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THE RECRUITMENT OF SCIENTISTS: A CASE STUDY IN CANADA

CONTENTS

... one might ask, where is science going, and how much of it do we want? At the present time in some highly industrialized countries about half of one per cent of the population are engineers or scientists. Of course, most of them are not engaged in research, but about a quarter of them are. The rate of expansion of research is about twice that of G.N.P. or a little more. Research is not only expanding but the rate of expansion is also increasing. Obviously this cannot go on forever. At the present rate, in a century or two everyone will be engaged in research and no one will be left to provide food, clothing or services. Some time we must level off, but when? Certainly not for a few decades yet, because the increase in technological innovation is expanding production rapidly.

How many scientists do we need? The popular outcry sometimes suggests that the number is unlimited, but obviously a slow-down will come, though not for some time yet.

E.W.R. Steacie: Management Conference, Queen's University, June 16, 1959.

... In a research organization a few people make all the difference. If 5 per cent of the staff of a research laboratory are really first-rate, with imagination and initiative, all is well. Without this 5 per cent very little that is worthwhile will emerge from the laboratory. If we are going to expand, these are the essential people. This is where the shortage will develop.

The problem is to develop people of this type: to get behind them when they appear and give them the opportunity to develop themselves. In both Britain and the U.S. the source of supply of such people is from the universities. The problem is how to hold more people of this type in the universities where they will help out the training of research students, and themselves develop the experience and ability to direct research ...

E.W.R. Steacie: Canadian Industries Limited, Beloeil, October 22, 1954.

Introduction:

This thesis is concerned with certain social aspects of natural science[1] in present day Canada. It is possible to view science as a body of knowledge and to examine it independently of its social origins. Many histories of science do exactly this. On the other hand, there has been a growing awareness in recent years that scientific knowledge does not accumulate automatically as an inevitable consequence of rational thought but depends upon specific kinds of social organization. Thus in this study the body of existing scientific knowledge is regarded as but one aspect of the organization of groups of scientists. Furthermore, scientific groups are but one element in the total social structure and are themselves conditioned by, for example, the character of economic and political institutions. I shall not be directly concerned here with how or to what extent the structure of human groups can influence scientific fact or theory. However, there is implicit in the present study of scientific organization the assumption that the character and even more the rate of growth of scientific knowledge is intimately related to the social organization of science. As a result, any conclusions which emerge will have implications with respect to the future development of scientific knowledge and technology, and perhaps indirectly to the direction and speed of general social development.

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1 Natural science is taken to include physics, chemistry and biology, but not psychology or such social sciences as economics, sociology, etc.

One of the major aims of this thesis is to indicate how the organization of scientific groups has differed and still does differ from that of other social groups. However, it is possible to think about social groups at varying levels of abstraction and I will begin by putting forward certain categories which can be used to study any group at any time. These are as follows:

1) Role structure, including internal power and prestige hierarchies.
2) Values and major goals.
3) Mechanisms of social control.
4) Systems of internal and external communication.
5) Processes of recruitment.

Although these headings will provide the basic framework for the analysis offered here the primary focus of the study will be upon the process whereby individuals are recruited into scientific groups. As a consequence, no attempt will be made to provide a <u>comprehensive</u> account of the current organization of science in Canada or the United States. Instead, stress will be laid upon those features of social structure which are thought to be important aspects of the recruitment process. For example, in those chapters dealing with university science and science within industry and government, much more attention will be paid to group values than to mechanisms of social control. The reasons underlying this emphasis upon "scientific" values will be clarified in the chapter on occupational recruitment.

It would doubtless be possible to conceptualize the social aspects of science within any one society as a single complicated network. For my present purposes, however, it will prove more fruitful to conceive of science as composed of three distinct role-complexes each within a separate institutional framework. Thus we have university science, government science, and industrial science. I shall adopt this approach in part because past research has shown that scientific roles, values, goals, etc. tend to vary as between these three institutional orders and in part because I will be stressing the process of recruitment. Recruitment of scientific personnel can be seen as taking place at the point of entry to the sphere of university science. Virtually all scientists are educated at a university. Some remain within the university and fulfill their major scientific roles as academics. These individuals can be regarded as having been permanently recruited into university science. However, the great majority of scientists are only temporary residents within the educational milieu and move out of the university into employment within industry and government. Thus there are further processes of recruitment into these fields. Although in this study I shall be mainly concerned with the initial entry of undergraduates into university science, some consideration will also be given to the nature of commitment to university science and the character of departure into industry and government. For these reasons it appears preferable to make some distinction at the outset between science as found in the university and as organized in industry and government.

It is not intended to imply that the sole useful way of splitting up the social organization of science is as above. Shepard[1], for example, writes of the 'social system of pure science'; a conception which is almost but not quite synonymous with that of university science. He suggests that it is only possible to distinguish between 'pure' and 'applied' science by reference to the values and general social system from which the two categories of scientific activity arise. In contrast, Hirsch has argued that the distinction between pure and applied science is of little utility, at least when considering the relations between science and political authority. Theoretical as well as applied science, he suggests, can be used instrumentally to meet non-scientific needs; e.g., Lysenkoism in the U.S.S.R. Thus Hirsch[2] distinguishes between instrumental and non-instrumental science, claiming that the basic distinction to be drawn is in terms of the social organization involved rather than the nature of the scientific knowledge. It might have been fruitful, therefore, to have made some such notion the basis of my approach had there not been two important drawbacks. Firstly, there has been little or no research couched in these terms; and more crucially it would have directed interest away from a conception of interlocking groups certain of which are dependent upon others for replacement of personnel. Insofar as we stress the recruitment process it is useful to view university science

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1 H. Shepard: Basic Research and the Social System of Pure Science: in Philosophy of Science 23 (1956).

2 W. Hirsch: The Autonomy of Science in Totalitarian Societies: in Social Forces 40 (1961).

as linked to the high school and the family on the one hand, and industry and government on the other. It is in the university that the prospective scientist experiences his first prolonged contact with a social group structured primarily around science. Although the student has already been selected and moulded in high school, largely through the actions of the science teacher, it is within the university that he is first exposed to persons playing predominantly the role of 'scientist' (researcher), rather than that of 'teacher', emphasizing the values characteristic of science with a stress unprecedented in the wider society, endorsing 'scientific' methods of social control and using characteristic channels of communication. Later in this study we shall examine an empirical investigation of this crucial point of entry into the social ethos of university science. Clearly it is of theoretical and practical importance to know what kinds of individuals enter the sub-culture of science in preference to other sub-cultures and also what factors lead these persons to make this particular choice. The process of recruitment is theoretically significant because it is a feature of all social groups. It is of great practical consequence currently because certain difficulties are being experienced in expanding science as quickly as industrial growth seems to require.

At this point, before starting upon the actual analysis, the reader will probably find helpful a brief outline of the structure of this study. Chapter I presents a short account of the stages of development of modern science; viz, amateur science, academic science, professional science. It attempts to provide, not just a historical background, but also an account of some of the mechanisms involved in scientific growth and their bearing upon the recruitment process. Chapters II and III are concerned with describing more fully certain aspects of current scientific organization in North America with particular reference to the professionalization of science. In Chapter IV there follows an account of some of the major studies of the recruitment of scientists. Chapters V and VI present the findings of a study undertaken at Simon Fraser University, British Columbia with regard to the factors involved in entry into university science. Finally, in Chapter VII, there is a general, though necessarily tentative account of the process of recruitment into professional science which attempts to integrate the findings of the S.F.U. study with the other available material.

Chapter I: The Growth of Modern Science

The main theme of any history of modern science must be the fact of continuous change and development. Change has been characteristic not only of the extension of scientific thought but also of the social organization of scientific activity. In this chapter I shall examine certain aspects of the changes which have occurred in social organization. I shall begin by reviewing some of the statistics relevant to the growth of modern science.

If we measure the direction and rate of growth in terms of any crude index of size e.g. numbers of scientists, numbers of new recruits, numbers of journals, articles, new journals etc., several interesting characteristics reveal themselves:

1. Growth is exponential i.e. the greater the size, the faster the rate of growth.
2. The rate of increase is very rapid. Depending upon which index is measured and how, the doubling period varies from ten to fifteen years.
3. The normal exponential curve applies with more than usual accuracy to diverse kinds of data and over long periods of time.
4. These accelerating growth rates are not a recent phenomenon but appear to have been

characteristic of modern science at all times.[1, 2] Statistical information undoubtedly becomes less and less reliable as we consider earlier periods. However, we can be certain of the exponential pattern of growth during the twentieth century, fairly certain of the preceding century and what studies have been made of the eighteenth century confirm the pattern. Furthermore, if we extrapolate the long term exponential backwards in time we find that its point of genesis lies in the mid-seventeenth century; and this is exactly the period during which historians of science such as Butterfield, have placed the birth of a new type of modern science.[3]

These general characteristics of the statistics of scientific growth can be exemplified in several ways. I shall concentrate here upon numbers of scientists rather than papers published, journals established, or growth of science-based industries etc. The reasons for choosing to stress the growth of scientific personnel are obvious. Firstly, there is

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1 D.J. de Solla Price: Little Science Big Science.

2 Gerald Holton: Models for Understanding the Growth and Excellence of Science in Excellence and Leadership in a Democracy etc. Graubard & Holton.

3 H. Butterfield: The Origins of Modern Science.

the fact that the major focus of this study is on manpower recruitment. Secondly, all other criteria of growth will be directly related to the number of active scientists. Price[1] estimates that the number of scientists in the United States has increased in the following way.

Table 1. Increase in Numbers of Scientists in the U.S.

Year	Number of Scientists
1800	1,000
1850	10,000
1900	100,000
1950	one million

In the mid-seventeenth century there were so few men of science that they could easily be named and known by one man; but now in the U.S. there is a population in the order of one million with scientific and technical degrees. Furthermore, every doubling of the world population since the rise of modern science has produced at least three doublings of the number of scientists. Thus scientific growth rates have not been a simple result of population increase. Nor can they be explained as but one aspect of the growth of professions in general. Ben-David[2] provides comparative figures of the growth of professions which demonstrate this

1 D. J. de Solla Price: op. cit.

2 J. Ben-David: Professions in the Class System of Present-Day Societies in Current Sociology Vol. XII, no. 3, 1963-4.

point. As a criterion of professional development he uses enrolment in and graduation from universities; and on the basis of the statistics of higher education he distinguishes three educational systems, viz. the European, that of the United States, and that of the U.S.S.R. In Europe there has been traditionally a great emphasis upon the professions of medicine and law, and until the Second World War these faculties dominated university study. However, the combined percentage of university students in law and medicine dropped to less than thirty-five percent of total professional enrolment in all European countries after 1945. At the same time the university enrolment in science and technology increased considerably. Thus science has tended to absorb an increasing proportion of an expanding population of university students. Some of the relevant figures for France and the U.K. are reproduced below.[1]

Table 2. Student Enrolment by Selected University Faculties in France and the U.K.

France

Year	Medicine	Law	Science and Technology
1932	32.3%	29.6%	19.4%
1958	18.2%	16.5%	35.1%

U.K.

Year	Medicine	Arts	Science	Technology
1930-1	21.2%	52.8%	16.8%	9.2%
1956-7	17.4%	43.1%	22.2%	17.3%

The development of professions in the U.S. during the first

1 Ibid

half of this century has differed from that in Europe in two important ways. Firstly, the rate of growth has been much faster. And secondly, there has been a great proliferation of small "miscellaneous" professions. However, with respect to the transfer from traditional professions to science and technology, developments in America have mirrored those in Europe. Whereas the fields of medicine, law, and the humanities have declined proportionately, science and technology have held their own in a university enrolment which has expanded much more rapidly than that of Europe.

