a society that has scientific management built into its very structure, namely the Soviet Union; so it is a very serious business.

We are in the face of a shortage which is growing because we are not so successful in recruiting students to become scientists and engineers. I'm afraid it's getting worse rather than better, and I wish you well in your discussion. It is a very important subject. I have my own pet ideas, but I must say that the evidence that they are the correct ones is far from convincing. My principal notion about the management of scientists falls into two categories: One, the research scientist working on pure fundamental research should not be managed in any way. On the other hand, the project scientist should, and I think he requires it. The research

scientist should be expected to produce good work. It is difficult for the non-scientist to know what good work is, but the scientific community can recognize it. There is a vast difference between the two activities. The project and development program needs management in the worst way, and the pure research scientist has no real role for the direction of that kind of work. I think perhaps we should reward him with salary and honors, but don't make him vice-president unless you want him to cease being a scientist.

This brings up another point. I think that many laboratories are used as a training ground for administrators. I must say I don't think it is a very good place to train them. However, it may be the need for finding information in high management as such that justifies the practice but certainly it is disruptive of scientific technological progress. We in the university have a major responsibility to hold this kind of meeting, I think, and I am so happy that U.C.L.A. is the leader in this respect in the whole community. It is a very fine thing that we have a continuous series of this kind of interchange with the community.

I note in your textbook that there is considerable discussion of how to hire scientists. It is very interesting, and it is a job that is usually not too well done. It is a very difficult thing to do. In the university we are very careful about this. We have an eight-year assistant professorship before tenure is given. It usually doesn't go that far. The answer is usually reached much earlier one way or the other, but there is this definite matter of a period of trial of several years. I think in some of these positions, especially in the pure research laboratories, many companies could adopt a similar practice. Essenti-

ally pure research is the kind of practice that might be thought about. The need for understanding of sciences has never been greater than right now. We have a major crisis in policy respecting the support of science. I'm extremely worried as we fall farther behind the Russians in the space program. I am not worried only because of the defense applications but because of the future engineering technological developments in this area.

There is a relationship between the university and industry which I think isn't used enough, such as the professor in residence or the professor on leave. This type of thing might help a great deal in making people work more efficiently and more happily. I don't know why it doesn't work. It is a thing that would seem to be just what is needed in many cases. It doesn't seem to work very well.

DR. OSTERYOUNG: That is an interesting remark about tenure. You think that the commercial organization or non-university laboratory can really hire people for those positions? The laboratory really wants good people. It is competing with the university and you feel that even with your research laboratory, that a commercial organization can get people if they say, "All right, this is a non-tenure position," whatever that may mean.

DR. LIBBY: Yes, I think so. This is done in some commercial laboratories. For research in engineering, Standard Oil of New Jersey does essentially that. I forget the title they give it, but in the special title, they are taken off the projects, and essentially they do anything they wish. It isn't so much a matter of tenure as it is of a special position and freedom of action. Those who don't make it may become vice-presidents.

DR. ALBERT WILSON: Is there any non-university that essentially does what a university does, bring them to appointment that is clearly temporary where a decision--

DR. LIBBY: No. They don't. They don't flaunt it. It is, shall we say, normal employment, and then after a few years, they are given this special salary and special freedom and special title. I think it works rather well. With some of the others, there is a difference. They move on to other parts of the company. It is our only protection here.

Another thing in the matter of hiring is the University system. That is, we go through an anonymous committee. As Director of the Institute of Geophysics, I never know the members of the committee. If I do, it is a pure accident. A nominee of mine is reviewed by the five-man committee, a secret committee, who passes the recommendation to the Chancellor. The Chancellor nearly always takes the advice of this committee. So we have to present a case.

DR. HAMERMASH: What is your batting average? How often does the review committee actually turn down a department recommendation?

DR. LIBBY: I think we bat better than 75 per cent, but at th same time, you see, we know there is no use putting up some people however much we may like them, and, of course, we all sit on these committees, too.

DR. SALZER: You made a comment about the difficulty in coordination between the university and industry. That was a very short comment and it sounded very sweeping. To what extent does it work and does it not work?

DR. LIBBY: I find that there is too little connection, too little discourse, between the university and industry--I mean the university laboratory and the industrial laboratory. I have always consulted a great deal. I have always done it not only for the extra money but for the contact.

When I was a professor at the University of Chicago, we had a contract where the funds from consulting had to be turned over to the university, and I did just as much consulting then as I do now. I was about one quarter of the time away from the campus in one way or another, and now I do it not only for the money and the contact, but I do it for my students. Half of my ten students are doing at least part of their theses in laboratories elsewhere. Now, they are not all industrial laboratories. Some are government laboratories, and it is this kind of relationship which is greatly beneficial in my work to me and my students.

DR. SALZER: This kind of relationship I thought does not exist fairly consistently.

DR. LIBBY: Not widely enough.

DR. SALZER: Do you think there are any other avenues of relationship?

DR. LIBBY: I do. Our industrial people could come in to the University to help more with the teaching.

DR. SALZER: You mean like an extension school here?

DR. LIBBY: Yes, but I would even take it a little more seriously. I think we could mutually--

DR. SILVERMAN: One thing that your remarks bring to mind is the fact that many students, in fact, most of the students, that go into industry are not prepared for industry at all.

DR. LIBBY: Not at all.

DR. SILVERMAN: They are strictly academically oriented.

DR. LIBBY: That is one of the benefits that we get out of a closer relationship. I don't know if we could go so far as to find another job for a year or so during their training, but at least give them a taste of it to see what it is like while they are in school.

DR. SILVERMAN: Along the same line, your remarks seemed to indicate that you think industry should adapt some of the practices that the universities have adopted.

DR. LIBBY: No. Our job is different. Our job is teaching. Your job is something else. We do research and learn to teach graduate students. I have a whole drawer full of absolutely brilliant ideas nobody has worked on because I haven't been able to sell them to anybody. Every research in my laboratories is connected with somebody who is here to learn. That is our business, you see. It is quite different from yours. Now, that doesn't mean that you don't have to do some teaching, on the job teaching; you do. But incidentally, we might be able to help you there, you know. But no, the objectives are quite different.

We could collaborate more, I think, and U.C.L.A. is one of the schools leading in this already. Some universities do very little, and I think they are failing on parts of their job.

MR. BOYKIN: You have touched briefly on a critical subject, the difficulty in attracting young people with potential into the scientific field. You are now associated with an institution that started without great renown in the physical sciences and is getting more renowned all the time. I happen to be an alumnus of

the other type that always seems to have a guilt complex because it isn't great in the humanities and the social sciences. All its alumni publications and all its people are promoting all of the things I don't have quite as much appreciation for. These are the so-called social sciences, and I am almost ashamed that they are de-emphasizing the engineering and the science courses.

DR. LIBBY: That is right.

MR. BOYKIN: Is there anything we can do about this?

DR. LIBBY: Well, of course, we can just try. That is the main job of a teacher. He has to sell the subject, and we work hard at it, but I don't think we are doing too well. The enrollment in physics in particular is falling and that is a very serious matter. Engineering enrollment is not holding up well. The enrollment in chemistry, my own field, is allright, but nothing great, and I think a lot of it is due to the "ballyhoo" about the social sciences.

DR. SALZER: Considering a program, I am coming back to anoth topic because if this bothers you, maybe something should be done about it.

I know a few examples that have moderate success. I know Cornell, for instance, has established a research park on campus where they rent facilities to industry and thereby establish a very close relationship over a limited amount of time. I don't know how successful this has been. It is rather new.

DR. LIBBY: If this kind of thing helps, but you know that being neighbors isn't adequate. I think the kind of thing you want is where the professor consults with the company, works on its problems, and the industrial scientist comes and actually

helps in the teaching process. This is one kind of relationship. Perhaps there are other ways of really effectively collaborating.

DR. ALBERT WILSON: Do you see any hard division between the higher areas of research that should be considered by a company doing basic research and, say, what is going on in the university?

DR. LIBBY: Yes. I think when one is doing a project, management has a real role, but in the basic research laboratory, I think all you want to do is pick the good people and then eventually turn them loose within your budgetary and space limitations and hold them to producing.

DR. ALBERT WILSON: Don't you have to have some restraints at least, for example, in terms of area?

DR. LIBBY: No.

DR. ALBERT WILSON: That means that your concept of an industrial basic research laboratory is that it is basically uncoupled.

DR. LIBBY: You should have an industrial basic research laboratory. The only people who should be in this laboratory should be those who can do research and want to. That brings up the problem that not everyone is so motivated. But when you have such an organization, there are enough people in it to spread out over the field of science. You know within your laboratory that you have people who are reading literature and are knowledgeable, and know where the frontiers are. In these various lines, they are kind of built-in consultants.

I think the good relationship to management is that these people work part time with the project divisions, but the time they spend in the basic research laboratories is spent doing research

on anything they want within the budget.

DR. SILVERMAN: But isn't one of the roles of management in that kind of organization to choose certain areas?

DR. LIBBY: Not in the research field, no. By and large, you cannot manage research. You can manage development.

DR. SILVERMAN: I am talking about management in the sense that you decide that you want to work in a certain area and you choose your people.

DR. LIBBY: Yes, but I would advise against it if the company is any real size, because you never know the impact of the development of, say, biochemistry on the electronic solid state physics. It may be major, for instance, or vice versa. You just never know where any fundamental knowledge is going to have an application.

Now, most companies only place a small part of their Research and Development funds in such a basic research group, anyhow, and they are justified, if the research is well done, by the feeling of confidence that the management can have that they are not going to miss out on a whole great new development. They are at least going to know what happened.

DR. SILVERMAN: Why not go to the universities for this kind of consultation.

DR. LIBBY: Well, you have the problem I just mentioned that we are subject to the whims and appetites of our graduate students As I said, I think I have some very critical problems the students seem to like very well, and they, in a sense, run in fashion to some degree. The students choose to take their degrees in certain areas like solid state physics, which is now having a good run, and in superconductivity which has an excellent run. There

are little bits of fashion in this. The real breakthrough may lie in some of those "dog" problems they don't want.

INTRODUCTION: SCIENTISTS AND THEIR PRODUCTIVITY

The productivity of a scientist is a sensitive subject. Both managers of scientists and the scientists themselves shy away from this topic for quite different reasons. Managers are held accountable by their superiors for the quantity, quality, and timeliness of scientific results as these are related to applied resources of manpower and capital. For managers, the effort-results ratio is critical but their actual experience in managing scientists leads them to be wary of applying this economic measure of productivity. They know from past practice that they get a negative response from their subordinates whenever a naked application of this measure of efficiency is made.

On his part, the scientist is not being merely temperamental. He feels strongly that the correlation between his effort and the results he gets is most unpredictable. Correlation is good when he states the problem correctly in the first place and when he selects the correct approach, also in the first instance. All strive to do this but it is very doubtful that many succeed. Failure in these steps eventually requires backtracking, rethinking, and the problem of devising new approaches. This process might take ten years; for another group assigned to the same problem it might take six months. These uncertainties are real and they explain the scientists' view that input-output ratios are simply unrealistic. The scientist is more frustrated by these problems than anyone else and he is noticeably sensitive whenever the matter of his productivity is raised.

Work is the exertion of effort to accomplish some end. The end toward which the scientist strives is perhaps best described as understanding. The scientist is essentially a problem-solver. Deriving from a feeling that he has to know, whether it be called curiosity or challenge, he must state the problem correctly, generate ideas concerning the approaches to its solution (including ideas concerning the implementation of the approaches), evaluate results (which often lead to a restatement of the problem and the generation of new plans to solve it), and interpret the results. This, the experimental scientist. The theoretical scientist likewise is a problem-solver. He especially is seeking understanding of phenomena. To this end he concerns himself with correctly formulating the issues, hypothesizing relationships (often employing mathematical tools for their testing), and suggesting a relationship, which if proved, leads to understanding.

This view of the scientist's work is borne out in this survey Asked what he does, as a scientist, the fifteen managers and fifty scientists mentioned idea generation and evaluating results 46 times; communication 33 times; and planning, measuring, observing, problem-solving, and keeping up with current literature 30 times each. The reporting of results in one form or another was mentioned with nearly equal frequency.

Both managers and scientists were asked how they thought productivity should be measured. Since this was an open-end question, an understandably large variety of terms were used to expres ideas. Some terms were undoubtedly synonyms and others reflected a partial overlap, but they are retained in the following table in order to preserve the flavor of the responses. Furthermore, an

attempt is made to group the responses in terms of the value of the scientific work as judged by other scientists and as judged internally in the enterprise. Even here there are overlaps though the prime consideration of the respondents comes through clearly.

TABLE I

THE MEASURES OF SCIENTIFIC WORK

Value of Work as Judged by Other Scientists	Number times Mentioned by Scientists	Managers
Publications	13	8
Judgment of peers	6	1
Papers read	5	4
Contribution of scientific knowledge	4	1
Stature (includes honors, awards)	1	2
Work quoted	1	0
Reputation (includes invited talks)	0	2
Value of Work as Judged Internally		
End item produced	7	3
Quality of work	6	1
Reports	5	2
Number original ideas (includes inventions, innovations)	5	2
Patents	1	6
Consulting	1	1
Products (including hardware)	1	1
Success of proposals	1	1
Unique laboratory facilities developed	0	3
Unique analytical techniques developed	0	2
Application to new products	0	1
Number of Respondents	38	15

The number of times publication was mentioned is a bit frightening. There seems to be as much reliance on this "measureable" factor in industry as there is in the university. And yet, the thoughtful person will certainly agree with the respondent who commented:

> I think the only meaningful measures of productivity are 1) evaluations by members of the whole scientific community (for people who are great); 2) evaluation of work by people who are in the same field; and 3) evaluation of contributions by colleagues. The common method of counting publications is very poor since many are not only valueless but actually detrimental to science. Much time is frequently wasted in proving that somebody else made a mistake. Of useful papers, some are at least 100 times more useful than others. Citation indexes are somewhat better but the incorrect paper will still be cited by all the people whose results contradict it; and compilations or review papers will be cited by many people although they contain no new information.
>
> If number of publications is used as the measure of productivity you will almost certainly find that people under pressure to publish do indeed publish more papers. However, their contribution to science is likely to be less than that of people working in a more relaxed atmosphere.

A more positive approach to this problem was suggested by another respondent:

> To measure output you have to define output. If output is defined as "published works of value to the scientific community" then I propose a unique and simple way to measure this. We would make use of the Science Citation Index which indexes the current publications in more than 1500 technical journals by the reference to the previous literature which the current papers cite. Since there is an abundance of journals that will publish almost anything, simply counting publications by Institution A with environment A versus Institution B with environment B is meaningless. But if the scientific community as a whole makes use of and refers to the publications of Institution A to a greater extent than those of Institution B, then by our previously accepted definition, the output of A is greater than B. Obviously, refinements are necessary, such as some sort of weighting inversely proportional to the number of authors (a paper with 5 authors has less "unit output" than a paper with only 1 author), and normalization by the number of scientists employed in the particular institution. Also, it would seem that a correction should be made for citations by an author to his own previous work. Actually, since the Science Citation Index is produced from computer tapes, it is conceivable

that entire output evaluation problems could be programmed for the computer.

Judging from the number of times these several measures of scientific work were mentioned by the scientists, it would appear that the latter have a greater sense of security in the evaluations of peers external to the enterprise than they have in the evaluations made internally. Indeed, all the terms used in this category could very well be interpreted to mean "judgment by external peers." The scientists' concern about their reputations may reflect a lack of confidence in internal measurements of productivity: it may also reflect a fear of becoming isolated in the enterprise laboratory, a fear of losing contact with the scientific community, and a fear of relying upon internal judgments that control their careers. Their mobility is much enhanced if their work is highly regarded by external peers--one way of saying that they withold exclusive identification with their employers.[1/]

On the other hand, it should be remarked that scientists seem to show considerable respect for internal evaluations also. It would be difficult to prove, but it is probable, that scientists now reflect a greater respect for this type of evaluation today than they did twenty years ago.

The managers of these scientists are also much concerned about the evaluations of the external scientific community, but probably for different reasons. They can use these evaluations as a guide in recruitment, as confirmation of their own judgment, and as a means of motivating their subordinates. They clearly

[1/] A conclusion confirming that reached by H. M. Vollmer, Work Activities and Attitudes of Scientists and Research Managers: Data from a National Survey, (Menlo Park, California: Stanford Research Institute, May 1965), page 5.

have considerable confidence in their own measures of productivity since they stress patents, end items, and the development of unique facilities and new analytical techniques even though these leave scientists quite unimpressed.

The inherent difficulty in measuring productivity should not be obscured by the foregoing responses. The fact that only thirty-eight of the fifty-one scientists in the survey attempted to respond is particularly significant. The remainder felt that the question could not be answered. On the other hand, their managers reflected more confidence, if one may judge by the fact that all of them in the survey did respond. One may even go further and say that the managers feel confident of their ability to measure even though the evidence of external peer judgment be absent. This view is reflected in their techniques of appraisal, a subject to be considered at a later point in this manuscript. When it is recalled that these managers are scientists in their own right, their views are of great importance.

The productivity of scientists is influenced by many things, some within the control of the scientist himself. For instance, the quality of the scientist's education, his personality characteristics, and his wisdom, all bear on this problem. Scientists vary greatly in the knowledge they possess at the time they graduate from college, in the degree to which they keep up with the state of the art, and in their mental discipline. The scientist's personality is also a vital factor. His curiosity, the insight he possesses, his unflagging attention, and his integrity are immensely important. Out of all these and with experience added, the scientist develops wisdom. This factor was mentioned

by one scientist when he stressed the efficiency with which a man worked, "He simply avoided mistakes of judgment in stating the problem and in selecting the best means of investigating it." All of these factors are under the control of the scientist. He brings to bear these abilities and his results should certainly be affected by them.

On the other hand, there are numerous other factors that affect productivity which are not within the control of the scientist. They are under the control of the manager. These can best be analyzed by grouping them into those that relate to planning and control activities, organization of the laboratory, the selection and appraisal of scientists, and the direction of their work.

CHAPTER I

THE MANAGING PROCESS

In our society, characterized as it is by achieving objectives through organized effort, there is no activity as vital as the quality of managing. The manager occupies the key position; he alone is accountable for the results of group effort. And yet, despite the critical nature of this function, it remains generally misunderstood. The verb 'to manage' has many connotations and this characteristic invites carelessness in its usage. If advances are to be made toward a science of management we must strive for exactitude of its terminology.

The manager is the only one who engages in the process of managing and he bases his actions on his understanding of a body of knowledge called management. The managing process comprises those functions peculiar to the manager as he attempts to achieve objectives by the sagacious combination of resources. These the economists have long since called land, labor and capital. The manager, as a fourth factor of production, emerges when it is desirable to secure selected objectives through the organized effort of specialized labor aided by capital, equipment and space.

Organized effort has been a characteristic of human societies since the dawn of history but the separate skills of the manager were not recognized until recent times. Even as late as the 1920's American scholars were trying to discover what functions managers performed as distinguished from the functions of non-managers. This was no easy task. The men who managed were employed early in their careers for their technical skills in such areas as

accounting, engineering, selling and manufacturing. It was universally thought that those who succeeded to managerial positions required these technical skills. Thus, in our early history production problems were seen as of prime importance and production managers typically succeeded to the top managerial positions. During the first quarter of the twentieth century production had caught up with the market and the important problem became that of marketing huge quantities of products. In these circumstances sales managers tended to be appointed to presidencies. During the second World War engineering problems had top priority and industrial firms tended to select presidents from the engineering staff. At the present time finance is seen as most critical and hence American firms are tending to turn to the finance people for top managerial positions. This whole process is entirely illogical and does point up the fact that managing as a separate skill is still not fully recognized.

This is not to say that managers do not have to understand the activities required to produce goods and services. Quite the contrary, it is essential that they be fully steeped in the technical processes and the efficient means of their integration. Their wisdom derives from the analysis of their years of experience gathered as they rose through organizational ranks. By the time they reach general management positions they hopefully are skilled managers but they certainly are not technically skilled. There are two factors that account for this situation. First, the general managers may have had at one time a high skill in some technical activity such as engineering, accounting, selling, or law, but man does not live long enough

to acquire technical skills in all functions. Thus, the general managers typically reach their positions with a record of early technical skill in only one of several key functions. If they do not have skills in several, why do they need it in one? Second, the front line managers who are selected from technically proficient non-managerial ranks not only have but they must have technical skill in their area of concern. However, as they move higher in the organization structure, through middle to top positions in management they clearly lose their technical proficiency. When they reach the top of the structure they frequently bring with them a rich knowledge of the managing process and a full understanding of the technical skills required in the several functions of the organization. But they cannot perform the technical job itself: this must be accomplished by the expert non-managers.

OBJECTIVE OF THE MANAGING PROCESS

It would seem that we have a very human need to distinguish between the purpose and the objectives of cooperative effort. It is the function of the statement of purpose to carve out a broad area of achievement and communicate it in sweeping terms. The preamble to the constitution of the United States is a good example. The purpose of the civilian space agency is to explore our galaxy. The purpose of a university is to educate students. The purpose of a particular business may be to manufacture steel products. The State and some of its agencies are monopolies that will not share their purposes with others but competitive institutions often do have the same purposes.

Since purpose is really not actionable all associative activities develop objectives which, if attained through time, will realize purpose. Objectives comprise a group of goals to be striven for in the short and long term. They are quantified specifics, arranged in order of priority and of simultaneity, for whose attainment productive resources are selected and accumulated, integrated, and directed. Theoretically the achievement of each objective should take the enterprise a step further in the accomplishment of its purpose. But since purpose may be very long term in nature, is often very vague, and is subject to different interpretations by different managers and even to changing interpretation by the same manager it often happens that it is never fully realized and that selected objectives may cause effort to be canalized in conflicting ways, and with changing emphasis. The more dynamic the environment the greater the chance of changing purpose and the choice of objectives to accomplish it.

The accomplishment of purpose in cooperative effort requires that the managing function be executed. In all human experience the successful coordination of resources for the attainment of a purpose requires the services of a manager who is held accountable for results. He goes by many titles: king, president, chairman, director. Groups cannot be held accountable for results because they are inefficient, anonymous, and unstable. This is not to say that they are not used. They exhibit all the negative characteristics and either dissolve because of impotence or permit the emergence of one who is supreme among "equals". Everywhere it is the manager who is accountable for the realization of purpose. And if he is accountable he will execute the functions essential for the success of his undertaking. His first duty is to design the process.

DESIGN OF THE PROCESS

The manager who is accountable for the attainment of purpose may be appointed by others, as is the case of the top administrator of a government agency, of a president appointed by a board of directors, or a subordinate manager appointed by the enterprise president. He may also be an entrepreneur who visualizes a self-determined purpose and sets about its achievement. In any case there is no doubt about the supreme importance of succeeding within, of course, the limitations of the law and of the ethical constraints of the environment. The importance of all other activities in which he engages are subordinate to the achievement of purpose.

The manager is first concerned about understanding the purpose to be achieved. Vagueness must be replaced, at least in his own mind, with greater clarity. The original purpose will require defining, refining, additions and exclusions until a clear outline of its image emerges. This is a highly essential process because it is important to know more certainly when the purpose is achieved, what must be done in order to achieve it, and because it is then much easier to communicate the purpose to those who are concerned.

Although often neglected it is certainly critical for the manager to ask himself, What evidence is required to assure that purpose will be attained? In every case the evidence will be complex in the sense that it will be comprised of several

pieces of knowledge. The university president whose purpose is the education of students should decide what would show that his graduates are indeed educated. This would surely require a follow-up study to determine the relative success of these graduates in achieving personal perfection in contributing to knowledge, in the progress of institutions of which they are members, and in facilitating the pursuit of happiness for all mankind. The president of a business firm may seek the needed evidence in the financial health of the firm, its relative competitive standing, and its contribution to our society. The director of a research laboratory within a corporation may seek his evidence in contributions to knowledge, support of other divisions of the firm, and in an esteemed reputation for the laboratory. Any manager who tries to predetermine the evidence he will require would find himself moving back and forth between clarification of purpose and identifying the needed evidence until he is satisfied that the problem is understood and can be optimally solved.

Within this framework the manager selects the objectives of the enterprise. These are integrated with respect to time so that the long range objectives are supported and buttressed by short term objectives. All are quantified so that it will be known specifically whether they are achieved and also because quantification will have a direct effect upon the nature and extent of resources that will be required. The objectives will be examined from the standpoint of priority and lead-time, and analyzed in terms of the kind of activities which must be undertaken and the quantity, quality and nature of resources that will

be needed. At this point the objectives are actionable and are ready for fractionation and assignment in some manner among the subordinate managers of the enterprise to be.

One other step in the design process involves a decision about the kind of internal environment that will prevail. This is really another way of stating that the manager's philosophy of managing needs to be clarified. Decisions have to be made about decentralization of authority, the quality of cooperation, the reward system, and community relations. The intended results may conceivably be attained by several combinations of these factors but the manager will choose that arrangement which yields him the maximum personal satisfaction from his efforts.

It should be inferred that designing the process by which a purpose is to be achieved requires a high order of intellectual effort. The pursuit of every purpose must make its positive contribution to our social objectives. For this reason it is essential that the managers who design the process have a broad knowledge of our society, its culture and institutions; understand the market to be served and the economics of enterprise; and possess the ability to analyze the total situation. Ability of the order required would seem to be most scarce if one is to judge by the rarity of even outstanding, if not brilliant, conceptions. On the other hand the mediocrity of selected purpose and process designs which one can see at every turn, whether it be a government agency, a university, a hospital or a business, may lead one to conclude that the critical nature of this function is not understood. If it is the general belief that "anyone can manage" or that managing is merely a "high order of

clerical activity" then surely performance of the function will run the gamut from indifferent to tragic.

FUNCTIONS OF MANAGERS

The concept of managing as a separate skill is so recent that one may recall the struggle of investigators to identify the manager. This was no mean proposition. If one had no knowledge of managing and if he were sent to an agency or a firm for the purpose of screening out the managers, just how would he proceed? He might list those who had the title of manager--but he would miss many such as supervisor, president, and directors. He might ask everyone to point out his superior--and everyone would be able to do so. And he might inquire and observe what each person does--and get such answers as solder a wire, sign checks, operate a punch press, arrange for working capital at a bank, sign a lease, type a report. These responses would surely add up to many thousands and none would necessarily aid in distinguishing managers from non-managers. Actually, this technique is highly productive but it is adopted too early in the analytical process. The key first step is to isolate those people who have subordinates reporting to them, a decision based on the knowledge that "manage" is derived from the Latin manus (hand) and probably influenced by the French "menage" (housekeeping). At this point it becomes significant to identify what people do, compare the activities of those having subordinates and those having none, and strain out the actions of those having subordinates which are common to those without subordinates. At this point there would be a list of actions which only superiors perform and these superiors are now commonly called managers.

An examination of the long list of what managers qua managers do quickly leads to the conclusion that some method of classification is necessary if progress is to be made in understanding the process. As in the case of other sciences many suggestions for an appropriate system of categories have been made. The one adopted here is to group these activities into the functions of planning, organizing, staffing, directing, and controlling. This choice was made because it was found that communication between manager and investigator was facilitated when this particular system was employed.

PLANNING

Planning is the logical process of specifying a future objective to be achieved, identifying the constraints within which it must be attained, selecting the best available course of action to achieve it, and scheduling the chronological activities essential to its achievement. No plan can exist until all these steps are executed. But simple as they are to list, each requires very careful consideration on the part of the planner.

Specification of the Objective

The selection of the objective and its proper formulation requires both understanding and experience. Many objectives occur to the planner as he contemplates the route to the realization of enterprise purpose. They differ in terms of priority, in the lead time required, and in the support which short range accomplishment must provide for the economical attainment of long run goals. The process is not the simple matter of selecting an objective and planning to achieve it. The whole series

of objectives must be conceptualized and arranged in the order of attack. Only then can priorities in terms of importance and timing be identified.

Once selected, the objective requires definition and quantification. Any vagueness or uncertainty in its description at this point will vitiate the whole process. Therefore a convenient method for describing the exact goal needs to be found, and when it is, it needs to be stated in such a way that the degree of accomplishment can be measured. Anything less than this can only lead to inefficiencies and ineffectiveness. For instance, it is insufficient to choose as an objective the development of a channel for the distribution of a firm's products or the development of a plastic shield for an airborne nuclear reactor. In the former case it is necessary to specify which channel is chosen, the number and location of outlets, the qualification of outlets in terms of resources, and the time for the completion of the task. In the latter case it is necessary to specify weight in relation to lead, physical characteristics that bear on the objective, perhaps time. Quantification in similar terms yields two important benefits. It makes possible a relatively accurate determination of the extent and quality of resources needed to accomplish the objective and it can be known exactly whether and to what extent the desired objective will have been achieved.

An important aspect of objectives is that they be actionable, or possible of achievement. In practically all cases the statement of objective can be made to qualify under this head. But the area of theoretical research does seem to be an exception.

Much can be known about the desired objective as far as relevant factors and the desired formulation of relationships are concerned. Timing is quite a different matter since achievement cannot be predicted. The planning of research beyond the frontiers of knowledge is inordinately difficult for this reason.

Another roadblock sometimes encountered in the proper formulation of the objective is the seeming inability to quantify some objectives. In such cases as these the planner certainly should not abandon his task. Rather, he should look within the elements of the desired objective to see, perhaps even to conduct an experiment to see, if some significant quantifiable elements can be identified which correlate with the desired objective. If found, such elements can be used as a substitute for the original statement of the objective.

Identification of the Premises

Planning premises are the constraints within which the accomplishment of the objective is to be achieved. They are comprised typically of policies, forecasts and budgetary limitations. Policies are guides to the thinking and actions of managers; they do not tell a man what to do but they do indicate that when action is taken it must be within the guidelines of policy. They have several functions. Sometimes they specify how objectives are to be approached. Wage policy may be to pay competitive prices for labor, tax policy may be to encourage voluntary compliance, recruitment policy may be to employ proven competent scientists. Policies also predecide numerous recurrent issues and thus make continuing decisions unnecessary. In the planning process it is important to identify those policies which affect

the way in which the objective is to be sought. In this sense they are an economical device which precludes the development of plans which violate policy.

Definitive forecasts of future events that have a bearing upon the accomplishment of an objective are planning constraints. In business enterprises the sales forecast is of prime importance. Once it is made and accepted by top managers it becomes a restraint for all subordinate plans developed by marketing, production, finance and other internal functions. Plans involving these functions are all based upon the assumption that the sales forecast will be achieved. Similarly, forecasts of tax changes, wage levels, available skills and other factors must be made if they are relevant to the achievement of the objective. Plans made in defiance or in ignorance of these types of constraints almost certainly will have to be made again.

Approved operating budgets are also planning constraints. Since funds are always scarce in terms of perceived needs it is essential to plan expenditures by means of an intelligent budget. This provides the upper guideline on permissible spending and as such stands as a constraint on operating plans.

From a logical point of view the identification of premises is quite unnecessary in the planning process. Rather, it is a recommended step in the procedure because it is an economical practice. Planning is a costly process under any circumstances and if the identification of premises forestalls the development of plans which cannot be executed because they ignore constraints it will have accomplished its purpose. Replanning for this reason will be unnecessary.

Selection of the Best Course of Action

Efficiency demands that the best available course of action be followed in the pursuit of the objective. Time, money and knowledge are ordinarily much too scarce to permit an exhaustive search for the ideal course of action. Judgment must be used to determine the extent of the search. On the other hand, men being creatures of habit and perhaps lazy in addition, it is altogether too easy to follow a course of action used in the past, or one that first occurs to mind. Between these extremes there is a broad, practical basis for identifying competitive courses of possible action. There are always alternatives. For instance, any manager has available to him his past practice, the practice of competitors within and without the firm, articles in technical journals and technical histories, and his own innovation which might be comprised of the better elements of competing courses of action. He may even be inspired to create an actionable procedure.

The special importance of identifying alternatives is that the best among them has a chance to compete. It is not too much to say that a particular course of action being followed at a moment in time is rather unlikely to be the best one. This is due to the neglect of the review function. The very fact that resources are always limited argues in favor of a search for the most efficient procedure. Once this is done, selection or decision making is almost anticlimatic. Some alternatives may be eliminated at first consideration, others may have to be costed, and ultimately the judgment of experience may be brought to bear. Whatever the result, the planner knows that he has the best

practicable course of action to follow.

Schedule of Activities

The last step in the planning process involves the scheduling of activities. There are at least three important elements to be identified: activity, who is to perform each, and when. Some would add the element of cost. It is often a very difficult matter to determine exactly what actions are essential to the attainment of an objective. The mere fact of planning assumes a series of actions hundreds and even thousands in number. And yet the planner must know what are these actions and in what order they are to be performed. Their chronological listing serves the purposes of understanding and efficiency in their control.

It is equally important to specify who is to accomplish each action. Good management requires the accountability of individuals for productive activities: it is obviously futile to specify an action and not know who is responsible for its successful accomplishment.

Scheduling the time when the activity is to be started and completed, and perhaps the quantity to be finished within that span is also essential. Consideration of this factor will require attention to the time when the objective is to be completed and permit the planner to work back in order to allow for sufficient lead time for successive operations and for opportunities to schedule simultaneous action where feasible.

Practical Considerations

Formal planning as described above is a costly process. As a consequence, it is only sensible to identify certain ob-

jectives for this treatment. One need not plan in making even a serious decision. The major elements can be recognized, weighted, and evaluated without a plan. Neither is a formal plan required for the attainment of rather simple goals. On the other hand, formal planning is certainly required for top priority objectives whose accomplishment involves numerous activities carried out over a long period of time. The human being is simply not capable of keeping in his head thousands of actions spaced in time. Furthermore, from a financial point of view it is ordinarily important to budget for and keep track of costs. This requirement is facilitated by adopting a formal plan.

All plans should permit flexibility in their execution. Men are not clairvoyant and no one needs to be reminded that numerous errors creep into original schedules due to failure to forecast accurately when in fact each activity will be undertaken. The manager has a need to shift resources and timing in order to get back on schedule and he should certainly be permitted to do so. The need to develop a totally new plan is a rarity indeed. It does occur when unforeseen cataclysmic events intrude. For instance, a shift from a war to a peace footing, a major cyclical depression, or a catastrophic plague would surely force replanning. But anything less can be handled through the device of flexibility.

Another fact of life about planning is that any decision to proceed to a specific objective necessarily involves the cost of sacrificing other goals. Since resources are scarce but essential in the attainment of objectives it follows that basic decisions of priority and timing, and even of exclusion, have to

be made. A plan to finance the college education of a child excludes the use of funds for other purposes. The sacrifice involved is the measure of the cost of following the plan. A decision to devote resources to development may exclude the employment of funds for research. A manager should be aware of the human tendency to evaluate positively the gains to be achieved by securing a particular goal and to ignore the costs, called alternative by economists, of sacrificing other potential goals.

Despite these practical issues there does remain the central fact that planning is an instrument that permits us to command the future. We need not be in the position of waiting for or responding to a future event. Planning is seriously misunderstood, as it is by most businessmen, if it is conceived as merely a guess about what conditions will prevail at a future time. Planning specifies what will happen at a specified future time: the degree of certainty is astonishingly high if the plan is well conceived and is executed as anticipated. True, there may be the catastrophe that upsets a plan. But these are few indeed, and anything less can be absorbed by flexible action. We are indeed approaching the time when we can really plan what will occur in the future, and see that it happens.

ORGANIZING

Organization is a social invention created in order to focus the energies of enterprise cooperators upon the accomplishment of some purpose. From a conceptual point of view he who would organize has a need to understand the many activities which must be performed in order to reach his goals. These activities are then grouped into what is conceived as the best means of facili-

tating the flow of work towards the desired end. The chief problems encountered in constructing the formal organization structure are the span of management, line-staff-service relationships, decentralization of authority, and the use of committees.

Span of Management

The central issue in the span of management is the number of people who should report to a particular manager. This problem has been intensively studied. Some writers are interested in reporting what managers actually do about the problem, others have tried to develop mathematical formulae, and a few choose a specific number and suggest that it neither be exceeded nor underplayed. The fact of the matter is that no generalization can be made because there are too many unstable variables to be considered.

The manager strives to determine the number of subordinates that he can effectively supervise. He himself is one of the variables. His proficiency in conceptualizing his job, in executing effectively and efficiently his several functions as a manager, in the use of his time, and in his choice of control devices such as formal reports compared with face-to-face conferences are all important variables. And of course, managers differ from each other in these respects.

Subordinates are another variable. The amount of supervisory time which they require differs with respect to each of them due to their training, dependency, need for attention and encouragement, and the rewards which they seek. Since time has its influence on all these factors subordinates do change in terms of experience, reliability and efficiency. Also, the per-

sonal identity of subordinates changes as a result of promotion, transfer and termination. The "correct" number of subordinates that fits one set of circumstances at a moment of time will surely be incorrect as each day passes.

Another category of variables concerns the environment in which the manager and his subordinates must work. The internal environment is affected by the management philosophy of the top manager, the atmosphere of autocracy or permissiveness he creates, and the tradition of numerous meetings, conferences and committee work. The external environment is affected by the scope of the enterprise activities, trade association work, the meetings of learned societies, and traditions or even requirements of customer servicing. These circumstances affect the available time of any manager to supervise his subordinates and thereby affect their number.

Full time and part time managers have quite different problems with respect to their spans of management. The part time manager is frequently encountered at the supervisory level. He manages some subordinates but is also expected to engage in the technical work of his group as is any other subordinate. Sometimes this arrangement is used in an emerging department where the scope of work does not yet call for a full time manager; sometimes it is a response to the contraction in staff resulting from a decline in the work load; and sometimes it is a deliberate arrangement, often encountered in engineering and research organizations. Whatever the reason, it is abundantly clear that the part time manager will certainly have fewer subordinates reporting to him than his full time counterpart.

Every thoughtful manager is concerned about his span of management. He feels continually the stresses and strains of supervising subordinates from month to month and year to year. He strives to determine the correct number of subordinates for him. He readily knows when he has reached the extreme of underemployment because he gets bored; he knows when he has reached the extreme of overemployment because his effectiveness sharply declines. Between the extremes there is always much uncertainty about whether his span is really correct. Stable organization structures reflect this latter condition. Organization change is the normal correctional procedure if the manager is operating at either extreme.

Line-Staff-Service Relationships

These types of organizational groups are distinguishable in terms of their functions, the reasons for breaking them out, and the authority of their managers. Line functions represent the indispensable activities required to produce the services or products of the enterprise. Their nature depends entirely upon what is to be produced, and the relevant technology: the way they are grouped depends upon the manager's skill. Group titles such as Engineering, Teaching, Auditing, and Research are just as meaningful and appropriate as Manufacturing, Marketing and Finance. The managers of these groups are fully accountable to their superiors for results and are delegated the authority needed to accomplish them.

The service function is closely allied to the line because it derived therefrom. Activities implied by the terms Accounting, Personnel, and Maintenance were typically carried out by line managers

until the firm grew in size to the point that economies were gained from specialization. Additional advantages can be obtained from this segregation of function because the personnel employed are experts in their specialties and because the group can be used for monitoring policy. The particular function of service groups is service. They are primarily in existence to facilitate the line operations, Accounting by providing financial visibility, Personnel by providing standards for recruitment, wages and salaries, appraisals, and industrial peace, and Maintenance by providing repair and upkeep services. Service group managers often possess functional authority over the other peer and subordinate managers. For instance, Accounting may require financial information at specific times and in particular forms, Personnel may have an industrial relations function (or vice versa in large firms) whose head may carry on negotiations with unions and make contract interpretations, and in some situations the maintenance managers may be in charge of safety and have the authority to shut down an operation.

The pure staff executes the functions of investigation and recommendation to line and service superiors. They come into being when there is a need for a continuing full-time attention to the study of particular problems. Needs that are occasional and that are best met by several people are normally filled by consulting firms. The staff is always comprised of experts in narrow fields, such as economics, planning, taxes, markets, and law. It has no authority over anyone else and thus its function is served when persuasion is used to influence the acceptance of recommendations.

Decentralization of Authority

The degree of decentralization of authority is a relative matter. Very small firms with only one manager obviously remain fully centralized; at the other extreme, the full decentralization of authority to the technician level would produce only chaos. Practically all enterprises operate with authority decentralized to some point within these extremes. All managers at the various levels of the organization must have some authority and therefore some degree of decentralization always exists. But it can be in greater or less degree depending upon numerous circumstances. The quality and extent of the education and experience of employees is an important variable, as is the desire to provide opportunities for the training and development of subordinates, the critical nature or situation in which an enterprise or any of its parts finds itself, and the proven ability of the several managers. It follows that decentralization may be greater in some divisions and departments than in others. Furthermore, authority over some functions such as direction of subordinates and staffing positions and over some parts of them such as budget responsibility and contract negotiations may well be decentralized while planning for and control of the total enterprise must be centralized.

Authority decentralization may best be viewed as a technique of the manager. He is concerned with getting the best results with available resources. To this end he will plan as effectively as he can, structure the organization in the way that yields the best results, select the best combination of personnel, and decentralize authority among managers in the

degree that achieves the best results. It is the manager's judgment that, in the end, is the critical factor. This is why the manager needs a broad and deep knowledge of his external environment, of the internal operations, and of how he can realize the highest degree of productive capability from his subordinates. He must apply this knowledge with intelligence not once and for all, but in a continuing manner as he grows in wisdom.

Committees

A committee is comprised of two or more people of equal organizational stature who are assigned a specific problem for investigation and recommendation. The committee may come from within an organizational group such as a department or it may represent several organizational groups. In the first instance its primary function is to focus attention on some problem that needs solution. In the second instance its chief use is to aid in achieving cooperation among peer groups. An exception to this classification is the plural executive used for legal reasons as is the case of the board of directors of a corporation

Committees can be useful. They can bring together knowledge and experience not possessed by one individual; they can broaden the knowledge of its members about the functioning of other groups; and they can recommend solutions for problems that otherwise would not get solved. When employed by the common superior of the membership for these purposes the committee device can be highly productive. Unfortunately, this is not the typical result. Committees are frequently used for unproductive purposes such as to delay action, to take the place

of a single manager, to permit avoidance of personal responsibility, and to substitute for a poor organization structure. It is clearly the responsibility of the manager to employ the committee technique properly because its potential for high cost and frustration is enormous.

STAFFING

Among the many terms used in management literature that of staff and staffing present serious difficulties. In ordinary business practice if staff is used as a noun it means employees; in the sense of a staff meeting it refers to the subordinates of a particular manager; and if used in contrast to line it means certain experts employed to investigate and recommend action to their superiors. As a function of the manager staffing is the process of recruiting, training, evaluating and promoting managers.

The special attention implied in this definition to the problems of choosing and maturing our managers is fully deserved. The manager is the key person in cooperative enterprise. He is responsible for its success and for its failure. Through his lack of skills he can easily destroy a vigorous enterprise and he can rescue a desultory enterprise and make it strong and successful. Wherever success or failure are discerned there stands behind it a manager who caused these results.

The able manager, few though he be, rises to the challenge of enterprise. He identifies the opportunity before it is clarified for others to see, he gathers the resources essential for his purposes, and establishes the environment within which all employees, both subordinate managers and technical personnel,

are encouraged to realize their full productive capabilities. On the other hand, the mediocre manager, of whom there are legion, imitates the activities of this able manager, but always too slowly to establish a market advantage, too unenlightened in selecting and managing resources, and too ready to blame inevitable failure on government, competition, or on the indifferent contributions to effort made by poorly chosen employees.

Critical as is the function of the top manager of enterprise it should not be overlooked that the activity of the subordinate manager, whether this be at the division, the department, or the section level, is almost as critical. True, if identified on time, the inadequate subordinate manager can be removed and the sore of his deficient operation cured. But the major problem is that the work of the enterprise gets done at the cutting edge between front line supervisor and his technicians and professionals. The top manager is a long way from this point. He must rely on many other people, his peers, the body of middle managers, and his supervisors to act in unison, as he would act, to accomplish his intended results. The frustration potential in this organizational system is immense and so also are the rewards. The solution to the problem is the integrated power of the body of able managers. There is little science and much art in selecting these men, and maturing them.

Selection

Although the results which we want managers to achieve can be described in rather accurate terms the problem of identifying with assurance the man who will produce them almost

defies solution. The situation is ideal for the advocates of fads and fancies and techniques because it is enormously complex and we have no science to aid us.

The front line supervisor who oversees the work of non-managers such as technicians, engineers, scientists or accountants has a key role to play. He is the only manager who interfaces with the technical force. He must be management-oriented because he is in a position of trust, reflecting the objectives of his superiors and their operating philosophy. On the other hand, he creates the environment which he deems will best facilitate the most productive response of his subordinates. Such a person must really want to be a manager and he must have demonstrated that he is a man of integrity and possess leadership ability. Other essential qualities such as the abilities to communicate effectively and to utilize logical analytical methods he can learn. He will be most likely selected from the technical personnel because he needs technical capability to recruit, train, oversee and inspire subordinates. Indeed, the process of selecting the front line supervisor is both critical and complex and should never be approached in a cavalier fashion.

The selection of middle and top level managers can be undertaken with much less chance of error. They have created a management record and its quality is still the best device for reliably predicting their future success. Although errors may still be made in estimating how a candidate will interface with higher level peers, and whether he will "top-out," there really is no excuse for appointing mediocre middle and top managers.

Men at this level manage managers and it is inevitable that the higher they rise in the organizational structure the less current will be their technical capability. This phenomenon has long been recognized and is universally accepted as a certainty. This factor, however, has not noticeably restricted the success of large institutions. Nevertheless, it is the current fashion of scientists, engineers and other specialists to demand technical excellence of their middle and top division or laboratory managers. They often expect these managers to prove their currency by carrying on personal research or other technical activity. Should they have their way they would seriously limit the growth of their organizations because the number of people who could be supervised would be limited, and the quality of the managerial function would deteriorate through neglect.

Development of Managers

Development is a progressive concept that envisions growth in managerial skill. Growth is presumed to be the product of understanding the principles of management and the highly developed art of their application. The opportunity for development is provided by the employer and the manager eagerly seizes upon it. This picture of the developing manager has been cultivated for some time. It has been a natural conclusion from the premise that men cannot be made to learn, but they will learn of their own accord if the opportunity presents itself.

This view of the manager, eagerly making the most of the development opportunities offered by the firm, is very, very

far from reality. The proportion of managers who really fit this conception is surely very low, perhaps less than 10%. What really occurs in organized enterprise is imposed development. Thus, the subordinate manager grows in wisdom to the extent that his superior coaches and counsels him, and insists upon improved methods of executing the managerial functions. This, of course, can be a highly successful technique if the superior understands the managing process himself and is able to teach it. If he cannot do this, no amount of "training" by outsiders will be productive of results except for the insightful 10%.

At the time that a scientist or engineer is selected to become a front line supervisor he stands in great need to know how to deal with his external environment. He needs to become acquainted with the myriad details concerning the use of support and service groups. Budgets, accounting reports, supplies, maintenance service, procedures and policies, personnel services, and purchase requisitions are all mysteries; the authority he really has is always indeterminate; enterprise philosophy, division or laboratory objectives need to be known and interpreted in terms of the contributions of the new supervisor to them; numerous internal issues concerning the execution of the managerial functions await his acquaintance.

The most effective way to come quickly to grips with these needs to know is through on-the-job training. If the newly designated supervisor can be assigned for a month or so to a successful, experienced supervisor who can teach there would be created a learning situation with the highest potential for

results. The motivation to learn would be self-propelled and the needs to know would be obvious.

The successful practice of management for several years at the front line supervisory level is the typical preparation for selection as a middle level manager. What, in addition to his past experience, does such a candidate need to know and how can this be learned most effectively? At this point in his career the newly appointed middle manager needs a philosophy of management. He needs to have an opportunity to achieve a comprehensive and cohesive understanding of the process of managing. From this point on in his career he will be managing managers and to do this effectively calls for a clear understanding of the principles of management. As always, the most effective coach for this purpose is his new superior. The incentive to learn and to apply principles skillfully could not be more favorably disposed. In practice, however, the duty of explaining management philosophy to newly appointed middle managers is typically assigned to an outside instructor. This, of course, is a very inferior way to achieve the intended results because the learning situation leaves much to be desired and there are very few outside instructors who have an operational philosophy of management. It is perfectly clear that enterprise will not achieve its potential for best results until its superior managers begin to discharge their personal responsibility for the effective development of their subordinate managers. This is a duty that could be effectively discharged by the retired managers of the enterprise.

Candidates for top management positions normally achieve this status as a result of successful experience in a single division or function. They are broadly experienced in a narrow activity: what is needed for top management position is men who are broadly experienced in several activities. Of course, it is not possible, since there is a limit to time, for any man to be fully experienced in all functions of the enterprise which they would head. In a practical world the firm should provide them with broadening opportunities when they reach the top of the middle level managers. This can be done in several ways. Putting them in charge of a full-function division, locating them in foreign lands to head the operations there, or perhaps having them run operations of a public relations nature are the means available. So long as the key to these broadening experiences--actual accountability for results--is always kept in mind the development opportunities are maximized.

Appraisal

It would appear obvious that managers are appraised and that the most reasonable basis should be the results of their managership. But we do not always do what is obvious. For several decades the typical evaluation was based upon a list of personal characteristics, ever changing in content and always unmeasurable. This was a preposterous situation, sometimes amusing to operating managers and sometimes frustrating if they took the matter seriously. It was a long time before the academic types really understood that managers are paid for getting results, not for demonstrating an arbitrary list of

personal characteristics.

The common insistence of personnel managers upon appraisal forms that reflected personal qualities was based upon the assumption that those who possessed these qualities in high degree would be successful managers. This approach has been a failure because there is no known group of qualities that managers must have and because managers are not employed just because they possess such a set of these characteristics. They are on the payroll to get results desired by the enterprise. Thus, the logic of appraisal points to an evaluation of the degree to which specified objectives have been achieved.

There is a high degree of discipline required in the definition of objectives. An analysis needs to be made of the degree to which the end-results of departmental or divisional, or corporate activity assumes that the manager's charter or mission or function is being realized. An examination of these results in terms of their timeliness, quality, cost, overlaps and gaps will reveal goals for action which, if achieved, will improve the accomplishment of the manager's charter. It is in the comparison of current end products and improved end products that there is elicited a number of objectives which the manager should strive to attain. When these are identified, quantified, and approved by his superior there develops a basis for appraisal by results. These are constantly under review. Their attainment reflects excellence in management: their non-attainment calls for diagnostic procedures.

The first requirement in the diagnosis is to determine whether uncontrollable events made it impossible for the

manager to achieve his goals. If this was not the case, it becomes necessary to determine why he failed. This inquiry leads the manager and his superior to inquire into the quality with which the the managerial functions of planning, organizing, staffing, directing and controlling were executed. Weaknesses in applying the principles which underlie these functions are identified and provide the basis for coaching by the superior manager. If this analysis fails to highlight the cause of failure, the diagnosis can then be directed to the attitude and techniques utilized by the manager. This may reveal important personality defects which interfere with the process of goal achievement.

A program of this nature has many advantages and no discernible disadvantages. It focuses attention on the manager's results--that for which he is paid to get. It overcomes the enormous failures of appraisal interviews by directing the analysis to the objective results attained, which are no surprise to the manager because he is the first to know of his failure. It provides for continuing review rather than the wooden and useless annual or semi-annual review often insisted upon. And it has the great merit of providing the superior manager with the opportunity to focus his coaching on specific and known weaknesses of his subordinate.

DIRECTING

The managerial function of directing is concerned with assuring that the interpersonal relationships between the manager and his subordinate managers are such as to induce the latter to operate at the peak of their capability. Those who would direct effectively are concerned about the continuing orientation of

subordinates, the quality of communication with them, the issues involved in motivating them effectively, and the quality of the superior's leadership ability.

Orientation

The orientation process is much more complicated than the original, one-time acquaintance of the subordinate manager with his working environment. Essential as this is, it is more constructive to think of orientation as a continuing need of the subordinate. Enterprise is dynamic, its environment changes and adjustments must be made in consequence, objectives change through modification, enlargement and elimination, and organizational changes quickly follow. Subordinate managers should be informed of these matters to the fullest extent that security permits because they can then understand the need for adjustments, they can better integrate their own duties with the view to improving their own accomplishments, and the knowledge itself will cut down on the wasted time for gossip about uncertainties. The chief instrument available to the superior manager is his staff meeting. Normally this is a weekly affair and provides the opportunity to inform all subordinate managers simultaneously of pending or accomplished change and give the group the opportunity to discuss the personal implications of change.

Communication

Communication is the transfer of information from one person to another. It is a fundamental skill on which depends all interpersonal interchange. It is the basic skill that makes possible the integration of effort in cooperative endeavors. The history of its development is fascinating in its own right but only

specialists are concerned here. The problems of communication in enterprise lie not so much in the lack of ability to use the language, but in the ability to conceptualize the need and in the will to effectuate. To conceptualize the need it is necessary for the manager to understand the advantages which potential recipients would realize if information were transmitted. This empathetic ability to place oneself in the position of the recipients and "feel" the importance of the communication is a rare thing indeed. The self-centeredness of people is proverbial: they tend to ignore the needs of others. In the case of communication it is easy to be unaware of the needs of others for information. The will to communicate is another matter. Here there are the known advantages to others of potential information accompanied by the placidity of inaction. It takes determination and energy to execute a communication, be it by telephone, memorandum, or carbon copy. It is so very easy for the manager to procrastinate and to ignore. Conceptual ability is most generally present but the will to communicate is flacid.

There really is no cure for the failure to communicate. This is why the communication process in enterprise varies from poor to embarassingly hopeless. The failure is not evaluated in the appraisal of managers. It is a frustration that the individual attempts to overcome, from the receiving viewpoint, by the devious means of the grapevine. From the sending viewpoint, improvement can only come from self-discipline.

Motivation

The motivation process is concerned with influencing subordinate managers to operate as near their maximum capability

as possible. Any manager responds to inducements and these may be visualized as emanating from three sources. The first level is concerned with the manager himself and his external environment. The need to make a living for his family and the cultural duress for productive employment are an important part of the external environment. So also is the personal ambition and drives of the manager himself. The manager works to make an increasingly satisfactory living, to exercise power, and to bask in the prestige conferred on his success by society.

At the second level, the enterprise itself can motivate managers by creating an environment which facilitates the realization of the objectives of managers. It establishes aids to the achievement of financial stability such as salary levels, merit systems, fringe benefits relating to investments, retirement, and catastrophe insurance. It also provides the capital for space, buildings, and equipment, and the budget for materials and services which it places at the disposal of the manager. In this way the enterprise opens wide the door for the productive accomplishment of its managers. It cannot do more.

At the third level the immediate superior of the managers in question has numerous opportunities to provide inducements for superior performance. These are often individualized, that is, they are conceived in terms of the peculiar needs of each subordinate manager. Doors are opened for the meritorious advancement of deserving men; opportunities for broadening the experience of capable managers are devised and implemented; those with promotional potential are carefully cultivated; and controls are relaxed for those who want to be both free and productive.

There are no "givens" in the field of motivation. People, including managers, are individuals. Each responds to a complex system of drives originating in his environment and in himself. It is the responsibility of the superior manager to know what incentives maximize an individual's productivity, how these incentives change in weight through time, and to utilize these incentives in the interests of realizing the full capability of the subordinate manager to contribute to enterprise objectives.

Leadership.

For leaders to lead there must be followers to follow. Their number and the zeal with which they follow depends upon the influence which the leader is able to generate and the advantages anticipated by followers if they support the leader in achieving his objectives. Every manager is a leader, though of widely varying ability. His followers are his subordinates, his peers, and sometimes his superiors. His subordinates are captives in a way, at least so long as they work for him. These the manager leads by influencing them to work with zeal and confidence. If he exercises leadership over his peers and his superiors it is because they see in him the vehicle that will transport them to their own objectives. Thus, the laboratory director is in the position where he can and should be the leader of all the personnel in that group. He should be able to influence all these subordinates to work with zeal and confidence. His success may cause his peers and even the enterprise president to see in him the means by which their own objectives can be fulfilled. They will follow his lead so long as they perceive this to be true for he has no other hold upon them.

The manager's ability to lead is often referred to as a charismatic quality--an unexplainable aura that envelops the leader who attracts enthusiastic followers. Whatever it is, the leader is able to imbue his followers with an urgency to perform zealously and effectively. He may subtly apply the motivational incentives discussed above; he may use success--perhaps the easiest to apply--as a promise of future successes; and he may even use failure and deprivation to spark an unworldly devotion. Great leaders seem to know instinctively just what incentives to use, in what degree, and at what times. But the world has produced few great leaders.

In the management of enterprise it is quite possible for a department, division or even the whole concern to operate in a successful fashion without the exercise of great leadership ability. To a very considerable extent managers are self-motivated and are moved by social pressure. This alone enables them to achieve at least minimal levels of success within their own organizational group. If their superiors merely avoid blunting the ambition of these self-propelling subordinates, good results can be attained. It is at these levels of leadership that nearly all enterprises operate. Few there are that are blessed with one or two managers with outstanding leadership ability. For this is a quality that can be learned but cannot be taught. There are few people indeed who consciously cultivate their leadership skills and hardly any of these are in industry.

Overall it must be admitted that managers perform the directing function with a low level of skill. This is quite understandable because they are dealing entirely with interpersonal

factors and there is little known for sure about the nature of man. Consequently the discerning manager will approach this function with a keen sense to interpret the results of trial efforts. Eventually he will be able to distinguish a pattern of cause and results which works for him, a happy event indeed. For those managers who have not the interest, patience, analytical skill and introspection required to reach these results the quality of their leadership will be depressingly meager.

CONTROLLING

It is unfortunate that the very term 'control' tends to be associated in the minds of so many with constraint on individual freedom. Of course these restraints do exist. A life without constraint is completely unknown for it could be experienced only by a Robinson Crusoe before he discovered his Friday. In all enterprise from the family to the largest formal organizations individual freedom is restricted. In business the purpose of restriction is to better achieve the ends sought, and therefore hours of work, position designation, minimal rules relating to health, welfare and custom, and benefits are all spelled out. Disciplinary rules are set forth as the means of enforcing conformance. Nor is our technique unusual. Every society from primitive to advanced and from ancient times to the present required conformance to known rules of behavior from everyone.

So accustomed are we to these constraints that very little objection is taken to them and conformance is largely taken for granted. Enterprise managers are more concerned about encouraging the exercise of freedom on the part of subordinates to make suggestions for technique and product improvements, growth, cost

improvement, innovations, and the removal or lessening of restrictions no longer needed. Every opportunity to be productive and efficient, and to utilize their personal initiative in the service of the enterprise is provided. This trend has been especially noticeable with the rising level of education of employees, and this is why the maximum freedom is found in laboratories, in engineering divisions, and in universities. The chief restrictions felt by employees working in these groups of activities are capital, budgets, and in the choice of objectives approved by the enterprise managers.

In the management sense, the control function is concerned with monitoring the implementation of plans for the accomplishment of important objectives. The control process involves the establishment of standards, comparison of actual with planned achievement, and taking corrective action where indicated. The information system required for control can be very expensive, and therefore it should be evaluated in terms of certain qualities.

Standard for Control

It is quite obvious that no control can be exercised unless there is some basis for measurement. This is readily found in the plan wherein the quantified objective is set forth, a strategy for its achievement is selected, and a chronological schedule of events, accompanied by decisions concerning who will perform each and when he will start and complete the activity, is set forth. The successful implementation of such a plan will certainly result in achieving objective sought. However, there are few plans indeed that can be implemented as scheduled. If this were not so, there would be no need for control. The execution

of each plan is made difficult due to errant forecasts of uncertainties such as securing the number, quality and timed availability of staff, the vagaries of financing, the inability to control the performance of antecedent groups, labor strikes and slow-downs, and unanticipated engineering problems. The effect of these forces on the plan can be known only if relevant information is forthcoming.

Comparison of Actual to Planned Performance

The information system must supply actual performance data in terms of quantity, quality, timing and cost so that one can know where he stands with reference to where he planned to be. The actual comparison is very simple, but it tells a very significant story. The manager knows the degree to which he is ahead or behind schedule, he can make a rough comparison of his percentage of completion and the proportion of budget spent, and he will know who was responsible for the activity that is in trouble. On the bases of these comparisons he will judge whether corrective action is necessary.

Corrective Action

Taking corrective action implies that the plan itself is flexible. The objective is to get back on schedule and this means that modifications in the plan will have to be made. Where the plan is off-schedule for uncontrollable reasons the manager may be able to rectify the situation by borrowing people, working overtime, sub-contracting, and shortening the lines of communication. Other correctives may involve stricter control over funds, better quality control, or securing external help to solve technical problems. Changes in the methods of managing his subordinates

is rarely indicated, though they might be. He may need special training / time, or he may want to review the strategy involved in the plan. If the latter is found faulty it is rather certain that a new plan will have to be devised, saving, of course, as much of what has been done as is economical.

Essential Qualities of The Information System

If it is to provide useful and economical information the enterprise intelligence system should possess certain minimum qualities. Since the manager must be in command of his operation the system should provide him with his need to know. Every manager is different from all other managers in terms of education, experience, and interpersonal relationships. Even successive managers of the same group require different information to the end that they remain in command. Thus, the system must conform to the manager's needs.

The information received by a manager must flow separately from each of his subordinates so that it can be known who is responsible for results. No corrective action can be taken if there is no personal accountability. Neither can rewards be fairly distributed under these circumstances.

The information received by the manager must be timely. This concept is not related to meeting report deadlines. Timeliness for a manager means that the information must be received in time to make comparisons with planned accomplishment and to take corrective action. Actually, there is real doubt that any information should be gathered if it cannot be used for this purpose. It may have historical value and it may be used as a basis for disciplinary action but these are not the reasons for

collecting information. Its principal purpose is to enable the manager to control his plans.

A final quality of the information system is that it be economical. One of the amazing things about the cost of control is that no one ever knows. This circumstance leads to the conclusion that there are no cost standards associated with an information system. And without standards there is really nothing to limit the demands for information in multifarious forms by every manager. Even self-restraint is not enough. Another tool is necessary and the best one available today is strategic cost control.

This device rests upon the manager's clear understanding of the flow of materials, work, and paper associated with his activity. There are several means of depicting such a flow and they should be utilized in order that the total process can be visualized. Once this is accomplished, the manager selects from among the multitude of points where information is available those particular stages in the flow where to know is strategic. No action would be taken on information provided for the non-strategic points and therefore its gathering would be superfluous as well as costly. The actual selection of the strategic points for control rests upon the manager's judgment. The particular selections in the initial use of this technique may well be inappropriate but tests of the information received and the action taken in response to it will reveal whether the points are really strategic. Thus, selection is a trial and error process refined by the judgment of the experienced manager. It is the most efficient means available at this time to minimize the cost of control.

THE MANAGER OF SCIENTISTS

The laboratory manager is personally responsible for results. To achieve these he has resources of space, equipment, employees and budget at his command. The more skilled he is in understanding and executing the process of managing the more assured he is that the desired results will be attained. The same is true of each of his subordinate managers. Since there is so little science and so much art in the skills of the manager nothing but years of experience, evaluated in the light of results, will make of him an efficient and effective executive. If he is ever to achieve this degree of excellence he must understand his functions as a manager and the principles upon which their successful execution rests. This is not the province of an administrative clerk, as is so often thought by scientists. It is a unique skill whose application takes the full time and attention of those who would succeed.

In the chapters that follow an examination of the quality of management exercised by laboratory directors and supervisors will be made. The standards by which their proficiency will be judged are the principles which underlie the functions concerned in the managing process. Comparison with actual practice will be made, and the conclusions will point to the nature of corrective action.

CHAPTER II

PLANNING WITHIN THE LABORATORY

Planning is a logical technique employed by managers as a means of improving their chances of accomplishing important objectives. The process includes first, a clear identification of the objective to be achieved. Then, having taken due notice of the constraints imposed by relevant policies and other planning premises, a selection is made from among alternatives of the best way to proceed. The next step is the scheduling of actions that will be taken in chronological order by identified personnel in specific time periods. Obviously, the development of complete plans does not, of itself, ensure that the ends sought will be achieved; the schedule of events must be properly executed. Only implementation can make planning pay off.

The planning function of managers is most likely to be executed effectively if the underlying purpose of the enterprise and its parts is to achieve its ends efficiently. This is the basic assumption of the free enterprise system. Enterprises may, of course, be operated on entirely different assumptions. For instance, efficiency may be abjured in favor of maximum employment of people.

Whenever the subject of planning is raised with managers, particularly those at the lower and middle levels of the organization, the theme that is visualized concerns work-planning. There may be several reasons for this limited view. The work of industrial engineers for many decades has concerned work-planning; the emphasis placed on planning by superior managers has

been largely on the necessity of getting out the work, either service or products. In contrast, the recent progress in planning has been made at top manager levels where the subject matter has been broadened to include purpose, strategy, market penetration, finance, and staffing. Our scientists and their managers were no different than other employees in this regard. In the material that follows it will be observed that they likewise are concerned about work planning.

It was quite natural for business managers to apply planning techniques to research activities. This function, executed on the assumption of efficiency, was introduced into the laboratories when research became a recognized business activity. But rigid schedules were found to be totally unacceptable to scientists because discovery and invention could not be planned in the traditional manner. This clearly was not the way to manage research: but neither was the opposite extreme. Scientists, if they let go their imagination, could dream of an environment in which they would be wholly without restraints. Indeed, society could, and perhaps should, sustain in anarchy the blessed few who are productively imaginative. But for the rest, and for the unproven, managerial processes are required that will produce an environment that is conducive to getting the results wanted. Scientists will always need managers who are sensitive, on the one hand, to the capabilities and personality of each individual and, on the other, to the achievement of enterprise objectives.

Participation in Planning

In the present study, the managers of research units reported, almost without exception, that they encouraged their subordinates to participate. Their subordinates reported that participation varied from "complete" or "full" through "adequate" to "none at all." It is clear that participation is an inexact term: as a managerial technique it merely implies that to a greater or lesser degree scientists are encouraged to become involved in planning research programs. Managers need a better guide than this.

One variable is the environment to which the research laboratory is exposed. Research objectives vary from a broad pursuit of knowledge to discoveries needed to support the company product line. The laboratory is sometimes wholly supported by company funds; at other times it is expected to provide much of its own support by successfully marketing its services. As a consequence, the opportunity for scientists to participate in research planning is circumscribed by the constraints of budget, objectives, and strategy. Within these parameters, however, the potential for participation in formulating laboratory research plans should be fully exploited by managers on the sound principle that people do their best when carrying out their own rather than imposed plans.

A second variable is the capability of the individual scientist. Commonly, this term "scientist" is loosely used and correlates indifferently with capability. It is applied to the untested recent university graduates and to the gifted, mature man. It follows that the manager will permit the maximum freedom, within environmental constraints, for those scientists he trusts to

plan and execute their own research. On the other hand, he will closely guide and monitor the efforts of scientists who have not yet won his entire confidence.

While scientists are universally encouraged to participate in laboratory planning they are primarily concerned with their own projects. To this extent there is no question but that full participation is generally practiced. The unit or section manager is intimately concerned with the scientist's activity and he can help in problem definition and in exploring various approaches to its solution. Thus, planning of individual projects is largely a cooperative process. Agreement to go ahead then becomes a budgetary and a priority matter.

In large laboratories the participation of individual scientists in developing the overall research program tends to be limited because most scientists are mainly interested in their own activities, and in those of colleagues which impinge upon their disciplinary areas. Those who become involved in overall laboratory plans have considerable influence in shaping goals and policies and they profit by the understanding induced through better communication.

Communication of Plans

Managers in general have a continuing communication problem: research managers are no exception. Communication of objectives and the plans to achieve them involves both explanation and understanding. The managers concerned in this study were clearly dissatisfied with the degree to which their subordinates really understood the unit or department plans. The subordinates of those managers who were most confident of their communications often disagreed with

their supervisors. On the other hand, sometimes the scientists expressed a higher degree of understanding than their own managers felt was achieved. Assessment of the quality and extent of understanding is most difficult, perhaps impossible, in any circumstance. Managers who are most conscientious in this regard probably tend to be the most skeptical of results. Those managers who are careless in communication may not think it is important that scientists gain a good understanding of plans and objectives, or they may simply assume that understanding is achieved.

Is it important that individual scientists understand the research programs of their superiors? It depends upon the need for integration of individual projects and the potential for useful knowledge gained by other scientists in the group. If there is no danger of overlapping among projects of the several scientists, and if these projects are so distinct that the gains in knowledge resulting from their investigation are unlikely to be useful to colleagues within the laboratory, then the need for full understanding of overall plans is minimized. In this case the communication problem is largely concerned with assuring the scientist that his personal objectives can be achieved within the laboratory environment.

To the extent that the communication of proposed plans is practiced the oral technique is universally used. This may occur in formal discussions between the manager and his scientists in staff meetings or seminars, or it may be informal on an individual basis. Only rarely are such techniques as memoranda and briefs used. The follow-up techniques used by managers to further assure understanding of plans and objectives tend to be much more formal.

Oral communication is a continuing process, on both an individual and group basis. Seminars devoted to data evaluation are common: so are written periodic progress reports and briefs. By these means and sometimes as a by-product of them, the manager assesses the quality of understanding of laboratory plans and makes corrections or explanations as required.

Source of Research Ideas

To inquire into the source of research ideas may, at first glance, seem quite naive. Scientists are quick to point out that they produce these ideas, that in so doing they are fundamentally affected by their background, training, knowledge, and curiosity, and that the insights which occur as a flash of genius may come in the most odd and unlikely circumstances. There is little reason to disagree with this view. To a considerable extent it "explains" the hypotheses which the gifted few formulate and hasten to test. Also, this concept of the source of ideas is occasionally used by some scientists to explain to the uninitiated just why scientists cannot be managed!

The problem here is not so much the source of ideas but rather whose ideas are researched. The answer depends on the reason for establishing the laboratory. If it is to be supported by government contracts, the subject to be researched may originate either with the scientist who makes the formal unsolicited proposal, with the research arm of a government agency, or it may be a compromise between them. In a very broad sense a "product line" is always involved but this does not necessarily impair the quality of research.

If the laboratory is supported by in-house funds a strong "product line" orientation may or may not be present. If it is, the scientists are expected to research ideas or projects largely initiated by the research director and his subordinate managers and by the operations managers who rely on scientists for consultation and problem solving. In this situation the spectrum of research is likely to include little that is basic and much that is developmental.

On the other hand, there are a few laboratories supported by in-house funds that are concerned solely with basic research. No product line is implied. Here the scientists are wholly free to identify and pursue their own projects. An organization of this type is frequently looked upon as a status symbol, but it does have a fringe value insofar as its existence is often a selling point used by operating divisions in their search for government contracts, and its scientists may have an interest as consultants on some of the basic problems of other divisions.

Laboratory managers are very careful to maximize the opportunity of scientists to explore those events that pique their personal curiosity on the sound principle that people are more effective when doing what most interests them. On the other hand, scientists will choose to work in those laboratories whose policies best suit them. An assertion that the best scientists work in the freest environment because it is here that they can research their own ideas cannot be proved. Even poor scientists are as likely to prefer these circumstances. However, the latter are unlikely to be hired in the first place, or retained very long in any case. Thus, by selection and attrition it is at least

an acceptable hypothesis that the best men will tend to be found in laboratories where unrestricted basic research is encouraged.

The actual decision to undertake a specific project seems to be shrouded in considerable mystery. It was difficult for the scientists to respond. They were sure that in the great majority of cases they themselves made the decision. Their immediate supervisors, however, were equally certain that they or the laboratory director made these decisions. It would appear that a kind of policy exists to approve projects which fall under the umbrella of company research objectives and which can be funded. This pre-decision makes it appear to scientists that they indeed are the decision makers: it would also explain why their managers do not feel that they have abdicated an important function.

Evaluation of Proposed Research Activities

Scientists appear to evaluate their own research proposals (or ideas for research) by significantly different criteria than their immediate supervisors think they do. The latter think scientists give equal weight to prospective company benefit and to potential contribution to scientific knowledge. On the other hand, scientists rate projects highly if they consider them potentially challenging, if they involve "good" science, and if they have a personal interest in them. These criteria point to a strong personal orientation towards scientific activity.

The above misapprehension on the part of the managers of scientists could be serious. It may cause poor communication within the laboratory, lead to inadequate motivational techniques,

and seriously interfere with a sound personnel appraisal procedure. It points up how easily a manager can fall into error when he assumes he knows what interests people in their work.

These managers evaluate the projected research of their subordinates in very understandable terms. They want to know whether the project is technically sound, whether their men have the ability to carry the project through to a successful conclusion, whether it fits in with the laboratory goals, and whether it can be funded. About half of their subordinates think the managers use company oriented criteria such as goals, funds, etc.; an interesting few thought that supervisors used the scientists' criteria. And an alarming number simply did not know how their superiors evaluated research projects.

Why should scientists not know the criteria used by their superiors to evaluate research projects? There is a clear failure here to communicate downward. The reasons are unknown but one may conjecture carelessness, an assumption that a scientist does know, or does not care to know. Whatever they may be, there is no question of the urgency resting upon managers to correct this communication deficiency in their operations.

Research Plans

In most cases the managers of research make annual plans. This is a format that is probably forced on them by company budgetary practice. Funding is related to the common annual budget. If this were not so it may be that various terms from a month to several years would be associated with specific projects without reference to or integration with the annual plan.

In some instances the annual plan is concerned with research programs running from two to five years. From the manager's viewpoint it is desirable to strive for long range planning. If other parts of the enterprise undertake planning of this nature, as is the usual practice, and if the laboratory has a part in contributing to the realization of enterprise goals, it is clear that the best interests of the research laboratory would be served by a careful inquiry into its needs for resources over both the short and long run. Furthermore, the long range planning framework provides important guidelines for the approval of short range projects.

It is not implied here that research goals can be achieved in planned fashion. So much depends upon the strategy of the approach, the interpretation of discoveries, and the state of the relevant art. These variables require constant reviews of what has occurred to determine what has been learned, its value to the goals sought, and whether there is a sufficiently strong basis for further support. On the other hand, given time and funds, scientists are optimistic about goal accomplishment.

Both managers and scientists agreed that adequate flexibility was provided for in research plans. They worked closely together in evaluating both the obstacles encountered and the new knowledge acquired. On these bases agreement to modify the plan in an intelligent way was rather automatic.

Budgeting the research plans is highly centralized, but budget administration is decentralized. The scientists themselves estimate the cost of their proposed projects. These costs are reviewed by their immediate superior who recommends his budget

to the department head and thence to the laboratory director. He, in turn, must defend his proposed budget before the corporate budget committee. At each stage in this upward flow proposed budgets are modified by negotiation. Upon the ultimate approval of the corporate research budget there is a correspondent assignment of research funds to the basic managerial unit.

DIALOGUE OF THE SEMINARIANS

DR. O'DONNELL: Do scientists want to be involved in the planning of the objectives of the laboratory, or is this too far removed from them?

DR. OSTERYOUNG: That is a difficult question because it seems to me that the matter of responsibility arises here. Presumably the director of research really has the authority and the responsibility for certain kinds of functions.

You have indicated earlier a reluctance to get involved in the selling aspect. That is a managerial function. It seems to me that the scientist should get involved but he should recognize the consequences. In other words, if he wants to get involved, it's going to be time consuming. For example, how are laboratory objectives supposed to relate to the company, how should it operate, and so on? I think generally he should be given the opportunity to participate because I think that he should have a chance to say that he doesn't want to. But he ought to be made aware of this problem.

DR ALBERT WILSON: I would agree with that statement. The giving the opportunity to participate is very important, even though in / opportunity you maynot get a total response that people want to participate.

In our laboratory about one-third of the scientists are very concerned with planning laboratory objectives. About two-thirds don't want to be bothered, preferring to focus on their own problems. The percentages may vary widely but I think you will always find a split reaction. On the other hand, if the opportunity is not given, the fellow who wants to participate becomes frustrated and irritated. In either case, the fellow who doesn't want to be bothered is free to stick with his own problems.

MR. WELTY: Are we talking about technical objectives?

DR. O'DONNELL: Yes.

DR. MUIR: I think somebody mentioned the polar extremes of the laboratory: the ivory tower with its open-end research, and the commercial "goody-box" builder, the company that builds gadgets to sell which have a high scientific content. I think the answer to this question of to what extent scientists want to participate in the formation of laboratory objectives would be quite different for scientists in different environments.

DR. O'DONNELL: Different in what ways? Would you continue, Arthur?

DR. MUIR: Well, I would suspect that in the ivory tower situation perhaps the scientists would be less concerned with the planning objectives because these are much more open. The ivory tower is described as a box. You put scientists in and let them rattle around, and there is no, "We have this deadline to meet, and we must have that information." They produce good science for the sake of good science or personal satisfaction. On the other hand, scientists employed by the goody-box company might be very

very concerned with what the objectives are. In other words, will this type of research lead to good product development: Will it help the company?

DR. SALZER: I wonder how many laboratories or research organizations have clearly defined objectives?

DR. DONNA WILSON: I want to respond to this question of "best" objectives, having gotten terribly involved last year in trying to define objectives in a systems-type analysis. This was very frustrating.

In the ivory tower I think one could have a higher mental objective, because you know you are doing science. I would say that it is not possible to make that any more specific. I mean that this gets into all kinds of contradictions about what the scientific method is and so forth.

Now, that for me could still be a well defined objective, although it doesn't seem to be as specific at the lower levels of research.

DR. SALZER: Yes, I agree that there could be objectives in each. Furthermore, I feel that I don't want to put research on a business basis, but I think we should at least go through the exercise as though it were, because it is worth it if you define objectives. Objectives might be defined on a very long-range basis. I will give you a very good example. I don't think we would have color television today if Sarnoff hadn't said, "We are going to have a color-television tube developed." That is an objective but it doesn't mean that Joe Blow would have to do something or another. It means many things and opens a lot of possibilities for scientists. But he established an objective,

and without it I think the money that was spent on it would not have been provided. I think the scientists got a great deal of satisfaction knowing that they contributed to something like this that is very valuable. If the same kind of bits and pieces had been created in industry, without an objective, I don't think that they would have become nearly as useful.

You can go back and take some reports a hundred years' old and ask yourself, "How can I apply that knowledge or that invention or that thinking to some satisfactory objective?" and you will find that you can. The information died a hundred years' ago but the individual didn't have the satisfaction of seeing his results. It's nice to have the satisfaction that you are working toward an objective. The objectives don't have to be stated in as clear terms as the television tube. They can be stated in many other ways, but I think they are very important. Furthermore, I see a good reason to encourage scientists to participate or react to objectives. If it does nothing else, it is a good means of communication.

Is there an objective, and what is it? Really only in terms of that, can it be said how you should then deal with the scientists, how you should manage them and how a scientist wants to react.

In the laboratory, the objective is often very vague. If you go into the ivory tower type of operation, the objective is actually not as vague, but still I would like to see something more than just, say, to do anything you want to. Here is where scientific management has a very

important role, namely, to pick the brains and try to make two and two add up to five. There's no reason why this shouldn't be done. It is the scientist's manager who makes the connections that creates something.

DR. DONNA WILSON: I would really like to endorse what you are saying about objectives, but I would like to share a similar experience that created all kinds of hostility among astronomers in working with the space systems type who needed information and knowledge from astronomers.

I was participating in the middle, talking to both sides, since my training is in astronomy. It became very clear to me after the study what we should have done rather than what we did do. This is always the story of one's life. We made the mistake of going to the astronomers and asking them what were the objectives in the exploration of space. They would usually start off by describing, in very specialized language, that the objective is to get the ultraviolet spectrum of O. B. stars. Any one man could only think in terms of his particular observations. That is what he wanted to do. On the other hand, when you left the job entirely to the systems type who is used to working with objectives, he wanted to put as the top objective: to discover the origin of the universe. When you try to bring these two levels of objectives together on a flow chart, the astronomers get mad and everyone else gets mad.

I'm glad you say the manager has the role of trying to pick the brains of specialists and putting specific objectives into words. I think it can be done but it takes a person in the middle. You will never get a person who is in the ivory tower, who is dedicated to science for science's sake, even to consider it important

to specify the objective.

DR: LYON: Let me suggest that in the context of scientific research it is improper to talk of objectives beyond, say, that you want to expand the frontiers of knowledge. At that point all you really should talk about is activity, not objectives in areas in which you want to work. The only modulation on that that I can see is selecting the people that you want to work for you. Beyond that, you can't ask them to say what their objectives are.

I think that in the way the question is asked here, "In what sense does the scientist want to participate in planning the objectives of the laboratory?" I would say that all he is really concerned about is his being sure that what he wants to do falls within the framework of what the laboratory management people want to have done. We have to be careful about objectives when we are talking about research.