Table 3. Per Cent of Bachelor's and First Professional Degrees Awarded to Students in U.S. in Selected Specialized Fields[1]

Year	Science & Engineering	Arts	Law	Commerce
1901	16.6%	25.3%	11.2%	0.2%
1931-5	18.4%	16.1%	6.1%	6.9%
1951-3	19.4%	12.0%	3.7%	14.4%

The situation in the Soviet Union has differed from that in both Europe and the U.S. There the main emphasis has been upon science as a major element in planned economic growth. Consequently by 1955-6 fifty-seven percent of university students studied the natural sciences.

We have seen that in all industrial societies the rate of scientific growth is very rapid. This fact has

1 Ben-David, op. cit.

become particularly noticeable in recent years but rapid growth has actually been a permanent characteristic of modern science. We have also seen that the growth of science outstrips that of population and that there is a strong tendency for science to recruit an increasing proportion of professionals. However, in this study the main area of concern is Canada. Thus the question remains: Does Canada conform to the general pattern? In fact it does. During the period 1931-1951, when the total civilian labour force increased by twenty-six percent and professions by fifty-one percent, most occupations connected with science grew by over one hundred percent. For example, employment in mining and chemical engineering increased by two hundred and eight percent, and employment of chemists and metallurgists by one hundred and fifty-eight percent.[1] It is impossible to refer to figures more precise than this for Canada in relation to the comparative growth of professions. However, a quotation from the conclusions drawn by the Royal Commission on Canada's Economic Prospects on the basis of a whole range of statistics similar to those adduced above will demonstrate the point equally well.

> " Since the early 1900's, Canada, in evolving from a predominantly agricultural country to one based on the exploitation of many primary raw materials and on growing manufacturing and service industries, has required increasing numbers of scientists and engineers per unit of the economy's output. In addition, economic progress depends to a growing extent on the application of new scientific knowledge to production processes. The impact that advancing technology and a dynamic economy can have on a country's requirements for scientists and engineers is well illustrated by developments in the United States. Between 1930 and 1954, the number of scientists and engineers in the U.S. increased by 226%, while the population as a whole increased by only 32%."[2]

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1 Skilled and Professional Manpower in Canada, 1945-1965 Department of Labour.

2 Ibid.

Despite the fast growth of science in Canada, scientists still constitute only a small occupational grouping. In 1961 the Register of Scientific and Technical Personnel listed 82,000 scientists and engineers of which perhaps one-quarter were natural scientists.[1] This compares with a total number of professionals in Canada at that time of around 600,000.[2] In contrast to the U.S. Canada is a scientifically underdeveloped society. But Price[3] has suggested that the later scientific growth takes place the faster it tends to proceed. If this holds true for Canada we would expect to find that the expansion of Canadian science during the next few decades will be very rapid indeed.

The statistics presented so far have implications which can only be dealt with here in a summary fashion:

1. Science as a body of knowledge and as a social phenomenon has grown cumulatively larger during the last 300 years.

2. This kind of growth is probably not found in Pre-Modern science.

3. At least since Spencer and Durkheim, growth in size of social organization has been seen by sociologists as associated with changes in structure and especially with increases in complexity and specialization of social role.

4. Since scientific growth patterns have remained relatively constant over long periods of time and despite radical changes in the social organization of science and the social

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1 Professional Manpower Bulletin No. 10, Dept. of Labour.

2 Changes in the Occupational Composition of the Labour Force N.H. Meltz.

3 op. cit.

milieu, we can expect to find that the basic dynamic lies in some fundamental aspect of scientific knowledge and innovation.

5. One major aspect of science is that of a body of knowledge which has been expanding cumulatively and which has necessitated increased specialization. We can expect therefore that scientists will face a perennial problem of communicating and absorbing new information. Many changes in the social organization of science may be directly related to this communications problem.

I have so far described in crude terms certain measurable aspects of scientific growth and pointed out some implications with respect to changes in organization, complexity and communications. The next step is to describe, in simplified qualitative form, the nature of those social developments which have accompanied scientific expansion. It seems to me that we can discern three fairly distinct stages of scientific development in Western Europe and North America, which we might call amateur science, academic science, and professional science. I shall outline here only the main features of these stages.

Amateur Science:

Amateur science emerged during the seventeenth century when educated men began to gather together to discuss the new natural philosophy. These men could hardly be called 'scientists' for their major social roles lay outside the sphere of science. At this stage of development even the leading thinkers such as Newton relied upon some other activity for economic maintenance. Men indulged in science as a source of intellectual and social satisfaction. Furthermore, there was no need for specialization because the quantity of scientific knowledge could be easily absorbed by an intelligent man in a short space of time. Main social features of amateur science:

a) The amateur scientists were not isolated scholars but were organized in groups of scientific enthusiasts, e.g. The Royal Society.

b) There was a new stress on communication of knowledge within and between groups.

c) Scientific knowledge was not a source of recognition or prestige within the wider society.

d) Amateur scientists tended to emphasise specific values:

    (i) Rationality: reliance upon reason.

    (ii) Empiricism: stress on observation and experiment as a method of verification and of obtaining new knowledge through sense experience.

    (iii) Universalism: the source of and claims for truth are to be subjected to pre-established impersonal criteria of validity.

    (iv) Organized scepticism: with respect to authority and tradition.

    (v) Individualism: reliance on the judgment of the individual scientist, rather than on political or

(v) ... religious tests of scientific truth. [1, 2, 3]

e) These groups of scientific amateurs were composed of professionals and men of leisure who, in their scientific activities, were satisfying intellectual but not economic needs. At this stage of scientific growth recruitment into science was relatively simple. To begin with, very few persons were involved. Secondly, practically nobody depended upon science for a living. Thus science recruited from among those of independent means, the few individuals who had an intellectual affinity for natural philosophy.

<u>Academic Science:</u>

In Western Europe this amateur organization of science lasted throughout virtually the whole of the eighteenth century. Towards the close of that century science began to establish itself within the university and this development accelerated rapidly during the nineteenth century. In France, which was perhaps the leading scientific nation during the first decades of the nineteenth century, scientists within the university long retained their 'amateur', unspecialized status.

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1 G. DeGre: <u>Science as a Social Institution</u>.

2 R.K. Merton: "Science & Democratic Social Structure" in <u>Social Theory and Social Structure</u>.

3 The question of the cultural values of science will be discussed more fully in Chapter II.

> " The academic career changed very little in France through the nineteenth century. Appointments were made from an undifferentiated group of practitioners - amateur scientists - and usually at a fairly advanced age. Even academically successful persons did not become full-time scientists before they reached their forties or fifties, and since the chair to be vacated was not known they had to maintain as broad interests and activities as possible. ... The large majority of the scientists had independent means or a lucrative profession (very often medical practice, even in sciences not connected with medicine), and pursued their scientific interest in their free time, often at a considerable personal cost. This idealistic pattern seemed to fit perfectly that sacred pursuit of truth which was science. Academic appointments therefore were regarded as honors rather than careers, and turning science into an occupation would have seemed something like a sacrilege."[1]

However, in Germany, which gradually became the model for the organization of science in Western Europe and the U.S.A., this situation did not apply. Because the German system of higher education was relatively decentralized, unlike that in France, no single institution was able to lay down standards or general policies in relation to the organization of science. Consequently, scientists were able to exert pressure upon competing university administrations with the aim of eliminating traditions which were perceived as retarding scientific development. More specifically, this pressure resulted in three main innovations:

(i) Creation of regular academic careers for scientists.

(ii) Recognition of specialized disciplines.

(iii) Spread of contemporary research facilities.

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1 J. Ben-David: 'Scientific Productivity and Academic Organization in Nineteenth Century Medicine' in Sociology of Science eds. B. Barber and W. Hirsch.

As countries such as the U.S.A. and the U.K. became aware of Germany's expanding scientific productivity, science in the Western World tended to be organized along the lines of the German model and to become entrenched within the universities. At the same time during most of the last century, any close relationship between science and industry was not conceived.

> " Before 1900, most professional scientists were teachers in Universities, technical institutes and trade or secondary schools. Relatively few were employed in industry, with the major exceptions of the dyestuffs and electrical fields." [1]

This stage in the growth of modern science differs, then, from that of amateur science and can be characterized as follows:

a) The university is the centre of scientific activity.

b) A distinct role emerges for the scientist. It has two major aspects viz. - research and teaching.

c) The rapid extension of scientific knowledge virtually eliminates the non-specialist as a contributor of the first rank.

d) Specialization increases at an exponential rate within science as a whole and within most sub-divisions of science.

e) " Choices of scientific work were largely an individual matter and were neither coordinated at the level of the university nor at the national level. The system was largely self-starting, self-maintaining, and self-regulating

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1 J. Beer and W. Lewis: 'Aspects of the Professionalization of Science' in Daedalus, Fall 1963, Vol. 92 No. 4.

e) ... - to a degree unparalled in almost any other institution in society."[1]

f) The complex of scientific values and the scientist's relatively low prestige within society at large probably remained much the same as in the earlier period.

g) We have no direct evidence available on the recruitment of scientists into the academic science of the last century. Nevertheless it is clear that scientists, as they increased in number, must have been drawn from a wider spectrum of social groups. Furthermore, as scientific activity became an occupation rather than a pastime, the whole motivation of prospective scientists must have changed. Increasing scientific specialization demanded prolonged training and consequently a greater investment of time, effort and foregone opportunities.

Professional Science:

This second stage of scientific development has sometimes been described as 'laissez faire'. Certainly there was sufficient autonomy, individualism and independence from the rest of society to justify the use of this term. However, during the last quarter of the nineteenth and the early years of the present century there emerged firstly a growing interdependence between science and industry, and subsequently between science and government. The extent of this change can be seen if we compare the occupational distribution of

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1 N. Kaplan: 'The Western European Scientific Establishment in Transition' in American Behavioral Scientist, December 1962.

scientists as described above by Beer and Lewis with the distribution in Canada in 1962 viz.

a) Government employment - 48%

b) Industrial employment - 38%

c) Universities and colleges - 14%.

Clearly this has implications for the nature of the social organization of science. Whereas academic scientists operated as autonomous guardians of knowledge concerned with self-justifying research, scientists now work within the confines of large scale bureaucracies which channel their research towards fulfillment of the goals of the bureaucracy. At the same time, structural changes have evolved in response to the problem created by an exponential growth of literature and by a continuous need to specialize more narrowly. These structural changes have produced a network of informal, highly specialized groups within which information is passed on through personal contacts rather than through the impersonal medium of publication. Furthermore, the mature scientists of whom these groups are composed tend to circulate around the major scientific research institutes financially supported on the whole by public funds and utilizing research equipment which is similarly financed. This aspect of professional science is important because it points to perhaps its fundamental characteristic namely, the intimate association of science and government. The close relationship between science and government arises partly from the need for central control over the major source of technological innovation (in the interests of national security as well as economic growth), partly from the inordinate cost of contemporary research and development, and partly from the need to supply financial rewards sufficient to make science an attractive career for the best talents.

Main social features of professional science:

a) Professional science is much larger and more specialized than either amateur or academic science.

b) There is an increasing bureaucratization of the scientific milieu and greater stress upon the instrumental value of science.

c) Thus control over research is seldom vested in the individual nor is research of an unplanned laissez faire character.

d) Government plays an increasing role in the direction of scientific activity while at the same time scientists are more active in the formulation of government policy.

e) Science is recognized as a major resource in relation to economic growth.

f) Large scale science can no longer rely on those few individuals able to derive a peculiar intellectual and emotional satisfaction from more or less isolated intellectual activity.[1] Large scale science requires large scale recruitment and consequently the kind of rewards which can attract a relatively large proportion of those with high level intellects. There can be no doubt that these rewards have been forthcoming in most industrial societies.

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1 Anne Roe: The Making of a Scientist.

g) The peculiar values of scientists have been modified in the direction of greater conformity with the values of professional groups generally within Western culture.

So far I have described tentatively and in outline form three stages through which the social organization of science has passed in the Western World. An attempt has been made to substantiate the claim that over time the major internal development within science has been that of a cumulatively increasing complexity and specialization. At certain levels of specialization the existing form of organization becomes insufficient to generate further productive thought. The amateur generalists have to give way to more specialized academics operating more or less as isolated individuals. Finally, this laissez faire structure is replaced by groups of specialists (the individual is no longer capable of commanding sufficient information) and by bureaucratic control over a highly complex network of R & D. A simplified account of the internal dynamics of scientific growth, then, can proceed along these lines: cumulatively increasing knowledge (facts plus theoretical interpretations) gives rise to difficulties with respect to communication and research techniques which can only be resolved by narrower specialization. As specialization increases new forms of financial support must be found (private income gives way to the teaching role, which in turn is gradually replaced by government grants) and as the numbers of specialists expand so new and higher rewards must be made available. Social organization varies in accordance with the system of rewards, support and specialization, which in turn depend upon the growth of knowledge.

The account given above of the growth of modern science has been more descriptive than explanatory. However, this is sufficient for my purposes. I am concerned here primarily with the processes of recruitment into science and so, in a study of limited length, I must turn to the relationship between recruitment and social organization instead of trying to explain in any detail the course of scientific change. In investigating this relationship between recruitment and social organization I have made three basic assumptions:

1. that different institutions and the same institution at various times will attract different types of persons.[1]
2. that the processes of selection vary according to the nature of the particular institution and its stage of development.
3. that persons selected into any specific institution will be encouraged to develop along distinctive lines[2] and discouraged from developing in other directions.

If these assumptions are justified[3] and if the description of growth is reasonably accurate then we would be led towards the following expectations with respect to the processes of scientific

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1 'Type of person' refers not only to personality type but also to occupational values, occupational image, and so on. This will be discussed more fully in Chapter IV.

2 in terms of personality, occupational values, self-image, etc. See Chapter IV.

3 For an attempt at providing a theoretical justification for such assumptions see H. Gerth and C.W. Mills: Character and Social Structure.

recruitment in North America. Firstly, we would expect that recruitment into science will differ from selection into other occupations roughly to the extent that science differs from these occupations. Secondly, we would expect that as the social organization of science changes so will the character of recruitment into science. As it has been claimed above that science has become increasingly professionalized i.e. increasingly similar in many respects to professions such as law and medicine, we would expect to find that selection into science and into such professions had become increasingly uniform.[1]

The remainder of this study will be concerned firstly with describing certain aspects of contemporary science in university, industry and government and then with examining recruitment into science. Before I proceed along these lines,

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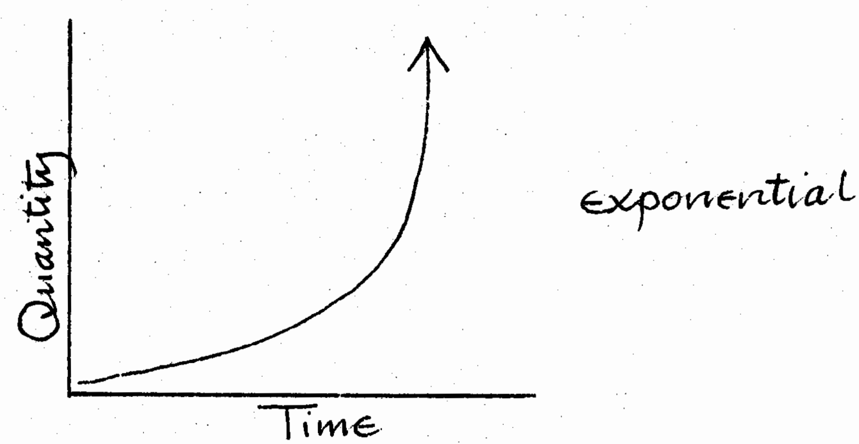
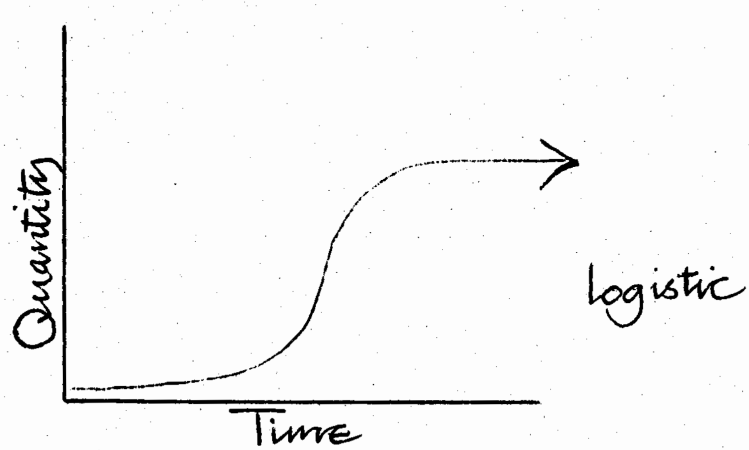
1 Yet, for two reasons, we would not expect to discover that the processes of recruitment into science and into other professions had become identical. The first reason is that the transition from academic to professional science is as yet relatively recent, having been given its greatest impetus by the 1939-1945 war. Secondly, as I hope to show in Chapters II and III, university science retains strong traces of the form of organization I have called 'academic'. It is assumed here that university science is more 'academic' than university law or university medicine, etc. There is no direct evidence to support this assumption but it is a reasonable one because the professionalization of science is so recent. As the university is the major agency whereby scientists are recruited and can be expected to leave its imprint upon the process of selection of personnel, we will receive indirect evidence about the organization of university science when we examine the recruitment of scientists. Nevertheless, more studies are required with respect to the divergent structures of university faculties before we can come to any firm conclusions in this area.

however, I can be a little more specific about trends in scientific recruitment even on the basis of the facts considered so far. We have seen that scientific growth has tended to be exponential up to the present day and usually a very fast exponential at that. However, exponential growths cannot continue indefinitely. This kind of pattern:



must inevitably become:



Periods of rapid exponential growth generate in due course, no matter what the nature of the phenomena involved, more or less severe stresses and strains with respect to those resources which are crucial for growth. It is the shortage of such resources which produces the transition from rapid growth to stable maturity. The resources necessary for scientific expansion are primarily capable personnel and adequate finance and, in fact, the recruitment of scientific personnel has recently been classified as problematic by any number of official documents, e.g. the Bladen Report in Canada. To put this problem in its crudest form we can say that if present, and past, rates of growth continue to the year 2000 then every member of scientifically advanced societies will be a scientist by that time. Similarly finance can be seen to constitute a problem if we examine the rate of growth of expenditure on research and development in, for example, the U.S.A. during the last decade or so. In the early 1960's national research and development expenditures were around 2% or 3% of the Gross National Product; by 1973 at present rates they will make up 10% of the G.N.P. To quote Price:

> "If the per capita cost of supporting scientists were constant, we should only spend in proportion to their number, so that the money they cost would double every 10 to 15 years. But in fact our expenditure, measured in constant dollars, doubles every 5½ years, so that the cost <u>per scientist</u> seems to have been doubling every 10 years. To put it another way, the cost of science has been increasing as the square of the number of scientists." [1]

A good case then can be made in support of the assertion that science during a period of transition from rapid growth to relatively stable maturity will develop new features in relation to finance and recruitment of personnel.

The implications of all this for the recruitment of scientific manpower appear to be that whereas academic science could persist by recruiting persons who were capable of deriving a special kind of emotional gratification from autonomous

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1 op. cit.

intellectual activity, professional science can only continue by appealing to a much larger proportion of intellectually capable persons. Consequently professional science may have to offer such additional rewards as high income and social prestige in order to reduce its manpower difficulties. However, considerable growth is possible even without extending the kind of rewards offered, simply by expanding educational opportunity in the field of science and technology. The analysis so far has concentrated upon the increased demand for scientists which is associated with a rapidly growing science. But the size of professional science also depends upon the supply of potential scientists and this supply is largely created by the way in which educational institutions are organized. For example, in the U.S.S.R. there has been a very rapid expansion of science since the 1920's. This expansion has, on the whole, been generated by the education of more scientists and technicians and by the restriction of educational opportunities in other areas. Thus educational development is an inevitable corollary of scientific growth in Canada. While educational expansion continues the shortage of scientific personnel will probably not prevent scientific growth. But once educational development ceases science will be unable to expand without increasingly severe competition with other employment sectors. In short scientific growth will tend to be accompanied by changes in the nature of rewards offered and by a widening of educational opportunities. These developments will provide sufficient new scientists for a limited period but in time scientific growth will only be able to continue by drawing resources away from more productive fields. At this stage a position of stability is reached, scientific growth slows down and radical changes in the social organization of science cease.

Chapter II: University Science

Within the universities of North America the structure of academic science has been retained almost inviolate as an ideal. This ideal stresses, as described in Chapter I, that science rests upon the continuous development of valid conceptual schemes and that this activity is impossible without freedom from external constraint and without acceptance by scientists of specific values. I can provide no evidence of the persistence of this ideal in Canada in terms of representative surveys of practising scientists. However, the opinions of E.W.R. Steacie can serve as a substitute on the assumption that they are not entirely unrepresentative of scientific thought in Canada, for Steacie was President of the National Research Council until his death in 1962 and was acknowledged by many as the 'Leader of Canadian Science'. He argues as follows:

> " The chief reason why the university is the ideal place for scientific work is that the work is uncommitted. The university man is free to proceed in any direction which he sees fit, and should not be in any way influenced by practical considerations. The university is, in fact, virtually the only place where science can be pursued for its own sake."[1]

Yet Steacie is aware that this is a prescription rather than a description, it is an account of how university science ought to operate and not how it does work in practice. He continues:

> "In recent years there has been a very sharp rise in the cost of equipment and facilities which has led to financial pressure on the universities and has caused them to accept 'sponsored' research projects, that is, projects with a technological motive. Such ..."

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1 Science in Canada: Selections from the Speeches of E.W.R. Steacie ed. J.D. Babbitt.

> " ... support can be very helpful provided that it is for the problems chosen by the investigator. Often, however, the support is for specified projects, and the effect of such work can be most unfortunate. It leads to lack of freedom to follow whatever path the worker may see fit, and to outside planning of university research."

These quotations provide clear evidence, on the one hand, of an ideal which values highly the laissez faire organization of scientific research and on the other hand, an awareness of the threat to the autonomy of university science posed by external and instrumentally oriented bureaucracies such as that of government.

Associated with this ideal of an independent, informally organized science have been certain cultural values. I shall devote considerable space to an analysis of these values largely because they are that aspect of the social structure of science which is most relevant to the recruitment process. In one influential paper Robert Merton[1] characterized the basic values of scientists under the following headings:

1. Universalism: the source and claims for truth are to be subjected to pre-established impersonal criteria.
2. Communalism: all scientists have the right to share in existing knowledge.
3. Disinterestedness: absence of emotional attachment.
4. Organized scepticism.

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1 R.K. Merton: 'Science & Domocratic Social Structure' in <u>Social Theory and Social Structure</u>.

In another paper[1] Merton stresses the importance placed upon

5. Originality: 'he suggests that this institutionalized value generates extreme competition under appropriate circumstances.

Bernard Barber[2] adds two more to this list viz.