DR. OSTERYOUNG: Universities don't want this. They go out and hire people in the chemistry department. They hire an organic chemist, for example, because they want somebody to do the work in a specific area. They have a specific objective here and they want somebody to work in a given area. They don't, generally speaking, wind up with just a random assortment of people. There really is some management.

DR. SALZER: There are two kinds of planning--the deductive and the inductive. In both cases you have to establish objectives. The kind of argument here lets the scientist work in whatever he wants to work. That is very good, but you have to make use of his discoveries eventually: the process of making use of them may be a rationalization of objectives. I call that inductive

planning in which you create various things and try to put them together so they will amount to something. The other is deductive planning, and a clear example was the invention of the color television tube. You would do anything that is needed to deduce from that objective whatever should be done.

If you say there are no objectives, I think you have not directed research, and I don't consider that very valuable. I can't picture an industrial organization that would tolerate it and underwrite it except with the secret motivation that it can steal enough out of what is accomplished to make something out of it.

DR. SILVERMAN: I have to agree with you. Let's face it. If we are talking about industrial research, the company that you are working for is in business to make money: and if it can't see a way to exploit its scientists it is not going to have them. You can't exploit an unstructured type of organization. One way to exploit this thing, one way to set the objectives, of course, is not to employ bioscientists or biochemists if you are not interested in that field. If you are interested in developing better transistors, then you hire people who are good solid state physicists and chemists, and you don't hire other people; so in that respect you are setting objectives.

I also find from my own experience that everybody is very much concerned about the objectives. I think they are concerned because they want to be sure that the objectives of the organization fit their own personal desires and interests. They do want to be clued in on what the objectives of the organization are, where they are going, how we expect to get there.

DR. SALZER: I once interviewed a man who showed me a list of his patents. They reached about two hundred a year. That is the man that I think can be utterly worthless in an organization because obviously he has no criteria of selection or of wanting to achieve anything. He is just a very inventive person. Now, you can use a man like that, but you need about ten people who can do something with theseinventions and combine them with something else to create and achieve an objective.

DR. LYON: I still believe that there is a need for and even room in our commercial organizations for what we would call undirected research. This is a gamble on the part of management. You couldn't do all your research that way, certainly, but I think there is justification for allowing some of your people to do this type of activity. They are going to do some worthwhile thing that you can later use in your productive development.

DR. SALZER: How are you going to make use of that unless you monitor it?

DR. LYON: You don't monitor it. After they produce something of value, you then utilize it; you exploit.

DR. SCHNEIDERMAN: There are a few things which come to mind concerning objectives of the laboratory: for whom and for what? One point of view is that the objective of the laboratory is to provide some financial return for the investment. This is the classic one. The other end of the spectrum is that the objective of the laboratory is to provide a means for pure or undirected research.

I might call to the attention of the gentlemen here who indicated that no company provides--I don't remember the exact

phrase--so-called pure scientific research. It doesn't have any objective. I submit to you that more enlightened companies, of which the Aerospace industry is among the least, spend or permit the expenditure of considerable funds on the so-called pure research basis: Du Pont Company, The Standard Oil Company, and let's say one of the pharmaceutical houses like Merck. Now, you might say there is traceability. You can say that some place along the line if a man is doing theoretical study on adsorption for, let's say the Du Pont Company, they can sell that adsorbent to a company in the oil industry for the adsorption of a particular compound. Insofar as the research man in the laboratory is concerned, the ultimate objective in the company's mind may be to tie his results to a practical end. The scientist puts out a paper in the Journal of Chemical Physics that has to do with the adsorption of something on some sort of surface. Now, that is the type of research which is about as close to the university, highly individualistic research, that I know.

On the other end of it, is the sort of thing with which we are plagued in the Aerospace industry. The United States Government in many areas says "If you do it this way, the manager gets money."

If I want to say that somebody is supposed to do work in infrared or ultraviolet spectrum, the person might say, "What are we going to do with that?" So you write him a little blurb that says, "Well, now, you know if you get this you are going to be able to have a better guidance system for tracking stars, and this will make us many many millions in connection with our satellite programs."

So I submit, sir, that we should be thinking of planning the objectives of the laboratory in the sense of for what and for whom, Cyril.

MR. WELTY: I would like to point out that actually there are two aspects to this planning. One is creating the idea or opportunity, and the other is the selective process. Certainly the people at the lower parts of the organization want to contribute in actually creating the opportunities, and the laboratory that does not use this capability is going to be at a disadvantage. Actually I don't think there is any priority within the hierarchy as far as the ability to promote a good idea is concerned. In fact, the likelihood is that you will get good ideas promoted at the lower end of the vertical organization more than you will at the top.

Now, there is a selective process, and it seems to me that it has to occur mainly at the top. Of course, there is a good reason why you want your manager to know about what he is managing, which means that he has to be fairly familiar with the technology that is going on.

I really cannot have the people at the bottom of the organization doing the selective process because they are actually putting in competitive ideas.

DR. O'DONNELL: The personnel on the bottom of the organization primarily are interested in freedom to pursue their own personal research objectives. The laboratory provides this freedom. I would guess that this would satisfy them.

MR. WELTY: That may satisfy them but that is not a very effective thing to do. I think that even the random search has

to be somewhat selected.

In certain cases I don't see any immediate use for this, but it looks as if it is opening up a big door where something might happen. On the other hand, any organization that says, "I am going to tolerate anybody to do whatever he wants" will soon find a lot of people doing things that actually aren't very productive in general scientific information or to the product of the company. So, the selective process has to go on.

DR. O'DONNELL: I would like to go back to Dr. Wilson for a moment. This one-third of your scientists--do you know whether they are interested in laboratory objectives?

DR. ALBERT WILSON: I think one of the points that was brought up was that one feels a certain sense of security if he can locate his own work in a firm context. Scientists get a greater feeling of security when what they are doing is central to the objective of the laboratory. In this sense, everyone is interested in laboratory objectives.

MR. BOYKIN: Cyril, you stated rather succinctly in the report that people usually do a better job of carrying out their own plans rather than carrying out plans that are dictated from above. It would appear that insofar as scientists are people, they would in the long run be happier if they felt they had something to do with determining the course of action--maybe not the profit objectives of the company, but--of the laboratory. Hopefully, somebody has delineated what the laboratory generally should do, and then if the scientists formulate how the laboratory should perform, they would potentially be happier.

DR. OSTERYOUNG: If the scientist is involved in the planning, he gets some feeling for the goals of the organization. I wonder if the problem isn't that the scientist doing basic research, say, in Aerospace, doesn't have a basic sense of insecurity. If he can participate in the planning of the organization which results in at least some stated goal, he can get some inkling of the manager's functions and how he is trying to operate. I think his sense of security is really in the unstable situation, and this is something that we have to recognize. I suspect that the justification for the existence of a laboratory really should concern the individual scientist.

DR. O'DONNELL: So the planning process you would see as a kind of communicative function?

DR. OSTERYOUNG: Yes.

DR. SALZER: I think we see one thing that seems to be developing here, the feeling that if you have objectives and plans and directions in research, then it cannot be basic research. I never meant to say that.

One way of running a research organization is to let scientists define their own personal objectives. That's a very healthy thing if you can do it. It is difficult because a scientist is never really able to state clearly his personal objectives. He is not that clear about them. The manager really has to feel, not listen only. People come to me and say, "This is the way I want to do it," and somehow I know it is not exactly so. If they are interested in certain materials problems, high temperature problems or what have you--well, let them do that. But somebody has to worry about how the results are used, in

achieving the objectives of a bigger unit like a laboratory. This is part of scientific management really.

DR. ALBERT WILSON: To paraphrase a quotation attributed to Mees: Who are the best people for deciding what a scientist does? The scientist himself is the best person to decide his own projects. The second best is the director or manager of research who is closest to the scientist. After these you leave the realm of best people. A committee to decide what research is to be done is wrong about 50 percent of the time. But worst of all is a committee of vice-presidents. They are wrong a hundred percent of the time.

DR. SALZER: I had a project going on for years which originally started out to meet some objective. I'm not going to describe it because I might want to sell it to you. It resulted in some intermediate results. It was evaluated by a customer, and it took three years before somebody decided to find out what was right or wrong with it. That research program has been and still is flopping around, because it couldn't find its objective. It is an invention in search of an objective.

DR. SCHNEIDERMAN: You have got three situations, Cyril. One of them has to do with the theoretical or pure research; the other one is applied research; and the other is this word "project," and I have a strange feeling that you and I have been on this street corner before.

DR. O'DONNELL: I think that we have.

DR. SCHNEIDERMAN: But I think it is quite important right here and now. In the broad sense, if it is a theoretical or pure research program, I think that the scientist

wants almost exclusively to formulate and direct his own program. I think that is what most of the people here have been really talking about. It is a sort of admixture and whether he likes it or not the director of research as a manager gets into it sort of ankle deep. What I call the project type of research really isn't research; it is development, and by and large you may wish to investigate certain fundamentals regarding it. That's where I believe that the scientist wants to participate. That is when you get to these weekly conferences in which the results are presented, and with the manager you try to evaluate one or two of the next fifty alternatives that you have to follow. In the project type of research you will generally have to come out with some kind of definitive answer that will help you get a black box or a widget of some kind. There is just a lot of togetherness because management is breathing down your neck saying, "What are you doing with my project, and when am I going to get the results so I can get this thing out the door?"

Going back to the initial point, the theoretical pure research scientist wants to participate almost exclusively and almost to the rejection of the ideas--if he so desires--of the manager or director of research. It is a highly individualistic and subjective thing. "It is my research, and don't you get in my way, Cyril."

DR. GREEN: But the scientist should have a keen sense of responsibility in his research to select and formulate the objectives of his own research. I often ask myself if I'm contributing in any incremental way to the understanding of the generally operative processes in nature that can help to create

a system or perpetuate a system in the industry where I am employed.

Secondly, am I interacting? If I am in industry, am I interacting with the divisions, with the more applied units in the company? If I am in a university, am I interacting with other departments in formulating my research? If I am in government, am I interacting by monitoring contracts with universities or with industry?

So interaction by direct or indirect means is an important, very important, aspect of research activity anywhere. From the standpoint of ego, am I creating prestige for myself or for my institution? Am I creating or contributing to--it's an overworked word--"image," and public relations? These factors are looked at by management.

Finally, am I in danger of encapsulating myself in my research?

For example, there have been some abortive programs by government organizations on the concentration of selenium by growing loco weed. This is an encapsulating type of research, I think. To recap, factors very germane to the scientist in formulating his research project should include:

(1) ultimate creation or perpetuation of a system or product (in industry)

(2) opportunity for interaction with scientists in host and outside organizations

(3) avoidance of setting up a program of encapsulating research.

THE MANAGEMENT OF PLANNING

On the basis of what is know about the theory of planning[2/] and on the views of scientists and their managers who were involved in this study it is appropriate that certain guidelines be set down for those who are engaged in planning the activities of research laboratories. There is no lack of understanding of the logical process by which a plan of action is selected as the best means of achieving a known objective. This process is indeed the bread of life for scientists. There is, however, a great deal of misunderstanding about the operational aspects of planning. The issues involved in decisions about who should plan, what should be planned, the time spans of plans, the communication of plans, and the formality of plans are not part of the scientist's conception of planning despite the fact that he will have a positive, specific opinion about any of these aspects when he is asked to respond to a specific issue. Of course, one may well point out that such a defect in conceptualizing the planning function is of little concern since the responsibility for planning lies with laboratory managers. But in reality, there is not, within the laboratory, such a clear-cut division of duties. Scientists in varying degrees want to have a hand in the development of various kinds of plans. So long as

2/ See, for instance, Ewing, E. D., Long-Range Planning for Management, rev. ed., New York: Harper & Row, Publishers, Incorporated, 1964; Root, L. E., "Development Planning for Management Decision," in Organizing for Effective Systems Planning and Control, Special Report No. 12, New York: American Management Association, 1956; Scott, B. W., Long Range Planning in American Industry, New York: American Management Association, 1965; Steiner, G. A., Top Management Planning, New York: The Macmillan Company, 1969; and O'Donnell, C., The Strategy of Corporate Research, San Francisco: Chandler Publishing Company, 1967.

this is the case it is much better to improve their perception of the planning process.

Conceding the desire of scientists to participate in some of the laboratory planning in no way relieves the various managers within the laboratory of their total responsibility for the proper execution of planning. When, in addition, it is recalled that these managers are most likely to have once been scientists in their own right, and thereby possessed the typical views of planning that scientists tend to have, there is clearly a need to increase the depth and breadth of their understanding of operational planning.

Subjects of Planning

The matter of what to plan about is serious for all managers. They can be readily convinced of the theoretical case for planning but when it comes to its execution there is need for a subject. What should be planned? There are certain guidelines that the laboratory managers might keep in mind. The first of these is that the purpose of the firm in creating the laboratory should be clearly understood by everyone in the enterprise. Purposes, of course, do vary. They may be extremely vague, such as to imitate competitors, to reflect prestige on the firm, or to serve as a symbol for capability. On the other hand, they may be quite specific, such as to provide a source of knowledge that can be used for the development of proprietary products and product lines, to provide consultant service to operating divisions, or to earn a profit from its own efforts. Whether the purpose be frivolous or profound, foolish or wise, emotional or rational, there is no question but that it becomes a premise for all future plans. It is for this reason that the particular

purpose should be known and understood by everyone who may influence the future of the laboratory; and communication variance being what it is, it should be written and published.

It should not be assumed that the purpose of a laboratory is fixed through time. It is generally true that the purpose for having a laboratory tends not to change in at least short periods of time, but nevertheless, the possibility of changing purpose is ever-present. For instance, a laboratory might have originally been established as a center of basic research but the annual cost of its support might eventually force a firm to make it self-supporting. Changing purpose is not something that occurs as a complete break with the past. This would be a rare thing indeed. Most often change occurs through a blending of duality; it is achieved informally; and awareness of change is a halting process. For the laboratory director these processes come as no surprise. He, above all, senses a changing attitude on the part of his peers and superior; he is involved in the discussions looking toward change; and he interprets top management decisions in this regard. Whether he believes it to be in the best interests of the laboratory to communicate the sense of change to his subordinates reflects the maturity of his judgment.

Objectives. Although sometimes confused, there is a clear distinction between laboratory purpose and objectives. The latter are selected in such a way that their realization will partially or wholly discharge the purpose of establishing the laboratory. Furthermore, the nature of the purpose has a profound effect upon the quality of specificity with which objectives will be stated. If the purpose of the laboratory is to make a contribution to knowledge it is clear that no objectives at all will be estab-

lished. Its scientists will simply be invited to engage in research projects of their own choosing. To the extent that there are laboratories in existence for the achievement of this purpose one would look for them in a university, and only very rarely in an industrial concern. On the other hand, if the purpose of the laboratory is to establish a patent position which will support a proprietary product line its selected objectives will be quite firm. Some understanding there will be concerning the basic materials or technology which will support the product line. Thus an oil company would hope that the product line would emerge from patents concerning the nature and use of its raw materials or their derivatives. It would be unlikely to anticipate a product line that rests upon new knowledge relating to solid state physics. Once this matter is decided it becomes a premise for the further refinement of laboratory objectives. The sources of ideas for what to research are many. They include the scientist himself who wants to do good research in the known general area, a sales or marketing type who wants a material to meet a specific need, the manufacturing superintendent who needs an unknown lubricant to perform a known function, or customers whose need can be satisfied only by the discovery of a new element. These and numerous other needs-to-know can be given a priority rating after considering numerous factors such as market potential, contribution to welfare, availability of laboratory resources, the degree to which the technology is beyond the horizon of knowledge, the presence, ability and interest of scientists to become concerned, and the politics of the situation, i.e. how long can the company officers be expected to provide support before results of a useful nature are obtained? Consideration of

these and similar factors should put the director in a position to spell out more clearly the characteristics of the objectives. He will at least be able to say what the unknown must be able to do and to identify some safety specifications.

Derivative objectives. At this point the laboratory director has made considerable progress towards the specification of objectives for the research program. Much of what he will now do depends upon the organization of the laboratory. If he is the sole manager, all his scientists will be reporting directly. In this situation what needs to be done is to assign as a project each objective to individual scientists or a group of his scientists. On the other hand, if the laboratory is large it will be divided into departments, and these in turn may be divided into sections and units. In these circumstances the director needs to decide whether one or more objectives shall be assigned to individual department managers or whether a single objective should be accomplished through the identification of derivative objectives, each of which might be assigned to a different department manager. In either case, the department manager proceeds similarly in assigning whole or derivative objectives to his section heads. In either case an objective as a whole or as a series of derivative objectives become projects when they reach the level of the scientist.

Plans to Achieve Objectives

Important, nay indispensable, as it is to define the objectives of a laboratory no progress toward their achievement is likely to be made without the development of a series of complex, interrelated plans. Among these is the work plan. With this the scientist and his manager are familiar. It involves a restatement

of the objective in such a way that permits measurement, the consideration and selection of procedures, the tentative timing of phases, the resources required, and the development of a budget. Work plans are continuously reviewed, perhaps modified, or even replaced depending upon the progress made in a changing environment. Scientists tend to live with their work plan with an intensity that often prevents them from realizing the need and existence of other plans. Too often this is also true of their managers as well andherein lies a potentially serious malfunction. It is the manager's responsibility to recognize the need and to execute other plans equally supportive of objective achievement as is the work plan. Chief among these are policies, planned action to carry out the managerial functions, and plans to establish and maintain a specific environment.

Planning for policy formulation. In the language of management, a policy is a guide to the thinking and action of enterprise employees. Once established and communicated it is respected by both managers and non-managers. In this respect it may be likened to constitutional law, arrived at with great care and seldom changed. As a guideline, a policy will set forth how organizational purposes will be achieved and, inferentially, how they may not be achieved. A policy does not require action but when action is taken it must be within the four corners of policy. Furthermore, policies are not developed to cover all action contingencies. Rather, only the most important and most frequently encountered are likely to be settled through policy agreements. In this way, policies pre-decide many issues and thus tend to increase the conformity with which issues are settled.

A laboratory, like any other organizational unit, may find that it operates more efficiently and consistently if it adopts such policies as to subcontract work that requires a capability not possessed, to employ only those scientists with an established reputation, to encourage non-directed research, etc. It may be observed that stating policy in this manner does not require action of anybody, it certainly makes clear what action will be approved and what will not, and it gives a consistent thrust to the activities of the organizational unit.

The source of policy is quite diverse. It may be imposed on a company or one of its subordinate units by an outside agency such as government, labor union, public opinion; it may reflect the operating philosophy of the company founder or its board of directors, or of the manager in charge of the organizational unit; it may derive from requests for a policy by subordinates who see it as a pre-decision device or as a means of reducing some of the effects of unlimited competition within the company or laboratory. In all cases it will be a matter of careful consideration, strategy, and timing. Policies are likely to remain a long time and they should not be hurriedly adopted.

Whether policy should be widely communicated can be a very sensitive matter. In some cases the enterprise may feel that its image is improved if its policy of paying competitive wage rates, or its policy of producing quality products is widely known. On the other hand, the officers may not want to publicize a policy of producing products that barely meet the legal requirements for health and safety. Therefore, it should not be surprising that some policies are written and broadcast while others remain unwritten and known only to a few.

The laboratory manager is faced with exactly the same problems in regard to policy formation as is any other manager. Normally his policies should be consistent with those that cover the entire company. Also, laboratory policies will set out some of the guidelines by which scientists will approach the unit's purpose. To this extent conformity and coalescence of action will result from those issues that are pre-decided by policy. But there will be areas covered by unpublicized policy, and many action areas where there is no policy guideline. This is by no means a bad situation; it reflects a management decision that the timing is not right, the superiority of strategy is not demonstrated, or sufficient information concerning need and advantage is not available.

Planning the execution of managerial functions. Laboratory managers, whether they operate at the level of supervisors, department head or director, must carry out the managerial functions of planning, organizing, staffing, directing and controlling. The efficiency and effectiveness of their efforts will be enhanced if they customarily apply the logic of planning to determine the best means of achieving specific objectives.

The organization function is concerned with the problem of focussing the efforts of many upon the accomplishment of particular objectives. There are many alternative ways to group people to this end. The application of the planning process to this problem will enhance the assurance of the manager that the best basis for grouping people has been selected. It is not implied that once selected the type of organization structure should remain the same. Any manager knows that he lives in a world of change; if he is alert he will re-examine the basis of

organization systematically through time in order to make sure that he always has the most efficient structure.

The manager's staffing function concerns the selection, training and evaluation of personnel. Certain aspects of these activities yield best to the logic of planning. For instance, the issues involved in deciding the quality of scientists to be recruited and in the selection of laboratory managers are very complex. Many alternatives are present in each case and they should be weighed with care. Similarly, the ultimate selection of the most effective and timely training method and of the technique for evaluating performance is best accomplished through the logic of planning.

The direction of subordinates, both scientists and managers, is primarily concerned with their motivation. The enterprise as a whole does have good reason to plan a motivation system, and whatever is the decision, its application to the laboratory becomes rather automatic. Scientists and their managers appreciate fringe benefits, salary levels and potentials, and company perquisites as well as anyone else. Internal to the laboratory there is every reason to question whether the logic of planning a motivation system will yield worthwhile results. It is quite probable that at this point, motivation becomes individual and personal, and there is little opportunity to generalize the system.

The application of planning technique to the control function is very necessary if good results are prized. Control seeks the assurance that plans are being accomplished on schedule but it is perfectly clear that achieving complete assurance is much too costly. Compromises must be made and these become premises in

the selection of the best means of knowing where the individual or department stands with respect to the execution of plans.

Budgets are financial plans. As far as the individual scientist is concerned his budget is associated with his work plan. For managers at any level the budget is the financial plan for operating the laboratory, the department or the section and therefore is more comprehensive. Comparing budgetary expenditures with planned output is a common and salutary management technique. But the type of cost control system that underlies the budget should be carefully planned for there are several alternatives and each has different levels of effectiveness, cost and visibility.

Planning the environment. The environment of a research laboratory is critical in its effect upon the staff. The concept itself is very complex. To some degree it is a resultant of location, climate, and facilities; to a critical extent it is a resultant of company philosophy with respect to sustaining the laboratory, the quality of laboratory managers, and interpersonal relationships. The laboratory director carries the responsibility for determining the quality and nature of the environment and for the planning necessary to achieve it. He will select his strategy in approaching the top managers of the enterprise for approval of laboratory purpose, objectives, and budget; he will carefully integrate his staffing and direction plans so that they will contribute to the desired environment; and he will establish controls that tell him the effect of change in the variables upon the environment.

Execution of the Planning Function

Besides the question of what to plan about, the laboratory

manager is also concerned about the execution of planning. Just how this is done, and the degree of personnel involvement permitted, can ruin the planning process or assure its success. In each of these areas there are certain guidelines that laboratory personnel may find useful.

Formal planning. A formal plan is reflected in a written and/or charted document. Such a process is costly and therefore should be applied only in those cases where numerous variables or factors must be accounted for and where execution of the plan requires considerable time. Thus, the formal plan is merely a recognition of our human frailty for keeping our attention focussed on many variables through time. Informal planning is used when one or other or both of these factors are absent, even though the decision to be reached may be especially significant to the success of the operation. For instance, a decision to establish a laboratory is not formally planned even though there may be notes or items for discussion jotted down in writing. Although there are many factors involved the time required to assess them can be very short. Similarly, there are other major decisions that are reached informally. The essential point for the laboratory manager to consider is when formal planning is preferable.

The planning period. Much has been written about the length of the planning period. Such descriptions as long and short range planning have entered the literature and have been adopted by managers as a required characteristic of a plan. In real terms the planning period for any objective is that time within which accomplishment is both desired and possible. No standardization in timing is desirable even though the financial short

and long range plan may run for one and five years respectively. Laboratory plans can be fitted into this format whenever necessary by developing phases of a work plan whose objective is beyond achievement within a one year period. Thus, the laboratory manager should anticipate that his plans will have different dates for accomplishment, and may cover periods from a few months to several years.

Effect of change on plans. Those who plan assume that they are working with the best forecasts of future events and they proceed as if these will actually be realized. Nevertheless, planners are very conscious of the continuing effect of change and they provide for this in two ways. Plans are always conceived of as flexible to the extent that they can be and are modified in the future as real events disclose errors in forecasts. This phenomenon is not so much a matter of changing the plan as it is one of allowing for navigational change in the plan. On the other hand, unforeseen but quite cataclysmic events such as a war, a devastating earthquake, or a scientific break-through can render a formal plan quite unworkable. In such circumstances a complete abandonment or redrawing of the plan may be required. The cost of procrastination in taking action as a result of the forces of change should not be endured even though the decision to replan is hard to make. Some changes can be readily assessed but there are others that are difficult to evaluate in terms of time and impact. The laboratory manager must be decisive even though he may be wrong.

Personal involvement in planning. The question of who should plan cannot be answered in categorical fashion. It is perfectly clear that the laboratory director and his subordinate managers

are personally responsible for planning. They simply cannot avoid the discharge of this function. They may not personally engage in the development of proposed plans but they certainly must see that the work is done and they must approve what is finally acceptable. In other words, they must see that the appropriate subject areas of planning are actually covered by either formal or informal plans; whether they personally accomplish the planning depends upon the availability of staff skills and the productivity of participation by others.

The scientists within the laboratory will certainly want to develop their own plans for accomplishing selected projects. Also, they will want to develop the financial budgets to support such plans. Those who lack experience, of course, may want help in these regards but eventually they will want to assume nearly complete responsibility for these types of plans. In addition, some scientists will want to participate in the development of plans which are the responsibility of the director. For instance, the selection of policies, matters affecting the laboratory environment, the constitution of a library, cooperation with outsiders, and safety plans are matters in which the existence of the opportunity to participate is vital to the success of the plan. Not all scientists will want to participate in areas of planning that do not directly affect their own work, but the principle of inviting their participation should always be observed.

CHAPTER III

THE CONTROL OF RESEARCH

Control is the management function of making certain that enterprise events conform to plans. The manager achieves control by establishing standards, comparing performance with standards and taking corrective action as required. Planned action is the standard whether it is formal or informal, and planned action is what is controlled. No control can be exercised until planning becomes definitized.

In the research laboratory the fundamental planning document is the work plan. The projects are derived from the laboratory objectives and are often divided into steps or phases. From these are developed subsidiary plans for staffing, equipment, space and budgets. These tools of the manager were not clearly envisaged by the respondents to this inquiry. The plans usually meant the physical research plans and the other factors were looked upon as constraints to the achievement of physical results.

Functional Authority Over Research

Besides the line authority within the laboratory the managers of other organizational segments of the corporations exercise varying degrees of control over research activities. Chief among them, and for obvious reasons, are the managers of administration and of finance. The former is a constraining influence in the areas of wage and salary, recruiting, and industrial relations. The latter is concerned with budgetary control.

In general, the respondents were either unaware or uncri-

tical of these functional relationships. Of the fifty-one scientists involved, twenty-two said there were no external authority constraints, eleven did not answer, seven identified administration and five pointed up finance. The remainder identified interference by operating divisions, computer services, and government agencies. The fifteen supervisors of these men were equally unclear about the matter. There were five who failed to answer, four identified their own laboratory director, two said there was no outside interference, two identified finance, one pointed to the operating divisions and one to the contracts department.

These data lead to one important conclusion: neither scientist nor supervisor feels that the corporate control system significantly inhibits research activities in general. Having taken this position, however, two thirds of the scientists did not want to say whether these functional relationships hindered or aided their own research. Neither did the same proportion want to say how frequently these authority relationships were imposed upon them. The general feeling seemed to be that since they did not recognize the control system as burdensome or restrictive they either were unconcerned or were quite unaware of its impact. Probably they assumed that this must be their supervisor's problem.

Of course there were a few scientists who really felt the restraints of the control system. The imposition of external authority was specifically noted by seven and the same number felt that the impact interfered with the accomplishment of their unit's objectives. Since all these people worked for four

particular research organizations, it is altogether possible that they were simply unfortunate in having weak supervisors who were unable or unwilling to shield their men from the functional control system; or, perhaps, these supervisors simply did not know how to manage. When the managers themselves were asked to respond to the same question none was critical of their external authority relationships. They saw them as necessary if not good, but at the same time they certainly failed to communicate this feeling to their unhappy subordinates.

Comparison of Actual to Planned Progress

Accomplishment of the research plan was monitored both in phase and at its termination. As observed in the accompanying table the most usual method of comparing actual to planned action was the informal oral review, including close personal supervision.

TABLE II

CONTROL OF THE RESEARCH PLAN

Techniques	Responses by Scientists	Managers
Oral, informal	18	9
No review	9	0
Progress reports	6	2
Periodic briefing	4	2
Group reviews	3	1
Other	5	1
No answer	12	3

Note: Actual number of participants was fifty-one scientists and fifteen managers.

The ubiquitous progress report and periodic briefing were employed by four managers. Group reviews were used especially in cases where the research plan called for contributions from two or more scientists. Two other points are of

interest. The significance of the rather large number of scientists and managers who did not answer the question remains unexplained. The other point is that nine scientists thought there was no checkup at all but their managers certainly did not agree with them. Scientists seem to cherish the ideal of complete freedom from supervision and some of them may convince themselves that this is actually the case. In these instances the reign of control is held lightly indeed.

Budgetary Control

Budgets are both plans and instruments for control. The most convenient way to budget a research plan is to use man-hours or man-months rather than to convert these physical estimates to dollars. This device was reported as being in use by all the managers and by thirty-seven of the scientists. However, one laboratory reflected a different picture. The manager and two of his scientists agreed that they budgeted in the approved way but six of his subordinates claimed that their projects were not controlled by this means.

Changes in the Research Plan

Another important control over research is related to decisions involving a change in plans. As reported by nine managers and twenty-five scientists the decision to change emphasis or direction was made by the former. On the other hand, fifteen scientists claimed they made this decision but only one of their managers agreed with them. Two laboratories accounted for seven of the fifteen responses but in each of them there was one scientist who said that his manager made the decision.

Of course, in all cases, the scientist's opinion was sought. Because the decision was generally made in consonance with such recommendations the researchers may think that they really made the decision. There is no discounting the importance of these kinds of recommendations especially when it is recalled that senior men are really the technical authorities in the matter, they are very scarce, and their morale would be jeopardized if they felt rebuffed. But laboratory objectives and resources are hard facts that the manager always has in mind. He simply must make the decision if these restraints are exceeded by the recommendations of his subordinates.

Decisions to extend the project or to terminate it were seen in exactly the same light as the decision to change direction. There can be no exception to managerial authority in these respects in organized enterprise. Of course it should not be assumed that the scientists are stubborn in their tenacity to retain projects. They often want to get on with something more promising after repeated failures of their planned research, and are generally content at the abandonment of potentially unproductive work. Their views concerning the extension of a project depend upon circumstances. If they have a major interest in the area and see a prospect for highly productive work they naturally want to broaden the field of inquiry. This is the point where the constraints of laboratory objectives and resources are most noticeably in evidence.

Evaluation of Completed Projects

It is good control technique to compare the accomplished results with what was originally planned. At such a time it is

worthwhile to look into planned and achieved objectives, planned and actual costs, and planned and actual techniques. These are all important factors in establishing standards for future planning as well as for evaluating the performance of the scientist.

This type of over-all evaluation was carried out in six of the eleven reporting laboratories and was approved by eleven of fourteen responding managers. Of the scientists twenty agreed that this was the common practice, thirteen said that only an evaluation by phases was undertaken, and four did not know what occurred.

There was a surprising degree of disagreement about the practice between managers and their subordinates. Of the eight scientists reporting to the three managers who said they did not employ the practice of completed project review only three agreed with them. Of four managers in three laboratories, three subordinates agreed with them that there was such an evaluation and seven said there was not such a practice. Only in two laboratories was there full agreement between managers and their subordinates that there was a completed project evaluation.

The differences in the way managers and scientists look at the review process and subject matter are both striking and understandable. The managers were interested in reviewing performance against plans. The scientists were interested in a review of their reports and publications. In both cases the review technique was informal.

The laboratory managers see the review as a real control device providing them with important data on accomplishment, techniques,

costs and the abilities of scientists. Several of them have clearly not seen fit to involve their men in this type of analysis. On the other hand, most scientists do not see this type of review as a control device. They are chiefly interested in their manager's opinion of their work and in the publication potential of their contributions.

Conclusion

The great majority of scientists responding to this survey do not object to the control system established for the operation of their laboratories. On the contrary, they see the system as being helpful, or at least needed for operational purposes It is part of the environment in which they are very satisfied to carry on their research activities.

There was a minority of scientists who strongly resented interference in their work by "outsiders" whether these included other company divisions or government agencies These men may be young and inexperienced in organized enterprise; they may be the less successful scientists; or they may be victims of poor management. In any case, it is these men who seem to create the impression that scientists resent the control systems imposed on laboratories. Their views are not supported by the outstanding men in well-managed firms. Is it not that success cures the bite of frustration?

The managers clearly understand their control function They feel a heavy responsibility to get results within the restraints imposed by their superior managers They utilize sophisticated control techniques but they do so in a manner that is not offensive to scientists. This result is achieved by involving their subordinates as little as possible in the control process

DR. O'DONNELL: In what sense does the scientist want to participate in controlling the course and continuation of the project? I think the problem we ought to discuss is not solely his desires but to what extent can his desires be met by management.

DR. LYON: Well, I think certainly the scientist would want complete control of the course of the project. It is a matter of desire. As a practical matter, it comes down to the question of economics and productivity of the work itself, and evaluation by management as to whether it should continue.

I think it is about as simple as that. The scientist would certainly want to participate in it one hundred percent, and I think he should; but he may not make the final decision and probably should not make that final decision as to whether the project is continued or not beyond the research point.

DR. O'DONNELL: You may have two propositions here really. One that I can visualize is the situation where the scientist would want to maintain control and continuity of the project because he is very much interested in it; and the other one is where he has lost interest in the thing, and he wants to cut it off long before management is willing to permit him to do so.

DR. HAMERMASH: How many such cases do people know about here?

DR. SALZER: I know about such a case.

DR. HAMERMASH: It is very rare.

DR. SALZER: Usually because he fell in love with something else which is even better or different. Now he wants to do that.

DR. FRANTZ: In the case of someone who was working on a government contract, he may have lost interest but he is locked into it.

DR. HAMERMASH: You see, we keep mixing this up all the time. We hear from the ivory tower and then we hear from the contract, and we begin to mix it up all the time. I am talking about some one who has been hired by the ivory tower. He picked the area and he loves it. He keeps publishing papers year after year. That is an entirely different situation. And to have him say, "Yes, I am tired of it, but I'm not going to tell the bosses for three years." Do you know of examples of that?

DR. SALZER: Frankly I never was interested in the ivory tower operations so I really can't say. But I know of a case where a man did have a choice of going in one direction or the other, and he almost dropped the ball completely although it was his original invention that was involved. In fact, he wrote his doctoral thesis on this topic. I had to bring in others and let them steal his project because I felt it was valuable and I didn't want to drop it.

Whether he wants to participate or not, he is going to participate. You can't force a man very long to do something he doesn't like to do because you lose the basic motivation that you have to depend on in all these operations. So, if you really want to switch to a different area, sooner or later you had better let the scientist go or he will go anyhow.

You might persuade him or somehow get an understanding with him that, "Well, let's finish this phase of the project," or something like that, but you can't force him to continue. This

is fundamental in the management of scientists. You cannot force him to think one way or the other. You have to let him use his own motivation to a great extent.

The development of guidelines for those managers who must exercise this function within research laboratories is difficult because scientists seem to obscure the function with terminological prejudice. They are not, of course, the only persons who are betrayed by the language of management. This social science uses common terms such as "plan," "control," and "staff" which have several meanings in their ordinary usage to denote a specific concept. Management simply cannot be understood unless its terminological definitions are understood.

The term "control" is most widely interpreted as a constraint on individual freedom. There is good reason for this interpretation for in any society it is perfectly true that such constraints are enforced. In our own society we establish official constraints on personal behavior and economic activity at a minimum level wherein the people may not use their freedom to impinge upon the similar freedoms of others. In addition, there are many informal controls by particular groups over the activities of individuals. If this concept is carried into the research laboratory it would mean that the freedom of employees would be constrained to the extent that (a) the welfare of the laboratory may be otherwise adversely affected, and (b) resources are limited.

In the literature of management these constraints are taken for granted and they become basic but silent premises of all organization activity. The term "control" loses nearly all of its connotation of constraint on freedom of action and instead it embraces the concept of monitoring the execution of plans. Thus, control is seen as an essential function of the manager.

Since plans are based upon forecasts and judgments about a complex of circumstances and since these are subject to error it is commonplace to observe that actual events scarcely ever conform to planned achievements. Under these circumstances the objective of the plan is in jeopardy. The planning activity itself becomes entirely useless unless it is possible to "control" its execution. This is done by identifying deviations and correcting them while hopefully there is yet time to achieve the objective as scheduled. Within the research laboratory this concept of control is very well understood as it applies to work plans and to budgets; it seems to be forgotten by scientists when "outsiders" speak of control within the laboratory.

The Function of Operational Control

Every manager is deeply concerned about the control process because this is his only means of keeping informed about the progress made toward the fulfillment of his objectives. With this information he can feel confident that he is in command of his operation; without it he is completely blind to what is happening. The information itself may please him or displease him. In the latter case he at least will know he is in trouble and if he has designed his control system properly he will have time to get back on schedule. If he happens to be a manager in a research laboratory however, the assurance that he will get back on schedule will be lacking because we cannot yet achieve discovery on schedule. The most that the control system can do for him in this case is to show that he is in trouble.

Guidelines for Operational Control

In order to realize these important advantages of control there are certain guidelines which managers within the laboratory

may find particularly useful. They are derived from considerations of theory and the practical views of the scientists involved in this study.

Prepare plans to serve as the standard. Since we cannot control events unless there are standards against which actual occurrences may be compared, and since the planned events must be arranged logically through time in order to achieve a desired objective, it is essential that the manager make certain that all plans be characterized by high quality. Formal plans will be developed in written and charted form to cover the achievement of a distant objective when a complex set of variables is involved. Major physical events need to be identified, integrated and provided with proper lead times; each of these needs to be further broken down by elements and their expected accomplishment scheduled. No long period of time for the achievement of a task should be scheduled without some means of determining what has occurred within that period of time. When these steps have been observed the physical plan is ready for conversion to a financial plan, and both then provide the standard for control.

It is formal plans of the above type that most people have in mind when they refer to the planning process. And, indeed, if formal plans are actually developed when circumstances of time and complexity demand they will normally absorb a very high percentage of the total work to be done in the organization unit. If this figure is 80% or so this means that the remaining work time will be devoted to accomplishing informal objectives for which there is no written plan or budget. The progress toward these objectives needs to be controlled also if the time is to be used productively. The standard is almost always merely the

accomplishment of the objective; there is little need for attention to progress toward the event because, by definition, the goal is near term and the variables are few.

Select the strategic points for control. The theoretical concept of strategic point control is readily comprehensible. It takes cognizance of the high cost of gathering and reporting total events as a plan is executed and suggests a compromise be made along the scale of total information and no information. The recommended points for information reporting are strategic because it is at these points that any needed corrective action is likely to be taken.

The manager takes this concept and makes it operationally viable. He knows, for instance, that each plan is unique and therefore must be examined individually. The only generally applicable points for control are start-up and completion. Between these extremes it is necessary to identify strategic points where information will be reported out and made comparable with planned accomplishment up to that time. In locating these points the manager will keep in mind that bad news is more important to him than good news. Of course it is comforting to know that the execution of the plan is on time and within budget, but if he could be assured that this happy event would always take place he would not accept the cost of gathering such information. It is because plans tend to be optimistic and unforeseen events usually have a negative effect upon execution that accomplishment tends to be underrun and budgets exceeded. The manager is typically fighting trouble; he has a need to know where it is and when he should take corrective action.

In locating strategic points there are no exact rules. A

flow chart of sequential and interrelative events is highly recommended as a way of depicting the total set of essential actions for accomplishing a task. Based on his experience, a manager will identify those points where information will be reported. In the selecting process he will consider such matters as essential lead time, sequential and simultaneous events, reporting points required by the customer, and points at which deviations from plan will trigger corrective action. Of course, there is a certain amount of trial and error involved in selecting the reporting points. In a complicated flow of events it is almost certain that trouble will occur at points where no reporting has been required; it is equally certain that some points selected for reporting reflect only small and unimportant deviations which do not trigger action. The manager makes the indicated corrections of these errors as they are revealed with the execution of the plan.