6. Rationality: reliance upon reason.

7. Individualism: the individual scientist has a moral duty to follow the dictates of his own judgment.

We find also many of these values endorsed more or less explicitly in the writings of natural scientists themselves. For example, J.R. Oppenheimer stresses the relation between science and the 'open mind' (universalism, disinterestedness, organized scepticism). He also emphasizes such values as individualism, freedom, and so on. However, perhaps the most clear and extreme treatment of this topic of scientific values by a scientist is that of J. Bronowski in 'Science & Human Values'. Bronowski's claim is that certain values are not only found among scientists but are essential attributes of an ongoing science. He suggests that the following are the relevant values:

1. Truth (universalism)
2. Independence (individualism)
3. Originality
4. Ability to dissent when necessary (individualism)
5. Freedom e.g. of speech, thought, inquiry
6. Tolerance (distinterestedness, universalism)
7. Justice and respect for human dignity.

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1 R.K. Merton: 'Priorities in Scientific Discovery' in Social Theory & Social Structure.

2 B. Barber: Science and the Social Order.

Bronowski seems to conceive of the social organization of science as a network of miniature democracies.

> " The society of scientists must be a democracy."
>
> " In societies where these values did not exist science has had to create them."

These claims are similar in content to those made by Barber et al. They differ only in being less qualified. To suppose that these so called democratic values are a necessary aspect of scientific organization is questionable. The connection may be no more than historical, a view which is in part born out by the rapid growth rates of science in U.S.S.R. and Communist China[1] where such values have been endorsed much less fully as compared with U.S.A., Canada and Western Europe. Insofar as Western scientists do endorse such values as truth, freedom, independence, etc., this may be no more than an acceptance of values commonly found in Western societies, or perhaps an expression of the values of those middle class groups from which scientists and professionals in general are predominantly drawn. However, despite these reservations, it is possible, by combining the laissez faire ideal of university science with these postulated 'scientific' values, to construct a consistent 'ideal type' of university science along the following lines. The basic goal of university science is the construction of new conceptual schemes, the generation of valid knowledge about the physical world. The primary values are expected to determine the role-behaviours of scientists and to facilitate the attainment of the basic goal.

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1 D.J. DeSolla Price: Little Science, Big Science.

Thus valid knowledge emerges as individual scientists discuss and evaluate the work of their fellows critically but rationally and impartially. The social structure of university science, then, takes the form of what Parsons[1] has called the 'company of equals pattern' within which each scientist is roughly equal in authority, relatively autonomous, and pursues the goal of extending knowledge in accordance with the morality and methodological convention absorbed from colleagues. Underpinning this whole system of social interaction is the acceptance of controlled, repeatable experiment as the ultimate criterion of scientific worth. On the basis of this 'objective' criterion of worth a hierarchy of prestige and authority emerges. Individuals are evaluated in terms of their fulfillment of the basic values, their contribution to the extension of knowledge and the effect of their studies upon existing theory.

> Highest honors go to those whose work involves radical reformulations or extensions of theory or conceptualization. Next come those who do the pioneer experimental work logically required to round out the conceptual structure. Next come those who carry out redundant experimental work of a confirmatory nature[2]... Last are the doers of sloppy or dull work.

This kind of group probably recruits persons who are content to become totally absorbed in intellectual activity and to remain aloof from involvement in many aspects of social behaviour. I shall deal with the character of scientific recruitment more fully in a later chapter but here the kind of behaviour expected of university scientists before the advent of professional

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1 T. Parsons, unpublished lectures: reference taken from B. Barber: Science and the Social Order.

2 H. Shepard, op. cit.

science can be exemplified by quoting from J. Robert Oppenheimer's description of his life during the early 1930's.[1]

> " I have never read a newspaper or a current magazine ... I had no radio, no telephone ... the first time I ever voted was in the presidential election of 1936 ... I was interested in man and his experience, I was deeply interested in my science; but I had no understanding of the relations of man and his society."

This ideal typical account of university science is too consistent to refer to reality in detail, although it would undoubtedly have applied more closely to university science during the academic stage than in recent decades. Thus our task at this point must be to examine the current applicability of this model and to indicate which factors have been responsible for modifications of its structure.

Empirical study of scientists' values is rather patchy though there is some support for the propositions of Barber, et al. In 1948 Fortune magazine asked a sample of American Ph.D's in the natural sciences whether a scientist should withhold a discovery from the world when convinced it would produce more evil than good. Around 80% of respondents thought that such a discovery should never be withheld. This seems to suggest the existence of one or more of values in favour of universalism, communalism, disinterestedness and individualism. However, what the response of the general public to this question would have been we do not know, nor do we have information with respect to scientists in other societies. The

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1 In the Matter of J. Robert Oppenheimer (Washington, D.C. U.S.G.P.O. 1954).

analysis by H.S. Hall[1] of a number of Congressional hearings in the United States concerned with the domestic control of atomic energy and the establishment of a National Science Foundation shows, among other things, that American scientists at this time were intensely committed to the values of communalism and individualism. Communalism underlay their proposals in favour of the international dissemination of scientific information; and their resistance to political control of research aims was a clear expression of individualism. We also have such historical examples as the reaction of European scientists in U.S.A. against the threat posed by Nazi Germany in 1939 and the organization of American scientists to prevent the military control of atomic energy after 1945. In both these instances scientists were in a privileged position owing to their possession of scarce and crucial skills and on both occasions their actions can conveniently be explained as being primarily concerned with defending specifically scientific values e.g. individualism, disinterestedness. A fact which supports this interpretation is the resolution of certain leading German scientists during the 1939-45 war to keep hidden the destructive potentiality of nuclear fission and to prevent the development of the atomic bomb under the Nazi regime. However, evidence such as this is highly selective and can hardly indicate conclusively the actual values of scientists. Perhaps the best kind of data available is that provided in a study by S. West of the

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1 H.S. Hall: 'Scientists and Politicians' in Barber and Hirsch: "Sociology of Science".

ideology of academic scientists[1]; its major defect is methodological in that the study is based only on 57 persons within one American university, of whom a few were sociologists and therefore strictly outside the scope of the present study. Yet despite these defects the findings remain highly relevant and probably point to certain modifications which need to be made in the ideal typical account given above of university science.

West undertook lengthy recorded interviews with members of faculty in a midwestern university selected from the departments of anatomy, biological chemistry, mathematics, physics, physiology and sociology, with particular reference to their views on freedom of research, disinterestedness, universalism, communalism, etc. Complete freedom of research i.e. unlimited choice of research problem was 'indispensable' for only 14 out of 57. The remaining 43 were more or less willing to accept restriction or direction of their area of research, though 35 of the 57 believed that freedom of research was at least, desirable. What we have, then, with respect to this value is a continuum of evaluations, with a small number of individuals willing to accept direct control by superiors but with a much larger proportion favouring individual autonomy more or less strongly. A second value studied by West was that of impartiality (disinterestedness). Respondents were asked whether facts should be described impartially without passing judgment or whether some evaluation of their consequences should be offered. Answers were distributed as follows:

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1 S. West: 'The Ideology of Academic Scientists' in <u>IRE Transactions of Engineering Management</u> June 1960.

No exceptions to principle of impartiality	19	respondents
Scientist cannot judge as scientist but can do so in other capacities	13	"
Information can be withheld	8	"
Exceptions for special cases	7	"
Consequences must always be considered	10	"

A similar distribution of responses is to be found here as in the evaluation of research freedom viz. a tendency for a larger proportion of scientists to uphold the 'classical' values of science but with a considerable number of divergences to such an extent that 10 scientists out of 57 support a view entirely opposed to that of scientific impartiality. West also investigated scientists' evaluation of free access to scientific information. Various responses were possibly in terms of different kinds of scientific information e.g. medical, industrial, defense, etc., and according to the categories of possible recipients of information e.g. dangerous persons, untrained persons, etc. Thus more than one reply was possible from each respondent to the suggestion that 'scientific' information should be accessible to all persons who wish to have it. Out of 105 replies, 22 favour unrestricted access, 28 partial access and 55 completely controlled access. In this area, then, the expected pattern of values is reversed. Only 1/5 of replies support the value of communalism in an unqualified manner. Most responses favouring restricted access to scientific information were couched in terms of national security. The most obvious explanation of this divergence from 'classical' scientific values is that increased contact with government since 1940 plus the orientation of so much research to problems of armaments and defense have habituated scientists to making an exception in relation to free access to politically relevant data. This may well be true. Yet West found no significant difference between prewar and postwar generations; if values have changed during the last two decades we might well have expected such a difference. However, it may be that prewar scientists, although initially socialized in terms of totally unlimited access to scientific data, have learned to adapt this view as a consequence of the cold war. If we compare the Fortune poll of 1948, mentioned above, with West's findings this interpretation is supported for, as we have quoted above,[1] the vast majority of scientists favoured communalism at this earlier date.

However, in this context, it is important to remember the growth rates which are characteristic of most scientific enterprises. Given that the number of scientific personnel expands exponentially with a doubling period of around fifteen years, the population of qualified scientists in the U.S. would have increased by perhaps 60% or more during the ten years which passed between the Fortune survey and that of West. If we can assume that the newcomers, who had experience only of cold-war science, predominantly endorsed values which were relevant to their actual situation i.e. a situation in which science was intimately involved with and controlled by government, then we can explain the altered values of scientists largely in terms of the influx of new men. We can accept, tentatively, that the university scientist, qua scientist,

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1 p. 34.

tends to endorse at least some of the postulated values, while recognizing that there is a considerable divergence in this respect among academic scientists and that the exponential growth rates may entail very rapid changes in the values predominant among them.

We have seen so far in this chapter that the laissez faire organization of university science persists as an ideal but that there is only partial support of those values associated with such an ideal. At this point we must examine some of the pressures which have led to modification of the values and departures from the ideal. Firstly, there is the simple fact of the growth in scale and specialization of science itself which was stressed so much in Chapter I. As associations increase in size they almost inevitably become specialized, formal and hierarchically structured.[1] Thus modern, relatively large-scale university science has tended to become bureaucratically organized and there can be little doubt that the bureaucratic imposition of a formal hierarchy of authority works against the scientific company of equals pattern and such values as individualism, communalism, and so on. In addition to this development within science of bureaucratic tendencies there have arisen a whole series of relationships with other large-scale bureaucracies, which have also worked in the direction of greater bureaucratic control. To some extent this latter situation has emerged as a result of the convergence of two sets of

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1 P. Blau: Bureaucracy in Modern Society.

factors; on the one hand science has become highly relevant to technology and on the other hand much scientific research has become extremely expensive. The need of university scientists for financial support has coincided with the need of industry and government for scientific research and development. Where industry's R & D requirements revolve around the goals of reducing costs and maximizing efficiency, those of government derive more from the aims of national security and the effective use of natural resources.[1] A great deal of such R & D is performed outside the university. But considerable research is undertaken within the university on behalf of outside agencies. As Steacie suggests above[2] sponsored research tends to diminish the previous autonomy of university science. At the same time it changes the social structure of university science in a more subtle fashion. For those scientists who have a reputation for excellence outside the scientific community can more easily gain financial support. This gives them additional authority among fellow scientists. In a study of decision-making in the physics department of an American university Marcson has investigated the effect of bureaucratic pressures upon the scientists' ideal pattern of behaviour[3]. Marcson calls the ideal pattern one of 'colleague authority'[4]; this

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1 e.g. timber and mines in Canada ...

2 See p. 30.

3 S. Marcson: Decision-Making in a University Physics Department in The American Behavioral Scientist December 1962.

4 Marcson does not deal with colleague authority specifically as an ideal pattern.

refers to a system of social control in which authority is shared by all the members of the group.

> " Authority is deemed to rest in the group rather than in an individual. In colleague authority there is delegation of decision-making authority to individuals, but the members view such authority as originating in the colleague membership."

This group structure is virtually identical with the company of equals pattern. The basic characteristic both of the company of equals pattern and of colleague authority is that authority is never attached formally to a particular position in the group. Decisions with respect to administrative procedures as well as scientific validity arise out of informal interaction between qualified individuals. This emphasis upon informal decision-making within the group has two major implications. Firstly, it implies that authority cannot be located outside the group. And it also means that the formal hierarchy of authority within the group should be minimal. In both these respects it is evident that the growth of large-scale science has brought many divergences from the ideal.

As long as universities were relatively small communities of scholars it was quite possible for them to avoid formal structure and specialized administrators. But modern universities tend to be large and 'multifunctional'; they provide for instruction of graduates as well as undergraduates, they cater for research in addition to teaching, and they operate professional schools as well as attempting to stimulate the academic search for knowledge. Within such an organization professors are unable to administrate on a part-time basis. In the same way that we have seen the development of specialization within science, so within the university the administrative role has become separated out. Thus we find an academic bureaucracy composed of registrars, bursars, deans, research administrators, and so on. These administrators are indispensable and they have taken over much academic decision-making from the teaching and research staff. As a consequence authority becomes at least in part removed from the faculty. Furthermore, the administration has a strong tendency to restrict the laissez faire attitudes of the academic scientists and to impose upon them a minimum of uniformity. Similarly within the teaching staff there is specialization and an hierarchical organization of decision-making. The professorial ranks are the locus of authority, particularly with respect to appointments and promotions.[1] Appointments and promotions tend to be awarded on grounds of teaching and research ability. Consequently these abilities have to be evaluated by the professors, not by the group as a whole. It is also true, at least in the instance studied by Marcson, that scientific competence is only one of the factors taken into account in the evaluation of the individual; equally important seems to be how the individual will influence the balance of power within the group and the distribution of rewards. We can conclude therefore that scientists form one part of the university bureaucracy and are subject to its rules; that within the science faculty there is further bureaucratic organization; and

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1 S. Marcson: op. cit.

that internal decisions are not necessarily made in terms of 'scientific' criteria.

At this point we can examine some of the implications which these trends within university science may have for the values put forward above[1] as being especially characteristic of university science. The value of universalism requires scientists to evaluate scientific work and persons on the basis of pre-established impersonal criteria. It is probably true that scientists, when judging published papers in relation to their own research, do make use of the pre-established criteria entailed by repeatable experiment, successful prediction, and so on. But we have seen that the process of evaluating individuals is complex and more personal. For instance, quantity of published material tends to be more important than its quality[2]; and quantity of research is not necessarily related to its worth. Reliance upon the criterion of quantity appears to be one of the simplifying rules of thumb which emerge in bureaucratic contexts. In addition, ability to fit into the group seems to be as crucial as the ability to teach or perform satisfactory research. Thus the criteria employed in the evaluation of individual scientists are far from impersonal. Not only does all this run counter to the value of universalism but it also departs from the value of disinterestedness i.e. the absence of emotional or personal attachment,

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1 pp. 30-31.

2 S. Marcson: op. cit.

for many aspects of the current structure of university science operate to involve the scientist personally in the results of his research. The modern scientist is faced with a formal hierarchy of prestige and income within the university. In order to ascent this hierarchy he must satisfy the requirements of those already in positions of authority. As we have seen, these requirements are often not impersonal or 'scientific' but stress quantity of research publications and personal conformity. As a consequence the scientist acquires a vested interest in satisfying these non-scientific requirements. He does not undertake disinterested research but research calculated to improve his career prospects. Furthermore, the scientist can enlarge the variety of his occupational roles immensely by reaching the professorial rank of the academic hierarchy. Once the researcher has achieved a favourable reputation within university science he can begin to act as consultant to industry and government. Thus during his academic rise the scientist is tempted to direct his work so that it will prove useful to these outside agencies. When he has attained academic eminence the scientist is likely to find that he is forced to become a research entrepreneur i.e. he will be concerned with organizing research teams, providing adequate financial support, interviewing personnel, preparing speeches, and so on. This kind of activity is quite removed from that of the academic scientist of the last century. It is mainly instrumental in character and places diminishing emphasis upon universalism and emotional detachment. The research entrepreneur is concerned with getting things done rather than extending knowledge.

The changing role of the academic scientist is unlikely to leave other 'scientific'' values unaffected. Individualism, which underlies the company of equals pattern, does not accord with bureaucratization. Where the former stresses the scientist's moral duty to follow the dictates of his own judgment the latter requires subordination to formal rules. For example, the individual scientist is not allowed to pursue that line of research which seems to him most likely to be theoretically fruitful but must submit to a whole range of decisions made by others situated above him in the formal hierarchy and better placed to know the needs of those bureaucracies equipped to supply financial support. Similarly the value of communalism is bound to suffer when so much research is instrumental rather than self-justifying. Communal knowledge is available to all scientists. But if this is the case in practise all scientists can qualify to undertake research related to this knowledge on behalf of industry and government. In contrast, knowledge which is restricted to one university gives that institution an edge in the competition for research funds. Communalism is also adversely affected by the new invisible colleges for these groups are structured around an informal communications network whereby prescripts and unpublished material generally are made available only to those within the group. In this social context the number of persons seen as qualified to benefit from highly specialized knowledge is considerably limited. This method of communicating knowledge is much less communal than the customary method of publication in specialized but nonetheless generally available journals.

When we examine university science in contemporary North America we find that the laissez faire organization of science and values such as universalism and disinterestedness survive as ideals. As ideals they undoubtedly influence behaviour. Thus most writers on the topic conclude that the university remains the most favourable setting in present-day society for uncommitted intellectual activity.[1 2] But even the sparse overview presented in this chapter demonstrates that university science is by no means made up of a company of equals. University science is rather composed of a series of increasingly bureaucratized structures, each situated within its own university bureaucracy, influenced in its behaviour patterns by its connections with the outside bureaucracies of industry and government, and internally structured in terms of a small group of influential men surrounded by a much larger group seeking qualifications and financial support. There are therefore many reasons to believe that the values of university scientists have been changing and the little empirical material available supports this contention. However, the main concern of this study is with processes of recruitment, and the question remains: What effect have these changes had upon the recruitment of scientists? We must postpone any attempt to answer this question until the role of the scientist in industry and government has been examined more closely, and the 'professionalization' of science treated in more detail.

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1 E.W.R. Steacie: op. cit.

2 L. Coser: Men of Ideas.

Chapter III: The Scientist in Industry & Government

It is only since the late 19th Century that natural science has become sufficiently systematic and inclusive to provide a basis for continuous technological development. However since that date, it has become increasingly obvious that applied science can form the basis for various kinds of national superiority in both economic and political spheres. Consequently, the great majority of scientists have come to work on research and development in relation to the needs of industry and government. There can be little doubt that the role of employee in government and industry changes the social behaviour required of a scientist compared with the role demands found in a university setting. One, at least, of the major goals of industry is that of profit, which is attained in part through efficient production of existing goods plus the introduction of new and superior products. Although this may be a crude description of the aims of industry it is sufficiently accurate to indicate that considerable incompatability could arise between the goals of scientists and those of industrial management. For the latter the extension of knowledge tends to be no more than a means to economic ends, whereas for the scientist it tends to be self-justifying. As a consequence management cannot endorse such values as communality or individualism for these may endanger their basic economic aims. Furthermore, scientists' stress upon originality, universalism and organized scepticism does not engender harmonious adjustment to an organizational hierarchy which is legitimized in terms of formal 'non-scientific'' norms. For the scientist, prestige and power are more usually derived from personal competence than from position within a formal hierarchy. This organizational divergence is also exemplified within the spheres of social control and communication. In place of control through the medium of experiment and evaluation by peers the scientist finds formal bureaucratic direction and use of economic sanctions. Instead of informal, personal contact and publication in specialized journals he is faced with formal, impersonal and instrumentally oriented directives.

Yet we must not overstate our case. In recent years certain attempts to solve this particular role conflict have been made within American industry. For example, one major chemical firm in U.S.A. has established two distinct hierarchies within research departments corresponding to the expectations of scientists oriented towards research and those favouring administrative tasks. Upon entry into the firm the young researcher is classed as a "Research Chemist". If he stays in research then the positions open to him are 'Senior Research Chemist', 'Research Associate' and 'Research Fellow'. In contrast, if the recruit rises within the sphere of research administration he becomes a 'Supervisor', 'Senior Supervisor', 'Manager' and perhaps eventually attains a seat on the Board of Directors. A basic distinction between these hierarchies is that whereas advancement within the latter inevitably entails wider responsibility and control over policy, within the former it is more an honorific recognition of papers published, quality of research, etc. 'At the same time, many scientists in industry continue to publish in academic journals. It is clear that the research hierarchy is modelled upon that of the university and that its primary aim is to provide the kind of recognition of academic worth which is normally found within the college environment but found much less frequently within an industrial bureaucracy. To some extent we have here an attempt to perpetuate the values and ideas of the university scientist e.g. recognition of worth founded upon contribution to the extension of knowledge, within an industrial milieu.

Even where this kind of modification of the industrial and governmental bureaucracy has not taken place, and it is of course very rare as yet, the situation is not quite as extreme as I have indicated above. Paula Brown, for example, in her study of a government bureaucracy[1] found that research scientists and engineers were able to resist bureaucratic direction to some considerable extent.

> " Formal work orders to the persons doing the work are rarely made. Occasionally, an order is written after the work has started."

It seems that, within this particular laboratory, assignments and fulfillment of projects emerge from a network of personal relationships among individuals who perceive themselves as 'professionals'. Many research supervisors feel that because their formal 'subordinates' are highly qualified specialists

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1 Paula Brown: 'Bureaucracy in a Government Laboratory' in Social Forces, 32 (1954).

they must be treated as equals and must be given the opportunity to solve their problems in their own way, to organize their work as it suits them best, and so on. This is very similar to the company of equals pattern which exists, at least as an ideal, within university science. However, Brown does not attempt to explain the success of this group of scientists and engineers in modifying the formal bureaucratic structure simply as a consequence of the persistence of values and role-patterns learned during their period of training. More or less explicitly, she suggests that three major factors are relevant:

1. complexity of the research and development field;
2. special competence of scientists; and
3. high prestige of scientists and engineers within American society.

It is clear that in the view of scientists within the laboratory studied by Brown, their special autonomy within the bureaucratic structure derives directly from their esoteric knowledge and their rank as professionals. They believe that administrators are unable to comprehend their technical problems and are thereby not qualified to judge the kind of social organization needed in the resolution of these problems. Their success in modifying the usual pattern of government bureaucracy has been due in part to the acceptance of these claims by the administrators, even though many of the latter are or have been active scientists, and partly a product of their crucial role in the attainment of government aims.

In discussing the scientist as an employee we have already had occasion to refer to the common tendency to define the scientist as a professional. It will be worthwhile pursuing this topic more intensively as a means of clarifying what social characteristics of scientific groups are distinctive and also of drawing attention to certain changes which it seems to me have been accumulating in recent decades.

Most analyses of the professions in North America have been phrased in functionalist terms. Within this frame of reference professional occupations are seen as characterized by three major independent variables:

a) they are service occupations i.e. oriented to the benefit of the wider society;

b) they apply a systematic body of scientific or abstruse knowledge to problems which

c) are highly relevant to certain central values of society.[1]

Professions are seen as constituting a problem of social control for society because their high degree of learned competence prevents laymen from judging their work or even setting them concrete goals. The problem of control would be less acute if professions were not so important for the realization of major social goals. A solution is provided, however, by the professions themselves which tend to institute rigid internal patterns of control:

a) a long process of socialization in techniques and values;

b) this being effected within special professional training schools;

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1 Rueschemeyer: Doctors and Lawyers - A Comment on the Theory of the Professions in Canadian Review of Sociology and Anthropology, February 1964.

c) a strong emphasis upon individual self-control and adherence to professional values;

d) informal pressures to conform applied by qualified colleagues;

e) formal pressures exerted by professional associations.