Compare actual with planned results. There are many circumstances in which this guide for control is straightforward and encompasses no difficulties. If one has planned to have a piece of equipment in place at a specific time it is easy to determine that the event has actually been accomplished. In the work plans of our scientists the matter is not so easy. This is especially true when one is trying to determine the congruence of percentage of work completed and of moneys spent; some phases of a project yield slowly and grudgingly while others flow with ease. Similarly, managers have trouble in comparing actual to planned progress in recruiting, morale building, custom equipment design, and plans to accomplish other typical objectives.

Another problem arises in making comparisons of actual and

planned accomplishment. It is the meaning of the reported information. For instance, if the manager learns that a phase of a research project is off schedule it may worry him but not to the point where he will take action. He does not have sufficient confidence in his control system to do that. Of course, gross error undoubtedly will trigger action but something less than this may cause him to wait and see. He doesn't know whether a correct procedure is being followed. The meaning of the evidence of discrepancy is not always clear, and the manager should not assume that it is.

Corrective action. The whole point to comparing actual with planned results is that corrective action will be taken to get back on schedule. If no action need be taken or if no action will be taken there is no point at all in incurring the costs of control. Furthermore, if the corrective action taken is too late to secure the intended results and to permit the appropriate integration with correlative achievements the whole planning and control function is aborted.

The chief error that managers make in the execution of the control function is to procrastinate. It is difficult to understand this failing because it may be due to many factors. There is, for instance, a lack of action just to make sure that action is indeed indicated. Of course, if this is really the case then the control system needs revision because this behavior rests upon a lack of confidence in the meaning of events. Sometimes the failure to act for this reason is somewhat forgiven by establishing a zone of indifference above and below the planned action. Managers are then told to take action when deviations exceed the zone of acceptability. Such a zone is really a crutch for the

indifferent manager. As a man looks at the history of action there may well be no need to act, even beyond the zone, if the trend of events plus what one knows about the future is favorable. Thus, the zone technique is no better than considering real differences between planned and actual results.

Another deficiency of some managers becomes apparent when they know action should be taken, but they are uncertain what to do. It is not always clear whether a laboratory experiment should be held up because anticipated events do not occur. It is not always easy, or perhaps desirable to lay off people while a new proposal is under consideration. And morale can readily be jeopardized by the way that action is taken. In this area managers find that there are no clear actions that are indicated by the control data.

Finally, there is the manager who is simply indecisive. Unfortunately there are too many of these men. They will worry about making the decision, they will avoid making the decision often by keeping busy on something else, and they present the data to their own superiors with a view to having him make the decision. This is the kind of a manager that no enterprise can afford. When it is said that even wrong decisions are better than no decisions it becomes clear how advantageous it is to a firm to have needed decisions made promptly. Subordinates respond to the decision-maker, their morale is enhanced, their path is made clear, and coordination is gained as all move forward toward the objective. Thus, inferior decisions are often made good; and wrong decisions can be rectified by prompt acknowledgement.

Need for review. It is worth while for a manager to keep in mind that there is always a need for reviewing his control

system. Of course, when a laboratory project is one of a kind there is little opportunity for reviewing the control of planned action. But for many types of major plans this is not the case. Plans for capital acquisitions, for recruiting staff, maintaining morale and the expenditure of money are repetitive. This circumstance provides the occasion for reviewing the effectiveness of historical control to determine just what are the strategic points, just what lead times are essential, whether personal responsibility for results is being measured, and to reassure each manager that his system really keeps him in command of his shop. Experience teaches us that reviews of this type on an annual basis often results in simplifying the control system, thus making it both more effective and more efficient.

Applications of the control process. The execution of the control function within the laboratory requires a keen sensitivity to the needs of subordinates. For instance, it is particularly annoying when the manager provides no shield for his staff from outside interference. There are many people in other departments and divisions within the company who may have a keen interest in the progress of discovery in some projects. They look at the matter from their personal viewpoint. The manufacturer may be waiting for a better material, the controller may be worried about budgetary excesses, and administration may be wondering if the labor laws are being properly observed. Even outsiders, especially the customer, may want a direct line to the researcher. Whatever is the case, it is clearly the function of the manager to shield his scientists from as much of this frustrating inquiry as possible. If he is a full-time manager

it is probable that he will have better success because he can give the matter adequate attention.

Plans for accomplishing laboratory projects are controlled, of necessity, but the manner of their control may vary widely. The senior scientist stands in little or no need for surveillance--maybe just some friendly shoulder to cry on. At the other extreme it is clearly appropriate to review progress with the inexperienced at frequent intervals. These people need and usually want close attention for discussing technique, procedures, the meaning of results, and the need to know their efforts are appreciated. The timing, the review of plans and controls, and the means of doing so are the decisions of the manager. If he is to be effective he will safeguard the interests of the laboratory while at the same time the needs of his scientists will be met with an appropriate mixture of unobstusion, support, interest, advice and counsel, and the use of time-saving techniques.

CHAPTER IV

ORGANIZATION OF RESEARCH ACTIVITY

Organization as a process begins when the manager identifies the activities whose execution is essential if the specific objectives of the group are to be achieved. He classifies these activities in some rational way that contributes to efficiency, places someone in charge of the grouped activities, and defines the authority relationships which will relate each group to every other one in the total enterprise. Only in this way can organized effort be accomplished, and this, in itself, is desired solely because it is considered to be the most efficient way to accomplish objectives when two or more people are involved. If efficiency is no object, managers need not, and quite likely will not, adhere to the organization process.

The establishment of a formal organization structure is obviously not an end in itself. It is the device or tool by which group effort can be focussed upon the realization of objectives. There are many ways to structure organized effort, each having its own efficiency quotient. It is the responsibility of the manager to choose the best way at a given moment in time. This requirement applies equally to all managers, including the managers of research activity. The organizational process can and does affect the productivity of scientists: the manager should strive to maximize its positive influence.

Scientific Orientation of Research Laboratories

It is quite probable that too much emphasis is placed upon distinctions between product oriented research laboratories

and those devoted solely to the advancement of science. The whole debate is reminiscent of the idle chatter on university campuses about the vocational orientation of business schools and the "purely" intellectual orientation of liberal arts schools. The graduates of both will, in our time we hope, have to earn a living and they will use their university training to this end. Those persons who feel that product oriented research is tainted are often unable to see that "pure" research achievements are also often turned to economic uses by someone else. The sole difference in concept between product oriented and pure research lies in the degree of remoteness between the scientist and the product. Good science can conceivably be undertaken in either organization but the likelihood of its emergence in product oriented laboratories can be quite low.

It is important to keep in mind, when trying to understand the positions taken by the scientists involved in this survey, that some of the laboratories were product oriented to a considerable extent and that four of them were mainly devoted to the discovery of knowledge. There are always various degrees in which research is product oriented. From an organizational point of view there are considerable differences in managing a laboratory comprised of 150 employees and of managing one with less than ten. Formal techniques are, as a practical matter, applied in the large laboratory while a rather informal structure is more effective in the smaller one.

Laboratory organization is concerned with this problem because its purpose is affected thereby. Activities would be differently grouped if it could be said that scientific (more

likely engineering) effort were fully oriented to the development and support of products, as compared with the organization of a laboratory that had no obvious end product. Organization affects productivity in several ways. The orientation of the men who will undertake the work is a pertinent factor; the isolation or cooperative factor is radically influenced; and the authority structure will be affected. If product support is important, the engineering and manufacturing divisions will have more influence in laboratory operations than would otherwise be the case.

Only three of the nine managers reporting on this topic considered that their groups were product oriented as measured by the devotion of over half their time to activities which were closely related to a product. The scientists in only three laboratories felt the same way. In contrast, there were the scientists in five laboratories who considered their orientation to be towards the general discovery of knowledge. There was, however, a significant point of difference between managers and their own subordinates about this matter. Irrespective of whether the managers saw their groups as product oriented, their own subordinates disagreed with them in seven of nine cases. This points up a major problem that recurs throughout this study: managers of scientists have many misconceptions about their subordinates, and these can lead to conditions that negatively affect productivity.

The scientists who responded to this survey did not feel that their pursuit of knowledge was particularly constrained by the degree of product orientation present in their laboratories. The problems that arose were such that they not only evoked

strong intellectual curiosity; their solutions made important contributions to knowledge. And there is another aspect. The scientists were not averse to aiding engineering or manufacturing divisions in solving a difficult problem or to general consultation. Indeed, they were pleased to be asked! The only objection arose when too much of their attention was required for these tasks.

Alternative Bases of Organization

The normal basis for grouping laboratory activities rests upon the intellectual disciplines involved. Typical of the titles used to describe these groups are Plasma Physics, Marine Sciences, Computer Sciences, and Decision Processes. Among the managers involved in this study the only deviations were related to project management, an organizational concept most difficult to rationalize.

It was clear that the scientists who reported to these managers did not usually understand the basis for organization. Most of them either did not know or thought the basis was product, process, or other. This fact is, of course, scarcely pertinent to their personal productivity. They didn't really need to know until they became some type of supervisor themselves.

A job description is a management device used to define the subordinate's area of activity. It is supposed to act as a tool of communication, to clarify for the subordinate the scope of his activities, and even to point up to the manager any overlaps or gaps in his work assignments. The practicality of this device is open to serious question. It is very difficult to identify all activities, the description soon gets out of date, it seems to be referred to only at the time a subordinate is introduced

to his work or at times when quarrels occur between subordinates over who should be doing what. The subordinate is inclined to interpret the description in accordance with his own aggressive tendencies. Some narrowly read the description so that they can logically minimize the scope of their jobs; others insist upon a broad interpretation. All in all, the hopes originally felt for the usefulness of this device have not been fulfilled: it is acclaimed by theorists and neglected by practicioners.

The managers of scientists still typically use job descriptions. There is a strong presumption that they do so because it follows company practice. Three-quarters of the managers responding to this question not only had job descriptions for their subordinates but also thought the statements fairly described the actual job.

As usual, the scientists in this survey tended to disagree with their superiors. Although twenty agreed that there were job descriptions, nine said there were none; twelve thought the descriptions were fairly accurate, seven thought they were not. There were twenty-three scientists who did not know whether job descriptions actually existed.

It is very clear that the job descriptions so carefully maintained by managers were not doing the scientists much good. Since this would be the normal expectancy for any kind of enterprise the better cure would be to abandon the whole business rather than attempt to make it work. There are other and much better means of achieving the ends sought through this device.

Authority Relationships

This survey reflected the happy circumstance that those who establish and manage research laboratories thoroughly understand the importance of having clear lines of authority. Since the right to command is the cement that holds an enterprise together it is a matter of serious import. Every manager of scientists in this survey, with but one exception, acted as both an administrative and technical superior. felt that he made the final decisions on these matters as far as his / subordinates were concerned. Only six of some fifty-one subordinates failed to understand this arrangement. Perhaps such agreement is over-optimistic. The scientists might have been thinking chiefly of administrative decisions because a much greater proportion of them feel <u>they</u> made the technical decisions.

Laboratories are affected by the functional authority of administrative and support groups in the same manner as are other organizational units. Budgets must be approved, research plans sanctioned and controlled, and enterprise policies and procedures followed. The exercise of authority over those matters by others, outside the laboratory, was generally looked upon as good. To this extent scientists are beginning to understand the necessity of management. In those cases where operations divisions were able to <u>require</u> the devotion of scientific effort to their problems, considerable resentment was aroused. There seems to be a question here of how much and who decides. Scientists do not object to spending a small amount of time on manufacturing problems but they do not want these assignments to interfere with the progress of their own research. Furthermore, they resent a

political situation that permits operating managers to dragoon their own superiors to approve excessive attention to operations by individual scientists.

It is also refreshing to learn that formal committee management of the laboratory is abjured by all the groups included in this study. There was a time when it was thought that managers, particularly those of research activity, would get better results if they abdicated their power to make decisions in favor of the majority decisions of their subordinates. Scientists simply don't like it this way so long as they are not personally involved in the decision. They are interested in their own research, not in the general management of others. And they abhor time-wasting committees as who should not?

Size of The Research Unit

The size of the research unit may be measured by the number of persons reporting to a given supervisor. From a management viewpoint it is desirable that this number be such that the manager is fully employed in managerial duties but not so large that he performs these duties ineffectively. The part time supervisor spends some time on managerial aspects of his job and the remainder on technical work indistinguishable from that performed by his subordinates. In all organized enterprise this arrangement is considered inefficient, primarily because management duties are invariably neglected.

Both managers and scientists were asked the number of scientists in their own organizational unit. There was certainly no modal response. Each manager, who surely should know, had a different number of scientists excepting two who supervised

sixteen. The remainder ranged from ten to two. There are several explanations of this atypical relationship. The sample of nine managers is undoubtedly very small; the survey was made at a time when every employer seemed to be in the market for scientists; and the practice of organizing a unit too small to require the services of a full time manager seems wide-spread. Interestingly enough, the scientists themselves disagreed with their colleagues and with their superiors on the number employed in their own organizational unit. In the latter case twenty-nine out of thirty-four were misinformed.

Among the laboratory managers three of eight thought they had the right number of scientists, the remainder thought they had too few. None believed they had too many! On these points their subordinates agree with them. A difference in opinion cropped up, however, concerning the adequacy of the technical support. The managers, with one exception, thought they had too few technicians to support their scientists. Nearly half of the latter thought the number was proper. This result is certainly unusual because scientists might be expected to dislike the technical work of set-up, maintenance, and knockdown of equipment, and the tedious work of waiting and counting. Indeed, this seems so reasonably human that it is safer to assume that the sample was inadequate to reflect the general situation.

Whether the absolute size, counting all employees, of the research group influences its productivity seems to be a moot point. The scientists participating in this survey were divided two to one, the majority feeling that size had little influence. It is possible that their differences would be less marked if

they could discuss the point at leisure. Some were very positive that scientific work is individual anyway and hence the unit size would be immaterial. There were others, however, equally sure that there is a critical mass that optimally affects productivity. A group of this size would maximize the gains from intermember contact and minimize the communication difficulties which large groups ensure.

When asked to suggest the size of the optimal group fifteen scientists thought that the number would be in the range of ten to nineteen; fourteen thought that less than five would be best, and twelve felt that the number was not important. It is difficult to know what occasioned this variety of response. Perhaps the scientists were merely reporting the size of the group to which they were attached, having no other experience from which to generate alternative answers. This could occur despite the fact that thirty-five scientists did have work experience with other firms. Just how standardized is the size of laboratory groups is unknown. Another possible explanation is that scientists may not have been conscious of possible relationships between productivity and group size and consequently paid little attention to the matter. Another variable is the nature of the scientific activity itself, and the number of fellow scientists in the group who would be capable of discussing common problems. Finally, the concept of critical mass is itself vague. Even though it has variable parameters the mere fact that a fifth of the scientists were concerned about it indicates that it can be a factor of some significance.

The respondents to this survey were asked to come to grips with this problem of productivity and group size. Eighteen of thirty-nine scientists reported their preference for working by themselves, fifteen preferred to work with one other scientist (they were equally divided when asked if the colleague should have similar scientific interests), and only six preferred to work with two or more scientists (with diverse interests). This does not mean that scientists who prefer to work alone do not communicate with others. With only two exceptions all the scientists in this study conferred with other scientists who had or were working on similar problems. They really did not care where these men were located. Some six scientists preferred to consult with men outside their own firm, thirteen preferred consultants from within the firm, and thirty-three had no preference. Scientists are clearly a talking group. They achieve a "critical mass" of communication either within or without the firm.

The managers of the responding scientists appear to be very uncertain about the whole matter. Looking, as they must, at productivity, they were equally divided between those who thought scientists worked better alone, with one other scientist, or with more than two. In five specific laboratories scientists and their managers generally agreed on this topic. In the remaining three cases there was marked disagreement. In one prominent laboratory the manager thought his men were most productive when working with two or more scientists, but four of five of his own subordinates preferred to work alone. In another case when the manager thought his men were most productive if

they worked alone, all of his men disagreed. And finally, there was the case of one manager who assumed that his men were most productive when working with one other scientist of dissimilar field of interest. His subordinates preferred to work alone in five of eight instances. Of course, the managers of these three laboratories could have been right in their estimates. If so, their men were producing in a satisfactory manner even though they would rather enjoy other arrangements. Or, on the other hand, perhaps the managers' practices were different from their convictions.

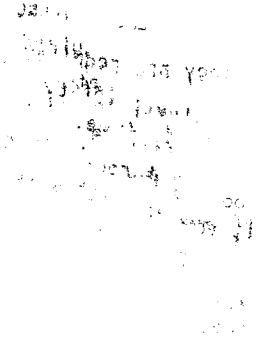
Summary

The organization process is carried out by laboratory managers in a generally effective manner. Perhaps this merely means that it is more effective than this author expected. There is considerable evidence that the basis for grouping activities is properly chosen and that the discipline of authority relationships is effectively as well as properly established. Both of these factors are highly important in contributing to the productivity of scientists. Whether the managers permit their subordinates to spend too much time solving engineering and manufacturing problems is moot. Of course, one of the reasons why the managers of enterprise approve of the establishment of laboratories in the first place is to have a talent reservoir to draw upon in case of need. However important this factor is toward the winning of government contracts, the case is quite clear that the productivity of scientists is not enhanced (although over-all work enjoyment may be) by this use of their services.

Despite the overall effectiveness of the organization structure and operation in contributing to productivity, certain weaknesses become apparent from the analysis of this survey. Any time and attention given to job descriptions is probably wasted. This technique might be replaced by work planning and review. The evident desire of most scientists to carry on their work alone should be satisfied. On the theory that people will be more productive if they can work in a manner that meets their own needs, it is desirable that the work be planned in such a way as to permit scientists to follow their preferences. Space and equipment will need to be tailored to each effort as planned.

Perhaps the most difficult organizational problem to handle properly is the part-time supervisor. From the management point of view this is clearly an inefficient way to group people. The cure would simply be to add subordinates to the point where the full time of the supervisor would be absorbed by the execution of his management functions. This solution is typically opposed in engineering and scientific groups because the supervisor wants to continue his own technical work. He has a deep fear of becoming technologically obsolescent if he withdraws from the bench and becomes a full time manager. Also, scientists themselves want to report to a superior who is an active scientist in his own right. This is much more a matter of security than of snobbery. A respected, technically sound superior can give more reliable advice and counsel than one whose technical knowledge is out of date. This is another way of saying, however, that the superior can be relied upon to guide and support the scientist if he/is actively engaged in scientific work.
himself

On the whole it is quite probable that at the front line supervisory level, laboratories will continue to be managed by part time technically trained managers.



DR. O'DONNELL: One of the things that is not clear is the use of committees within the laboratories. Why are they used and what does the scientist think about participation in committee work?

MR. IAMS: I might begin the discussion by saying that at the Hughes Research Laboratories there are three formal committees of which scientists are members. (They participate in some other committees occasionally.) The first is the Library Committee, where their concern is with the scope and adequacy of the information being obtained. The second is the Inventions Evaluation Committee, and the third is the Published Papers Awards Committee. In the latter instance the question to be decided is whether a given paper meets the exacting criteria for a significant financial award.

DR. O'DONNELL: Let's go back to the scientists and ask them: "Do you enjoy participation in these types of committees?"

DR. FRANTZ: I have never been on a committee. I couldn't say. I really have no answer to that.

DR. ALBERT WILSON: Scientists are willing to carry the load if they are required to serve on shop committees, recruitment committees, safety committees and so on, and they are usually very effective. In general, however, I think they would just as soon be through with committees and get back to their own work, if the responsibility doesn't have to be on their shoulders.

DR. O'DONNELL: They look at it as a part of their job but they don't really enjoy it?

DR. ALBERT WILSON: Part of the job, yes.

DR. MUIR: I have been asked to serve on a couple of committees and I agree with what Dr. Wilson was saying. It is something you do because you are asked to do, but very few people, I think, have volunteered for a committee.

These committees incidentally, at least in my experience, were concerned with some sort of day-to-day business type of thing. I suspect if one was on a committee that made very important policy decisions, for example about research funds or capital expenditures, then the view might be quite different.

DR. O'DONNELL: Do you have committees in your laboratories which are comparable to those which Harley mentioned?

DR. HAMERMASH: No, no formal ones. On the other hand, we are willing to talk within informal groups for special purposes involving, say, important issues like criticism of some method of operation or improvement. Then, I find there is a tremendous desire to participate, particularly if you pick an area wherein the fellows have been complaining for the last five years. The same people who wouldn't be able to spend an hour to come to a seminar will spend hours participating in things like that.

GEN. CAVE: Would you mind elaborating on the kind of subjects about which they complain?

DR. HAMERMASH: I will give you a specific example. It concerns a soheme that we used a couple of years ago to disperse company funds. There was a lot of criticism of this. So, this past year we arranged for committees or informal groups, to discuss this issue with a view to finding out what the real problems were and what might be done. We used this as a vehicle, first of

all, to get some data and then to generate a more meaningful approach to the problem.

DR. OSTERYOUNG: What you are talking about, is this idea of getting the scientist to participate in certain things that really affect policies. The committees described over here are certainly not policy-making in any sense.

Most organizations, I think don't have committees which really do this sort of thing, but maybe it is a way to permit people to participate. Again, if the individual wants to, I think it is very worthwhile where it really affects him.

DR. HAMERMASH: What this means is that you allow the people to participate in some of the areas which the managers usually keep as their own?

DR. O'DONNELL: Is this basically a search for information--your old communication problem, Robert--or is there an interest in affecting policy?

DR. HAMERMASH: It is both.

DR. OSTERYOUNG: Somebody makes a policy decision as to better ways for divvying up the pots.

DR. MUIR: There is one other similar function although type it is not really a committee activity.

I know that in a number of laboratories there is an internal review before a paper can be sent out for publication. Sometimes this is done by one of the managers, but more than likely the paper would be fielded to some other scientist.

Most of us, I think, circulate our papers among our colleagues anyway, just as a matter of getting constructive criticism. This is the type of an almost-committee-like activity that I think the scientists generally regard as being very worthwhile.

It keeps them aware of what is going on in the laboratory. They learn something new. It also helps the laboratory.

DR. LYON: We have many different types of committees, and the ones that serve the functions naturally are very good. Sometimes you can abuse them and replace a function which is properly done by one individual by a committee. Those kinds of committees I don't like.

DR. O'DONNELL: Our questionnaire indicated that scientists, not the managers, took a rather dim view of the amount of time they have to spend on committees.

DR. SALZER: I was very much surprised that anybody wants to serve on committees. My experience is that the only thing they want to be able to do--and excuse the expression--is to gripe for not having been invited after all the results are out, saying "I don't like something." This is their right, but generally they are not interested in committee work. They would be interested in reviewing papers not as a committee function but as a scientific function. If it is in their areas of specialty or interest, they would be very interested and very happy to do that.

I found out that it is generally much more effective to use either line management organization to carry out all the functions so far mentioned, or to establish some staff functions that are scientific in some sense.

I don't see any reason why people who are really motivated to achieve things in science and get recognition as scientists would want to work on committees unless this is directly in line with that objective.

GEN. CAVE: May I specifically ask, how about those group activities that have to do with planning capital budgeting in the Research and Development area?

DR. SALZER: They are interested in making selections as to what factory equipment you buy, and they even call the suppliers to make sure that the electron microscope that gets ordered has two little holes in it or something. But that is because they consider it their tool in scientific endeavor. If I wanted them to come on a committee to evaluate capital equipment acquisitions and planning, no.

GEN. CAVE: For those electron microscopes?

DR. SALZER: No.

MR. IAMS: Those who evaluate inventions should both understand the technology on which the proposal is based and be able to visualize its practical utility. Particularly in dealing with the often esoteric ideas generated in a research laboratory, a committee composed largely of scientists may be superior to one comprised of managers.

DR. SALZER: I would say this: I don't agree with you for two reasons. One is that Dr. A is a scientist interested in evaluating scientific achievement in his field and is absolutely not interested in looking through the list that comes to these committees. Patent committees reject at least 50 percent of the disclosures as being worthless. The other 50 percent they have to mete out administratively to specialists, and that is the committee function. The point where the scientist wants to come in is when we get down to three specific inventions. He is supposed to comment on them. At that point he is very happy to do this because we know that that is his field, and he can really

contribute to the evaluation.

DR. OSTERYOUNG: I disagree. I think at the policy level, which will really affect the scientist, he wants to be in the discussion. For example, what sort of computing operation do we want? The scientists who are involved are not really the computer people per se but experimentalists who have some interface problems. It is a policy matter because it involves how much money you are ultimately going to spend. If the decision comes down without their participation they may be very unhappy about it.

DR. SILVERMAN: I think there is one point of disagreement. Consider the safety committee which has to meet every month and discuss routine tasks. I think that you will find the scientists kind of rebelling at this task. When it comes to some sort of special problems that are confronting the laboratory that have to be solved in order to make the laboratory work more efficiently, I think you will find scientists are really willing to cooperate. But when it becomes routine like reviewing a dozen patent disclosures, none of which may be of any value, then they kind of rebel about this.

I think there are possibly two reasons why you respond to this type of thing. One situation is where you need a multidisciplinary force to look at something like safety. You probably can't find one man who is able to evaluate safety in every laboratory. The undesirable case is where you have a committee because nobody is willing to accept the responsibility for making a decision.

DR. O'DONNELL: Let me go back to Jack for a moment. What is your attitude toward committee service?

DR. GREEN: I am only on one, the Library Committee, which meets irregularly. It is valuable to monitor the heart of a laboratory and I appreciate this responsibility. For specific laboratory problems, I think a special meeting of those scientists involved is necessary. If a person has something to say he should call it to the attention of the manager or director. However, I believe the research scientist should be fairly free of routine committee work.

DR. O'DONNELL: Would it be fair to say that the scientist is willing and anxious to serve on committees that affect him and his own research work?

DR. GREEN: Yes.

GEN. CAVE: If there were no representative from the laboratory on the safety committee and there wasn't going to be one unless you volunteered--

DR. GREEN: Then I would volunteer. There are certain housekeeping chores that you have to perform. If you are in a certain type of laboratory, you have to write proposals; you have to do a lot of things you don't want to do. You have to be realistic. In writing a paper, you have to compose your own bibliography. There are dishwashing phases in every aspect of research.

GEN. CAVE: Actually in asking the question, I was thinking of some of the real hazards that might crop up in a laboratory unless someone with a good scientific background were there to say, "No, let's not."

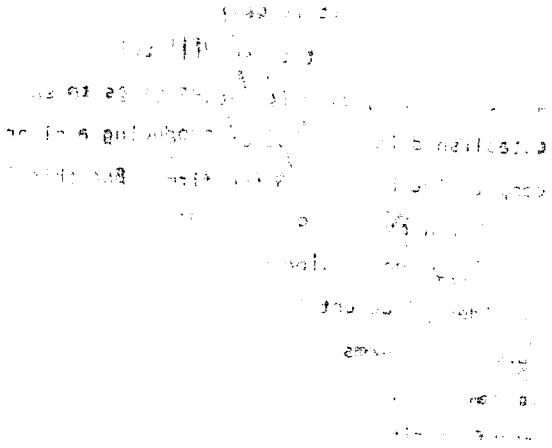
DR. O'DONNELL: Dr. Lyon, do you feel that there is an unnecessary use of committees in the laboratories?

DR. LYON: No.

DR. HAMERMASH: I don't think there are enough of these informal special purposes committees. I think we can use a lot more of them. I think that the managers can assign a lot more tasks to groups, can get a lot more feedback from them.

DR. O'DONNELL: John, does that answer your question on committees?

GEN. CAVE: Yes, I think it supports my view that committees are not altogether unwelcome if the scientist can see their relevancy to his own activity. I wonder if scientists are any different from everyone else when committee work cannot be connected with the work they are doing.



MANAGING THE ORGANIZATION FUNCTION

The way in which laboratory personnel are organized and decision-making is structured can have a considerable impact on the productivity of scientists. Organization is a facilitating function and it should be accomplished in a way that protects scientists from incursions upon their time and attention that detract from their research activities. Consequently, the manager of scientists should concern himself with such issues as the location of the activity, grouping of personnel, the size of groups, and the establishment of clear lines of authority.

Organizational Placement of Research

The selection of an organizational home for the research activity involves several important considerations, and in their weighing a different answer emerges. Standing at the head of these variables is the reason for establishing the function. Corporate managers are really not too clear about why they want a research arm. It is easy enough to resort to vague and even gracious phrases but these will seldom shed much light upon the question. They find it rather gross to say that research is established in the hope of producing a clear financial and competitive benefit to the firm. But this is truly the case even though it does sound materialistic.

With recognition of the purpose of research it becomes clear that its placement in the organization structure should be decided in terms of its contribution to this end. Several choices are available. The research personnel may be located within a manufacturing division, they may be in a separate department reporting on the same level as production and sales, or they may

be a separate division physically isolated from the other corporate functions, and reporting in at the top corporate level. The orientation of the research group will largely determine where it can make its best contribution. This may range from the one extreme of development to the other extreme of completely unrestricted basic research. The location of the activity within the over-all organization structure depends very much on just what place on the continuum research lies. The closer it is to development the lower it will report into the structure; the closer it is to basic research the higher it will report.

Another important consideration which affects the organizational home of research is the size of the group involved. If there are only a few scientists, such as five or less, they would probably find themselves within the purview of some division manager who likely sponsored them in the first place; on the other hand, one may visualize two or three scientists associated with an Einstein reporting in at the top corporate level. In practice, however, if only very few men are involved they are also more likely to be development oriented and therefore they would find themselves within an engineering or production division. As the group grows beyond this mere handful it will gradually take on the attributes of a university-based group. The orientation will move towards increasing emphasis on basic research and in order to permit or indeed facilitate this trend corporate managers see the advantages of a separate research division or a research subsidiary. These, of course, would report in at the top level of the organization structure.

In the discussion of this question there was no implication that the research group starts in a small way and grows to larger

units. Especially for those firms that have reached the decision that basic and developmental research can contribute in a significant way to their competitive posture the probability is that a separate research division will be created. A division director will be the first to be employed. He will be provided with a budget to support a building, equipment, and staff, and he will be expected to be in operation within a year or so. In this way firms get into research in a large way within a very short period of time.

Separateness, or the degree to which research is independent from other corporate divisions, is very important if its orientation is largely in basic research. Scientists need to be completely free to select their own projects and explore them and they can do this better in the separate division than as a department of an operating division. On the other hand, the purpose of research should not be forgotten. If the activity is to improve the competitive and financial prospects of the corporation, there is a definite need for liaison with development, a function normally found in engineering divisions. Someone needs to be the catalyst who can see the developmental prospects of a basic research effort, or of the pieces of basic research effort, and make certain that its potential is explored. It is rarely the scientist who can do this. Normally it will be the responsibility of the research director who may engage in the process personally or provide for direct communication between development and research personnel.

Subordinate Scientific Groups

Within the laboratory, wherever placed in the corporate structure, the problem of grouping activities does not arise if

there are only a few scientists aboard. In this case each person would report to the director or senior scientist or whoever is placed in charge of the activity. As the number of scientists increases there comes a time when the director must think in terms of grouping them in some manner because he alone cannot effectively supervise all. He may very well identify a few senior scientists who will undertake the duty of technically supervising one or more subordinate scientists. From the director's point of view, the term "senior" scientist will stand for more than a status or salary classification. It will reveal that such a person is in the position of technically supervising the work of subordinates. And such a person will be chosen on the basis of his capability for the direction of research work identifiable by subject matter, e.g. quantum physics or bio-chemistry or decision processes. Organization seems to polarize around the intellectual discipline of the men who are hired though men with interrelated disciplines are often grouped together when progress in the state of the art depends upon their close cooperation.

If a laboratory continues to grow in the number of employed scientists, a point is reached when the senior scientists described above must be grouped together under the direction of a department manager who in turn will report to the laboratory director. Thus, more formal techniques of organization are required in large laboratories than in small ones simply because adequate attention cannot be given to all by the director. It is quite uncertain at what point this regrouping must be undertaken. It is fairly certain that some directors will want to delay regrouping as long as possible; on the other hand, directors who want to engage in research themselves will hasten the

process.

Size of Research Groups

It should go without saying that the actual number of persons reporting to any manager within the laboratory should be that which maximizes the productivity of the group. The ideal is perfectly clear; how to achieve it depends upon optimizing several variables. One is the degree of support which the firm decides to provide for a particular effort. The budget provides for a staffing pattern which may limit the number of scientists to very few or to a considerable number. In the former case the pattern may provide for a part-time supervisor; in the latter case it may or may not so provide because it is not certain that the technique of full-time supervision will be utilized. At this point the preferences of the supervisor become important. If he prefers to be a part-time manager (or supervisor), the managerial style will be the same in both small and large laboratories.

Whether a laboratory director should move from the use of part-time supervisors to full-time supervisors as the number of scientists increases can be determined logically on the basis of the relative productivity of the two techniques. Clearly, the firm would prefer that organization pattern which will maximize productivity. The problem is that one cannot say categorically which organization technique will yield this result. From the viewpoint of management theory the specialization of managers on a full-time basis should give the better results because their work is extremely complex, it requires years of practice to excel in it, and therefore it should have undivided attention. On the other hand, scientists are fond of saying that they prefer to work for a part-time supervisor who is presumed by this reason

to be actively engaged in science; and the part-time supervisor prefers it this way because he looks upon himself as primarily a scientist with a career as such. It is probable that this argument will never be settled. Indeed it could be so only by experimentalist techniques, and neither the firm nor the scientists seem interested in furthering the science of management by this means. Since the potential gain from knowing the answer cannot even be visualized at present, it is probable that enterprises will go on their uncertain way so long as they can afford to support a laboratory.

Committees

The judicious use of the committee device can make it a useful managerial technique. Their specific purposes need to be clearly defined in order to achieve responsibility and to prevent improper usage.

Committees are comprised of two or more persons of equal status, as far as voting power is concerned, who are assigned a joint specific duty. They may be of a standing nature or they may be ad hoc; they may have authority or they may not. For instance, the board of directors of a corporation has both the authority and the responsibility to manage the firm. On the other hand, a committee of executives reporting to the president is only an advisory group. They cannot make final decisions. Indeed, practically all standing and ad hoc committees found in organized enterprise are advisory in nature. Exceptions would be those having a more routine duty to perform such as the activities of a library committee which usually has the authority to make purchases and order cancellations, but this is done within the safeguard of a budget.

Students of committee behavior soon come to realize that the members can and do have a very great weight in influencing the decision-making process. First, there is the matter of membership. This is selected by the common superior of all members, and he will see to it that he has a majority of people who reflect his views. Of course, he will appoint prominent members of a contrary philosophy but this is only for the purpose of simulating disinterest in the nature of committee recommendations, and giving the appearance of arms-length dealing.

A committee of this nature does work very hard and comes in with solid recommendations to their common superior, or to the group of which it is a part. The mere fact that the committee members do spend a great deal of time in studying all aspects of matters referred to them and reach a decision based on both the evidence and their personal philosophies places the committee recommendation beyond the reach of all others of the larger group who may instinctively oppose the selected course of action. The latter have not become acquainted with the details, they have not consolidated their position, and they have not had time to organize their larger membership in opposition. Consequently, there is little wonder that committee recommendations really have much of the authority of a line decision.

The foregoing evaluation of the recommending committee is particularly apropos to universities and political groups. In a business enterprise the overtones of power politics is less in evidence. For one reason, the firm cannot afford to reach a wrong decision very often. In a competitive world rational answers to tough business problems must be reached if the firm is to survive. In this environment the quality of the recommendation

is extraordinarily high and therefore is greatly valued by the responsible superior.

There is an important on-going fringe benefit produced by committee deliberations. It has to do with the ability to facilitate communication. Committee members gradually become a well-knit group, even if they are opposed philosophically. They are well acquainted, they know just how far each can be trusted, they derive from various parts of the firm or division, and each tends to know what all know. Therefore committee service is often highly valued for its communication benefits in addition to the power it confers upon the membership. Each is in the forefront of knowledge about what will be done and each acquires status just for this reason.

All managers should use the committee device if it will help them achieve their objectives. With experience, they will find that some members are much more effective than others. Particularly in laboratories it well may be that many do not wish to serve; they should not be required to do so because it will lessen their available time for research. On the other hand, there will be many who want to influence decisions, to be a part of the managing process, and quite possibly to seek a career in management. Committee service is a good proving ground for this group.

Need for Clear Lines of Authority

The term "authority" like "profit" and "autocracy" seems to have suffered considerably at the hands of those who simply don't like any authority except that which they themselves exercise. And yet the manager of a laboratory does have and must have the right to command subordinates to act or to refrain from acting with respect to certain clearly defined areas of activity.

Scientists are notably sensitive about the authority of their managers when the subject is discussed in generalities. And this is as it should be because scientists who will be engaged in basic research do have a need for certain kinds of freedom from the commands of superiors. But even these men see the necessity of their superior's right to command in such areas as consulting, inventions, publishing, equipments, and many others.

In any discussion of authority within the laboratory there should always be the generally accepted assumption that the degree and scope of the authority of a manager should be directly related to the productivity of the group. Ultimately this is what is wanted and if it can be furthered by specific authority that is delegated to a laboratory manager this should be done. Those who have decision-making authority are entrusted to use it with the view of furthering the best interest of the firm. Of course, authority can be and sometimes is abused by a particular manager. But it is not the fact that he has authority that is at fault: it is the failure to select the proper manager.

The authority to make contracts, to order equipment, and to employ and terminate personnel is exercised by laboratory managers. It is essential that this power lie in the hands of a responsible manager even though he may very well seek the advice of anyone in its exercise if he pleases. But only the manager is personally responsible for results in these rather typical areas of decision-making. There are other areas, especially of policy interpretations, that are often overlooked in any discussion of authority. The manager should clearly be concerned about intrusions of outsiders especially on the time of the scientist. Demands of producing and engineering divisions for consulting time can be

so great as to seriously limit the effectiveness of the scientist. Here is an opportunity for the laboratory manager to discuss the matter with his subordinates and develop a policy statement that sets forth the limits of the consulting function. When this is proclaimed, any scientist can point to the policy as justification for refusal to give more than a particular portion of his time to such activity. In this way, the laboratory manager can protect his subordinates from unwarranted intrusion. The approval or denial of permission to travel, to present papers, to publish is likewise an exercise of authority carried out, hopefully, in the best net interest of the firm. Considerations of long and short term advantage are important, as are reflections upon the status, prestige, and morale of scientists. Only chaos could be expected if the manager did not have and did not exercise the authority to make decisions in these appropriate areas.

The exercise of authority over the selection of research projects and procedures, their continuation or modification or termination is often quite another matter. The trusted senior scientist would not expect any limitation upon his freedom to act in these matters and no intelligent manager would try to limit that freedom either. But all scientific personnel are not qualified senior scientists. They come in complex forms: some very junior and inexperienced, many who cannot make a decision, others who have inferior judgment, the fanatic and the carefree. It would clearly not be safe for the laboratory manager to delegate authority to these types to select and engage in science with complete freedom. Rather, he should reserve the authority to intervene as common sense would dictate. People respond uniquely to the exercise of authority; it is the manager's duty

to use it sensitively. He should be finely attuned to the needs of people in order to know how to use this power; that he has the clear authority to act there should be no doubt.

CHAPTER V

STAFFING THE LABORATORY

People make the difference and differences in the abilities of people spell out the future for any organization. It is for these reasons that the staffing function of managers is so critical and especially those within the laboratories because it is here that so much depends upon so few. The laws of average do not provide security as they may very well achieve in large here groups. The decisions involving recruiting, developing and evaluating scientists and their managers are necessarily made in the clear view of all, and the results are equally apparent. It was for these reasons that considerable attention was given to the staffing function as it was carried out in the laboratories considered in this survey.