In return for this self-control professions are granted high prestige and income. However, all professions are subject to some degree to control by government and public opinion. This kind of analysis has been derived from study of a limited range of occupations which would normally be called 'professional'. In addition, the functionalist approach is not the only framework in which professions have been viewed.[1 2] Because this thesis is concerned primarily with science and only incidentally with professions in general there is no need here to consider alternative theories of the professions. Thus this section has been inserted, not as a definitive account of professional occupations, but as a means of highlighting certain recent developments in the social organization of science. For my purposes the functionalist approach to the professions simply provides a consistent model which can be applied to any occupational group and which thereby facilitates its study.

Professions are 'collectivity oriented'. They provide a middle way between laissez faire capitalism, with

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1 A.M. Carr-Saunders and P.A. Wilson: The Professions.

2 T.H. Marshall: The Recent History of Professionalism in relation to Social Structure in Citizenship and Social Class.

its reliance upon the harmony resulting from the conflict of individual interests and extreme socialism, which stresses state protection of personal rights. One aspect of the growth of professions in some modern societies lies in the transfer of the responsibility for individual welfare away from both individual and state, and into the hands of certain occupational groups which provide specialized services. If we examine the emergence of modern science e.g. in the writings of Bacon or the early history of The Royal Society, we do find great stress laid upon the role of scientists as benefactors of mankind. Yet it is clear that an ethic was evolved which emphasized the necessity of objectivity, emotional neutrality, etc. During the 18th and 19th centuries scientists were almost wholly amateurs and teachers. They were concerned with the extension of knowledge for its own sake and not with its application or consequences. Even as late as 1948, as we have noted above, the Fortune survey found this high evaluation of the disinterested search for knowledge to be widespread among American scientists. There is reason to believe that this attitude was held in even more extreme form in the U.K. and Germany. Certainly we can say that up to the end of the 19th century scientists were not collectivity oriented. They were concerned with the growth of new objective knowledge and, only secondarily, with teaching as a source of self maintenance. In all professions there are small groups directed to extending, modifying and refining their system of knowledge e.g. theologians fulfill this role among the clerical profession. However, before the 20th century virtually <u>all</u> scientists were concerned with this goal instead of applying existing knowledge for the benefit of society at large.

Science then has not been primarily collectivity oriented, it has not been undertaken as a public service. Scientists on the whole have been overwhelmingly involved with the extension of knowledge and the development of theories and conceptual schemes. And those activities tend to be carried out with a conscious intent to avoid evaluation or concern with society's use of knowledge. The functionalist theory of the professions assumes that the values of society and those of the professional community are in accord. This seems to be true, for example, of the contemporary American physician and his society. Yet it is not so evidently appropriate for either the cleric or the scientist. Furthermore, professions generally have assumed self-control through the formation of professional associations and one of the basic aims of such associations has been to help induce the convergence of the values of professionals with those of society. Although scientists have used the associational form of organization, scientific associations have tended to reinforce the values of innovation and scientific method rather than those of social responsibility and meliorism. If this is so then the functionalist model of the professions suggests that we should find that scientists have received lesser rewards, e.g. income, prestige, than other professions. It is clear that scientists have received less of these rewards in the past[1]

1 For limited evidence on Canada see B. Blishen: The Construction and Use of an Occupational Class Scale in Canadian Society eds. Blishen et al.

and this tends to support the analysis offered here.

Scientists resemble other professionals most closely in that they are concerned with a systematic body of knowledge which cannot be understood by the layman. Before 1940, although science was seen as relevant to certain central societal values, there was a fairly general assumption that this body of knowledge would continue to develop in a direction harmonious with these values. Since the explosion of the first atomic bomb this assumption has become much more precarious. Between 1940 and 1945 not only did scientists themselves become inventors, but their inventions threatened certain values, e.g. political security, survival. As a result of this dissensus between the products of scientific values and the values of society, scientists have been forced towards greater acceptance of their social responsibility and greater recognition of society's requirements. It is in terms such as this that we can begin to find an explanation of the divergence between West's study in the late 1950's and the Fortune survey in 1948 which hinted at a gradual erosion of such scientific values as communalism. Yet, despite this increase in the service orientation of science, particularly within government and industry, but also within the university, society has responded by increasing its external control especially through the mediation of the state. Insofar as science has been perceived as differing from other professions and insofar as it has been perceived as unable to control its development in the interests of society, so its autonomy and mechanisms of self control have become superceded.

With reference to the three major aspects of professional groups mentioned on page 51 we can make the following propositions:

a) Scientists have derived their position in society, like professionals in general, from their relationship to a body of systematic knowledge.

b) During much of their modern history certain groups of scientists, particularly in the universities, have not been concerned with applying this knowledge.

c) The scientific ethos has demanded that the possible relevance of scientific knowledge to society's central values be disregarded in the actual course of research.

However, developments during this century particularly with respect to points b) and c) above, make it clear that scientists have become increasingly professionalized. Although we have no figures available for Canada or U.S.A. covering the early part of the 20th century, European data suggests, as we have assumed above, that the majority of scientifically qualified persons worked in universities. In 1962, however, government employed the largest proportion of natural scientists in Canada, 48%, while industry accounted for 38% and universities and colleges absorbed only 14%.[1] If we compare these figures with those for U.S.A. we find a similar bias favouring deployment upon government research. In the early 1960's of 400,000 American scientists and

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1 Dept. of Labour: Professional Manpower Report No. 13.

engineers engaged in research and development, 280,000 i.e. 70% were employed in government-sponsored projects while the remaining 120,000 worked in industry on civilian objectives. These figures are not strictly comparable because the American statistics cover engineers as well as scientists. However, in both societies government research is clearly of overwhelming importance. More resources are devoted to government research in U.S.A. partly owing to the existence of 'space projects'. Yet the most striking divergence between the two societies in this connection is found in the manner in which government research is undertaken. The Canadian government employs directly 48% of scientists. Thus these scientists are likely to be intimately involved within the governmental bureaucracy. In contrast, although a greater proportion of U.S. scientists are concerned with government-sponsored research, much of this research is undertaken through the medium of contracts to university and private research institutes. It seems likely therefore, though there is no clear evidence to support this contention, that U.S. scientists involved in government research will be more able to retain their partial autonomy and their traditional role-behaviours. Whether or not this is correct (certainly there are many relevant factors left unconsidered). In Canada scientists in industry and government far outnumber those within the university.

The spread of scientists into industry and government has meant that scientists have become increasingly concerned with the application of existing knowledge and techniques in the furtherance of the aims of the bureaucracy in which they work and thus indirectly for the benefit of society. At the same time science has come to be perceived as highly relevant to the attainment of such major societal goals as economic growth and national security. This is an age in which an expanding technology is crucial for economic advance. Full employment and the successful implementation of Keynesian economics have meant that economic growth depends directly upon the application of scientific knowledge and technology e.g. electronics, nuclear power, etc. In addition to economic growth national security has come to rely more and more heavily upon efficient technology and scientific research and knowledge. Consequently scientists have come to play major roles in the determination of armaments and foreign policy e.g. nuclear test bans. In Canada this growing relation of science to dominant social values shows itself primarily in the high proportion of scientists employed by government: while in the U.S.A. it has created what amounts to a new scientific sub-profession, namely, that of scientific advisor.

In the U.S.A. most major government departments plus many independent bodies e.g. the Atomic Energy Commission, have part-time advisory scientific committees. Similarly the President has a Special Assistant for scientific affairs and an advisory committee under the leadership of the Special Assistant. What has emerged then during the last two decades is a whole network of scientific committees attached to the political executive. The members of these committees tend to be drawn from a select group of scientists (under 500 in number) who have not only distinguished themselves as researchers but who are also perceived as having the capacity to apply their knowledge to non-scientific problems. Scientific advisors in America are clearly a professional group. Firstly their role is based on access to and ability to apply esoteric learning. Secondly, they have a pronounced collectivity orientation. Thirdly, their actions are directly relevant to such central societal values as national security, etc. Fourthly, they are a relatively autonomous and self-selecting group. Self-selection occurs because non-scientists are not competent to choose their own technical advisors; for example, the President's Special Assistant is chosen by the President's Scientific Advisory Committee. Furthermore, although there is a hierarchy within the group, which is a kind of adumbration of the administrative hierarchy, it is not formalized and social control depends largely upon internalized standards of conduct and pressure from colleagues.

So far in this chapter I have referred to conditions in the U.S.A. to a considerable extent. This is largely because specific studies, like that of Paula Brown, have not yet been undertaken in Canada. However, a general characterization of science in Canadian industry and government can be offered which will show that, although Canada and the U.S.A differ in many respects, they do not diverge in a manner which affects my analysis. As can be seen from the figures quoted on page 56, one of the major differences is that Canada has a preponderance of natural scientists employed directly by the government, whereas a greater proportion of American research is carried out within industry. There are several reasons for this. Firstly, there is the fact that Canada remains in many ways a pioneer country and that the economies of such countries centre around primary, extractive industries such as mining, agriculture and timber. As a result, in Canada research facilities developed in agriculture and mining long before they emerged in industry generally, and in such fields, which involved the use of basic natural resources, government inevitably took a leading role in establishing R and D. A second reason for Canada's relatively underdeveloped industrial research has been the dependence of so much of Canadian industry on parent firms in the U.K. and the U.S.A. Because so many Canadian corporations are subsidiaries, most of the basic, innovating research takes place abroad and utilizes the facilities of the larger governing organization. This situation has been described as one of 'scientific colonialism'[1] and it is clear that industrial science under conditions of scientific colonialism will tend to be less creative, less autonomous, and more concerned with routine application of established scientific knowledge, than will the industrial laboratories of the more advanced nations. There is no reason to expect, therefore, that industrial

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1 E.W.R. Steacie, op, cit.

science in Canada will be less professionalized or bureaucratic than in U.S.A. However, as the largest proportion of Canadian scientists is employed by government, we must examine the structure of Canadian government science before we can be certain of the validity of this expectation.

Government science in Canada is co-ordinated in terms of two distinct principles.[1] On the one hand, there are many government departments which organize their own research. Almost all such research is applied. It is circumscribed by the requirements of the departments and in some cases the department must administer an Act of Parliament as well as cater for the needs of specific clients, e.g. farmers and miners. Once again we need have little doubt that this kind of organization is structured along the professional-bureaucratic lines described above and exemplified in the study by Paula Brown.[2] In contrast there is the National Research Council which was set up by Act of Parliament in 1916, but which is not a government department. The National Research Council is a corporate body outside the Civil Service. It has a governing board of independent, non-government scientists which can earn revenue, build its own buildings, and so on, but which reports to a Committee of the Privy Council on Scientific and Industrial Research. This latter Committee is itself composed of Ministers whose departments have to do with research or scientific affairs. In many ways the National

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1 Ibid.

2 See above, p. 49.

Research Council is similar to the system of governmental advisory committees in the U.S.,[1] although it probably has greater autonomy. In fact, the fundamental feature of the structure of the N.R.C. is that of an attempt to realise the value of scientific autonomy within the realm of government science. As evidence we can quote part of an address made in 1960 by Steacie, then President of the N.R.C., to the Special Committee on Research:

> " The fundamental feature of the administration of the Research Council ... is to make sure that the administration can never issue any instructions to scientists in connection with any technical subject whatever. This is the fundamental principle of our administration. It is the exact opposite of the administration of most government departments, where the administrative head is in charge. In fact, the scientific divisions have responsibilities to the senior director, who is an active scientist ... and all divisions report directly to me on scientific matters whenever they feel like it. It is up to the administration, which also reports to me, to make sure that things can be worked out with the scientific divisions, so that the administration act as a service to the divisions, rather than a control. The result is a highly decentralized organization."