Recruiting the Scientist

The criteria available to the recruiter of the inexperienced scientists are bound to be notably inadequate. The potential employer wants him for what he will produce and what this is has a very low correlation with what can be known about him before he has worked for anyone. The recruiter will inquire into the quality of education received--but he does this on the basis of selecting graduate schools which he and his competitors hold in high esteem. That is, the reputation of the school (which usually covers all its graduates) is a blanket sheltering all those who graduate. The recruiter can know something about the quality of the grading system used to evaluate students. The candidate's dissertation may be examined but here again it is not known what

part the student contributed of himself. Dissertation chairmen typically give very close guidance, provide alternatives, and closely follow the progress of the dissertation. Recruiters like to look into the length of time it took a candidate to complete his dissertation. But this is a valueless bit of information. Time is closely related to the degree in which the problem is correctly posed and the best means of attack selected. The student may be lucky on both counts, his chairman may have done the work for him, or the candidate may really be a potential genius. The recruiter is unlikely to know which is correct. He may inquire into the technical interests of the candidate to make certain that these coincide with those of the potential employer. This is useful with respect to broad areas of interest but heavy reliance should not be placed upon this consideration because interests may be very vague at this stage in a man's career, and they do change. A sound education in science would be a much better criteria. Finally, there is the matter of personality. The potential employer would prefer to have a man who can get along with others in his laboratory simply because it makes life easier to live. But he would not turn down a highly productive man or a genius just because he is also a devil. And how is a recruiter to know, anyway? Candidates are on their best behavior at such a time. Perhaps instructors can give an estimate of a student's worth--but this is subject to many vagaries because the instructor cannot generalize. All in all, the recruiter of newly graduated scientists must continue to be guided by hope, a little charity, but no faith.[3/]

3/ A trinity very familiar to research directors. See Cyril O'Donnell, The Strategy of Corporate Research, San Francisco, California: Chandler Publishing Company, 1967, p. 98ff.

The managers who took part in this aspectof the study gave no indication of awareness of the foregoing recruiting problems. On the contrary, there seemed to be a strong sense of confidence. The very use of terms such as education, personality, and ability carries the implication that these elements are knowable and measurable There seems to be a marked degree of naivete here.

The criteria for evaluating the experienced scientist who is a candidate for employment are much better. An employer wants him for his potential productivity and the best indicator is certain to be his past record. It is even refreshing to be freed from the uncertainties of the typical campus recruitment process and interview a man with a record--a record he has made, whether good or bad, because he has lived beyond his graduation. The record will be a complex of reports, papers, articles, books, patents, and actual laboratory accomplishments attested to by past employers. If one may assume (and an inquiry should be made about this) that the record reflects the candidate's own accomplishments and not someone else's it is a relatively easy matter to evaluate in terms of volume, quality, originality, and technical competence. With few exceptions the past forecasts the future.

The managers responding to this question faithfully followed this technique. The records of candidates were combed with patience, great care was taken to make sure the candidate's technical interests were complementary to those of the laboratory, and interviews were conducted to check out the personality factor. Of nine managers involved, four mentioned technical competence, three listed personality, and two mentioned

education and originality as factors of special importance. Elements mentioned once included references, interview, experience, publications, productivity, and interests. It would appear that the recruitment of experienced scientists has achieved a satisfactory level of sophistication considering our present ability to know people.

The scientists who report to these managers have a good deal to do with the recruitment of new members of the laboratory. They relied heavily upon past performance and technical competence of the candidate, twenty mentioning these factors. Comparatively, there were twelve mentions each of education and references, nine mentioned coincidence of interest, and eight cited personality. While the scientists generally agreed with their superiors, there was a marked difference in their reliance upon education and references. Of course, no manager would undervalue these factors if confronted with the question, but the mere fact that the managers rarely mentioned them while their subordinates placed considerable emphasis here may indicate that scientists have a broader field of reference than their managers. The professional man is imbued with the values associated with graduating from an esteemed university, and with the opinions of his peers. The manager, guided by the record, gets closer to the qualities that point to the potential productivity of scientists.

Appraisal of Scientists

Appraisal of subordinates in organized activity is a universal practice. Scientists are appraised, along with others, though there is a notable lack of enthusiasm for the practice

displayed by all parties concerned. The purpose of regularly evaluating subordinates is to provide a basis for the administration of an incentive system. Managers discriminate in order to establish a rational basis for distributing the rewards of salary, promotion, and status symbols on the one hand, and for assessing the negative incentives. Why is this evaluation process deemed necessary? The usual response to this question always includes a desire to show appreciation for good work coupled with the enticement of good employees to stay with the enterprise, and the determination not to support a man who is unproductive and uncooperative. This practice of individual measurement is a key factor in the development of western civilization and is so commonly accepted that its uniqueness is scarcely questioned.

Appraisal of Research

Managers appraised the work of their scientists in a wide variety of ways. Quantity and quality of the work and the evaluations of outsiders were the basic considerations. About half the managers concentrated upon the quantity of the work turned out as measured by the completion of phases of the research or the solution of the problem itself. The quality of the work was important to a few managers. These were concerned about the technical excellence, originality or merit of the accomplishments. Those managers who relied upon outsiders' appraisal of the work of their scientists looked to such things as publications, peer evaluations, and government contracts which resulted from research activity.

The managers were by no means agreed upon the proper evaluation methods. Those in enterprises which depended upon and expected positive results from their laboratories tended to stress the accomplishment of research plans. Those farther removed from product orientation tended to stress the prestige gained through outside recognition.

A majority of the scientists felt quite sure that they knew how their work was evaluated but the remainder were very unsure. Most of those who had positive ideas about the question thought that their publications and their completed work were the bases for appraisal. On the other hand, a third of the scientis either did not know how their work was appraised or did not answer the question. Here again it seems apparent that if their superiors were really convinced that it was important for the scientist to know how he was appraised they would surely have communicated the basis for measurement.

If the scientists themselves were required to evaluate their own work they would emphasize their growing understanding of phenomena as measured by solutions to problems, and by their publications, which confirm the quality and originality of the work as judged by their peers. Thus, the scientists would measure their productivity in the same way that they think their superiors are appraising it. These men are certain that they know how to measure their own work but they are not much concerned about comparative standards.

This certitude undoubtedly carries over into the managerial group. Since these men were once scientists, they are certain that they know how to evaluate their subordinate's

work: they just don't like to do it on a formal basis, and especially don't like to confront their men with evaluations that are negatively critical. In this respect they duplicate the attitude of managers everywhere.

Beyond the research performed by scientists certain end-products were either required or expected of them. The actual expectations of managers and their subordinates are reflected in Table III. While there is no serious difference between the views of both parties as far as relative weights are concerned, it is clear that managers had a more positive view than had their own men. If attempts were made by managers to communicate their expectations it is clear that here again several failed significantly. As one examines the individual laboratories it is apparent that this communication failure was encountered markedly in the four laboratories that seem to have marked managerial deficiencies.

TABLE III

REQUIRED OR EXPECTED END-PRODUCTS OF RESEARCH
(in percent of total number responding)

Item	By Managers	Scientists Believed Manager s Requirements or Expectations to be
Journal articles	9?%	7?%
Status reports	80	70
Intra-firm reports	7?	46
Unpublished articles or speeches	67	52
Patents	5?	?0
Use of findings by others	40	18
Consulting	0	6
No expectations	0	2

One would normally expect that the supervisors of scientists would evaluate exclusively the results of research activity. In all other aspects of enterprise operation this is truly typical

However, in the case of the laboratories which contributed to this study, the managers agreed that they carried about 70 percent of the weight in evaluating research and the scientists thought they themselves influenced the evaluation to the extent of about 45 percent. Thus, there is general agreement that managers do not exclusively evaluate research activity: they are very much influenced by the views of their subordinates. In enterprise activity as a whole this would be revolutionary: the possibility of conflict of interest on the part of the subordinates is obviously present. One must conclude, then, that scientists are unusually objective in the evaluation of their own work or their managers are exceedingly permissive in this regard.

There is no doubt that considerable confusion exists on this point. An analysis of the views of the laboratory managers and their respective scientists leads to this opinion. For instance, there were four laboratories in which the scientists felt they influenced the evaluation to the extent of 70% to 80%. In these same laboratories, the managers thought they carried a 70% to 80% weight! Obviously, something is wrong here. It would appear that these scientists labor under a misconception of the importance of their contribution--and perhaps their managers are not about to discover the truth to them.

The managers, with one exception, feel that the nature of the progess appraisal function affects the productivity of scientists. One in two of their subordinates do not agree with them. Both groups thought their present appraisal system was close to ideal. It is clear that those scientists who did not think the process could affect their research negatively worked

in laboratories in which they had a preponderate voice in the evaluation. As one of them states, "General policy is to hire well-above-average scientists to work in desirable research areas and allow them to determine what is the significant research to be done in this area and to carry it out essentially on their own. What is appraised is the final result. This is a tricky business unless you know the scientists involved are good. Actually, younger scientists and those whose ability has not yet been ascertained should be encouraged to start off in some degree of association with a more senior staff scientist."

Over-All Rating of Scientists

The over-all rating of scientists is practiced almost universally. A standard form is used by eight of nine managers. There is a considerable resemblance between these forms, since it is a practice of managers to see the forms used by others and to canabalize them when this promises to improve their own technique. The scientists are a bit irreverent, as is typical of other employees, in their references to the rating form. Since it is likely to summarize the estimate of a superior concerning the man's knowledge, technical judgment, level of effort, relationships with intracompany personnel, and his recognition by external peers, the individual scientist refers to this as a score sheet, report card, questionnaire, and numerical review (the elements are weighted). The rating occurs either annually or semi-annually and with three exceptions it is done by the immediate superior. In these exceptions a committee whose membership is comprised of a representative of the salary administration board, the director and associate directors of the laboratory,

and sometimes one of the group leaders.

The scientists themselves, in the ratio of one in four did not know anything about the rating processes. Of the 29 who knew there was a periodic appraisal, nine were wrong about who appraised them and eight did not know how frequently they were rated. It is apparent that the managers have a system but their subordinates don't understand it. Can they pretend it is of any value to scientists under these circumstances? If not, perhaps the main reason for its existence is to satisfy the requirement of someone in administration for a "form," useful or not.

Summary

The managers of scientists are certainly consistent in the execution of their staffing function. All were very confident of their ability to select men for their staff but they really should not have been. Nearly all of them had terminated one or more scientists, usually for low production and incompetence. One may well guess that those who were separated from the payroll were new graduates--men whom it is very difficult to evaluate. If this is not the case, then the employment of itinerent scientists was a careless process indeed.

The research work itself was consistently evaluated. To a greater or lesser degree the evaluation was accomplished through an agreement between the scientists and their managers. This practice reflects most favorably upon the scientists themselves: they confirm our common conception of men who have the character to live by their own standards of excellence. The fact that so many did not know how their superiors evaluated

research work points up a common inefficiency on the part of managers in communicating with subordinates.

Scientists are universally appraised on an over-all basis. This process is well understood by their managers who get the job done. But there is room for the suspicion that they do so unbelievingly because their own subordinates are largely confused about the procedure. Laboratory practice is most painstaking about evaluating research accomplishments but reflects a notable lack of enthusiasm for the over-all evaluation of scientists. This does not mean that scientists don't want to be evaluated: in fact, they very likely do. It does mean that their managers are at fault here because they are administering a system that they know will often create trouble due to its subjective content--a deficiency enterprise wide in its application.

DIALOGUE OF THE SEMINARIANS

DR. O'DONNELL: The major topic that I hope we will discuss today is the degree to which the productivity of the individual scientist is affected by the management process. One of the things we are sure of, as managers of scientists, is that we are not hiring a machine. Of course, we want the attributes of the individual scientist, his intelligence, his curiosity and his imagination, his training, and we hope these qualities will make him productive. But, in addition, we must hire the whole man. I often think that the managers of scientists sometimes forget that they cannot have part of the man; they've got to take the whole thing, and some of the attributes of his human nature are in conflict, really, with his potential for productivity.

The manager is primarily concerned about eliminating the environmental frustrations of the scientist, reducing the amount of time that he spends on non-productive work, and inspiring the scientist to better and greater things in his own particular area. We have a concept of what the management process will do or can do in this respect. The manager of scientists creates an environment in which the genius of the scientist can be brought to bear on his research. In exploring the relevant issues perhaps we might first inquire into the question, "What does the scientist expect of his supervisor?"

DR. FRANTZ: Well, you can't say what the scientist in general expects. Perhaps I can say what I expect or what I would like, and that is principally to choose the type of work that I want to do even if it comes within a certain bound of

orientation. The type of thing that I normally find myself up against is the problem of finding support, and the kind of thing I would like from the administration, let's say, is some protection from the needs to spend all of my time looking for money rather than doing research.

DR. DONNA WILSON: It is very interesting to consider this environment that one is trying to create. As a woman, it seems to me that it is exactly the function of one who has to manage a household. The various problems that come up are exactly those that are found in this kind of role. The family either goes ahead or doesn't, depending upon the environment that the mother creates. This environment is a very important and intuitive thing. It can't be put down in principle. The housewife knows intuitively and immediately the kinds of activities that require scheduling. In my experience, what I would like managers to do is to acquire a better sense of scheduling, the calling of meetings for example. One experience of mine concerns a manager who scheduled a set of computer classes which I very much wanted to attend in my staff capacity in the research laboratory, but he scheduled these on some other criteria. He never considered asking or giving alternatives to members of the staff. This kind of interruption, you know, is very frustrating to someone who is trying to do some research. My experience is that my schedule is set up several months ahead of time. For instance, I have known about today's conference several months ago. If my laboratory manager calls a meeting with short notice, that I am supposed or want to attend, I think it is poor coordination. Managers could, you know, wake up a little bit.

DR. LYON: Well, speaking from the management end of it, I would say that the role of the manager is to provide the scientist with what he wants within this context. From my own experience, I have tried to provide some insulation between the demands of management and the working scientist. I think this is the proper role of the supervisor, and I think that satisfies the desire for a certain degree of professional isolation that the scientist usually wants. There is always the question of leadership. I haven't heard any scientist say this yet, that he expects direction or leadership from his supervisor, and I am not saying that they should say that, I am just wondering if that isn't something that is expected. Certainly in this field it is a very difficult thing to provide on a deep, technical level. Again, I can't answer that, but I am curious.

DR. ALBERT WILSON: May I ask you to define what you mean by "leadership" in this case?

DR. LYON: That is a very good question. In its broadest sense, it would certainly include motivation. Leadership also includes the technical direction and stimulation of new ideas, or the development of ideas. It is sort of a relationship which you might continue on from your school days--the professor and the student relationship. I am mainly curious whether that sort of thing is viewed as being desirable from the scientist's standpoint.

DR. ALBERT WILSON: I feel that scientists in general expect their leaders to be good scientists as well as good administrators. In order to look up to someone in a science management position, they feel strongly that this man sometime in his past, or currently

must be a person they can respect as a scientist in addition to his other qualifications.

DR. SILVERMAN: You indicate in your document that the part-time scientist-manager is very inefficient, and yet one of the things that has been stressed here, is that scientists like to feel that the people to whom they report are themselves scientists. To some extent this means really working at it. In other words, you can't communicate with people who don't know what you are doing.

Is it inefficient, then, in terms of what you are trying to accomplish if the manager himself is not a full-time manager?

DR. SALZER: I thought it would be four o'clock by the time we reached the conclusion that anyone who wants to be a research director should have his head examined. It is very clear that the requirements of a manager of scientists are too many.

Let's look at each one of these requirements. The first comment by Lee Frantz was that, "Gee, I wish they would leave me alone and let me do my science, and let somebody else do the selling."

Now, this selling is really communication. Somehow you have to sell yourself. I don't think that just doing your work will do it. Somebody has to realize what that work is, which is already communication and selling. I know you mean "selling" to get money in the house, and I realize that.

DR. FRANTZ: There is a matter of degree here.

DR. SALZER: Yes, I understand. One of the problems in letting work be done without communication is that it is worthless. However good the work might be, there must be communication,

and this requires people to whom a communication can be made. These are the first-line managers, but somehow, the message has to get through the management hierarchy in order to be effective. In other words, somebody has to buy the idea that this is a good thing to do and that it should be continued. If somebody is heading a large organization, he will not be able to determine that each individual is doing good things; therefore, he will start depending on intermediate managers, and we have the management structure whether we like it or not.

Now, it is important that each manager keep his scientific acuity. I don't know whether it is important that he does scientific work. In fact, once he is above the first line supervision, he accepts the fact that maybe he cannot do this but just has to monitor, to be aware of what goes on. He maintains his acuity of judgment in these matters one way or the other. This is not just scientific judgment but judgment based on understanding what people say, how they judge it, and, therefore, how good it is, and in whom to trust. This takes time to develop, of course, and, that is probably all we should strive for.

I would like to come back to scheduling because it is exactly an opposite requirement of the manager. He should become at this point a good administrator with charts and tables on the blackboard, marking down everyone's progress and where he is going. This takes time. Whether he has help to do this or not, it takes time, and, therefore, it interferes with the other requirements. You immediately have to decide that there is a balance that has to be reached. This is the crucial thing in management in general, particularly scientific management.

There is no solution--that is what I am saying--for a manager to satisfy all of the requirements.

MR. WELTY: I don't really think that there is a stereotype scientist with that qualification, but I can take a look at the scientist that I think you are looking at. I think one thing that he would like to know is "What is the challenge?"

He would like to know the game he is playing. He would like to be sure that he is operating in a rational environment. In other words, if he is successful in doing what he thinks he is supposed to do, then he will get what he's looking for whether it is recognition or whatever the ultimate goal is.

I think that scientists who want their supervisor to be a scientist have a need to feel confident that the supervisor will be rational. He feels that scientists are more likely to be rational than non-scientists.

He also feels that if his supervisor is a scientist he will get recognition and not actually have his role circumvented by some other mechanism.

DR. MUIR: It seems to me that one thing that scientists and managers should have in common is respect. If a scientist is the type of scientist, and the laboratory is the type of laboratory where there is a lot of direct technical control of the scientist's work, then the manager must be technically competent, and the scientist must have respect for his manager's technical capability. On the other hand, if there is relatively little direct control, then maybe it's not as important for the scientist to have respect for the technical capability of the manager; but he should have respect for him as a person and as a reasonable manager.

For example, I had a colleague in another division of our company who was really frustrated because of his manager. The scientist was quite a creative individual, and would often write papers about some of his work. His immediate supervisor really didn't have the technical know-how to understand what he was doing, but the supervisor tried to "manage" this poor fellow by incorrectly editing and rewriting his papers.

I think that another thing that is important is the communication of the direction the research laboratory is to go. Periodically, companies go through some sort of reorganization, and at those times the rumor mills start. It seems to me at that point that the manager should act effectively to communicate to the people the direction that the laboratory is going. I know from past experiences when reorganizations occur much time is consumed by people discussing, "What is going on?" "Where is the next change coming?" This creates a very disquieting attitude, and it may disturb the scientist.

DR. SALZER: You assume that the manager knows?

DR. MUIR: That is a good point. Does the manager know what's going on and is he able to give out this information? This is a very tender subject. I think in terms of the over-all efficiency of the company, a great deal of time is lost and wasted in bull sessions--what does the new reorganization mean or what does the change in Department X mean--than it would be if these changes could be made perfectly transparent in a smooth fashion.

DR. SILVERMAN: I think he is better off by telling people that he doesn't know if he doesn't, because I think this sort of thing can be appreciated. At this point I think he stops a lot

of conjecturing. Well, he may not stop it, but at least it is recognized that somebody is aware of the problem. He doesn't have all the answers, and I think that the scientists are very sensitive to this sort of thing.

DR. LYON: That is a good way of saying how a supervisor should behave as a communicator, as to whom he has to represent--the scientist to management and the management to the scientist. So he is a peculiar machine with a complex filtering system that passes on what information should be passed on in this direction. It can be very difficult to do that sort of thing.

DR. SILVERMAN: I would like to tell an interesting story. We recently were trying to start up a fair-sized project in our company and the funding was coming from another organization. When it came to choosing the man who was to head up this project, we reviewed a number of candidates with this organization. One of the two representatives of this other organization was a business man. I suggested to him a few people that I thought were just ideal, and particularly one who had a long list of publications. He took one look at it, and he said, "Obviously this man isn't ready to be a manager yet," and rejected him right away.

In this man's mind anybody who is still spending time doing creative science could not also be a manager.

I think this also points up very succinctly the problem that a research man as manager faces. On the one hand, he has got to keep the respect of the scientists that work for him who are young, eager people, mostly very idealistic about their chosen profession. On the other hand, he has to keep the respect of his

superiors who are hard headed business people and do not appreciate the scientist just for the scientist's sake. The first-line supervisor in a research organization is really a split person. I think he has got one of the most difficult jobs.

DR. HAMERMASH: I think you probably would prefer that our supervisors be scientists before they become supervisors. I cannot visualize in any laboratory where this would not be true.

DR. O'DONNELL: Should he be a full-time supervisor when he is promoted to this position or should he carry on some personal research in addition to doing managerial duties?

DR. HAMERMASH: I was going to ask the group this question: When a theoretical physicist becomes a manager, I have seen him able to juggle both of these functions, but I have been in situations where I have seen experimental physicists become managers, and I have yet to see this work out successfully because of its competitive aspects.

No P---------- In the experimental group he is competing with all the others, and his position as leader just spoils the situation.

No P-Has anyone seen a successful experimentor being the director of a research group and actually actively running his research?

DR. SILVERMAN: The trouble is what you mean by "Director" and what you mean by "management." Again, does anybody in a management position find his managerial duties to be as large in one organization as in another.

Now, I think there are advantages, but there are some disadvantages to a manager who is a scientist part-time.

I think that most scientists feel that if they are any good

at all what they are doing is quite important, at least, to them. If it isn't, then they shouldn't be doing it. I think as they go higher up the ladder and are still doing science, then I think you are right. The managerial aspect tends to slide because they tend to be more interested in their own area of science, for example, than in other areas of science. I think this can get out of hand, but I think at the first-line level that most organizations are reasonably oriented scientifically.

I think that even an experimentalist, if he doesn't have too large a group, can be successful. Maybe that is part of the key.

DR. HAMERMASH: What do you mean by first-line, and how big a group?

DR. SILVERMAN: Let's say there is a group no more than half a dozen people, for example.

DR. HAMERMASH: Then, I think we are talking about different things. I am talking about a much larger group than that.

DR. DONNA WILSON: I would like to respond to your question about the difference between the attitude of the theoretical and the experimental physicist.

It seems to me that we do know a lot about the kind of environment that produces good science. I want to define what I mean. Most of us do have some criteria for judging good science. The words used around the room to describe this environment were protective, supportive, rational, and reasonable. So the question that we could concern ourselves with is, "How could we produce this kind of an environment?"

We could disagree whether this is the kind of environment that supports good science but if it is the kind of environment that does support it, then I think that we could very specifically say that the manager has to ask how his procedure of management affects the environment.

I don't think we can require splitting the manager in two. His is a facilitating kind of operation which has a very high value. It may be that our culture does not support this type of value, but I would argue from the point of view of a woman again, that this is her highest value, and it is really a very satisfying one. I don't think she has to compete with the members of the group that she is organizing. She can still have a high value for facilitating the environment which will best serve the members of her family.

DR. SALZER: Is it necessary for the manager to do scientific work?

DR. DONNA WILSON: No, I would say that the highest value as a manager must be the environment he creates which will produce science.

DR. SALZER: But can he create an environment without himself doing scientific work so that he can understand and sense the problems, motivations, forces, values of what goes on in the laboratory?

DR. ALBERT WILSON: I feel that the question is not whether the manager is currently doing science, but whether he is a scientist. In order to understand what the research process is, you must have done research at some time in your career. The man who has no feeling for research has no business directing research.

Now, as to the question about doing research currently while also involved in management. The difficulties of doing this are clear to everyone who has tried. I feel that there may be two solutions to this: A person could be involved in management full-time for a season and then go back and do research full-time. I feel a manager may get out of touch. This acuity that you were speaking of begins to deteriorate unless you get directly involved in research every so often. Could we convince managers to adopt a pattern in their activities so as to manage for a few years, then take sabbatical leave, and go back to do research for a year? I think once you have reached the management stage you don't want to do this sort of thing, but I think it is important to do something like it.

A second possible solution to the problem is to try to schedule all managerial and communicative tasks so as to lump them together as much as possible in order not to interrupt research except at scheduled times. At our laboratory we have three days a week reserved so that nobody will be interrupted unless in a real emergency, and two days a week are for seminars, committees, etc. This gives us at least some time each week during which we can work uninterruptedly.

I would like to ask the question, "What is the role of interruption in creativity or in the destruction of creativity--what are the basic time spans that research people need free of interruption to their work?" I would like to hear from those who have some experience bearing on this issue.

DR. LYON: I can't speak from experience on that, but I

would think that interruption after a period of half a day, four to six hours, say, might be healthy. Your attention span is certainly no more than that if you work on any given thought.

I guess that it depends on the type and the extent of the interruption, however. The way that you handle them at Douglas sounds very good, a period of several days where you can work uninterruptedly, where you choose to have it be that way.

I think that from my own experience I would observe that most of the interruptions that one experiences are from your associates--your office mates or your friends--and this is just part of life. There is no way you can protect someone against that.

DR. SALZER: I would like to explore this question of switching from management to research. What would be a reasonable schedule, three years at a time or something like that? I find it difficult to see how this can be done anywhere in general terms. It looks like it is a situation wherein all your publications would be coincidental with your management "period" and vice versa. Secondly, it is not very easy to get back in the swing. You become recognized as something like an expert in some field and people call on you to give speeches and write papers and they are receptive to your output. Then you say, "Now, leave me alone. I am going to manage for three years" and then three years later come back and say, "Why don't you call me now? I am not managing any more."

Another thing that makes it difficult is once you have tasted the pleasures of management--let's put it that way--or the feeling of management, there is satisfaction that you get out of it. I don't see how you can just drop it and go back and really apply yourself. Your whole attitude and approach to life has been broadened, and, in a sense, it is a little different. Now you switch that off and go back and force yourself to do the other various interesting things. I don't know how that would fit. I know that it would not fit me.

DR. SILVERMAN: There is a tendency, I think, both in universities and in industry to promote their most successful scientists into the position of management. There seems to be some correlation here between the most successful research organizations and the reputation, at least, of the manager of that research organization.

I would like to hear other people's opinion about whether this is really the best thing to do or should a research manager be selected for his ability to manage and less on his ability to do research.

DR. OSTERYOUNG: We were talking about leadership before. I wonder if the director of research, let's say, is carrying out some science which is identifiable as his own. Do not the people who work for him know at that point that he is still very concerned with not just management per se but science per se?

MR. WELTY: It seems as if we are fixed on a narrow spectrum of scientific activity which is basically a kind of ivory tower type of individual research effort. Today there is more and more group effort, military effort. Percentage wise, probably

78% of all scientists are working on large group efforts, not individual research problems.

I would agree, if you are looking at individual research projects, it would be well that your manager didn't have an independent private research program of his own. However, if you are talking about the other 80 percent of the scientists who are working in large programs that are not independent, then I would say that the quality of the organization generally can be measured by the degree that the technical concern goes upward in the organization. In other words, you might be talking about an organization that has five or six levels of supervision. In my estimation the quality of the organization has to do with the degree of penetration vertically of the technical concern and some contribution vertically in the organization. Basically the manager is still working, you know. He is still a scientist. If he ceases to be a scientist, that would depend largely upon his considerations. If he loses contact with what the real goals of the organization are, then he starts worrying more about other things and the quality of the effort goes down.

DR. MUIR: The point was made that the scientist or manager could, perhaps, after some period of management go back into science. I would maintain that this is only possible if he can continue to do a little science on the side. Talking as an experimentalist, I would say that this is exceedingly difficult to do. The state of the technique of your particular field of research moves so fast that if you are not more or less in there in the laboratory with your finger on the machine, you get completely swamped. On the other hand, someone who is theoretically

inclined can work independently. He can make his hours in which he does / science completely suit his convenience, whatever schedule it turns out to be. The experimentalist has to work with the shop, with the glass blower, with the technician: and all these constraints make it a/ near impossibility to manage while engaged in experimental science.

DR. SALZER: There is another aspect of this. We must not forget that management is inherently a hierarchy of arrangements. You take a research director who has three or four levels under him--manager-wise, supervisor-wise, and level-wise--and he has for three years determined the fate of some intermediate supervisors and also has been a privy to some rather confidential matters of the corporation. He would be at the bench next year with the other fellows just out of school. Nobody would believe that he completely forgot all the things he knew; and secondly, the intermediate managers would feel quite uncomfortable when they review him, for instance. Generally we have to realize that management is a structure of personal relationships. In many ways they can't just forget about it and say, "Now, we switch everybody and put a different setup in their brains, and now their relationship is different; we go on like this for three years." It is a very serious obstacle. You can't turn the clock back very easily.

DR. ALBERT WILSON: As a practical matter, having the manager be one of a group of researchers seems to be a good solution. No P---------- To preserve his acuity and to keep up with the techniques, the manager able to should be/ find enough time to participate with a group and be/ joint author of

a paper. This may be the ideal solution in this case.

DR. SILVERMAN: I'm impressed with the remark Professor Libby made early this morning that if you have a basic research group, then you don't really need a manager. Maybe you do need a director of research. This is a man who has a good reputation and is continuing to do science, and he can understand the research people who are working for him. By far and large, the majority of research people in industry are project scientists, and maybe in their case what you really need is a manager, not a director of research, because now you have constraints--schedules, budgets, space, and manpower--these are all of the traditional management tools. I wonder if most of our discussion so far hasn't really been about the director of research and not about the manager.

DR. O'DONNELL: What distinction do you make between the manager and the director?

DR. SILVERMAN: A director is a man who has basic people who are doing fundamental research in his organization. These are extremely capable and very talented people who are going to be left alone to do more or less what they want.

He is the keeper of the ivory tower. He has certain personal relations that he has to keep up and certain public relations, and he has to be a good recruiter. He has to be able to help train research people to some extent.

DR. HAMERMASH: John Salzer mentioned something about requirements or qualifications of a research director. He used words like "psychology" and the "minds of his people." Personally I feel that one of the most important talents that a director of

research needs is the ability to develop as complete a psychological map of his people as possible. On the other hand, he also has to be able to define the real world to his people.

DR. SILVERMAN: There is another type of manager who has to complete a project by a certain date and has to turn out a report. He has to have some data ready for the next step in the development of a spacecraft or something and his requirements are quite different than the one who is the keeper of the ivory tower. The latter is directing the research scientist and he is directing talented people. They may not be in the upper 99 percentile, but they are probably in the 90 percentile. He has got different problems, and I don't think we discussed his problems and his qualifications at all.

DR. OSTERYOUNG: I disagree. I think to some extent you are talking about a matter of time concepts, but you are talking about applied science.

It is true that you have projects in a sense to perform, but to some extent it is a matter of time concepts In other words, the one who is going to apply his science may be carrying out very fundamental work but he presumably comes to certain goals and conclusions and has a certain time span. It may be short, and his direction may be periodically changed But I think the director of even the fundamental laboratory will try to operate within the constraints of budgets, space, et cetera--all of the managerial functions. I don't think there is that much difference.

DR. SILVERMAN: It is easier to the extent that he doesn't have to direct people into certain areas.

DR. SALZER: I think it is harder in the sense that he really has to sell what he is doing to the powers that be in the organization.

DR. SILVERMAN: We are agreeing that the job is different. On the one hand, the job of managing his people may be a little bit easier, but his job of selling is more difficult. But the other manager's job of selling isn't so difficult because he has been given a job to do. He has got to sell this job to the people that are working for him.

DR. GREEN: I think the manager is closer to the scientist than the director, who is further removed because of administrative duties. We should first consider the managerial level of supervision. If you do, then you can look at at least five factors that deal with the qualifications of a manager, <u>the individual closest to the scientist</u>. First is the personality of the manager himself. The second is the nature of his research: Is it theoretical or experimental? The third factor I think would be the number of individuals that he has to manage. If it is three or fifty, there is a big difference in how he will spend his time. The fourth factor is the nature of the individuals he manages. Sometimes the individual scientist can consume quite a bit of the manager's time. The fifth, I think, is the most important. That is the laboratory environment, and its metabolism. I have spent some time in the laboratory where the metabolism was like that of a humming bird, where there was the constant rain of requests for proposals. I have also been in a laboratory where there was no contract environment.

These five factors I think will govern the nature of managing. This doesn't mean that it will be the same for the laboratory director who can be quite far removed from the scientist. To intelligently discuss the interaction of scientists with management, we must first define the managerial level to be considered. Who are we talking about? The chap closest to the scientist or the one furthest away? Then we should consider the five factors mentioned above.

DR. HAMERMASH: I prefer that we talk about someone who manages a group of fifty to a hundred and fifty technical people rather than the small department of three, four, five or six.

DR. O'DONNELL: You have a director of the laboratory in mind?

DR. HAMERMASH: This business of titles--directors, and managers--and no one has said anything about the snobbery aspect of this which is very, very important. As you well know in our organization, the word "director" is reserved just for the research organization, and people at comparable levels in the other parts of the organization are managers.

Now, personally, whenever I hear the word "manager," I always think of Casey Stengel standing in the dugout.

DR. SILVERMAN: I would like comment on Bernard's remark about Casey Stengel. I don't see anything wrong with this concept personally. I wonder if maybe there isn't a role in science for this type, a manager who has a number of stars working for him. We take a star--I don't care what great scientist we care to mention--and we say, "All right. Here is your laboratory; here is your salary. It's going to be greater than the manager's. Your prestige is going to be greater, but administratively this manager has got to tell you what your budgets are and he's got to get your equipment for you. He is your manager. He is going to tell you what position to play, and he may tell you how to play it."

I wonder if maybe there isn't some room for this concept of management in research laboratories. I don't know whether there is any place where it is working or where anybody has tried it.

DR. SALZER: I would like to step back a moment because we are getting into a point that bothered me. What is the purpose of the research organization that you are examining? This is really what we want to start out with because then management considerations will fall into place. The reason we have a laissez faire attitude in this kind of operation is because objectives are extremely different. I find about three. One is essentially the university where you say, "Do good work. Get something original. I have leaders here to stimulate you. Interact with them so that you know that your research is meaningful

and good and is not repetitious."

Here the purpose is to create new things--the kind that Dr. Libby talked about--without regard to exact information but more to create something. I want to say that I question the value of these things unless something is done with them. This is the big problem. This is what these gentlemen talked about when they referred to a director of the basic research laboratories, the laissez faire operation.

The other two that I can distinguish are industrial but very different industrially. One of them is striving for government contracts almost at the expense of giving up proprietary rights; and the other would not accept a government contract. The latter are the ones who say that we want all the research to be proprietary: help us to establish some position that beats out all competition.

Now, their whole approach to life is different, and Dr. Frantz would not have to do so much selling if he worked for the latter one because he wouldn't have to get contracts to support himself. You would have to show that what you are doing relates to the type of business that you decided to be in and in the type of production that you want to create.

As you take these three classes their problems are different and their management to some extent is different. But I still think that, regardless, there are some things that you can say about all three types of managers and scientists that are completely general and this is important.

DR. O'DONNELL: Could you find a key word to describe those types of environment? The first one would be laissez faire.

DR. SALZER: Yes, laissez faire.

DR. O'DONNELL: And you would put in the second category, I think, proposal activity, the humming bird type?

DR. SALZER: The humming bird was next.

DR. O'DONNELL: This third one is the proprietary type which allows the individual scientist to relate to the overall company goal? What differences in the management do you see, John?

DR. SALZER: Well, certainly in an environment wherein you have to attract contractual support, you have more communicative people, for instance. You will have people who will have to go out and touch base with the customer. You will have to relate your work to immediate requirements much more.

I don't know if the manager has to be very different. He has to be a sales-oriented person very definitely. In the other two he does not nearly as much. I would say that almost anybody that does any management must have some sales attitude in him. I would say that the humming bird research laboratory will create more view graphs and charts than any of the other two. This is the way I would distinguish it.

DR. LYON: I think it would be well if you could identify for us the scope of discussion today regarding what you mean by "scientist". I am having a hard time drawing a line between what I would call a scientist and an engineer. There is certainly a real spectrum of kinds of people. On the one end you have the pure scientist and at the other end the engineer doing engineering design.

I can't really understand where we want to draw the line between calling activities scientific and calling them engineering. When I hear fifty to a hundred fifty people referred to I can't quite imagine those as being scientists.

DR. O'DONNELL: My interest is in the scientist who is engaged in basic research. Let's try to keep away from the applied aspect of science entirely. I am interested in the people who are searching for new knowledge and trying to develop an understanding of phenomena.

DR. SALZER: Without regard to utilization?

DR. O'DONNELL: I can visualize the scientist, say, working for an oil company. He is a chemist, shall we say, and he is interested in the discovery of knowledge in the area of petroleum chemistry. I think that he can be a true scientist in that kind of an environment.

MR. BOYKIN: If you are talking about scientists concerned with basic research then there aren't very many. You might catalog two hundred ninety-nine of those people in the whole United. States.

DR. O'DONNELL: Yes, that is true, but at the same time I would like to keep away from the side of application as much as possible.

How would you describe your scientist in terms of the spectrum, Lee?

DR. FRANTZ: Well, I would say for myself that I am a scientist interested in basic research but living in an applied research environment which provides some of the problems that we are talking about. It provides the difficulties of doing basic research in that kind of an environment.

DR. O'DONNELL: But I would think that at least some of the scientists in your operation would be working in basic research.

DR. LYON: We have all kinds, I'm sure. In looking around the room, we have three major contingencies here. I am sure that I have left a few people out, but in each company there are probably both kinds of activities. In our own we have a science center which is devoted to what I think is exactly what you are talking about.

Now, we also have our scientists working in other divisions of our company who are operating in an engineering environment for the most part.

I think that they are in many cases dual personalities. They are sort of half engineers and half scientists, and they are valuable people in that regard too. We have individuals throughout the organization who do scientific work. Now, if we are talking about pure science we are only talking about our science center activities.

MR. BOYKIN: I wonder when people recruit for their ivory towers, how many of them are looking for a great discoverer of knowledge?

From the discussions that I hear and the acquisitions that I have noted around our company and closely associated companies, they do look for people who are renowned more or less in a field; and they are not just this: "One morning I guess I will do research and--."

DR. SILVERMAN: I think that was the point. I wonder what the survival rate is really going to be for an institute completely decoupled from the interests of the company. It can still do basic research but to some extent there has to be some overlap with the company's main interest.

In other words, if it could do perfectly wonderful science in an area, particularly in the Aerospace field where there is absolutely no interest, I don't think it's going to survive. The company is still a money making organization.

DR. OSTERYOUNG: Are we missing a difference in managing as providing direction? In other words, the technical management as opposed to some things that we mentioned before--providing the facilities. In other words, do you want to break up the two functions with one purely administrative?

Let's say that you can have a man who doesn't know anything about science at all, who is concerned per se of its worth and and essentially provides the laboratory with what it needs. Is that management?

DR. O'DONNELL: No. That describes what I would call an administrative assistant to perhaps a laboratory director.

I am thinking of the person who plans the work of the operation, the department or the laboratory, the person who develops some kind of control over what the plans are supposed to accomplish: somebody who is interested in how the laboratory is organized in terms of departments. I think in terms of somebody who is interested in the recruitment and evaluation and promotion of scientists within his particular group, and, of course, somebody who directs this group in terms of providing them with the environment that Mrs. Wilson was speaking of, communicating with them, providing leadership for the group.

Now, I would not think that your scientist who mothers two or three other young people in the group is a manager. He

would not qualify under my terminology, but the supervisor of a group or a department would, and, of course, the laboratory director certainly would qualify as a manager. Under these circumstances, I am moved to remark that there is a real question whether a person can be both a good scientist and a good manager. It takes different qualities, I think, to do these jobs well. Therefore, the idea of moving a person from a technical position on the staff into a managerial position as I have defined it isn't that easy. Although he may be moved, he may become a very poor manager. He could be a mediocre scientist and perhaps an outstanding manager. The idea that the qualifications of both people are the same, I think, is not true to life.

DR. SALZER: I believe with you the qualifications are different, but I don't agree that the same person couldn't have both qualifications. He very often does. In fact, it is almost like this when an excellent scientist decides at one point that he is going to be a manager. He makes an implicit or explicit decision which part of his total capabilities he is going to exercise for the rest of his life.

Now, I won't argue with the fact that in some people either one or the other qualities are better represented. I think that the management capabilities are the ones that win out invariably and deter the man from staying a scientist although he might be a very good one.

Are we losing too many scientists because these people are also good managers?

DR. O'DONNELL: Well, my concept of the ideal manager of the laboratory is a person who is a good scientist and a good manager.

I would like to see him with both of these qualities, but I would hasten to say that I think very few people qualify in this way. This is what we should search for all right, but it is very difficult to find.

MR. BOYKIN: It looks to me like scientists are different in that they are like a precious metal. They are a rare commodity that can really discover new information and knowledge that is useful to everybody else; but they are still very similar to other people because they are human.

Why should they be so different? If a man is going to be the head financial man, he may have stopped being a whiz in double entry bookkeeping, and at one time in his career he may have been one of the best cost control men. He gained the respect of his associates and he stopped being a performer.