The N.R.C. has three major goals: to advise the government on matters of science in general; to encourage 'pure' science, especially in the universities; to operate laboratories of its own. In striving to attain these ends the kind of loose-knit structure described by Steacie has emerged. As we have suggested above, it is a compromise between the ideals of science and the requirements of large-scale administration. In the absence of an intensive study we cannot be certain as

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1 See above, p. 58.

to how it operates in practice, yet there can be no doubt that organizations like the N.R.C. are somewhat removed from 'academic science' and that the movement has been in the direction of professionalism and bureaucratization.

My general conclusion with respect to the organization of science in Canadian industry and government runs as follows: Within both industry and government, which together employ around 85% of Canadian scientists, scientific research has come to take place within an increasingly bureaucratic milieu. At the same time most R and D has technological implications so that scientists have come to be primarily concerned with applying specialized knowledge for the benefit of society. In general then, Canadian science is as solidly 'professional' as that of the U.S.A.

We have seen that scientists have become increasingly professionalized within industry, government and within their more recent role of scientific advisor. There can be little doubt that these developments have had their effect upon science within the university. For example, the industrial fellowship involves the young scientist in service-oriented research at the beginning of his career. Similarly the massive predominance of government-sponsored research in the U.S.A. means that few university laboratories could subsist if they devoted their labours only to theoretically problematic areas. Although the degree to which the university scientist is caught up in the role of an employee has sometimes been emphasized,[1] there appears to persist sufficient autonomy, abstruse knowledge and service orientation to entitle him to be included under the category 'professional'. However, one important point must be stressed, namely, that it is no longer possible, at least in the U.S.A., and probably in Canada, to distinguish clearly between scientists in industry, government and university, for there is a great overlap of personnel. The situation seems to be that scientists of repute now tend to play a large variety of roles within differing spheres; for example, one man may undertake teaching and research at a university, participate in research at a private institute (perhaps an institute which the scientist himself owns), act as an advisor on several government committees, as an official within a professional association, serve on the editorial committee of a specialist journal, and even assist in the dissemination of popularized science through the mass media. One consequence of this great proliferation of roles can be seen in the recent tendency to concentrate new research institutes in the neighbourhood of those already in existence.[2] This concentration of scientists enables the government to draw upon their combined advice at short notice. It also facilitates the scientist's successful combination of his multiple roles plus the dissemination of highly specialized

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1 S. Marcson: "Decision-Making in a University Physics Department", American Behavioural Scientist (Dec., 1962).

2 e.g. the Sheridan Park Scheme outside Toronto.

information within the 'new invisible colleges'.[1] What we find, then, is a tendency for the successful scientist to play an increasing diversity of professional roles, or perhaps one major professional role with respect to a number of different clients. However, this applies only to a relatively small proportion of scientists, for the great majority of scientists perform applied research for one large-scale bureaucracy.

To conclude this short examination of scientists as professionals we can usefully rephrase our propositions with respect to the development of modern science. Modern science emerged largely outside the universities but stressing certain values, e.g. organized scepticism, communality, which were academically respectable and which became even more so over time. In due course science became established within the university and devoted itself to the extension of objective, verifiable knowledge. During this latter development the values and role behaviours stressed at the beginning of this paper, e.g. originality, universalism, became characteristic of scientific groups. However, since the late 19th century the crucial importance of research as a means to theoretical advance has increasingly been undermined as scientists have spread into industry and government, and have become predominantly concerned either with the application of existing knowledge or with the use of established theory and techniques

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1 See above, p. 20.

in the development of new technology. These changes and extensions of the scientist's role can to some extent be regarded as a professionalization of the scientist, though it must not be forgotten that the role of the younger or less successful scientist tends to approximate to that of the employee within a large bureaucracy. The role of bureaucratic employee applies not only to the less qualified scientist within industry and government, but extends to the university where the advent of massive government support has facilitated the introduction of such large scale research mechanisms as the cyclotron and, accordingly, the utilization of groups of younger prospective Ph.D's as research technicians under the control of more eminent men. However, in general we would expect that the university will retain more vestiges of academic science when compared with science in industry and government. This probability has several implications with respect to recruitment of scientists, to which we now turn more directly. The first implication is that as the university is the primary recruiting agency for scientists[1] the selection of scientists may still bear strong traces of academic science despite the marked professionalization of science. Secondly, it seems likely that the divergence between academic and professional science will make itself evident in the processes whereby scientific manpower passes from university into industry and government. I shall consider these questions more fully in subsequent chapters.

1 97% of those employed as natural scientists in Canada at January, 1962, had a university degree. Dept. of Labour, Professional Manpower Report, No. 13.

Chapter IV: The Recruitment of Scientists

Scientists must necessarily have graduated from a university.[1] As a consequence selection into the scientific sub-culture operates through the educational system in general and the university recruitment process in particular. One aspect of the educational selection process depends upon academic ability. But in addition to ability there is a whole list of specifically sociological factors which determine who will become scientists, at least in part independently of academic ability. Class and status differences have been found in all industrial societies to structure the availability of educational opportunities and thereby the chance of becoming a scientist. Relations between class and education have become increasingly well documented with respect to present day Canada. There is no need here to examine this area in any detail. It is sufficient to state in summary fashion that entrance into professions in general, and science in particular, will be influenced by such factors as differences in income, family size, geographical region, religious affiliation, and attitudes towards education,[2] so as to favour those with a middle class background. Sex status is also a crucial factor with respect to an individual's likelihood of taking up a scientific role, as are race and general cultural background. In Canada the prime example of this

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1 See note p. 66.

2 J. Porter: The Vertical Mosaic.

latter factor is found in the differential representation of English and French speaking Canadians in the higher professions including science.

Studies in America have suggested that the character of educational institutions can have a marked effect upon the production of scientists. However, later studies have thrown some doubt upon this 'institutional formation' hypothesis, indicating that self-selection has greater weight. Goodrich and Knapp[1] studied relative productivity of scientists by U.S. colleges over the period 1924-1934, using 'American Men of Science' as a source book. The main findings of this study were as follows:

1. Small liberal arts colleges were much more productive of scientists than any other type of educational institution.
2. There was considerable regional variation e.g. the Middle-West was most productive.
3. Productivity of graduates entering other professions did not follow the same pattern.
4. Highest productivity was found in institutions of moderate rather than high cost.

A similar study of Ph.D's awarded between 1946-1951 produced the following main findings:

1) Production of highly qualified scientists was confined to a small number of educational institutions, e.g. 50 institutions award around 80% of PhD's in the U.S.A.

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1 R.H. Knapp and H.B. Goodrich: Origins of American Scientist.

2 R.H. Knapp and J.J. Greenbaum: The Younger American Scholar: His Collegiate Origins.

2) Highest productivity was found in high cost institutions.

3) Universities were more productive than small colleges.

These findings are apparently conflicting in that the later study finds high cost, large, Eastern universities to be more productive of scientists than small, Mid-West, liberal arts colleges. Knapp and Greenbaum try to explain this divergence in terms of an expansion after the last war of educational demands on the part of an increasingly affluent society, an expansion which favoured the large Eastern universities. Whatever the value of this explanation, both studies concur in seeing the important factor in the production of scientists as the character of the educational institution. However, Holland[1] suggests that this 'institutional formation hypothesis' is largely mistaken and that much more attention should be paid to institutional selection or rather self-selection on the basis of ability and motivation. He selects a sample of high school students chosen by a National Merit Scholarship programme in 1955-56 and compares their 'expected' representation i.e. on the basis of numerically proportional selection, with their actual representation in the so-called high productivity colleges. Main findings:

1) Talented groups attend 'high productivity colleges' in frequencies which are three to fifteen times the expected frequencies.

2) Students attending such colleges tend to have ...

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1 John L. Holland: 'Undergraduate Origins of American Scientists' in Sociology of Science, eds. Barber & Hirsch.

fathers engaged in occupations which may generate an interest in science i.e. physical activity, scientific or social service rather than sales, persuasive supervisory, etc.

3) Students choosing high productivity institutions tend to explain their choices in terms of research opportunities and the intellectual reputation of the colleges.

There are two main drawbacks to this research for the purposes of this study. Firstly, whereas these studies are of U.S. society, I am concerned with Canada and it cannot validly be assumed as it so often is in practice, that what holds true of the U.S. applies equally to Canada. Furthermore, we have only to consider the small number of institutions in Canada which can confer higher degrees - no more than a dozen or so - compared with the United States where there are over 130 to see the difficulties facing any study in Canada along the lines initiated by Knapp and Greenbaum. Thus, any study of the Canadian system of higher education will hardly be able to compare regions without comparing individual institutions rather than groups of institutions. To distinguish regional factors from the ideosyncracies of particular colleges would, therefore, be far from easy. The second defect mentioned above refers specifically to Holland's study viz. that the explanation of why persons whose fathers had positions in manual or social service occupations, etc., should choose to become scientists is obscure. Investigations of this aspect of scientific selection need not only to probe more deeply into motivational factors but also to have a clear conceptualization of occupational choice in general.

As stated above, I have chosen to study the point of entry into the scientific community or in other words students' choice of science as opposed to other faculties when entering university. Commitment at this juncture to a given faculty is not normally regarded as final either by the student or by the university authorities. On the other hand, commitment to the general field of science tends to be more permanent than with respect to many other fields of study.[1] Furthermore, a recent survey of engineering and science graduates in Canada[2] found that the overwhelming majority intended working within the occupational sphere of 'science and engineering'; the only partial exception to this pattern being the engineers who, as in the U.S., were also interested in becoming administrators. The rather obvious point being laboured here is that choice of faculty at the moment of entry to university is also, in large measure and especially for scientists, lawyers, physicians, and other professionals, a choice of a general occupational sphere. Consequently, in studying the process of selection into science, I shall use a conceptual scheme usually associated with the problem of occupational choice.

I have already indicated certain factors which can be seen as channelling occupational choice, e.g. academic ability, education, class background, type of educational institution, race, religion, sex, cultural origins, etc.

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1 M. Rosenberg: Occupations and Values.

2 Department of Labour: After Graduation: Plans of Final Year Students in Engineering and Science, 1958-1963.

As a result of the interplay of factors such as these, only certain individuals will enter university. At the point of entry to university, some kind of choice or commitment is made which will determine, in a majority of cases, the eventual field of occupational endeavour. In addition, there is evidence to suggest that 'self-selection' into particular educational institutions may be more important than the process of institutional formation, at least in the production of eminent scientists. The problem in this chapter is to outline those factors which will determine occupational choice and sphere of study as the individual enters upon his university career.

In their so-called 'general theory of occupational choice', Ginzberg[1] and his associates have put forward the following main propositions:

1) Occupational choice is a developmental process. It is not a single decision but a series of decisions made over a period of years.
2) Each decision is related to one's experience up to that point, and in turn influences future decisions.
3) The process is largely irreversible. Basic education and other exposures can only be experienced once.
4) The process ends with a compromise, a balancing of a series of subjective elements with the opportunities

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1 E. Ginzberg et al: Occupational Choice.

4) ... and limitations of reality.

On the whole, these propositions are straightforward and unexceptionable. However, the actual process of occupational choice tends to be explained in very simple terms as the result of a person's decision in favour of an occupation, this decision being determined by values or personality needs. Becker[1] has pointed out that this model cannot explain two documented facts: the fact that occupational choices are not stable and the fact that many occupations are not so much chosen as accepted. Rosenberg[2] has shown that occupational choices do vary considerably over time and Becker and Carper[3] have demonstrated that most of their sample of physiologists had entered the field more or less by accident. Becker suggests therefore that the process whereby an individual commits himself to an occupational identity is more important than that of occupational choice and can more easily account for the two problematic items mentioned above. Without disputing the importance of 'commitment' it seems to me that some conception of 'occupational choice' remains necessary. For example, many of Becker and Carper's physiologists chose that sphere as being more closely related to medicine and therefore as being a suitable temporary pursuit while awaiting opportunities within medicine. Clearly we cannot explain the

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1 Howard S. Becker: 'An Analytical Model for Studies of the Recruitment of Scientific Manpower' in Scientific Manpower, 1958.