In the motion picture business, usually the best pictures have been produced, I think, by the actors who quit trying to be both actor and director and really concentrated on directing. So why shouldn't a man, who once showed his worth and ability as a scientist, instead of being both a scientist and manager, become a full time successful manager of other scientists? Whatis wrong with a scientist having the potential of being an excellent manager?

DR. ALBERT WILSON: Newton was an excellent director of the mint, one of the best they ever had. His job was given to him as a reward for his scientific creativity. This

brings us to a point about status. One of the difficulties with the scientist is that he feels that the type of intellect that he has should itself give him a measure of status. If you put over him somebody whose intellect he does not respect, you close this avenue to status. This is why the director of scientists should be an excellent scientist. Perhaps we could solve the problem of status by letting a man who is a good research man stay with research--he may or may not be a good manager--and let him move up in status through special titles and with the pay and the other privileges that go with executive jobs. In this way you might remove some of these difficulties. He is not necessarily content just with the recognition of his peers. If he's going to be in industry, he also wants to be recognized in the industry by its usual status symbols.

MR. OSTERYOUNG: In your reports somewhere you indicate thatto some fifty people the question was asked, "Do you want to be a manager of scientists?" And something like four said, "Yes."

You concluded that the prognosis was that the four might make good managers and the rest wouldn't. I really wonder if one of the problems is status. Somebody in the academic community once said, "Well, status these days is in turning down offers for department head rather than being one." I wonder if the recognition isn't really the external community by and large. So I don't really agree with your prognosis at all.

DR. SCHNEIDERMAN: I contend and I submit to you, dear friend,

that there are many people and there are many many many examples of people who are both good scientists and have moved into management positions with considerable success both in universities and in industry.

DR. SILVERMAN: I was going to say that you might liken this to a probability. The probability of a man being an outstanding scientist is very low to begin with, and, then, the probability that he is also going to have qualifications of being an outstanding manager--the probability of finding any individual who would be an outstanding manager--is very low; and, then, when you multiply these probabilities, the probability of finding one man possessing both characteristics is even lower.

I would like to make one more comment and then I will relinquish the floor. We were talking about the analogy between a motion picture producer and a manager--

MR. BOYKIN: The actor-director.

DR. SILVERMAN: Right, the director-and-actor concept. I say that a scientist is a very talented person, and therefore maybe we should look at the management of scientists in the same way that we look at the management of athletes and of actors and actresses. The outstanding scientist should, indeed, receive greater rewards than perhaps the manager, and in this way improve his prestige because in our society salary and prestige go very much hand in hand.

DR. O'DONNELL: This is a topic about which his manager ought to be very much concerned.

DR. SILVERMAN: Right.

MR. WELTY: I think there is a decorrelation between the motivations of a person who becomes a good scientist and a person who becomes competent in interpersonal relations. I think an important aspect of management is competence in interpersonal relations, and I think there is a mechanism that gives a decorrelation. Now, this is not a hundred percent. In other words, I am saying that one of the motivations that cause a man to become an expert--and I hate to use the word "scientist" because we are all scientists--technician actually may be correlated with the fact that he is not competent in dealing with interpersonal relationships. On the other hand, I also find that quite often motivating forces prevent the average manager from being competent in managing a technical activity, basically because he does not make an identification with the scientist. He makes an identification with non-scientists. There is an ego thing that goes on that tends to put down the scientist and actually inhibits eventually the capability of the organization itself.

Basically, I would say that a typical manager does not make a good manager of technical activities, and typically scientists do not make good managers; but fortunately the correlation or anti-correlation is not a hundred percent, and we do find some of both.

I think some of the best managers of technical activities I have known have been non-technicians, but they made a strong ego identification with the scientists, and even stronger than maybe the scientists make, which then provided the motivation for the scientists and also provided the environment in which the scientists could prosper and do good work.

DR. GREEN: Scientists can sometimes get into pseudo-managerial jobs, for example, by handling contracts or organizing and chairing conferences. They may do very well in these activities because it is within their speciality; but this may be a double-edged sword because management can observe these activities and say, "Look how well you handle this. Now you are ready for management." This may not necessarily be the case.

DR. O'DONNELL: One of the difficulties is that we train people to be scientists; we don't train them properly to be managers. Because we don't recognize the importance of managing everybody appears to assume they can be a successful manager.

DR. SALZER: Psychological studies now have indicated that there is a definite correlation between a very brilliant person and a very good athlete. The reason that one of these persons becomes an athlete and the other becomes a scientist is purely his motivation and interests. I would say that similar conditions might apply to why one becomes a manager rather than a scientist.

The other thing that I want to say is that I agree to some exclusiveness here, Dr. O'Donnell, in the sense of which phase of one's career we are talking about. When a person turns out to be a good manager of scientists, he is no longer a good scientist. But the same person could have stayed and become an excellent scientist if he had chosen that option.

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DR. O'DONNELL: Turning to the employing process, is it desirable to permit scientists freedom of action in the hiring of people who will work with him, people on his staff?

DR. MUIR: If you define "scientist" now fairly low on the level and then his staff as his technicians, I can't imagine any scientist who wouldn't want to have as much say as possible about who will be hired, granted layoffs in another division may force through some sort of labor situation, a certain person to be accepted. If it's a question of going out on the market and hiring a new body, I think that any scientist would be up in arms if he didn't have something to say about it.

DR. O'DONNELL: Well, I'm interested in how much. Is he a court of last resort?

DR. SILVERMAN: I think in almost any organization the scientist would have an absolute veto. If he didn't want somebody working for him, he certainly wouldn't be forced to have this person. If you have to go out and hire people to work on a project, usually the head of the project interviews all of the likely candidates. He is not required to go out to do the recruiting himself, but he will interview and make definitite recommendations on all candidates.

DR. OSTERYOUNG: Let's define this as, say, a senior scientist trying to hire junior scientific people who are in the science as technicians. I think the situation should be that that man would really have what is described as veto power. On the other hand, the management also has an interest for the following reason. The senior man in talking about an effort, wants to get it done. Sometimes there is a time press and he is going to take somebody who may be slightly less qualified simply because he feels the importance of the work is vital. After that particular task is finished or dissolved, management may now be stuck with people

that really the scientist doesn't want. The aerospace industry is a prime example of this.

DR. SALZER: I like generally to have some evaluation done by somebody else. Personnel should make at lease one of the reference calls. Usually some routine checks are made in each case, namely checking with the schools to see if the candidate really went there and got a degree or perhaps some security type investigations are in order.

MR. BOYKIN: At this point you may not like the way the question was worded. It says, "In what sense does the scientist want to participate in hiring staff for his project?" Apparently he wants to.

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MR. WELTY: I get the distinct impression that Dr. O'Donnell thinks of a manager as a housekeeper and he has got a bunch of inmates that he is keeping.

DR. O'DONNELL: No, I have not that particular concept.

MR. BOYKIN: Dr. O'Donnell has a very high opinion of the managerial function.

MR. WELTY: That is what I am talking about. If you are thinking about the manager as the housekeeper, he is providing for keeping the floors cleaned so that these guys won't stumble over anything and providing the pay checks and the money. This is a bad impression of management. Management basically is at least fifty percent concerned with what you are doing. You know you manage to do something. You don't manage for the sake of managing.

DR. O'DONNELL: You manage for results.

MR. WELTY: You manage for results and the person has to be concerned with what he is managing to do.

DR. SALZER: Welty, if you got this impression, I think that you are the only one. I certainly didn't.

DR. SCHNEIDERMAN: I think you also have to draw a line between management and direction. A man may be a manager of a research laboratory, and in some other cases there is a director.

DR O'DONNELL: By "director of research" you mean the person who is most closely associated with the scientist. Is that correct?

DR. HAMERMASH: Let's not leave the funding out of that. Let's leave all of the desks and space out. Let's keep the fundin in. I think it is a very important element.

MR. BOYKIN: How can you do research without capital equipment and why is it an incidental thing?

DR. HAMERMASH: I didn't say that.

MR. BOYKIN: I have read most of Professor O'Donnell's work on the practitioner in management. You can see very clearly that he has put in all of the functions that he expects of any manager. Cyril doesn't think of a manager as being an administrative assistant for furniture. That's not what he is talking about. It is really the total responsibility for meeting the objectives of the organization. The managerial functions are organizing, planning, staffing, directing, and controlling. He has been directing himself to getting your ideas on these functions

Titles such as "manager" and "director" wouldn't mean a thing to the professors of business administration. They are interested in the gentleman who is responsible for putting all these things together and achieving the end result. That is what he is talking about. He is not talking about an administrative assistant.

So, Cyril wouldn't put a lot of stock in whatever you call the man. Maybe the people around here would, and maybe when they use "manager" they really mean "administrator," which is sometimes used interchangeably with manager, particularly by Urwick, the British writer.

DR. SALZER: I suggest that the titles like director of research, manager of research, vice-president of research, should not be wasted on people who decide where the chairs will go. That is not what we are really discussing here at all. We are talking about how to get a body of scientists to work towards some aim and produce.

MR. BOYKIN: Just one slight challenge to that. This manager is not going to do the work anymore than he is going to carry the test equipment. He is going to be responsible that there are chairs, that there are buildings, that there is space, and/the right environment.

MANAGING THE STAFFING FUNCTION

The staffing function is concerned with the recruitment, selection, training, evaluation, and promotion of managers. It is not that the problems surrounding non-managerial personnel are *unimportant*; it is that these are adequately dealt with in other places, while managerial staffing is not.

It was a matter both of interest and concern that the scientists in our laboratories and their managers seemed to have a total misunderstanding of the managerial functions. The title by which a man is known has nothing to do with the functions he performs. There is no reason to assume that a front line supervisor of scientists is less a manager than he who manages the whole laboratory. The title can reflect status and it can help identify just where in the organization structure one may find a particular individual, but it does not distinguish what a man does. Managers are known by what they do: each is always engaged in planning, controlling, organizing, staffing, and directing in order to achieve results through group effort.

Recruitment of Managers

When a firm decides that it will establish a laboratory it necessarily must think of the director who will manage it. Such a person may already be on the payroll or on someone else's payroll. He will be identifiable by his reputation as a manager of scientists: his achievements as a manager of scientists will be checked out with past employers. Considerable interviewing will follow in order to make certain of the candidate's compatibility with those with whom he will be associated and especially to evaluate his attitude toward the function of the laboratory

within a private enterprise. On such evidence the eventual director will most likely be chosen.

Stress is laid on the past experience of candidates in managing scientists. Of course, not all laboratory directors will have had managerial experience, but their very lack of it adds a high risk to the appointment. One cannot tell from his non-managerial behavior whether a particular person will succeed as a manager. The very best evidence is successful experience in managing.

Once the director of the new laboratory is selected he will be concerned with filling the positions established in the staffing pattern. If the number of persons to be employed is small, there will not be a need for subordinate managers. On the other hand, if the number is large, subordinate managers will be recruited in much the same way as the director himself.

In an on-going laboratory managers should be recruited from within. At least this source should be fully exhausted before going outside for managerial talent. Because it is a form of reward for those who want to manage, the opportunities created by this practice builds morale among all subordinates. Furthermore, their existing knowledge about the company, the laboratory, procedures, attitudes and objectives are all known to the internal recruit. It takes the outsider a considerable time to establish himself securely within a new organization.

Selection

Since the laboratory director normally reports to the chief executive he should be selected by him. True, there will be many recommendations from other subordinates of the president and from outsiders, but it is the sole responsibility of the

president to make the final selection. Once this has been accomplished the director himself will make the selection of his subordinate managers--those reporting directly to him. In general, the most successful practice is that selections should be made by the immediate superior of the selectee, and approved by his superior.

In the established laboratory the selection of front line supervisors, viz. those who will be managers of scientists and are thus in direct contact with them, should be made from among the scientists themselves. It is very important for these new supervisors to have demonstrated their skills as scientists in their own right. Their path to management will then be made much easier because they will be credited with understanding both science and scientists, and perhaps for personal accomplishments of a scientific nature. Anyone else would have to prove these accomplishments and this takes time. The man who is selected for front line supervision may well be a successful scientist; he may also be one who wants a new and different career. Both will have one thing in common--they do not know whether they will like managing and whether they will be a success at it. And, of course, neither does anyone else. Only experience in managing can provide the answer.

The possibility of selecting a non-scientist as a front line supervisor is always present but such a practice would be unnecessarily dangerous. It would be too much to say that he would certainly fail, but the odds are very high that this would happen.

If there are intervening levels of managers between the front line supervisor and the laboratory director they should

certainly be selected from among those unit and section heads who have a successful managerial record. Although they are not likely to keep up to date technically, they at least will have once been scientists. With such a background they can readily provide the appropriate environment for those who do science.

Training of Managers

Skill in managing an operation does not come naturally. It is acquired by knowing what a manager is supposed to do and by practicing these functions, preferably under the direction of an experienced manager. A thorough knowledge of the principles of management is an absolute essential for anyone who hopes to become a sound manager. This he cannot get simply by osmosis or by watching others in managerial positions do what they think is managing--they may be watching someone who is as ignorant of the managerial functions as the trainee. Indeed, the evidence from this study points to a very spotty knowledge of the managing process by both scientists and their superiors.

The principles of management can be taught. Knowledge of them will give the potential manager an appreciation for the total function, its extraordinary complexity, and its influence on the effectiveness of the group that is managed. But this is not enough. Men learn to manage by applying managerial principles in situations where they are responsible for results. There is no other way. Even under the best of circumstances, one in which the superior is himself an outstanding manager and teacher of management, it probably takes well over two decades for the neophyte to mature. An appreciation of these factors is the first step towards wisdom in understanding laboratory management.

Evaluation of Managers

Everyone in this world is evaluated continuously and managers in any enterprise are no exception. This applies equally well to presidents of corporations as it does to laboratory directors and front line managers. The important matter to be considered, therefore, is how best to carry out this function. Since the results of any method, good or bad, relevant or inapplicable, will be used to reward those whom the system says are successful, and to punish in some way those whom the system says are weak or unsuccessful, it is clearly apparent that the system itself is a critical matter.

It is not an accident that down through the centuries it has been results that have counted in evaluating those who manage. Occasionally the quality of results was important, too. In recent decades efforts have been made to evaluate managers on such subjective bases as personality, intelligence, etc. A long list of qualities, few of which are mutually exclusive, have often been proposed. But success did not attend these efforts. Experienced managers first and last want to know what a subordinate manager has accomplished. Consequently, there is every effort being made now to get back to first principles: measure results achieved against objectives sought. Assuming the constraints of business policy and ethics are observed, this is a very successful approach to evaluating managers. And laboratory managers are no exception.

Promotion of Managers

It may seem to be quite an obvious thing that the more successful a manager the higher the likelihood of his promotion. At a remote distance there is little to quarrel with in this view,

but as one looks inside a laboratory the promotion process can get very uncertain. Once a vacancy is to be filled it is true that potential candidates are reviewed in terms of their accomplishments against projected objectives. This is not an easy or certain thing to evaluate on a comparative basis. It is one thing to be certain that objectives were achieved, but it is quite another to be certain that the objectives of two or more managers were equally difficult to achieve since both the environment and the resources available may have been quite different.

Another matter to consider is whether a candidate, otherwise qualified, will be able to manage a larger group as successfully as he has managed a smaller group. There is no way to discern the answer to this question before the fact. And there is the related matter concerning the ability of a candidate to represent and protect his new function in the face of competition from other managers at the higher level. The quality of the competition certainly becomes higher at the more exalted managerial levels. And finally, there is the chemistry of the situation. Will the personalities of the superior and his new subordinate mesh well or will irritation be a continuing factor? It is difficult enough to be a successful manager in an environment where other managers are compatible. A man would be well advised not to promote a person who is incompatible even though he has scored well in the past.

There is absolutely nothing more important to the success of an enterprise than the men who manage it. There is too little time and care given to this matter, especially in laboratories. The manager must be as proficient in his profession as is the scientist whom he manages.

CHAPTER VI

DIRECTING THE SCIENTISTS

From the conceptual viewpoint every manager makes ready, in the industrial engineering sense, by planning the work, establishing a control system, organizing the activities, and staffing the organization. At this point he can start operations and this is accomplished through the managerial function of direction. As a manager directs his subordinates he orients them, motivates them and leads them by means of communication. It is the subordinate non-manager who must do the work. He needs to know what is to be done, with whom, when, how, and with what support facilities. He needs to be motivated in ways which encourage him to use his utmost capability. It is the direction function, properly executed, which enables the manager to utilize human resources effectively and efficiently.

The manager of scientists has the same function of direction to perform as any other manager. This does not mean it will be executed in the same way. It is people who are directed: they are the least understood resource available to the manager. The general principle that people will strive to satisfy their needs is applicable to all. It is the manager's responsibility to understand what are these needs and to devise ways to meet them that will induce or permit scientists to maximize their contributions to enterprise ends.

Communication

Communication is a common but ill-understood term. To the participant in organized activity it is concerned with the interpersonal transfer of ideas and information. Transmission of

understanding is a many-sided thing. It may be looked upon as a technical matter, but, of course, techniques are merely the means and not the reason for communication. Subordinates have a need to know things about their environment because knowing may affect the quality and quantity of their work. They also have a need to know where they stand with respect to others because its knowing may be a positive motivational factor. Superiors likewise have a need to know. They need to know the state of the art and what their subordinates know of a technical nature so that problems whose solution would contribute to the enterprise objectives can be properly stated, promising analytical techniques agreed upon, and achievements be recorded. They also have a need to know and to understand their subordinates, especially in those aspects which relate to their motivation.

There is a good reason to believe that the communication of technical information is quite well done. Provision of libraries and the time to use them, attendance at professional meetings, internal and external consultation, staff meetings and reviews, and the direct flow of information between superior and subordinate are devices in almost universal use. The communication of enterprise objectives is under-accomplished, not for the interval between scientist and research program but between program and the enterprise as a whole. This is no serious loss where the science center is permitted to pursue knowledge in general: it is critical where the center is relied upon to gain knowledge of phenomena that can serve as the technical basis for a new product line or a new family of products. It is also critical where the center is concerned with the acquisition of information needed to solve

some facet of a development program. Scientists certainly take a great deal of pride in making a direct contribution to company objectives and anything that can be done to communicate requirements and the application of new knowledge not only serves to canalize research but also acts as a strong motivating factor.

It can be said that scientists and their managers are great talkers. A total of fifty-one scientists averaged only one-half hour per week in formal discussions with their superiors and three hours per week in informal conversation with them. The same scientists conferred with their colleagues just twice as long both formally and informally. Overall these men spent about ten hours per week in technical conferences with their peers and superiors. Only in two laboratories were there wide discrepancies between the conference hours per person reported by managers and their own subordinates. These might be accounted for by the smallness of the sample except for the fact that these are the same laboratories in which there is a persistent misunderstanding between managers and employees.

The fact that the managers spend an average of three and one-half hours per week in conferring with their subordinates leads one to conclude that effective leadership is being attempted. Attention is quite obviously given in greater degree to the new staff man and the slower producer while the proven senior scientists are largely left to themselves. This is as it should be after taking care that where company objectives must be served, the selected areas of inquiry are complementary and supportive.

Motivation of Scientists

The motivation of scientists, as is also true of people in general, is directly related to their needs. There are many classifications of these. For management purposes perhaps the most convenient is to think of them as basic, social and ego needs. The manager can understand these, and he can develop means of satisfaction for them to a greater or less degree. Enterprises normally take care of basic needs through salaries and fringe benefits. The manager is in a position to gratify some social needs by the way he organizes activity and to satisfy ego needs by appropriate actions. We will see most of these in play as this study turns to the motivation of scientists.

In an effort to discover the goals for which scientists strive, those in this study were asked to identify their short and long range objectives. The question being unstructured, various terms were used in reply but their sense polarized very well. Contribution to scientific knowledge was mentioned 17 times; to be a competent researcher was identified 14 times; recognition by peers was cited nine times; promotion to management position was named by four; and three wanted to continue teaching and research. The desire to contribute to the fund of knowledge is the only objective that is other-oriented. All the remainder strongly reflect the ego needs of the scientists. This distribution is especially portentous because incentives developed by managers will be most productive if they are designed to meet the needs of the individual scientist. It behooves the manager to know who is egocentric and who is outwardly oriented and to have appropriate incentives available for each type.

Although there is no evidence of individual attention for motivational purposes given by managers to their subordinates there is considerable information about the incentives actually available. The basic human needs are cared for in organized activity through the renumeration process. Productivity is officially cultivated by making available no-cost services, space, and equipment allowances. Ego needs are officially recognized by providing opportunities for scientists to develop satisfactory peer relationships. Thus, the official organizational incentive system takes cognizance, in varying degree, of the basic, social and ego needs of scientists. The knowledgeable manager not only administers this system in ways to maximize productivity, he also invents certain incentives which seem personally appropriate to the individual. This gamut of incentives is examined below.

Satisfaction of Basic Needs of Scientists

Evidence in this study relates to salary as the source for satisfying the basic needs of scientists. On a scale of one to ten representing the salary received as ranging from unsatisfactory to highly adequate, 50 scientists reported an average value of seven--about midway between average and highly adequate. None were below average (five for this scale) though the average in three laboratories was perilously close at 5.5. The highest rating, 8.5, was noted in two laboratories. These responses were close to the estimates of their managers. At a rating of 4, one laboratory was below the average salary in the estimate of its manager while, on the high side, one manager rated salary adequacy at nine, one at 8.5, and four gave a rating of eight. In

general, managers were slightly more satisfied with the salary structure for scientists than were their subordinates--a not surprising result.

Basic needs seem adequately taken care of. Most scientists are concerned about this but also concerned about their relative income. So long as this conforms to industry levels they are quite content. (See Table V). They are smart enough to know that if wealth is the objective, salaries are not the proper means to achieve it. They have abundant evidence before them that the organization of new enterprises, and the process of going public with them, or selling out to large enterprises, is the path to riches if they wish to pursue it.

In examining the views of scientists and their managers in specific laboratories rather mixed feelings were reported. In three laboratories the scientists felt that their salaries were more adequate than their superiors believed. In six laboratories the reverse was true. In only one was there an agreement, both giving a rating of seven on the one-to-ten scale. Again the question of the adequacy of communication is raised. It would certainly appear that improved morale could be achieved if there were a closer rapport between the scientist and his manager.

It would not be quite accurate to imply that scientists are really indifferent to salary levels so long as they conform to industry levels. The words "average" and "levels" imply salaries above and below these points on any scale. In this survey, 10 of 50 scientists specifically stated that their reason for working for their employer was the high salary paid. From this and other evidence to be considered later, it would appear that scien-

tists feel perfectly free to roam from one employer to another: they identify with their science and their earning power, but not necessarily with the firm.

Satisfaction of Social Needs of Scientists

There is very little evidence that scientists expect their employers to satisfy their social needs through internal company arrangements. Indeed, scientists are quite direct about this matter. They work for a firm for many other reasons such as those reflected in Table IV. Most important is the degree of freedom for research activities. Closely associated is the type of work undertaken by the laboratory, the availability of facilities and equipment, and the stimulating environment created by the presence of other respected scientists. Since 35 of the respondents had worked elsewhere these reasons for their current employment take on added meaning. It is apparent that scientists are not looking for an employer who satisfies their social needs. These are catered to through contacts outside the firm. The managers of these scientists are quite clear on this point, also, because there is no evidence that either the company or the manager provides incentives with this point of view.

The Rewards Most Sought

These findings fit in rather well with data concerning the long run rewards which scientists value most highly. On a scale of zero to ten measuring unimportance to extreme importance of selected long term rewards for scientific achievement 48 scientists and nine managers discriminated between them as is indicated in Table V. The listed values are not all mutually exclusive, as may be concluded by considering the close relationship of self

improvement and professional development; and recognition, reputation and status. Nevertheless, these are the factors scientists think about when they consider the long range rewards they seek. Of most importance is the sense of self-achievement. These men remain true to their training. Closely following is self-improvement and recognition by others of their proficiency. Scientists want to improve their skills so that they can enjoy the satisfaction of technical success and the ensuing prestige gained from these accomplishments. It is significant that these men are primarily concerned about external recognition. They think that, as presently administered, internal rewards such as money, promotion, and status are rather unimportant. The ego needs of scientists are clearly paramount, but the firm cannot satisfy them beyond creating the environment in which reputations can be made and making it possible for scientists to gain publicity for their achievements.

The managers tend to agree with the views of their subordinates. They are sure that scientists want the satisfaction of

TABLE IV

Scientists' Reasons for Working with Present Employer

	Number of Mentions
Freedom to do research	21
Stimulating environment	14
Good salary	10
Type of work	8
Good equipment and support	6
Plant location	4
Better position	3
Reputation of company	2

technical success and the recognition inthe scientific community which flows from these accomplishments. It would probably be very difficult, on the basis of this evidence, to determine whether

success was really wanted for self-satisfaction or whether it was the means of securing professional recognition. When asked how they expect to benefit from their publications, patents, speaking engagements, and the citations of their work by other scientists--all being ways in which a scientist is recognized outside the enterprise for which they work--a total of twenty-two expected their reputation would be improved, seventeen thought they would benefit financially, eight mentioned self-satisfaction and seven thought it would lead to a better job. Their managers did not believe that such recognition would affect either their reputations or their salaries. This looks very much like the managers did not want to believe these would be the benefits reaped despite their rather obvious applications.

There is an additional reason beyond prestige why scientists want professional recognition. Many of them seek this reward as a way of making more certain that their technical contributions to the furtherance of knowledge will be incorporated into the literature. Viewed in this light, recognition can serve both an ego need and a desire to make a useful contribution to the knowledge and welfare of others.

TABLE V

Preferred Long Run Rewards
for Scientific Achievement
(in scale 10-0)

	Average (48 scientists)	Average Estimate of Scientists' preference (9 managers)
Sense of self achievement	9.3	9.2
Self improvement	8.9	7.6
Recognition of accomplishment	8.7	9.0
Professional development	8.3	8.0
Reputation external to the firm	8.0	8.5
Higher research status (within the firm)	7.6	8.0
Financial reward	7.2	7.7
Promotion within the firm	5.0	5.7

There were important differences between laboratory managers and their own subordinates about the long term rewards which scientists seek. Significant differences were considered to be present if there were two points or more disagreement on the 10-0 scale between the manager and the average for his subordinates. For instance, in four of nine laboratories the managers underestimated the desire of the scientists for self-improvement. In other categories the managers were quite evenly divided in over- and under-estimating the degree of importance which their men assigned to individual rewards. Statistically this is of no importance, but for the individual laboratory, divisions of opinions can have a considerable bearing upon the morale of scientists and upon the incentives developed and applied by individual managers. For instance, in one laboratory the manager over-estimated the desire of his subordinates for promotion, status, and professional development. In another instance the manager overestimated the desires of his scientists for financial reward and promotion within the firm and underestimated their desire for self-improvement. Evidence of this type surely is sufficient for one to raise the question about the complementarity of the actual reward system and an ideal system that would better meet the needs of scientists (and, presumably, affect their productivity positively).

Those managers who believe that their subordinates can be motivated by promotion will be interested to learn something about what their men consider a promotion to be. Among those responding to this question, thirteen mentioned a higher salary, eleven thought favorably of being moved to group leader, seven thought

a higher title would suffice, and seven thought that there was nothing a firm could do that they would consider a promotion! The manager who merely assumes that he knows what his subordinates think is taking immense risks.

Enterprises generally recognized the importance of facilitating the desire for professional development of their scientists. Only two laboratory managers felt this was not being done while twelve were of the opposite opinion. The firms that employ scientists are very open handed in this regard. Practically all encourage their men to take educational courses and seminars, to teach, publish, and attend scientific meetings--all at the expense of the company. The scientists agreed in a ratio of forty-one to seven that this was true. But they interpreted professional development in an unusual way. Some twenty-three thought of it as the freedom to select their own projects, seven thought it included travel and professional meetings, and seven believed it embraced tuition fees paid by the firm.

It would appear the term "professional development" has quite a different meaning for the scientist than it does for his employer. The former thinks of it largely in terms of being able to develop his skill and knowledge in fields of his choosing. This would mean that the scientist himself feels he is most productive when he can select his own projects for investigation. His manager, on the other hand, feels that he is encouraging professional development when the firm pays the cost of education, travel and conferences, and permits the publication of papers and books. This contribution is merely facilitative; it reflects a failure to understand what the scientist means by professional development.

Freedom of Research

This does not imply that firms are not providing large measures of freedom for the scientist to identify his own projects. When asked to characterize their research unit, on a scale of ten to one, forty-nine scientists evaluated accomplishment at eight, indifference at three, and frustration at four. Their managers agreed almost identically, though they thought accomplishment as about nine on the scale.

Freedom in project selection was associated by scientists with productivity also. On the average they wanted eighty percent control over selection, and even the lowest on the scale among them wanted sixty percent control. As is to be expected, their managers were less generous. They agreed that scientists should exercise control over project selection to the extent of sixty-seven percent if productivity alone was to be considered. However, the range spread from forty percent to one hundred percent depending upon the laboratory involved. Managers clearly feel the weight of budgetary and product restrictions and in their light they must restrict the freedom of scientists in project selection more than either of them might wish.

Project freedom and the way it is managed is a many-sided concept. Concerning the freedom to select their projects, seventeen scientists considered themselves fully free, twenty-three thought the degree of freedom was very high, and nine thought they had little freedom in this regard. Only two of their managers permitted complete freedom but nine allowed a high degree and only three permitted very little freedom.

In the development of research design, methodology, and technique, twenty-eight scientists had complete freedom and eighteen a high degree. Only four felt a restriction in this regard. On the other hand, seven of their managers thought they permitted complete freedom and eight thought the degree was very high. In the area of project reporting seventeen scientists felt no restriction, twenty-six thought their freedom was quite high and only seven felt definitely restricted. Among their managers three thought there was no restriction, eight thought there was very little, and four agreed that little freedom was present.

The freedom to communicate ideas and information about research is definitely dependent upon the stage of investigation and completion. In the problem formulation stage, and in the actual research work eleven scientists felt free to discuss the matter with men outside the firm. At the conclusion of the research and also after patent information was protected, twenty-eight scientists felt free to communicate their findings outside the firm. In each instance their managers were in general agreement with them. Of course, this would be true because the degree of freedom to publish is a matter of organizational discipline. The general lack of restrictions imposed upon scientists, outside of security requirements, is a further indication that managers are aware of the importance scientists attach to achieving recognition conferring with peers and they facilitate the process.

Salary Adjustment Procedure

The salaries paid to scientists perform another task besides that of taking care of basic needs. They are useful as an incen-

tive to induce scientists to improve the quantity and quality of their research, and as a prestige factor that can reflect the differences in esteem with which scientists are held by their managers. To be in the highest salary classification for scientists, or to be a $25,000 a year man (or other figure to represent various plateaus) is a matter of personal pride quite beyond its implications for higher living standards.

In appraising their men for salary adjustment managers weigh heavily the internal performance of their subordinates and the outside recognition of it. Performance in this context covers several factors such as visible research results (another term for productivity), success in making contract sales (usually government contracts), and the quality of the work done (includes significance and difficulty of the work). External recognition in the form of publications, invited talks, and patents is valued as a confirmation of the quality of the scientist's work.

Salary adjustments resting on these bases make a great deal of sense, but on careful examination it is difficult to find objective standards for performance. Scientists are certainly hired in anticipation of the results they can produce, but what can or should be expected is largely a subjective matter. Managers try to overcome this difficulty, especially with respect to unknown scientists, by aiding in problem definition, analysis, definition of phases in the procedure, and checking performance against objectives. It is not implied here that this is an inferior procedure. It merely points up the general issue of subjectivity in evaluating scientific performance. Even this technique is valuable because it is directly related to productivity--

what a man should be paid for. There are still some managers who give up too soon in the face of a difficult task and assign merit salary adjustments on the basis of area averages and seniority. They should be severely taken to task for their defeatism because these are clearly unrelated to the reasons why scientists are hired in the first place.

The scientists themselves have both sound and unsound ideas about why their salaries are adjusted. They mentioned factors related to internal productivity twenty-four times and those related to professional recognition nineteen times. These square very well with the criteria offered by their superiors. However, there were eleven mentions of general knowledge, three of seniority, and two of politics. Perhaps the most astonishing remark, made by eighteen scientists, was that they did not know the basis for salary adjustment. No manager can be forgiven for permitting this situation to arise.

As one would expect, the degree of understanding between manager and scientist in the individual laboratories varied considerably. In five of these there was an excellent congruence. Of the eighteen scientists who did not know the basis for their own salary adjustments eleven were concentrated in four laboratories. The manager of one of these failed to respond to the question: he had four scientists at sea. Another manager reported that he made salary adjustment on the basis of visibility of research, contract sales, quality of research, and contribution to company goals--all excellent criteria, but four of his scientists knew nothing of this and one thought the basis was publications. Where situations of this kind exist one can only point to the incompetence or carelessness of managers.

Overall the scientists and their managers agreed that there was about a seventy percent chance that salary adjustments related directly to research achievements, and the same groups felt that on a scale of 1-10 salary adequacy was seventy percent. In four laboratories both managers and subordinates agreed that research achievement was closely correlated with salary adjustment. In five laboratories the managers felt the correlation was very high but their own subordinates did not agree with them. On a scale of 1-10 the difference between them was two to three points. In only one laboratory was the manager more pessimistic than his men about the certainty of reward for accomplishment.

It becomes very clear that if salary is to be used effectively as an incentive for scientists the laboratory managers need to develop their skills in the use of this tool. Many of them may be adhering to old rules of secrecy in salary matters. Several may be afraid to discuss the matter with their employees. Whatever the reason, there is no merit at all in any failure to communicate on salary matters with their own subordinates. Salary is a vital subject to everyone and it deserves full consideration between superior and subordinate.

Leadership

Leadership is the ability of the managers to imbue his subordinates with the zeal and confidence so essential if their capability in the achievement of objectives is to be fully utilized. Many managers get along without exhibiting leadership skills. They find themselves in charge of groups that work at the minimum level necessary to mere acceptability or of groups that are entirely self-motivated. It is clearly the leader's function

to maintain productivity at a level reflecting individual capabilities or at least not to interfere with those who are motivated by the determination to do good science.

It must be said that the scientists responding to this survey do not really understand the function of leadership. Their remarks about the leadership qualities of their superiors were quite clear on this point. Therefore, the exercise of leadership must be inferred from the total impression left by the survey. The question becomes, What actions did the managers take that would affect positively the zeal and confidence of scientists? The answer echoes, "Very few indeed." They administered laboratories on the basis of established company policies relating to freedom of research, equipment, and salaries. They might have been influential in the establishment of this environment and in developing budgets that would facilitate outside contacts for their scientists. Their over-all performance seems a bit desultory.

The general failure to secure the identification of the scientist with the firm is most convincing evidence of the failure of leadership. Scientists want to help the company to its objectives; they are proud of their contributions to this end. This attitude was not developed, at least in the laboratories considered in this survey. Rather, leadership was allowed to shift to influential colleagues who were encountered in professional meetings and to the editorial boards of technical journals. It would appear that managers of scientists do not understand their leadership function and have little skill in this area.

Summary

In general the execution of the direction function by laboratory managers is poor. Competition has forced enterprises to establish laboratories and an environment therein that is comparable in varying degree with other firms. The firm is trying to understand the scientist and it has gone a long way in permitting freedom of activity, publication of results, and creating research conditions that most scientists want very much. The companies attempt to do their job well. It is the managers they appoint over their scientists who demonstrate specific weaknesses. Several instances of neglected communications were noted; the incentive system was sometimes poorly applied to individual scientists; and the identification of scientists with the firm was not achieved. These managers have a need to be educated in management.

DIALOGUE OF THE SEMINARIANS

DR. O'DONNELL: It would be helpful to discuss the direction function of managers. In the managing process it is important that managers motivate, communicate with, and provide leadership for subordinates.

DR. SILVERMAN: I think we are getting down to the fundamental requirements for the management of scientists. You have to really manage those people. You have to convince them that they are in complete control of their destiny and their research project, and at the same time you have to guide them into what you want them to be in. I suspect that there are some very excellent research managers around who have been able to convince their people that they are doing exactly what they want to do and at the same time fulfilling the objectives of the company.

DR. OSTERYOUNG: I would say that one of the subtle measures that is used is in communication, really. You tell them what you want, and you give them certain information and hope that nine times out of ten if they come to a fork in the road they will choose the fork that is in the direction you really want them to go.

DR. SILVERMAN: One of the things we had better not fall into is generalizing on the term "scientists." I think that you will find even among scientists that there are those who prefer to be left alone to chose their own work, and they are very happy in doing that; and there are other scientists who require and need the very strong hand in telling them this is the area that they should be working in. There is a sense of security when somebody has picked out a field and has decided that it is an

important field for that particular scientist.

I also feel that many individual scientists, while they are achieving a certain amount of outside recognition, probably are looking also for internal recognition which is much more difficult to obtain. Managers of large organizations are not paying much attention to their scientists and are not treating them as important individuals or their work as being important. I think this is something that is really lacking in individual organizations.

DR. HAMERMASH: One of the things that I feel is very important in terms of the role of the director of research, for example, is that the scientist should feel that his supervisor is someone he can go to and have a sympathetic ear and a shoulder to cry on. I think we somehow ignore this. In fact, it is frowned upon in many technical environments, but this is an extremely poor thing. It is very nice to be able to come into someone's office, someone who can help you get over these periods, when for three or four months you feel as if you have done nothing.

DR. O'DONNELL: This would be a very important function of the leadership role, I would think.

DR. HAMERMASH: It is one that is very sadly lacking.

DR. SILVERMAN: One thing that we were talking about is what the scientist expects of the supervisor. He has a dual responsibility which he sometimes is unable to translate in either direction because he is responsible to the people to whom he reports and to the people who report to him. I think that one of the things that is really lacking, is communication. The question is, "How isolated should the individual scientist be?" I think that they

should not be isolated. I think the more that they know about the entire function the better. For example, you mentioned scheduling. There may be some perfectly good reasons that meetings are called on short notice and at various times. You can't coordinate everything with everybody. But I think, in general, management doesn't translate each problem to the people upon whom it impacts and this, it seems to me, is one of the roles of management. At the same time it is one of the roles of the individual scientist to recognize that the people above him have problems too--a budget of time, space, or dollars.

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DR. O'DONNELL: How do scientists want to be motivated?

DR. GREEN: That is a completely meaningless question because scientists don't want to be motivated. They are motivated if they are scientists. I can't think of any external mechanism whereby you can motivate anybody. If it's not in them, then it is not in them.

DR. FRANTZ: I agree that nearly anybody who is in science is motivated. I think the question to ask is "How can you align the goals of the company with the motivations that are already in the scientists?" I don't really know the answer to this. I think part of the answer lies in the fact that all of us whether we are in ivory towers now or not, have been educated in the ivory tower and have learned the motivations that go with that. A lot has to do with various forms of status, recognition, and so forth. That's the kind of thing you see mostly in the ivory tower, and I think we see much of that outside the ivory tower itself. People doing basic research would like to publish basic

research papers and be respected by their peers. If that is not available, then you have to find some other kind of motivation, some other kind of status. I don't know the answer.

DR. DONNA WILSON: I would really have to agree with the statement of Jack Green. In the ivory tower situation in which I live and work, the motivation has to be in the person or the scientist or we don't have it.

DR. O'DONNELL: And that is good and sufficient? Are there no other means of motivation that are possible?

DR. DONNA WILSON: I certainly can get interested in problems that my company has, and, you know, I feel a certain responsibility to find the relationship between those who support me and what I have to offer them, but I really think in phrasing it this way it is even a bit antagonistic toward the ivory tower type of scientist or the person who really is motivated to science. This is the same experience I had with trying to formulate goals in astronomy. That statement antagonizes.

DR. HAMERMASH: You say your situation is like being in the astronomy department at the university.

DR. DONNA WILSON: Perhaps to a certain extent.

DR. SCHNEIDERMAN: It is as close to it as you can possibly get in the industrial situation.

DR. DONNA WILSON: What I'm speaking about here means that if you can really point to one's loyalty, it is to astronomy and not to Douglas, Lockheed, the Giant Corporation, or any place else. It never can be, and I feel this very strongly.

In discussions with certain manager types I find that their loyalty is more to Douglas, Lockheed or the firm that

employs them. I'm not saying one is bad or good, but I think there is a difference.

DR. HAMERMASH: This question of loyalty--even if you have an organization where you do have an application orientation, you still have this problem of the major reference groups for technical people. There is the American Physical Society, the American Biological Society and others, and the rewards that the fellows get are from reading a paper at a meeting, and you have, say, someone pat you on the back and say that he read your paper, the one you published last month. That is a far bigger reward than something that happens in the company.

Now, what you are saying is that you are free to operate in that arena most of the time except for collecting your paycheck and reading some company memos.

DR. DONNA WILSON: The remark about the paycheck becomes a very very sore point for scientists. I would certainly agree with Jack, my neighbor down the hall, that I had better well relate my work and being supported to the goals of the company. I feel a great responsibility.

DR. HAMERMASH: That is a change of ground now, though.

DR. DONNA WILSON: But first and foremost, my motivation is for the problems that are intriguing to me as a scientist.

DR. HAMERMASH: Only secondly do they somehow fit some company goal.

DR. DONNA WILSON: Well, you see, again, that is motivation.

MR. BOYKIN: May I ask Jack Green a question? Scientists already have their motivation. I presume that it is possible to motivate them negatively. If you got your paycheck and you didn't

feel you got a fair one or some other company treated people in your situation better than you have been treated, would your motivation dwindle a bit?

DR. GREEN: You have to be practical. If you did not get a paycheck at all, you certainly would be motivated to go elsewhere. But that is carrying it to extremes.

I think that the salary scales for scientists in industry, government, or universities, are approaching a common level. If a scientist wants to do a certain bit of research and the company objectives are quite alien to this, then he will seek a government or university position. If the scientist has the ability, he can do much as he pleases. It sounds rather dogmatic, but I think this is an era where we are very fortunate.

DR. SILVERMAN: What you are saying is that part of your motivation is salary. There is enough differential between industrial salary where you do applied research and the ivory tower where you might indeed do some applied research.

DR. GREEN: If your salary is not sufficient to permit you to carry on the work you want to do because your family is unable to survive financially, then you're more or less obligated to seek another position. There are cut-off points at different levels for different scientists in motivation or dedication to his job as they relate to the welfare of his family, duty to his community or country, etc. In the non-extreme case, salary is important, but I do not believe it is the overriding consideration in selecting or retaining a position.

DR. SILVERMAN: What has your salary go to do with it one way or the other? The salary only has to do with your being

able to support yourself and your family as you would like to be supported.

DR. GREEN: The salary does not permit you to do research in the direction you wish. I am saying that there are a lot of research areas in which you may wish to enter and if you're unable to do so then you're more or less obligated to seek another position. Your salary is important, but it's not the overriding consideration.

I have carried this out to the extreme. In the beginning of this discussion we had no salary at all, you see.

DR. SILVERMAN: But you are talking in absolutes. What I am saying--I am talking in terms of degree. You start out with a university situation where you make X number of dollars, and you start out in an industrial situation where you make X plus some increment. Now, to get the increment you have to do a certain amount of dirty work--applied research as opposed to doing what you want. How much applied research are you willing to do for how many dollars, is the question I am asking.

DR. GREEN: That is a very cold way to put it. I object to your paycheck approach. I think the paycheck is an important factor, but it is not the overriding consideration. Again, you have to look at this dispassionately, and if you as a scientist have a certain line of research you wish to pursue, and if you can pursue it in an industrial complex, fine. But any good scientist can get enough money to maintain himself and his family in a comfortable standard of living in any of the major areas of university, industry, or government research. The paycheck is not that important.

MR. IAMS: We are talking about the management of scientists in industry, and about situations which include elements of both the ivory tower and the real world. There is no reason that someone who spends a significant part of his time in original intellectual effort leading to the discovery of new knowledge should feel that it is inappropriate for him to give some thought to its utility to mankind. In other words, applied research should not be classed as "dirty work."

DR. SCHNEIDERMAN: I think that we have to get another standard of reference here in regard to the unique laboratory with which these people are fortunately associated.

The advanced research laboratory with which I am associated is comparatively small, and we intend it to remain so. It is quite different from research and development laboratories.

In other words, Dr. Wilson is doing research in astronomy related to some phase of the spectroscopic shift that is going to help me get a better tracking device. She doesn't have to prove that to me at all. It so happens that I can understand it. I mean that I am just giving a different frame of reference. Dr. Wilson is as close to the completely theoretical pure research laboratory as you can get.

DR. SILVERMAN: But we are arguing about motivation, and I contend that part of the motivation is the paycheck that they get.

DR. SCHNEIDERMAN: Indubitably, my Lord.

DR. SILVERMAN: And each of us has a different degree to which we are willing to prostitute ourselves. We are not arguing. We are haggling about the price.

DR. OSTERYOUNG: I would agree completely that the scientist is motivated. If he is any good, he is internally driven really. You can motivate him, I think, in a negative way by putting impediments in his way that either slow down his productivity or drive him out. I don't think you can really motivate him positively.

DR. O'DONNELL: Take for example, the permission to publish or permission to read a paper or something of that kind that the firm might grant him. I would think that this is an important motivating element.

DR. OSTERYOUNG: No, that is part of his motive. Removing it is a negative factor.

DR. GREEN: The scientist will move away to a job elsewhere.

DR. O'DONNELL: Yes, so long as alternatives exist.

DR. OSTERYOUNG: On the other hand, the concept can be applied to what is the motivating force behind the whole laboratory. In short, what do the people who give the money want? They are going to have to decide how they want to motivate the people, and basically they are going to have to decide what, for example, accrues to them by having these people who are self-motivating, work for them.

MR. SCHNEIDERMAN: In my particular case the management of the company is quite willing to accept the intangibles for the return on their investment. I know that this doesn't sound real, but this is the way it is in this particular case. The concept of manager-motivation was not necessary. The idea that the company would get immediate productive results did not exist. This is a rather unique laboratory in this world of ours.

DR. SALZER: The question was, "How does a scientist want to be motivated?" The first answer to that was that he doesn't need to be motivated by others; he is motivated internally. Mrs. Wilson began to give us a clue to what motivates her.

I would like to know what motivates Jack and Lee and others, because I may learn something. Just tell me what motivates you: we may be able to provide those factors then for our scientists.

DR. FRANTZ: I will tell you what motivates me. It is the desire to turn out some research that I can be proud of, that

I know my friends in the physics business will respect and, therefore, respect me.

DR. LYON: Not in regard to your environment, to your office salaries?

DR. FRANTZ: Oh, there are motivations there too, of course. Those three. Let's see if I can really evaluate one relative to the other.

MR. WELTY: I think if you drew a parameter of continuity of your work and what you do from day to day, you would see these are two different divisions. I think there is some confusion. I think salary has a great deal to do with the decision you make whether you are going to stay at that company or move to another company but probably doesn't have a lot to do with what you do day to day. So you have to look at motivation in two directions: One, that it determines where you're going to work and two, after you have decided that, what you are going to do from day to day.

DR.FRANTZ: All right, I will answer the second one. When the contract that I am working on rounds out, I have to get it renewed or find another one, and so what I am doing right now is being motivated by the need to satisfy the requirements of that contract. Now, that is a kind of force-motivation.

MR. WELTY: Wouldn't you say that your day-to-day work is based upon getting recognition from your contemporaries?

DR. FRANTZ: Yes, it is.

MR. WELTY: Then, your salary and maybe your office facilities come into the decision whether you are going to stay where you are or move to another company.

DR. FRANTZ: The salary and the office facilities, I suppose, come in. I tend to think it is going to be much the same in any company; so I don't really think about moving.

DR. OSTERYOUNG: How about the climate in California?

DR. FRANTZ: To an extent. We are kind of running out of things that apply not only to me but to a lot of people.

DR. SILVERMAN: What about the reputation of the company?

DR. FRANTZ: It doesn't mean anything to me when I think about it.

DR. SALZER: Why are we trying to force things into your mouth? I honestly think most of the things that are cited here, except the ones that you have mentioned, don't add up to ten percent of the motivation in total.

There might be other things that you don't realize that are important to motivation, but certainly one that you mentioned probably far outstrips all the other things.

DR. FRANTZ: Which one are you talking about?

DR. SALZER: Recognition as a scientist.

DR. FRANTZ: I am not sure that I know how you measure it. Perhaps by reference to my work, pepers, and things that people say at meetings.

DR. HAMERMASH: What about recognition in the company?

DR. FRANTZ: That would be a nice thing. I'm not aware that it exists.

DR. HAMERMASH: What about when someone calls and asks for your advice in some other area?

DR. FRANTZ: Yes, it makes me feel good, but not a great deal.

DR. LYON: If they took you away from your office and put you out in the center of a big bay--

DR. GREEN: I have been in this situation.

DR. LYON: Now, would your degree of motivation change? Assuming the bay environment precluded research activities,

DR. GREEN: No./ I would go someplace else where I could be in an environment to do what I wished to do.

DR. LYON: Then one of the things that motivates you is the proper environment for you to do your work. Is this the answer to the question?

DR. GREEN: The environment makes it easier to carry out certain aspects of research but it does not provide the motivation. The motivation is there long before you move into the organization, I believe.

DR. DONNA WILSON: Maybe we are talking about a spiritual thing. I am not talking about the desk or the carpet or the floor; I am talking about the environment that allows me to work on the things I have to work on. The paycheck is one part of that, but it is not the overriding issue.

DR. SILVERMAN: It's not the thing that made you a scientist in the first place?

DR. DONNA WILSON: No. When I first went into astronomy I gave up a good job and started working for seventy-five cents an hour in a basement where scorpions fell from the ceiling and into the darkroom hypo pan. Everyone said that I was crazy.

DR. O'DONNELL: Do you recognize, Mrs. Wilson, that the company might conceivably do something to reduce your zeal--

DR. DONNA WILSON: Yes, oh yes.

DR. O'DONNELL: --as a scientist?

DR. DONNA WILSON: No, not as a scientist. They could do things that will make me go someplace else to do science.

DR. SCHNEIDERMAN: Quite a number of the factors are unique and distinct for the motivation of a highly individualistic, creative scientist. When you take the parameters of salary, desks, offices, parking spaces and so on--and these are in the realm of the more material--these are the same things that make a senior engineer go from one place or another. But I think the major difference between the fundamental research scientist and the man in the applied or the engineer's side of the house--and I have been on both sides--is that the people involved in fundamental research have at least the following few things as prime motivating factors, namely, the high factor for individual decisions, and the ability and the importance of pursuing research that they want to do in the manner in which they want to do it whether it is in the basement of a laboratory or on top of Mt. Wilson. It is like the individual artist who wants to paint his way. He cares not whether you like it. He paints because he is an artist.

I think that it is these factors that motivate or provide a good environment or provide the reasons why scientists will stay at one company or one university as distinguished from another. The things that cause him to leave for another vista, are salary or the desk or the office.

These are some of the factors involved, but one would be overriding. Let's say some ogre came in and said, "Dr. Wilson, you are not going to do any work in astronomy. That is all there is to it. I have had enough of that." Now, that's negative

motivation. I don't think Dr. Wilson would be there too much longer. She would go find something else to do.

MR. WELTY: We must decide what we are being motivated to do. If you are talking about pure motivation that has no meaning. Basically if you want to talk about being motivated to stay in a certain place, that is one thing. If you want to stay motivated to work in a certain direction, that is another thing. If you are talking about motivation to be cooperative with management, that is another thing. You have to talk about being motivated to do something.

DR. O'DONNELL: Well, I think you should really be talking about motivation of people to do what you hired them to do. In the case of scientists, I would think this would be achieving results from their research.

MR. WELTY: Well, you want scientists in hopes that they will do what you want them to do, but this is a complex thing. You have got to combine several things. You don't motivate them to do just one of them. As I have pointed out, salary mainly has to do with whether he is going to stay there, and not with what he does and how he approaches his work.

DR. OSTERYOUNG: Let me throw this around. I think that we are talking about the basic research scientist. When you hire him out of the university--use that as some baseline--he is motivated to carry out his scientific work. Now, if you hire him into a basic research organization I don't think you really can or have to motivate him.

My feeling, based on some observation, is that as you go down the line from a basic research organization to an applied

organization to some sort of trouble-shooting, fire fighting organization, the caliber of the people that you find actually goes down. There are, certainly, individuals who are comparable, but the scientific caliber of the people goes down. One of the reasons is that you cannot or haven't been able to motivate people who are basically oriented to move into some of these other areas. This is where industry makes a crucial mistake because it is precisely as you move down this chain that the dollar value of the organization goes up.

MR. IAMS: The words "basic research" does not necessarily mean the same thing to everybody.

DR. SCHNEIDERMAN: That is right.

MR. IAMS: To some, research is basic when there is no immediate application for it; and to others, it is basic when it derives new knowledge which may have utility. I think that many industrial laboratories do very fine research which extends human knowledge, but human knowledge in a way that can be applied.

I like to think that there are many fine scientists, and scientists in the best sense of the word, who are deriving knowledge with the intent to apply it.

DR. SALZER: Talking about furniture and physical surroundings, I am surprised that nobody mentioned that a scientist might stay with a company because it has an electron microscope whereas an alternative company doesn't. This is really part of the motivation, isn't it? You have the environment and the tools to do your work.

DR. GREEN: Most research organizations have a spectrum of "instrumental" research tools. That is more or less a common level, although there are great differences in the physical plant. One physicist may require a cyclotron or something. This is an exception, but micro-laboratory scopes and spectrometers are found in almost all large complexes.

DR. O'DONNELL: I am interested in how the managers respond to this input from our scientists.

DR. SALZER: I noticed too much weight is given to a salary level and paycheck. I truly feel that those are not major motivating factors.

DR. O'DONNELL: Yet I have heard the same people talk about comparable income or fringe benefits as motivations for the scientist. So many of the scientists seem to be drawn into a managerial spot perhaps against their will because they think there are more rewards available in management than there are in the scientific field. This means to me that this is an aspect of motivation. One might very well be persuaded to continue in the scientific role if the enterprise would provide this particular opportunity.

DR. SALZER: This was a factor twenty years ago. Today it is almost the opposite. In fact, we reviewed somebody whose salary couldn't be justified on the basis of management skills and had to be justified on the basis that he was also an excellent scientist and could contribute that way. So I think that this battle has been fought and won by the scientists.

DR. SCHNEIDERMAN: I submit that it has been lost by the scientists. I submit that relative to the truck driver, relative

to the ditch digger, the scientists, and in some cases the senior engineers, are the most deprived, underpaid people in industry. How say you? I submit to you that for the beginning Ph.D from school his initial salary in industry is around a thousand a month.

I submit to you that after twenty-five years of experience in industry, his salary hasn't come up to five thousand a month.

You take the journeyman, the technician, the man in the labor union who comes out of a sort of whingy-dingy school. In a number of years his salary will go up considerably. When you compare this ten years of experience and his salary increase percentage wise with the salary increase of a scientist--and let's now call it a good scientist who has published and is recognized in his field--I say that the scientist is one of the most underpaid, horribly treated persons in the whole of industry compared to the people in the labor unions.

DR. SALZER: You might be right that that battle was lost. I was addressing myself to the battle between manager and scientist.

DR. O'DONNELL: Perhaps I can formulate the question a little bit differently for the manager. Do you think you're motivating your scientists?

DR. LYON: Let me make a couple of observations before I answer that question. Lee's reaction to the question was one of having the situation in which he could do work that

DR. GREEN: Many scientific discoveries have been made in the home.

DR. LYON: The real subject is the relationship between the employee and the employer. What can the employer do to motivate the employee?

DR. GREEN: Nothing.

DR. SILVERMAN: I would like to point out that it seems to me that we all generally agree that the plushness of the environment does not help motivate the scientist, and I am willing to accept within degrees that the salary isn't what motivates the scientist. But you can, I think, envision situations wherein the same person working in one environment will be non-productive but working in another environment will be very productive, and I think that part of that is due to the people he is working with. I think that the personal relationships established among people in an organization can certainly help serve to motivate a scientist. They stimulate him to be more productive. The intercourse, the communication, with other people with whom you are working will help make you a more productive man. If you work in another environment where you have all the wealth and plushness and everything else, but everybody is sitting around doing nothing, you would probably find it much more difficult.

DR. GREEN: The scientist would seek out associations no matter where he is. If he is in a university or in government or in industry, he would seek out associations that might help him be productive, but I don't think they would help motivate him.

DR. SILVERMAN: Well, you just admitted that it would because you admitted that in one environment you would be more productive even though you are seeking out these associations. You are admitting that you need that environment to be productive and, therefore, I contend that this is motivation.

DR. GREEN: You are equating productivity with motivation.

DR. O'DONNELL: That is the result of motivation.

DR. SILVERMAN: That was the ground that we established.

DR. HAMERMASH: How would one de-motivate you, Jack? Let's put it that way.

DR. GREEN: I suppose loss of sight and mind.

DR. OSTERYOUNG: You are talking about the facilities, certain things which can increase the productivity or really the rate at which you move towards achieving those things that motivate you.

DR. SILVERMAN: Not mental attitude?

DR. OSTERYOUNG: I don't think it is a matter of mental attitude. In other words, you might well argue that if you were working completely isolated with all the facilities in the world, you would not be as productive as you would be if you were working in a larger environment with co-workers. But that does not mean that you are necessarily motivated.

DR. GREEN: That is what I was trying to bring out.

DR. SILVERMAN: How do you judge motivation?

DR. OSTERYOUNG: It may be, for example, that there are things you don't have access to, journals, for example, in given areas, your progress is not going to be as great, but you are motivated.

he would be proud of. To me, that is more a question of self-motivation or pride, and it is what we are really talking about. I would distinguish that from the things that the company can do or management can do that will bring out the best in the employee. In that category I would say that salary is one factor, the work environment is another. The expression of appreciation for the work that is done, the acceptance of it, by the company--these are all things that the company can do to make the scientist feel good, and this is motivation.

I am sure there are others, but I think it is factors like these that are really the subject of what you are trying to get at, and to the extent that it is possible in our company, yes, I think we are doing that.

This gets to be a real personal issue, and many times there are things you cannot do. It is sometimes difficult to set the scientist apart from other people paid on a comparable level and give one something else that the other doesn't have because he is a scientist. This sometimes restrains what you would like to do in order to provide the quiet comfortable environment for the scientist to work in.

DR. O'DONNELL: And getting back to Jack--do you recognize this as a motivation?

DR. GREEN: No. Motivation I think is self-motivation. The other aspects such as the physical environment, the laboratory equipment, the other fringe benefits, make it easier for a scientist to pursue his objectives. And why is he motivated? I think he is motivated mostly because he wants to know.

DR. LYON: You can do that in your own home.

DR. SILVERMAN: Talking about the desire to get off the chair and go out and do some work, I contend that if you are in an organization where everybody is out there working hard, you tend to want to work harder. Where everybody is sitting around doing nothing, you may tend to sit around and do nothing, but you may eventually get disgusted and leave. While you were there, you would do nothing. Then you are not motivated.

DR. MUIR: That is right. I say that the same individual in two different situations will react in two different ways.

DR. ALBERT WILSON: We have to divide this up a bit. There are people like Jack Green who are motivated no matter where they are. Then there is the intermediate group. This intermediate group takes a little bit of push to get something going. They may be turned off or on according to some of the environmental factors. Then there is the third group that no matter what you do they are not going to be motivated except that they have to eat. For basic research there is only one kind of person: the Jack Green type. For other types, you are just kidding yourself. They are not going to do basic research. Self-motivation and basic research are closely correlated. Other research may be externally motivated.

DR. SILVERMAN: I think we can argue because we don't have any facts. I don't agree with you.

DR. MUIR: I don't think any amount of management motivation would have gotten Shockley to develop the transistor, or Bloch to discover nuclear magnetic resonance. These were extremely gifted and motivated people, and I agree with the thesis previously advanced that the only thing the environment

can do is turn off a certain amount of motivation that is inherent in the man. In terms of a man's productivity, how much he can get done, then certainly the environment is very important. The library or whatever--these things are all contributing parts.

In terms of the salary, I think it is most important when a change has to be made. Once the scientist is in a situation, he feels he has made the right choice--maybe he hasn't--but he feels he has made the right choice unless his salary is cut in half or something. He knows that he gets an increase from time to time, and things are going along smoothly. He is not concerned with the salary. If he is suddenly offered an advancement or decides that he wants to leave that position, then the salary becomes more important in directing the change. But it's not the determining factor whether or not he is going to discover the transistor. That is not affected by the salary.

I think most of the ivory tower industrial laboratories somehow have to relate to or couple with the rest of the organization. The scientist has his own freedom, but somehow he must be coupled, and it is difficult to motivate him to couple his work to the rest of the organization. It is motivating his espirit de corps or something to take an interest in company problems apart from his own scientific problems. This is the difficult area.

DR. SCHNEIDERMAN: I think you took this word "motivated" from the conventional business administration usage. How do you motivate Johnny Jones to turn out more things on the lathe, or how do you motivate the secretary to do better typing? I think that maybe we should be talking about this thing called

stimuli to creativity and not use the word "motivation" as applied to scientists because there are the implications from the general business administration terminology. As Jack puts it, the motivation comes primarily from the individual.

But really what the individual scientist looks for, is the atmosphere or the things that provide some stimuli to creativity --perhaps the opportunity to participate in meetings, perhaps the opportunity to use the astronomical facilities at California Institute of Technology or, if they don't have a particular mass spectrometer, they have a limited license to go to Stanford and use the linear particle accelerator. These things can be worked out. That is, there is permissiveness to pursue these activities.

DR. SALZER: I notice that I have to defend the position of managers. We noted that scientists are self-motivated, and I accept that as an excellent way of being motivated.

Out of this discussion came this: That if a manager has any role it might be to reduce the motivating power in his scientist by putting obstacles in his way. That is about all that is left for the manager to do. I would like to look at it a little more positively than that because I know that the manager can do much more, not by changing the motivation forces in the individual but by using them. One way of doing this is to give recognition. That is the major thing that I have heard, "Let me do my work and give me recognition."

So those are the two things that the manager can definitely work with. He should just ask himself, "What can I do to let them do that work more fully?" "What can I do to give them recognition."

I would definitely like to get away from salary as a means of recognition. I found it to be extremely ineffective in semi-annual reviews in really assuring a person that he has the role to play. I found it to be much more effective for instance, to listen to them and indicate that the manager recognizes some of their achievements. And here is where I think managers have something to offer. Managers can guide them and indicate where they can make more of their results, and where else they can apply them.

The scientist discovers some basic phenomenon. What if it applies in a different field entirely, a field that he might not be thinking about? If you can point that out, you do a service as a manager of scientists. There is a difference between a manager who can do this and a manager who cannot. I say to you that scientists will select the place they work on this basis, all the other things being equal.

DR. OSTERYOUNG: One thing that has happened, for instance, in terms of using salary as a motivating force, is that it is not a motivating force. It is a rewarding force, but it has less impact than it used to for the very simple reason that you don't have very much to play around with.

The difference between the starting salary and somebody who has been working ten years or fifteen years is negligible. Now, with certain organizations you do have certain problems where the people look upon their relative salaries, particularly where they know what other people are making, as an item which tells them what their management thinks of them. I think in that sense salary makes people happy although it can only get in

their way. You can make them unhappy if they know, for example, that somebody who is universally regarded as doing nothing gets a higher salary than somebody who does something. That is the only way that salary is good. It does not motivate people, because if it really could then you could take a perfectly good fundamental scientist who has something that you want and you tell him, "Okay. If you do this, I will double your salary." As he weighs the pros and cons between what he wants to do, what motivates him? Do pure dollars motivate him?

DR. SILVERMAN: There have been some good people who have been hired away from the universities at very high salaries.

DR. OSTERYOUNG: Sure.

DR. SILVERMAN: So it is a question of degree, again.

DR. OSTERYOUNG: We have talked about, say, the scientist who is actually working science. There has been a tendency to give people, I think, increases in salary almost without regard really to what they are doing.

DR. O'DONNELL: Yes, I think the administration of salary has been very poor, but I should think that management certainly could do something to affect the psychological attitude towards producing results. I should think there is something that managers can do to smooth away or keep the scientist from worrying about things such as salary differentials. It is a positive thing to provide communication channels. Some of the other examples are leave to travel, and use of research facilities elsewhere. I would think that this would have a psychological impact on the zeal with which you approach your problems.

DR. GREEN: I think that the scientists should be aware also that they can become spoiled. Compare the working conditions of the Galileos and the Newtons with what the scientists in industry, the university, and government have today.

MR. WELTY: I would like to point out that generally the scientist is self-motivated. It is generally due to his preconditioning. His creativity quite often is highly correlated with his level of frustration, and if management treats him poorly--you might increase his creativity; however, you decrease his cooperation. So it is a matter of optimization. If you treat him too well, make life too good for him, he gets spoiled and his creativity goes down. This probably isn't true of the ivory tower type because he is playing to the field outside, and basically a large part of his motivation has to do with recognition from the outside.

In our industry we certainly notice that actually as things get too good for the scientists they tend to lose their creativity, and yet if things get too bad for them we definitely lose their cooperation. So it is a matter of trying to keep this thing at the optimum point.

DR. SILVERMAN: I really feel that the research scientist is not motivated by physical things and physical requirements nearly as much as some other individuals in our society. I think the research scientist is motivated by a desire to learn

new things and also by a certain amount of egotism in which he would like to get applause and recognition from his colleagues. One way that an industrial organization can help the scientist in the organization is to provide him with the opportunity to do both.

The industrial organization can provide him with the opportunity to work on a problem of his own choice and provide him with the opportunity to present his findings to the world. I think nobody would deny that if you were put in a room with no opportunity to tell anybody about what you were doing that your motivation might dwindle rapidly. It depends upon the person.

DR. O'DONNELL: I would see these as elements in the motivation system that managers can provide. It is supportive of the basic desire, it seems to me, to discover new knowledge, and these supportive things I would certainly think that management ought to provide.

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DR. ALBERT WILSON: In a certain sense, the scientist will never give his first loyalty to any firm. His first loyalty is to science, and he will find the place that best fits his mode of operation for doing science. In fact, to a certain extent--I don't mean to impugn the loyalties or patriotism of scientists--prime loyalty to science even crosses national boundaries. You go to international science congresses and you observe that national differences sort of disappear. It is the loyalty to science that emerges higher than any other.

DR. SCHNEIDERMAN: We tend to think in terms of antithesis. The loyalty is not to the company; therefore, you follow the conclusion that they are disloyal, and you don't mean that, not

at all. The word loyalty is an unfortunate one.

MR. WELTY: I think you can afford to use the psychological word "identified" instead of "loyalty." That is a good word. Scientists don't identify with the company. They identify with the scientific community.

DR. OSTERYOUNG: Where does the scientist get most of his recognition? It is external as opposed to internal, and the manager, for instance, gets most of his recognition internally.

I don't see how you can charge this situation to a lack of leadership on the part of the manager. The scientist is really a fiercely independent human being, and, therefore, his identification is through his company, on the inside. It is not the function of management to see how many areas of agreement can be made.

DR. SILVERMAN: I would like to make another point. Loyalty is a reciprocal sort of thing, and I wonder how many people here really feel that the company is loyal to their scientists. Whenever a company runs into trouble the first thing it does is cut basic research. Where does the scientist look for security? He looks for security from his external community, from his approval and reputation with other scientists who can then help him relocate.

DR. ALBERT WILSON: This has been used also as an argument against bringing in externally funded projects. If the funding comes from the outside, loyalty is to the funder rather than to company. You can't get primary identification with the company if you are supported from the outside.

MANAGING THE DIRECTION FUNCTION

The direction function is concerned with those managerial activities which are undertaken for the purpose of channeling the work of subordinates towards the accomplishment of pre-determined goals. In carrying out this function the manager is dealing with people. He wants them to work at their top level of capability and of capacity. This they cannot be made to do: they must be given the opportunity if they are driven by an internal zeal or they must be persuaded that their own best interest is served by this manner of behavior. Therein is the source of most managerial frustration.

A pervasive and continuing problem has many facets about which little is known. The direction of people falls in this category. People are highly disparate in their motives, attitudes, knowledge, and purposes, and all of these attributes are modified by kaleidoscopic change in both time and direction. This circumstance, in conjunction with very little scientific knowledge about human nature, creates a situation in which it is extremely dangerous to generalize about ways to achieve the maximum application of personal capability in securing pre-determined goals. And yet, organized enterprise simply cannot be effective without resort to rules, procedures, programs and plans. Consequently a compromise which, hopefully, will optimize the net result is selected. Such compromises really satisfy no one and most of them are probably suboptimum due to the vagaries of human nature. Nevertheless, managers must manage and part of this function is to see to it that the men they manage contribute to organization goals in accordance with their capability. To do this they are

necessarily concerned about communication, motivation and leadership.

The effective exercise of these factors within a laboratory is strongly influenced by the fact that scientists are involved rather than engineers, accountants, and production specialists. Scientists are people and will respond to direction in some respects like other individuals, but over and above this they reflect their training in ways that make them quite distinctive. Like their counterparts in universities they tend to be strongly individualistic. Those in industrial ivory tower environments tend to possess an internal zeal for discovery and creativity; they tend to identify with the community of scientists rather than with their employer; and they are intensely concerned with the integrity of their science. Resting upon these basic characteristics, scientists tend to develop certain attitudes that are of major importance for those who would direct them. They want to select their own projects: to them, "management" simply means a restraint upon this freedom and to avoid this restriction they search for the industrial, university, or government environment which permits this liberty. They are vitally interested in their environment only to the extent that it and any modification of it affects their work; they will cooperate with other scientists if this furthers their own research; and they want to provide for their own social needs. They feel ill-understood by the industrial firm because internal recognition is lacking, in times of business contraction the laboratory budget seems first to be reduced, and their Spartan conscience rebels in plush environments that somehow seem to be a trade-off for good science. The prosecution of their projects tends to give them tunnel vision with respect to

the applications for new-found knowledge and for bits and pieces of new knowledge. And finally, there is an almost universal demand for managers who are part-time scientists because these men can understand them--not because they know how to manage them.

These attitudes and convictions best describe the mature, outstanding scientist. But every laboratory will have many who do not yet qualify as accomplished researchers; perhaps they never will because genius does not travel the road of experience. Therefore, every laboratory manager will be faced with directing a group of men with widely varying abilities and experiences. Direction must ever be an art; and the manager an artist. His responsibility is to see that enterprise goals are achieved effectively and efficiently by people whose abilities must somehow be harnessed and given appropriate direction. The purposes of the laboratory and of its scientists must be brought into harmony so that their realization will redound to the benefit of both. Though there are no principles which will guide a manager to this achievement there is always common sense to be applied intelligently.

Communication

There has been a great deal of empirical research concerning the techniques for the transmission of information and the conditions for its reception. Generalizations have been made on the basis of this knowledge and there remains no excuse for a manager to be ignorant of them. But this state of affairs does not achieve good communication: it does not deal at all with the absence of a will to communicate. Communications within enterprises remains grossly inadequate primarily because people are careless, or lazy, or are determined for a multitude of reasons not to communicate.

It is particularly important for laboratory managers to cultivate their will to communicate. Their subordinates are highly educated people; their work can be affected by knowing or not knowing information which may influence them; they are human and therefore will waste much time in idle speculation when authoritative information is not forthcoming; and they tend to denigrate the influence of those who should but do not communicate.

Judicial choice of the form of communication characterizes the good manager. Elements of major importance about the work of a subordinate, such as goals, budgets, and special directions, should be written both because there will be frequent need for reference and because there is less opportunity for disputes to arise. It is not uncommon for managers to be rather vague in giving instructions or to change them through time.

Staff meetings with subordinates are the appropriate occasions for the communication of information which does not relate solely to the individual and his work. This is the place for passing on information of a general nature such as changes in the environment for subordinates, new corporate goals as they affect the laboratory, space and place changes, shifts in the scope of fringe benefits, budget preparation and modifications, and general news about the firm and its parts. The manager should make a point of being the authoritative source for information of this kind because this is an important technique for maintaining his position. He should be the first to convey this information insofar as he knows it and it should be transmitted to all subordinates simultaneously to avoid the appearance of favoritism. For similar reasons it is equally important to comment on his own lack of information if this is the case.

Motivation

It will be recalled that the function of the motivation process is to encourage subordinates to apply their full capabilities to the achievement of organizational goals. The motivation of scientists will remain a special case in the ideal situation because they are charged with an internal zeal to do good science. They are employed in the first instance because there is coalescence in the interest of the firm to have research undertaken in a particular area and in the interest of the scientist in working in this area. In the rather rare case where the firm is not particularly interested in identifying areas for research the scientist is also free to engage in projects of his own choosing.

In situations of these types it is literally true that the firm can do nothing to motivate the scientist--he is self-motivated. However, there is much that the firm and its managers can do which, if not done, will become negative motivators. The manager can see to it that the environment for research is fully facilitative. Such matters as providing needed equipment, making certain that salary and fringe benefits are such as to take the worry out of the employment situation, acceding to the scientist's desires for participating in the activities of the community of scientists, and encouraging publication clearly should be cultivated as far as the budget will permit.

But in any laboratory there are scientists and scientists. There are those with lesser abilities and there are the neophytes who are barely beyond the level of technicians. They are employed because they can do useful work. Those with potential may be inspired by working with senior, established scientists. Others

need the discipline of the active, exciting work place; they need close supervision; they need the incentive of near-term deadlines. In other words, for these types the selected motivation system is not unlike that for other employees of the firm.

Leadership

The leadership aspect of the manager's function of direction is concerned with the morale of subordinates--their zeal and confidence. The manager will utilize communication and the motivators as tools for his function of leadership, but over and above this he must be able to comfort, encourage and inspire his subordinates. There are no rules or principles to guide him. Leadership ability must be cultivated with intelligence and the lessons of failures and successes must be rationalized. It really becomes a matter of inter-personal chemistry. Leadership is impossible where personal relations are abrasive: it yields extraordinary results where these relationships are confluent.

The leader is concerned with the inspiration of his subordinates or followers. He tries to achieve this in many ways. There are scientists who get discouraged when everything they do results in failure: they need comfort and encouragement. There are scientists whose morale can be elevated by collaboration with those whom they admire, respect and even worship. There are scientists who can be refreshed by a vivid repainting of the fruits of success. And there are scientists who respond with vigor to the fear of disappointing those they admire. The manager who would lead should be a keen student of inspirational forces and make certain that he applies to each his own.

CHAPTER VII

THE MANAGEMENT OF SCIENTISTS

Men in organized groups must be managed even unto the scientists in our laboratories because this is the only way that coordination of effort can be achieved. To be managed has many connotations and those who fail to understand the managing process are much inclined to resent or to devalue management. Those who harbor resentment seem to visualize management as the process of treating man as a tool or a machine and causing him to produce to some fixed standard. Those who devalue management seem to view it as the clerical process of keeping and transmitting records and running messages. Neither of these views is tenable. The manager is the key person who is responsible for getting the results wanted by skillfully coordinating the factors of production.

The value assigned to coordination varies considerably with the function of the laboratory and with the scientist himself. It is not impossible to visualize a firm that supports a laboratory physically comprised of a desk, the space to contain it, a pad of paper, and peopled with one or two theoretical scientists. The problems of managing such an operation would be few indeed. The whole thing would likely be cared for by assigning the activity to some interested manager at the top level of the organization. /only a minute amount of attention would be required to do the housekeeping for such a function. Needless to say, there are few, if any, such efforts supported by industry but if there were, it would be in this environment that one may properly say that the scientist is requires little management. After originally exercising great care in selecting these scientists,

From this rarified tower of thought one might turn to the laboratory in which there is little research but much development. The physical requirements are expensive and the staff would be comprised of scientists of varying quality, technicians, engineers and numerous clerical types. Their numbers might run from fifty to two hundred. What little science there would be might be visualized as experimentalist Such an entity would need very skillful full time managers to coordinate the internal functions and to integrate the total activity with other organizational groups within the firm.

Between these extremes there exist many laboratories, modest in size, and with a more even balance between research and development. Some of these organizations are largely supported with internal funds, and some wholly supported by government contracts. These entities require management of a sophisticated nature to coordinate objectives and resources with the needs of the firm and with the interface between the firm and the customer Depending upon its size and its objectives the managers, at least at the top, may well be full-time, but at lower levels the part-time supervisor is typical.

Since it was the intention of this investigation to focus upon the management of scientists, particularly in the industrial environment, the laboratory with which we are concerned lies not at either end of the spectrum but rather between the extremes. The chief thrust of its activity is toward basic science though the potential application of new knowledge is not overlooked. This does not mean that the basic scientist has himself to see and propose applications of his discoveries; it

does mean that there are some persons there who understand the significance of what is discovered and can visualize its application to the solution of problems which the firm may face. Such a laboratory has to be managed and its productivity will certainly be affected by the quality of its managers. As they contemplate how to manage effectively they might consider the conclusions of the present investigation.

PLANNING

Since the planning process tends to economize effort in the accomplishment of goals it has an important place in the management of laboratories. The definition of goals for any organized activity or for any of its parts is by no means easy. Numerous are the manufacturing managers, the financial managers and the managers of quality assurance that are convinced of the desirability of goal definition and yet have not really defined them. They are content, or act as if they are content, to avoid confrontation with this problem and get along with a vague idea which they cannot communicate effectively to their subordinates. The laboratory director is no exception to these practices though he has a much more troublesome problem. It is just very difficult to define the laboratory goals because an articulation must be accomplished between the enterprise goals and the contribution which the laboratory can make to them.

And yet, the research director cannot avoid the duty merely because it is difficult. This is his responsibility and he should proceed through time to refine his techniques to bring into sharper focus his long and short range goals. He will not, of course, get much help from the scientists who report to him.

They would much rather talk about their activities than their goals. But the manager can control, to some extent, what these activities will be by the kind of specialists whom he hires, and he can achieve a degree of articulation between these activities and the laboratory goals which must be clarified to the satisfaction of his own managerial superiors.

There is another way in which some coherence can be achieved in the work of the scientists. There are frequent occasions when the problems of activity selection and activity cut-off come to the fore. The nature and scope of the activity is considered in detail by the scientist and his manager. Inevitably the latter will give the emphasis and direction necessary to promote a contribution by the activity to the laboratory goals. Furthermore, the action taken to cut off or expand the activity of the scientist is also taken with at least one eye upon its support of the director's goals. The manager's skill comes into play here; he may or may not wish to emphasize or make clear the weight of goal orientation in his decision-making.

The scope of the plans made by the laboratory director is much more broad than merely what scientific work will be undertaken. They also include plans for laboratory location and equipment, plans for licensing and for sub-contracting, plans for recruitment and development of employees, plans for public relations within and without the corporation, and budgetary plans. As he approaches his planning activity the director always has to consider the policy he will follow with respect to the participation of his subordinates which he will permit or invite.

The conclusion reached in this study is that there should be a policy of encouraging but not requiring participation. While some scientists may be interested in playing a role in all of the planning, all of them should have the opportunity of declining. The management principle upon which this policy rests is that the more participation in planning on the part of subordinates the greater their understanding and zeal in accomplishing plans. A feeling for the goals of the laboratory is, perhaps, best achieved in this manner and this can only result in an improved sense of security for the individual scientist. He needs the assurance that the organizational goals and the policies which guide activity towards them are consistent with his own research objectives.

CONTROLLING

The control function is carried out as plans for the achievement of objectives are being implemented. It is a monitoring function and should be accomplished in such a way that the needed corrections in the execution of plans can be made in time to achieve the projected goal by the established deadline. A control system that does not do this provides no control at all: it becomes a post mortem operation, useful only to the extent that the lessons learned may be applied to future planning and control.

The control function of laboratory managers seems to be very well executed. They use such techniques as informal reviews, progress reports and briefings, and group reviews in connection with the work plans of scientists. The degree of formality is largely determined by the kind of a laboratory, its size, and

the extent to which basic research is prosecuted, but in any case the control process involves very close relationships between scientists and managers.

On the other hand, there are often several types of plans that the manager himself controls with little input from scientists. These would include laboratory location and equipment plans, capital plans, budgetary plans, staffing and public relations plans. Should any of these get out of line to the extent of jeopardizing the realization of objectives the responsible manager will make adjustments personally if he has the power; if not, he will negotiate with others who may be involved, such as the vendor, the treasurer, the men who are concerned with long range planning, and he may confer with outside agencies such as university and public relations people, and with his own scientists.

There are some circumstances in which the scientist becomes vitally interested in the control process. Staffing plans which plot out the steps by which new capabilities will be introduced into the laboratory, or old capabilities dropped out, are of vital concern. The influence of the supervisor to clarify goals, techniques, and procedural alternatives available to the scientist is a control technique that must be used with skill. The young and the inexperienced may need strict control over their activities in these respects: but not always, for even among these may be a genius whose imaginative approaches may be much superior to those advocated by the supervisor. And finally, the scientist is, of course, vitally interested in the control that closes out his source of funds. In general, the

manager should be sensitive to the interests of scientists in the control process. The areas of interest are primarily those with implications for their personal involvement. The execution of the control process needs to be carried on with great circumspection, perhaps with intuitive skill, in order to achieve clear communication and understanding. But always the manager must control the laboratory plans for he alone is accountable for their successful prosecution.

ORGANIZING

It is fortunate for the laboratory director that the social invention of organization is such a flexible tool. It provides him with several alternative methods of grouping the activities of scientists, each with its distinctive effectiveness in reaching the goals of the organization. There is no essentially correct way to organize; this can only be judged in terms of efficient and effective results.

The extent and sophistication ofthe formal organization depends primarily upon the number of persons involved. It is perfectly clear that if only one or two scientists are involved there is no need for organization structure at all. It is equally clear that if several scientists, together with a veritable army of technicians, engineers and clerical personnel are involved there must be contrived a formal organization structure. The reason is, of course, that this is the only efficient means of focussing the effort of many upon the achievement of a specific goal. In this case, the usual basis for organization is the discipline of the scientists. This is as common and as natural as functional organization in all enterprises. Should goal

achievement require close and constant cooperation among two or more scientists, organization on the basis of discipline would be dropped in favor of grouping people by the objectives sought. In making these kinds of decisions the laboratory director considers the trade-offs between costs and benefits. For instance, the complexities of the managing process are greatly increased as the basis for organization shifts from a single discipline to one in which several disciplines are cooperatively involved. The management styles of the director also change because the latter type of organization requires a firm hand in the direction of the effort of scientists who have different personalities, different research goals, and a much greater need for communication. Indeed a drastic shift in organization structure may require a new director.

So important are the economies of operation and the need for policy control that enterprises normally centralize the operation of support groups. These are accountable for providing financial, personnel, and maintenance service to operating organizations such as engineering, manufacturing, marketing, and research. This ordinarily means that the laboratory director relies heavily upon these outside services, as indeed he should. It would be much too expensive for the laboratory to provide for its own support.

The director would be much more effective if he would take the initiative in dealing with his support organizations. Too many try to isolate themselves in the laboratory, respond by reaction, and complain of inefficiencies. This is probably a normal reaction of any director who does not fully understand

the purposes, functions and costs of support groups, but it is certainly his business to assume that the laboratory receives the best of support effort from others. He can only do this by understanding what services are available and by taking the initiative in calling out those services he requires.

Formal and informal committees are organizational devices that the laboratory director should use with the greatest circumspection. They have a potential for untold evil as well as for significant benefits. Committees are useful if it is important to collect in one place and time people who have unique information required for the solution of some problem. This explains why most laboratories will have such formal committees as safety and library, and very few if any others. The evils of committees are reaped in situations where they are formed for the purpose of doing what the manager in question refuses to do himself. In other words, where the manager wishes to avoid accountability he often resorts to the committee device for decision-making. The costs are enormous in lost time, procrastination in reaching a decision, in the morale of the participants, and in the quality of the decision.

Scientists react to committee service in the same way that other persons respond. If they are affected by the decision they willingly serve; if they are not affected by the decision they will participate only under duress. Knowing this, the laboratory director will approach the problem of formal committee management with keen circumspection, keeping them to an absolute minimum for fulfilling absolute needs.

The informal committee is less likely to get the director into trouble, if for no other reason than that scientists won't bother to attend them unless they are personally affected. Insulation of this nature ordinarily means that informal meetings to evaluate a colleague's paper are well attended because this is a means of keeping up technologically, and knowing what is going on in the laboratory. On the other hand, informal meetings to evaluate patent disclosures are notably boring and therefor ill-attended.

The productivity of the scientists within the laboratory can be affected by the amount of time they are called upon by other divisions for consulting effort. Normally a scientist is pleased to be called upon for this service because it is an internal recognition of his knowledge and status. The trouble is that the positive values soon wear thin if the amount of consulting time represents a serious inroad on the scientist's major effort. Thus, the problem that continues to face the laboratory director is the desirability of encouraging consultant activity on the one hand and the protection of his scientists from too many requests on the other.

STAFFING

The satisfactory solution of the problems which arise in the recruitment, development and evaluation of scientists and their managers is most difficult to achieve because there really are no available standards of general application. There are certain arbitrary rules regarding age, education and professional interests but these have little to do with determining whether a man will meet and exceed the subjective standards of

his immediate supervisor. Indeed, despite the costly process of recruitment of new graduates that is so typical of laboratory practice, there is little confidence that these recruits will actually develop in accordance with their estimated potential. This is, of course, no argument against the present recruiting practice; rather, it merely points up the fact that evaluating the potential that the candidate will actually realize is a very risky thing. No one really knows what his potential is in the first place nor can he anticipate the complexity of factors that will later determine the degree to which his potential is achieved.

The risks in the recruitment of experienced scientists are very much lower. They, as everyone else, produce a record merely by keeping alive. Generally there is little trouble encountered in securing this record, in proving it out, and in evaluating it. This is a cooperative process involving personnel administration, the manager involved, and the colleagues with whom a candidate will work. Even so, this is not entirely an objective process. There will always be many personality factors involving the supervisor, the candidate and the scientists already aboard that will inevitably come into play, and these can be as potent as the technical record in determining whether a man will be employed. The process should not be faulted for this reason, however. There is really no barrier for anyone to seek out that environment which best suits his personality, and fortunately the alternatives are so broad in the United States that such a selection is easily within the bounds of possibility.

From the point of view of the scientist there is no reason why he should not pursue that part of happiness which can be attained through doing good science in an environment of his own choosing. Life is much too short to conceive of the matter otherwise. From the viewpoint of his manager it is productivity that is important, and if he can get the best results by providing an environment for the scientist that the latter wants he should do so. For the manager it is not a matter of making a scientist happy; rather it is devising that environment of whatever nature that will encourage his subordinates to work up to their full potential.

The evaluation or appraisal of scientists may be viewed from two vantage points. The research results are continuously examined through the informal relationships of colleagues and supervisors. In addition, when the occasion is suitable, recourse is had to seminars and group conferences wherein results are assessed, approaches of an alternative nature are examined, and the approaches and results achieved by scientists external to the laboratory, but related to its work, are reviewed. These techniques of work evaluation are successfully used because high standards of good science are strictly adhered to.

On the other hand, the periodic over-all evaluation of scientists is a common practice that seems to be largely imposed by company procedures. It may be a useful aid for recalling a dozen or so elements by which individual scientist are compared primarily for purposes of salary administration and promotion. But it is at least a working hypothesis that the results of such a comparison would be the same with or without

the "score sheet." In its absence the evaluation of research results would serve as a sound basis for the determination of salary rewards and for promotion in the technical scale. Promotion into managerial ranks should rest upon an entirely different set of criteria.

When scientists think of the manager they have no really precise concept of this functionary. And from the point of view of their work the matter is of little importance whether such titles as supervisor, manager or director are used indiscriminately. But from the vantage point of clarity and economy in communication less confusion would be advantageous. In the study of the process of managing, or achieving results through the effort of a group, the term "manager" is generic. He it is who gets results through the judicious combination of physical and human resources. As organizations grow in size different levels of activity emerge because there is a limit to the number of persons one can manage. At these different levels there are managers but their status is purposely reflected by choosing for them such titles as supervisor, manager, director, and president as one scans the organization from the bottom up. The men with these titles are all managers. Only supervisors manage non-managers: all others manage managers.

Scientists seem to view their managers in purely utilitarian terms. They expect them to interface with managers outside the laboratory largely for the purpose of securing financial support and to provide insulation. The scientist wants freedom to pursue his work with little or no interruption from people outside the laboratory. Internally, the scientist

expects several things of his manager. He wants activities planned in advance and no surprise short-term calls to attend this or that meeting; he wants the manager, insofar as he has knowledge, to communicate all sorts of information relating to such things as internal politics, projected re-organization, expansion and contraction plans, changes in other divisions, and wage and fringe benefits. In much of these topics the expert will recognize that the scientist is as much interested in the grapevine as any other person. He wants the manager to provide such leadership as is implied in the direction of research plans, initiative in permitting or securing outside contacts of a technical nature, and in aiding the scientist to better understand the relationship of his research interests and those of the laboratory. And finally, the scientist expects the manager to create an internal environment that is conducive to effective research.

The mere listing of these expectations and their implications is sufficient to make clear that scientists have a rather good grasp of the functions of managers when they really think about them. True, their terminology is quite different from that of professional managers: they tend to think of specific services that will aid them in their work. Nevertheless, it is not difficult to see that the concepts of planning, organizing, staffing, directing and controlling are all here. In general, they see the manager as the person who is responsible for helping them get results. While he does many things they do not see, his ultimate accountability is unquestioned.

Compared to the clarity with which scientists see the duties of the manager, their conception of the qualifications of the man who can do this is notably vague and incomplete. Due to their strong need for a sense of personal security they are almost unanimous in wanting a scientist who is actively engaged in his own research to act as manager. They have great confidence in a scientist's rationality, and by implication, rather low estimate of the rationality of other people. It is quite probable that this feeling is a result of specialization in research that leaves little time or interest to understand other people.

There is no question at all that the managers of scientists, at whatever level, should have been scientists in their own right. At the supervisory level this experience is immediately in the past and therefor this manager should be fully capable of carrying out his managerial duties effectively. As time passes and supervisors are successively promoted upward through middle to top levels of laboratory management there will undoubtedly develop a technological gap in knowledge, but this fault, inevitable as it is, will be compensated by greater skill in the managerial functions, greater ability to deal with managers outside the laboratory, and greater skill in representing the laboratory needs to top managers of the company. And in addition, he will retain the rationality he previously developed as a practising scientist.

Scientists are very much concerned that their managers retain their scientific acuity. Their solution to the problem is an expressed preference for the part-time manager--one who

will combine his managerial duties with an active personal research program. Undoubtedly, this is a good resolution in situations, usually small laboratories, where there are not full-time management positions. But to organize a laboratory by deliberately cutting down management positions so that there will not be any full-time positions seems a poor solution to the issue of managerial acuity. Logically and experientially the part-time manager attends first to his technological duties because therein lies his basic interest, the greater he feels risk/in procrastinating with his research than with his managerial duties, and the real lack of incentive to learn and practice management skillfully. Such a denigration of the management process can only lead to inefficiency and ineffectiveness in the operation of the laboratory. While it is true that middle and top managers tend to lose their original effectiveness as technologists as they advance up the management ladder, this does not mean that their acuity is necessarily affected adversely. They are accountable for results and it would appear impossible for these to reach the expectations of the firm if the laboratory managers lose their understanding, their imagination, and their flair for good science. This does not mean that all full-time laboratory managers really retain their acuity: it means that they can and they should.

A good scientist can certainly become a good full-time manager if he is motivated to do so. But such a change in career cannot be accomplished quickly. If, as is widely held, it takes twenty-five years to mature as an effective manager we have a rough inference of the complexities involved in becoming

skilled in the management process. But the scientist will not be delayed any more than a person from any other field of knowledge. Indeed, their training and experience, their rationality and high technical and ethical standards can provide them with marked advantages if they possess the proper motivation.

DIRECTING

The manager who would direct his scientists effectively will be concerned with those activities which will improve the ultimate results of research. He needs to think in terms of what he can do to influence these results positively and therefor he will be concerned about communication, motivation and leadership.

The aspects of communication between manager and scientist which are critical have to do with the relationships between the company and the laboratory and with the internal operations of the laboratory. Scientists have a need to know the company purpose in establishing the laboratory in the first place, what it expects in the way of results, how it intends to finance the activity, and the degree of stability and continuity of these relationships that may be anticipated. All of these factors are important in the scientist's original decision to work for the company and for his sense of security. It is the manager who is in a position to interpret these relationships. It is his duty to understand and influence the thinking of top managers with respect to these relationships, and in turn, to make them clear to his scientists. His dual role requires an identification with both his superiors and with his subordinates.

Since change is the order of the day, and change affects company objectives, intentions, and mode of operation, it is apparent that the laboratory will also feel change through time, often relatively short periods of time. Scientists expect change, as would anyone else who is an observer, and they are keen to know in what way they will be affected by it. They can and will waste a good deal of time in speculation unless their manager is quick to communicate to them the nature and potential of change as it will affect them. This kind of action will increase the sense of security that probably all human beings want because they have the faculty for adjustment to a known change.

The manager is also concerned about internal communication. It is surely obvious that his scientists want to know about anything that personally affects them. This includes knowledge about how their work is evaluated, how they stand within the organization with respect to their peers and superiors, the appraisal techniques used by the manager, the relation, if any, of their work to that of others both within and without the laboratory, and the degree of facilitation they may expect from the company in their identification with the scientific community at large.

Other aspects of the need for internal communication do not directly affect the scientist's work but nonetheless interest him. Like any other human being, he is inquisitive, he has an interest in the news that flows through the grapevine, he gives attention to rumors of interest, and he often wants to know what his peers are doing. If the manager does not provide

this type of information he can be sure that his scientists will get it anyway, even incorrectly and at considerable cost in time. It is only common sense that leads a manager to make certain that he is the authoritative source of information and that he disseminates it promptly.

Good communication can do two things. It can provide the scientist with information that he needs to know concerning his work and his place in the system, and it saves time for creative activity which would otherwise be spent wastefully in learning "what is going on." It is the manager who is accountable for the quality of communications. If he is to be effective he will study continuously the complex problems of acquisition, interpretation, and transmission, and strive for continuous improvement in the execution of this function.

The manager is concerned about the problem of motivation of his subordinates solely from the point of view of positively influencing their productivity. It is most difficult to generalize anything that one might say about motivation because people are different not only in terms of classes but in terms of individuals and of time. They have needs that are largely unique. It is not even possible to generalize about the needs of scientists because their quality is so disparate, but if only the gifted research scientist is considered here, perhaps some guidelines can be provided for the discerning manager.

Fundamentally it is true that the really gifted man is self-motivated. He is driven internally to the discovery of knowledge. He has the will and the persistence to follow his interests before and during his employment and therefor there is nothing the company can do to light and maintain this drive.

On the other hand there is much the company can do to facilitate his achievements. His manager can create an environment that will attract and retain research scientists. He does this by seeing to it that salary and fringe benefits are at least competitive, that equipment and facilities are made available, and that identification with the outside community of scholars is encouraged. He can also devise ways to improve the status of scientists within the company. These may include parallel salary schedules corresponding to the renumeration of managers, titles, and devices to make certain that recognition of accomplishments and contributions not only to science but also to the company objectives will be widely achieved.

The manager will have a problem in deciding just how much facilitation is desirable. There is such a thing as "spoiling" the scientist and there is such a thing as the apparently high correlation between his frustration and his productivity. This becomes a problem in optimization, but it needs to be accomplished on a personal basis because individuals respond to these factors in different degrees.

So long as the gifted research scientist is being considered there is probably little in the way of leadership that his manager can provide. Yet, there are some things that can be done. It is the function of leadership to sustain the zeal and confidence of subordinates in the attainment of his objectives. Even for the gifted these qualities can lag occasionally. The direction of effort can stray down unwanted paths, frustration can dull zeal, and failures can undermine confidence. Somehow the manager must be there to counteract these tendencies. He

can help by keeping the objective clear, by exploring alternative procedures, by listening to the despair of the frustrated, and by encouraging enthusiasm.

It is evident that scientists tend to shy away from any discussion of direction by the manager because they conjure the ogre of restriction upon their freedom. This is clearly an unfortunate misconception of the true function of direction but it is understandable that this view could be developed through mere gossip and through experience with poor managers. The manager has to teach the lesson that the direction function is one of positively facilitating research. He is concerned with getting the same results as the scientist, although perhaps not for the same reasons. Therefor, everything he does, within the constraints levied upon the laboratory, will have the potential effect of enriching the productivity of these gifted men.

DIALOGUE OF THE SEMINARIANS

DR. O'DONNELL: The question arose in our informal talks as to whether any generalizations that we might make are really applicable due to the fact that many of the people around these tables work for government-supported institutions. If you worked for a firm that did not live off government contracts, would your viewpoint be different?

MR. BOYKIN: It is obvious that most--at least a majority of the people here--are in an area that is not representative of your definition of the basic research scientist. I would say we have colored the procedure by constantly--although we try to be objective--putting in our viewpoint. There are two things that the government environment does. It spends without an immediate regard for what it gets. It might subsidize to keep something going that no private firm could afford.

Another thing is that it reminds me of John Salzer's description of what goes on in Russia. Now, whether it affects the scientist and laboratory or not, I don't know. There is the need to go out and sell to get these government contracts; to observe the extreme rules of inventing on a fixed price basis, and to respond to configuration management. Everyday there are new requirements for a type of person that represents himself as wanting to be unfettered and free to pursue his research without restraint. There is not a more restrained place in the world where someone is working under a government contract.

If MacDonald-Douglas has created an environment that has protected Dr. Wilson's enterprise from that influence, I think

that is a wonderful thing for the few people that are permitted to work there. The role of the manager has to be to attempt to shield these applied scientists and semi-applied scientists from external impact.

DR. OSTERYOUNG: I think the brutal question to ask is how many of us would be in existence were it not for the independent research and development funding which is tacked on contracts. I think the answer is none.

DR. LYON: That is the point I wanted to bring up. Very definitely I think the answer to your question is yes, because in the commercial areas there is no write off, directly anyway, on I.R.&D. investment, whereas if you are working with the government as a contractor and negotiating annually, I.R.&D. funding can do scientific work. This has amounted to a refund of anywhere from fifty to eighty percent of the money that you spend. In a sense, you are not spending your money so you are going to do more research. If you were addressing a commercial group of people in non-government work, I'm sure that the magnitude of investment would be substantially less for that reason alone.

DR. OSTERYOUNG: The organization that is normally cited as the epitome of the industrial basic research area is Bell Telephone and I think this is completely erroneous. It is really a utility company and it's funding is drastically different from the Aerospace business. Bell Telephone knows what business it is in. Definition is very hard to get from the Aerospace industry. We don't know what business we are in.

DR. MUIR: Bell also has quite a bit of government research.

MR. BOYKIN: In the long range I don't think we yet know the full impact on the corporation when laboratories are financed by direct government contract. They will have no patent position to speak of. Let's say the government comes to them, and they say, "Go away. We will do research on our own or we won't do it." At least anything that their people come up with, they have title to. They could exploit it. They could put it back into their own business in the future to the degree they want to.

DR. O'DONNELL: The question is what would be the difference in your viewpoint if you worked in a government financed or privately financed laboratory? Would there really be any difference?

DR. ALBERT WILSON: With government and industrial research there is a certain amount of imbalance resulting in our society. We are becoming expert in operating space capsules a hundred miles above the earth, but we are having difficulty operating down here--traffic problems, smog, and so on.

Now, who, in the overall sense, decides what is to be researched? We find that there is something missing in the decision process. Somebody decides that we are going to hire a number of scientists to research the ocean or the moon. Why? Because we are going to get a profit or an application out of it. But we have no way of predicting the impact of such randomly chosen and funded individual projects. We are beginning to create something like a car running down a road without a driver.

The government sponsorship of research is partly the difficulty here. It must accept additional responsibility in overall directing research for balance or allow industry to make independent evaluations.

In deciding what is to be researched, is it the responsibility of the research manager, a remote funder, or the scientist? All of these people together determine the problems we work on, but in practice we are ending up with an environment that is becoming absurdly unbalanced. This is something that every research manager has to begin to think about.

DR. OSTERYOUNG: The fact is that the National Science Foundation is probably the only source of pure money, if you want to look at it like that.

DR. SCHNEIDERMAN: I don't want to disillusion you, but before the Friday after Thanksgiving of last year I would have said that you are so right. But today the National Science Foundation has to justify its existence.

I was really surprised when Dr. Forbes said that we have to find some means of proving to the Congress that the work of the foundation is important and worthwhile. The N.S.F. is getting quite seriously tarnished because it is almost up against the same situation that we are in private companies.

Every branch of government is being shoved through this Hitch package business. I don't think the Rand Corporation had this horrible monster in mind when they created some of this concept, you know, about the three seventy-five series, but it is certainly invading almost every facet of our government work.

DR. SILVERMAN: It's more than just that too. What is happening with the vast amount of influence that the Federal Government has on research in general, is that when it faces an immediate problem such as a war effort, the research funds become funneled into a very narrow range of activities. This means that certain problems that Dr. Wilson referred to are not receiving proper attention. I don't know how you change this.

One of the problems, of course, is that since all the companies are profit oriented there is a tendency to ride with the crest of funding from the Federal Government. There are very few organizations that can afford to antagonize the government by opposing its general policies.

DR. OSTERYOUNG: In that context, I think there are two situations. One is that I.R.&D. is a large part of our gross national product. The other problem that arises is that science has tended to withstand any inquiry into its reason for existence and it has said, "I am good because I'm good, and the devil with you."

DR. ALBERT WILSON: Well, I would go deeper than that. Does our culture have the basic motivation to go ahead in areas of research without reference to application?

DR. O'DONNELL: There is a real question whether we are culturally convinced that we should do free research.

DR. SCHNEIDERMAN: That is an interesting comment, Cyril, because before World War II, what was the source of fundamental research funds? It was from private organizations--there wasn't a National Science Foundation then. It is interesting that our capitalist society has provided the tremendous emphasis to individual thinking and given money with no strings attached. This was prior to World War II. What did we do in the universities? We went to the Foundations or to the Brookings Institute. It was interesting that they asked for just a notation, you know, that some work should be done, but they didn't say that it had to have any practical application. It was research for its own sake.

You didn't have to write long treatises as to what you were going to do. It was just a paragraph or two stating that you wanted to do research on certain bacteria and that you were an established person or someone of good reputation. Donors didn't inquire how you were going to use the funds. They just trusted your integrity as a university professor. That is an interesting point. In other words, we were a self-organized, self-driving system doing research for its own sake and we had no chains on us.

DR. SILVERMAN: That is the point. Research has become big business as opposed to what it was before World War II.

DR. MUIR: My areas of interest are nuclear and solid state physics. I ask where could I do basic research if it was not either directly or indirectly supported by the government? I

this goes for the industry.
mean/universities as much as for/ Where is this type of research done with totally private support?

* *

DR. O'DONNELL: I would like to know what you consider to be the critical factors in the success of a research laboratory.

MR. IAMS: I wish that I had a good answer. Certainly one factor for an industrial laboratory is to please the management of the company. In our environment this also means to please the ultimate customer, namely the government agency.

DR. HAMERMASH: You have almost hit the nail on the head. There is not much you can add to that.

I think we have to talk about the two kinds of laboratories that we are looking at. I would much prefer to think of a laboratory in which we have a mixture of basic and applied research, where we have to operate within a framework of fixed dollars, and where we must be able to satisfy all of the competing forces: the higher management, the ambitions of the physicists and chemists and the biologists and the engineers and the other divisions who want inputs from this organization. So being able to satisfy all those competing groups is sort of a measure of success.

DR. LYON: I think that I would say that the most critical factors are: First, doing good work, and that comes down most basically to having good people. Second, your parent organization has to be convinced that that work is of direct or indirect benefit to it in terms of the dollars returned. Now, there are very few companies, I think, that are willing to do research for the sake of anything else. So there has to be some confidence of management that this investment will pay off.

DR. SILVERMAN: We must convince the management that the research organization is paying off in terms of dollars-and-cents. This is a very difficult thing to do because there is no way of costing the results of research. How does one sell management on the concept of the very basic research organization?

DR. ALBERT WILSON:

There has been a feeling at Douglas that the private sector has an obligation toward basic research just as the university and the government have. An important freedom is to be able to participate in the definition of the future and private enterprise should also have a role in definition. Since this helps it is the research problems that you choose that define the future, you keep at least a small stake in defining the future by investing in basic research.

The Chinese have a saying that if you are concerned with the problems for one year, you plant rice. If you are concerned with ten years, you plant trees. If you are concerned with a century, you educate your people. We have to do all of these things, and the basic research laboratory provides balance. I think this is a point of view that at least a good fraction of the decision makers in our company have.

DR. SILVERMAN: To what do you attribute the failure of these organizations to survive?

DR. ALBERT WILSON:

I think it goes back to a cultural value whether to support research even when the company faces critical financial problems.

DR. OSTERYOUNG: You should not set up a basic research organization if you really expect to discover something because you cannot predict whether you will.

There are a number of other reasons used to justify a research laboratory. One is you could hire some very good people and call upon them to help with some very practical problems. By carrying out work in certain areas you might have an ability to couple things into those which the company could utilize. You could attempt to move people into the operating division, for instance, as technical management. It helps in doing business with the government, really, because of the R.&D. funding.

DR. SALZER: The biggest danger to survival of a laboratory is not that it is unable to meet its objectives. Usually the reason that research laboratories are eliminated is that the objective changed without telling the research organization that it did.

In a commercial organization where there is no government support at all usually the objective is to create new money-making capabilities.

DR. O'DONNELL: If a company hopes to live off its laboratory, isn't it doomed to disappointment?

DR. SCHNEIDERMAN: I cannot answer that question specifically but a few things stand in my mind. There is the application of analytic cracking methodologies of the petroleum industry. This came out of the research laboratory. Another example is the polymer of Carothers which resulted in the cloth that you wear on your back. There is a definitive relationship between the companies that did that kind of work and the final profit structure. I don't remember the anti-knock compound like

tetraethyl, but I think it started off as highly theoretical research, largely in the universities. Since then the research has picked up in a lot of companies.

CONCLUSION

The essential truth that emerges from this study is that the management of scientists is in no way different from the management of other men. The functions of the manager are the same; the relevant principles are the same. Since managing is still about eighty percent art, it is the skill with which this art is applied that denotes the successful laboratory manager.

It is the variety of the art that leads the uninitiated to believe that managing scientists is somehow different. The art of direction is applied differently as the needs of men differ. Scientists, like other educated men in industry, have prominent needs for self-actualization. Knowing this, the manager makes certain that the environment he creates with respect to the integration of physical and human resources is conducive to the maximization of the need satisfaction of his scientists, but only to the extent that such satisfaction contributes maximally to the objectives of the laboratory.

Management is a facilitative process. It cannot directly induce productivity among scientists but it can and therefore should provide the ancillary conditions for productive work. It is the manager's job to define objectives and develop the plans essential for their achievement. These include not only work plans but also plans for plant location and equipment, for the organization structure including authority relationships and support facilities, for the selection of scientists, for the choice of communication, motivation and leadership techniques, and for the control system. The effective execution of these plans will permit the scientist to concentrate upon his research and protect him from extraneous, time-consuming negotiations for support and from the untoward interference of external groups.

Only in this way can the manager be a constructive force in the productivity of scientists: the rest is up to the genius of his men.

APPENDIX

APPENDIX

CODE_____

N.A.S.A. STUDY:

THE PRODUCTIVITY OF RESEARCH SCIENTISTS

FIELD QUESTIONNAIRE

Prepared By:

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Spring 1966

INTERVIEW DATA

CODE_____

To the respondent:

We are conducting a study, of which this questionnaire is a part, to analyze what determines and contributes to successful scientific research. Our attention is focused primarily on the scientist and his environment. The study is supported by the following NASA grants to UCLA:

NSG - 237 - 62 - Suppl. No. 2
SC - NGR - 05 - 007 - 090

By prompt and thoughtful completion of this questionnaire you can assist us in better understanding this relationship between the scientist and his environment. Thank you for your time and interest.
(Note: all completed questionnaires will be confidential.)

Name of Firm_____

City_____

Firm's Product_____

General Industry_____

% Government Dependence (Financial)_____

List three other scientists in your firm for whom you have high professional regard. 1)_____ 2)_____ 3)_____

Instructions For Completing Questionnaire

1. In filling out the questionnaire form, follow the structure of the question, i.e., check appropriate box(es), record comments, etc.

2. Where written comment or response is indicated or required, be succinct.

3. In view of the fact that the questionnaire form is standardized, there will be individual cases wherein certain questions may vary as to their applicability. Accordingly, judgment should be exercised in responding to these questions.

4. Feel free to include comments, reasons, or justifications when specified in the questionnaire or when you feel your answer demands it.

5. If at all possible, please complete and return the questionnaire form by _____. A stamped, self-addressed envelope is provided for your convenience.

6. The completed questionnaire should reflect the opinions of the individual respondent. Do not collaborate.

Definitions:

Research unit: a research department; a superior and several scientists.
Research team: those persons involved on a special research project.
Project: a meaningful and self-contained research task or problem which constitutes distinct intellectual effort.

N.A.S.A. QUESTIONNAIRE - SCIENTIFIC PRODUCTIVITY

1. A. What are the objectives of your research unit?

   B. Are these objectives stated in quantified terms?
   Yes ( ) No ( )

2. What are your personal long and short range professional objectives?

3. To what extent do you have the opportunity to participate in the development of research objectives and plans?

   Comment

4. A. To what extent are research plans and objectives communicated to and understood by research personnel?

   Completely 10 9 8 7 6 5 4 3 2 1 Not at all

   B. How are they communicated?

   C. What follow-up techniques are employed to assure understanding?

5. A. Where do research ideas generally come from?

   B. Approximately what percentage of these ideas come from the researchers themselves?

   _____%

6. When you have an idea for a research project what is the procedure you follow in formulating a research proposal?

   Discuss

7. What criteria and/or policies are applied to the evaluation of research proposals by:

   A. The research scientist?

   B. His immediate superior?

   C. Other? (specify)

8. Regarding projects in your research unit, who decides that these projects should be undertaken?

   A. Immediate superior ( ) No. of projects _____%

   B. The research scientist ( ) No. of projects _____%

   C. Other (specify) ( ) No. of projects _____%

   Total projects 100 %

   Comment

9. For what time periods are research plans made?

10. A. To what degree do approved research plans allow for flexibility in their execution?

    B. From your experience, is this degree of flexibility adequate?
    Yes ( ) No ( )

    Comment

11. Are the projects that you work on budgeted by time and/or expenditures?
    Yes ( ) No ( )

    A. If Yes:

    1. For what time periods are budgets made?

    2. Are budgets made for each phase of a research project or for the over-all project?

    3. To what extent do you as a research scientist become involved in budgeting your own projects?

    4. In your opinion, do research budgets allow for sufficient flexibility?
    Yes ( ) No ( )

    5. Can/do you generally meet the budgeted deadlines?
    Yes ( ) No ( )

    Comment

    B. If No:

    1. Are there deadlines for either the stages of a given research project or the over-all project?
    Yes ( ) No ( )

    2. Do you generally meet these deadlines?
    Yes ( ) No ( )

    Comment

12. A. Who is your immediate superior regarding administrative matters?

Name_____, Title_____

B. Who is your immediate superior regarding technical matters (technology)?

Name_____, Title_____

13. Describe your research unit from the standpoint of:

A. The number of colleagues who also report to your immediate supervisor.

B. The absolute size of the research unit including all personnel.

14. A. What is it that you are doing when you are being scientifically productive? (Consider carefully: encircle activities.)

planning, measuring, observing, arranging for facilities, idea generation, screening of research ideas, communicating, directing subordinates, evaluating results, reading current literature, researching the state-of-the art, writing reports, presenting professional papers, writing articles, designing products, designing laboratory apparatus (or tools), writing research proposals, ordering materials, consulting, problem-solving.

other?_____

B. Do the encircled items above constitute your idea of what scientific productivity is?
Yes ( ) No ( )

Comment

C. What do you regard as scientifically unproductive time?

15. A. What do you feel are reasonable measures of the scientific productivity you have listed above?

B. Are these measures used as evaluations of performance at (name of institution)?
Yes ( ) No ( )

16. A. Do you feel that your productivity is affected by the over-all size or complexity of your research unit?
Yes ( ) No ( )

B. Comment (in what way?).

C. For your type of work, indicate what might be an optimal number of scientists in your research unit. (Circle number below)

1 2 3 4 5 10 100 infinite, not important

17. Indicate the orientation of your research unit.

Orientation	Emphasis (0-100%)
particular products or processes	_____
Comment:	
general discovery of new knowledge	_____
Comment:	
other	_____
Total	100%

18. What is the basis of organization within your research unit?

Discipline ( ) Product ( ) Phenomena ( )
Process ( ) Customer ( ) Other (specify) ( )

19. What specific departments or individuals in the organization, aside from your direct superior(s), exercise any type of authority (functional) over significant aspects of your research work? (e.g., personnel, administration, finance, etc.)

A. What is the nature and extent of their authority?

B. How often is their authority imposed?

C. Do you feel that the authority relationships described above are conducive to the efficient and effective accomplishment of your research unit's objectives?

Comment

20. In regard to your work or project assignments:

A. How many projects are you currently working on?

B. Is this a normal workload?
Yes ( ) No ( ) High ( ) or Low ( )

C. Are these projects closely related?
Yes ( ) No ( )

21. In general do you find that you work better:

A. By yourself ( )

B. With another research scientist ( ) - with similar ( )/ dissimilar ( ) training.

C. With two or more scientists ( ) - with similar ( )/ dissimilar ( ) training.

Comment

22. A. What function(s) do committees serve in your research unit with respect to:

1. Research scientists' transferral of knowledge?

2. The management of research projects?

3. Other (specify)?

B. Who serves on these committees?

23. A. Indicate on the continuum below the amount of project selection and operational freedom that you feel is most conducive to your productivity. (Circle scale number)

completely free in selecting and carrying out — 10 9 8 7 6 5 4 3 2 1 — no freedom in selection or carrying out

B. How do you feel your colleagues would mark this continuum?
Higher ( ) Lower ( ) The same ( )

24. A. Is there a formal job description for the position that you hold with (name of firm)?
Yes ( ) No ( ) Don't know ( )

If yes, briefly state the formal job description for your job.

B. Does it describe your work activity accurately?
Yes ( ) No ( )

Comment

25. What would you consider to be a promotion in your organization?

26. When recruiting research scientists from the outside, from your experience, what are the criteria upon which your department bases its selection?

27. A. What number and types of personnel are currently working with you as part of your research team? Indicate the adequacy of the size of each group.

	number	too many	too few	right number
Research scientists	_____	( )	( )	( )
Technicians	_____	( )	( )	( )
Secretaries	_____	( )	( )	( )
Maintenance men	_____	( )	( )	( )
Others (specify)	_____	( )	( )	( )

B. Do each of these groups possess the proper abilities?
Yes ( ) No ( )

Comment

28. Is your contribution to the results of a project evaluated upon completion of the project?
Yes ( ) No ( )

If Yes:

A. By whom?

B. What form does this evaluation take?

29. Does (name of firm) have a periodic appraisal program for their research scientists?
Yes ( ) No ( )

If Yes:

A. Who administers it?

B. How often?

C. What form does this evaluation take?

30. List and rank according to relative importance the criteria upon which salary increases and promotions are granted for scientists at (name of firm).

31. How do you expect to benefit from journal articles, patents, speaking engagements, colleague citation of research accomplishment, etc.?

32. In the realm of scientific output: Which of the following are required or expected of you?

1. Status reports during term of research ( )
2. Intra-firm reports of findings upon completion of research ( )
3. Unpublished articles or speeches ( )
4. Journal articles ( )
5. Patents ( )
6. Research colleague citation of accomplishment ( )
7. Other (specify) ( )

33. In your experience at (name of firm) has a basic research scientist ever been demoted or discharged?

If Yes:

To your knowledge, for what reason?

34. Characterize the over-all working environment of your research unit. (Encircle scale rating.)

A. Accomplishment high 10 9 8 7 6 5 4 3 2 1 low

B. Indifference high 10 9 8 7 6 5 4 3 2 1 low

C. Frustration high 10 9 8 7 6 5 4 3 2 1 low

35. Indicate the importance you attach to the following items as long-run rewards for research accomplishment. (Encircle scale rating.)

	extremely important									not important
Financial reward	10	9	8	7	6	5	4	3	2	1 0
Recognition of accomplishment	10	9	8	7	6	5	4	3	2	1 0
Self-improvement	10	9	8	7	6	5	4	3	2	1 0
Promotion within the organization	10	9	8	7	6	5	4	3	2	1 0
Reputation outside the organization	10	9	8	7	6	5	4	3	2	1 0
Sense of self-achievement	10	9	8	7	6	5	4	3	2	1 0
Higher status as a researcher	10	9	8	7	6	5	4	3	2	1 0
Professional development	10	9	8	7	6	5	4	3	2	1 0
Other (specify)	10	9	8	7	6	5	4	3	2	1 0

36. What is the degree of certainty between superior research performance and reward in the organization for which you work? (Encircle scale rating.)

very high				average				low
10	9	8	7	6	5	4	3	2 1

37. A. In general terms, why are you presently working for (name of firm)?

B. Have you worked for other firms?

If Yes:

What factors led you to change firms?

38. A. Are you motivated by research projects that seek:

Bits of new information or knowledge ( )
or:
To develop over-all-generalized hypotheses ( )

B. Do you generally work on research projects that are seeking:

Bits of new information or knowledge ( )
or:
To develop over-all-generalized hypotheses ( )

Comment

39. Do you feel that the firm provides you with ample opportunity to pursue your professional development?
Yes ( ) No ( )

A. If Yes:
In what way?

B. If No:
Why not?

40. A. How do you view your salary? (Encircle scale rating.)

highly adequate					average				low
10	9	8	7	6	5	4	3	2	1

B. How do you think your colleagues view their salaries? (Encircle scale rating.)

10 9 8 7 6 5 4 3 2 1

41. A. Where do you do your most productive work?

B. When do you do your most productive work?

C. What type of work are you doing in A and B above?

42. Excluding research projects of national security, does your firm encourage you to communicate new ideas and information:
(CHECK APPROPRIATE ANSWER TO QUESTIONS A, B, C, and D)

A. In the formulating stages	
B. During the actual research work	
C. At the conclusion of research	
D. After patents and legal coverage is assured	
1. To your immediate supervisor	
2. To your research colleagues	
3. Within your firm	
4. Outside your firm	

43. In carrying out a given research project, do you talk with other research scientists who are working (or have worked) on similar problems?

A. Always ( )
B. Usually ( )
C. Sometimes ( )
D. Seldom ( )
E. Never ( )

Comment

44. A. Approximately how many hours per week do you spend consulting with your immediate superior?

formally_____hrs. informally_____hrs.

B. Approximately how many hours per week do you spend consulting with research colleagues?

formally_____hrs. informally_____hrs.

45. Which do you prefer?

( ) consulting with researchers outside the firm
( ) consulting with researchers within the firm
( ) no preference
( ) other

Comment

46. With respect to your relationship with your immediate supervisor: (CHECK APPROPRIATE ANSWER TO QUESTIONS A, B and C)

A. Do you have in project selection			
B. Do you have in development of research design, methodology and technique			
C. Do you have in project reporting			
1. Complete freedom			
2. High degree of freedom			
3. Very little freedom			

47. To what degree does your immediate supervisor provide leadership for your research work?

48. Is there a problem or difficulty of a non-technical nature which you feel limits your ability to achieve your research objectives?

Comment

49. Characterize the general environment for research progress appraisal in your research unit. (Encircle the scale rating.)

complete superior appraisal 50-50 complete self-appraisal

10 9 8 7 6 5 4 3 2 1

50. What are the significant criteria which you use in evaluating the progress of your own research?

51. What are the significant criteria used by your superior(s) in appraising your research progress?

52. In the event that it is necessary to make changes in the research plan:

A. Who makes the decisions to:

1. Change emphasis or direction of research efforts?
2. Extend research projects?
3. Terminate research projects?

B. What is your part with respect to:

1. A change in emphasis or direction of research efforts?
2. Extension of research projects?
3. Termination of research projects?

Comment

53. What is the periodicity (days, weeks, months) of your self-appraisal of research progress?_____

Of your superiors' appraisal of your research progress?_____

54. A. Do you feel that the nature of the progress appraisal function can affect over-all research accomplishment?
Yes ( ) No ( )

B. If Yes: Indicate below what a more ideal environment might be.

		superior	self
1.	Who appraises:	10 9 8 7 6 5 4 3 2 1	
2.	Periodicity (days, weeks, months):	superior:_____	self:_____
3.	Criteria used:	by superior (list)	by self (list)
		_____	____
		_____	____
		_____	____

55. A. Have time-event or milestone control systems such as PERT been applied to research projects in your organization?
Yes ( ) No ( ) Don't know ( )

B. If Yes: What influence have these systems had in the planning and controlling of research projects?

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