2 op. cit.

3 James W. Carper and Howard S. Becker: 'Adjustments to Conflicting Expectations in the Development of Identification with an Occupation' in Social Forces 36 (1957).

choice of physiology simply in terms of personality or values, but if we make our conceptions rather more sophisticated we can plausibly avoid the difficulties put forward by Becker.

Let us assume that occupational choice is determined by the following factors:

1) Occupational values
2) Image of occupation
3) Personality needs
4) Image of self
5) Selective orientation of occupation, educational institution
6) Commitment and investment.

The earlier scheme of occupational choice cannot account for instability of choice because values and personality needs must be regarded as virtual constants. But there is no reason at all why images of self and of proposed occupation should not change, especially during the period of undergraduate study. Secondly, there is the 'fortuitous' nature of certain choices. But if we return to Becker's physiologists it would appear that the new scheme can cover their situation. Most of the physiologists are would-be physicians: occupational image, occupational values, image of self. They are, however, unable to qualify to be medical students: selective orientation of occupation, image of self. Their choice therefore centers on the nearest available alternative: occupational values, image of occupation, selective orientation of occupation. As the period of time involved in specialized study of physiology lengthens, so personal investment increases in the skills of this discipline, in commitment to its values, and in recognition and internalization of the definitions of 'self' offered by others. It will be noticed that this approach is similar to that of Rosenberg in Occupations and Values. The major points of difference are:

1) Stress on 'image of occupation' which Rosenberg does little more than mention.

2) Introduction of a new category viz. image of self.

3) Introduction of an additional specifically sociological factor, viz., selective orientation of social organizations.

4) Inclusion of Becker's conceptions of commitment and investment.

At this point, it is worth examining Rosenberg's study in some detail for the light it can throw on our problem.

Rosenberg starts with the assumption that values are important determinants of occupational choice and three main value-complexes emerge out of his empirical studies:

a) People-oriented value complex: Persons with such values tend to select occupations because they provide an 'opportunity to work with people rather than things', or 'the chance of being helpful to others'. Work is evaluated by such people primarily as a source of interpersonal relations. Rosenberg found that those respondents (students) choosing natural science as an occupation were the group least likely to evaluate occupations highly on this basis. This finding is supported by that of Anne Roe[1] who suggests on the basis

1 Anne Roe: The Making of a Scientist.

of psychoanalytic study of eminent scientists, that physical scientists tend to be 'isolated individuals'. Roe's study, if taken alone, suffers from the methodological defect of being retrospective. On the other hand, the findings of Rosenberg and Roe together suggest that those people entering science are not likely to be oriented towards other people for their major satisfactions.

b) Extrinisic reward-oriented value complex: Individuals with values of this type are concerned more with rewards external to the occupations they choose. They indicate that their reasons for selecting one occupation in preference to others lies in the perceived likelihood of high income or social prestige. Rosenberg found that potential scientists were not inclined to base their choice of occupations on such factors: only those entering teaching and social work laid less emphasis upon extrinsic rewards.

c) Self-expression oriented value complex: Respondents with values of this kind choose occupations that facilitate self-expression and creativity, that allow them to be 'creative and original'. Natural science was ranked fourth in this value complex, being preceded by architecture, journalism, and art. This suggests that natural scientists are inner-directed rather than outer-directed. Support is provided by Roe's work and by the fact that there appears to be a certain harmony between the putative values of potential scientists and those of established scientific groups, e.g. individualism, originality. One aim of this present study will be to examine rather more intensively the values of potential scientists as compared with those of non-scientists and the degree of harmony demonstrated with the presumed values of university scientists.

After examining values and their place in determining occupational choice, Rosenberg turns to personality factors and particularly that of self-other attitudes, i.e. the attitudes which influence an individual's usual way of relating to other people. Rosenberg makes use of a fairly standard typology of such attitudes, and accompanying personality types, viz.,

a) compliant, i.e. concerned with social approval, support;

b) aggressive, i.e. concerned with mastery, control;

c) detached, i.e. concerned with maintaining social distance.

As we would expect, the compliant personality type tends to be occupationally oriented toward social relations, the aggressive personality towards extrinsic rewards, and the detached type toward freedom from supervision and the opportunity to be creative and original. Consequently, we can hypothesize that the scientist will not only endorse the occupational values of freedom and originality but that he will also be 'detached' in his relations with other people. Rosenberg suggests that the most satisfying interpretation of these inter-relationships is in terms of values being an expression of personality. With respect to scientists, it is plausible to conceive of them as developing during the course of their life history a mode of relating to other people which is detached, i.e. which maintains social distance. Such persons are certainly likely to develop occupational ideals which stress the need for individuality, originality, freedom from supervision, concern with things rather than people, indifference to wider social issues, and so on.

Although Rosenberg's study was not primarily concerned with scientists it has enabled us to formulate two plausible hypothesese with respect to occupational selection by potential scientists:

1. Those choosing science will tend to have occupational values which emphasize self-expression, originality and perhaps other values found to be important within scientific groups.

2. Those choosing science will tend to have detached 'self-other' attitudes.

However, this study does not indicate just which 'scientific' values are most important for potential scientists. Nor does it clarify the social image of the scientist, particularly with respect to its different perceptions by scientists and non-scientists. In addition, certain reservations are b brought to mind by a recent unpublished study of occupational choice in Canada by Robson of U.B.C. Robson, starting with the assumption that values were an important determinant of occupational choice, divided these values into two classes:

a) goal-oriented

b) instrumental.

This distinction is clearly closely akin to that used by Rosenberg. Yet, Robson did not find that persons selecting different occupations were trying to attain varying values. His conclusion was that those choosing the academic profession (the topic of his major concern) and others did not differ with respect to their occupational values. If the implication that most people are attempting to satisfy the same values holds generally, then variations in image of self and occupational images become that much more important.

At this point then we need to consider existing studies of the social image of the scientist and their relevance for our problem. In the mid-1950's, Metraux and Mead[1] studied the image of scientists held by high-school children by means of qualitative interpretation of essays written in answer to open-ended questions. e.g. 'If I were going to be a scientist, I would not like to be the kind of scientist who .... ' The investigators suggested that the image was composed of both a negative and positive aspect:

1. <u>Positive aspect of image of scientist</u>

a) highly intelligent

b) highly trained

c) devoted to his work

d) devoted to knowledge

e) devoted, not to money or self-glory, but to the benefit of mankind and national welfare

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1 Margaret Mead and Rhoda Metraux: 'The Image of the Scientist among High School Students: A Pilot Study' in <u>Sociology of Science</u>, eds. Barber & Hirsch.

2. Negative aspect of image of scientist

a) too intellectual

b) work is uninteresting, dull

c) work conditions poor and income inadequate

d) no interest in family or social aspect of life

e) irreligious

f) subject to control by government and industrial bureaucracies.

This study reveals several interesting and informative facts with respect to the scientific image. Firstly, there appears to be a generally favourable stereotype which is expected in most social situations, viz. of the scientist as a brilliant individual devoted to the extension of knowledge and the benefit of man. This was the response most frequently given in completion of the following statement:

'When I think of a scientist, I think of ...'

However, when respondents were referred by the form of the statement to the possibility of either becoming or marrying a scientist, the negative image was much more pronounced. Thus it is reasonable to conclude that the image of the scientist is opposed to certain major values which are important, at least in U.S. society, in the sphere of occupational choice. These values are likely to be high income, social relationships and those personal relationships associated with the family. Scientists tend to be perceived unfavourably with respect to these values and consequently scientists are likely to be recruited more from those who do not share these societal values or who do not endorse the general image of the scientist.

A study by Beardslee and O'Dowd[1] tends to support the findings above with respect to American college students. On the basis of intensive interviews with college students, the researchers developed a questionnaire by means of which 15 occupations, including that of scientist, could be compared in terms of a large number of variables. In summary, the findings were as follows for the scientist:

1) highly intelligent
2) individualistic
3) socially withdrawn
4) relatively unhappy home life
5) radical social outlook
6) unstable
7) moderately well off
8) devoted to his work.

This image is similar to that found by Mead and Metraux. It was also found equally prevalent among juniors, seniors and faculty members. Comparison between freshmen who intended to become scientists with those who planned to take up some other profession suggested that the former, although accepting the general contours of the scientist's image, tended to modify the more unfavourable elements, e.g. indifference to social relations.

The first and most obvious fact which has emerged in this chapter is that relevant research is scarce and can offer us few even tentative conclusions. However, we can be fairly certain that occupational choice, whether it be of science or of any other occupational sphere, is not a unit act but should rather be conceived as a developmental process which begins in childhood and which ends only with a lasting

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1 David C. Beardslee & Donald D. O'Dowd: 'The College- Student Image of the Scientist' in <u>Sociology of Science</u>, eds. Barber & Hirsch.

commitment to a secure employment. In the next two sections of this study, I will offer the findings from an empirical investigation of one part of this process, namely, that of entry into university. But before we move onto this, we can usefully summarize what we have learned so far about the recruitment of scientists and indicate the areas of major concern in this study. We know first of all that scientists are part of a select few who receive university education, and that this minority tends to be recruited disproportionately from middle class backgrounds. We would expect therefore that unless other contrary factors are at work, relatively more scientists will originate in middle class families. Furthermore since, as we have seen, cultural values appear to form an important constituent in the process of occupational choice, we can assume that anything which affects such values may have an affect upon recruitment into science. In Canada, the two major factors in this context are religious affiliation and ethnic origin. It is common knowledge that persons from an English-speaking background are highly likely to attain high status occupations in Canada.[1] However, the importance of this factor varies regionally. In British Columbia, it is not of primary significance, and will not therefore be included in the study undertaken at Simon Fraser University where no new knowledge could be gleaned even although its significance in other parts of Canada cannot be underestimated. Thus, those general sociological factors which will be examined in this study will be religious affiliation, social

1 B.B. Blishen: 'The Construction and Use of an Occupational Class Scale' in Canadian Society, eds. Blishen et al.

class origin and educational experience.

When people reach the turning-point of entry into university, I have suggested, their choice of area of study and of eventual occupation can usefully be conceived in terms of occupational values, occupational image, image of self, etc.[1] With respect to the recruitment of scientists, we have a few leads as to how these factors operate in practice. On the basis of Rosenberg's work, we would expect potential scientists to endorse self-expression oriented occupational values. Furthermore, assuming that values are an expression of certain personality traits, it seems plausible that prospective scientists may tend to be 'detached' personalities, or at least less socially active than equivalent groupings. But, for the purposes of this study, Rosenberg's typology of occupational values is no more than a crude beginning. For example, in their acceptance of self-expression oriented values, scientists appear to be similar to architects, journalists and artists. If these values are common to such diverse occupational fields, then there is need to probe more deeply into the specific values of potential scientists. We can begin this probe by searching for traces of <u>anticipatory socialization</u>. By 'anticipatory socialization' I refer to the fact that in addition to choosing an occupation in order to satisfy a value, people may 'choose' a value because they consider it appropriate for the occupational position

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1 See above p. 74.

they expect to fill in the future. Thus we can investigate whether or not prospective scientists do endorse the supposed values of mature scientists, on the assumption that this is relevant to the recruitment process.

In addition to general sociological factors, occupational values, personality, and anticipatory socialization, we have noted above that occupational image and self image may also be determinants of occupational choice. With respect to image of self, we have no prior information with respect to scientists on which to base our study. However, there has been some research on the social image of the scientist[1] which has revealed that this image stresses the scientist's intelligence, devotion to his work, social withdrawal or inadequacy, irreligion, moderate financial position, and so on. We would expect there to be a convergence among the potential scientist's occupational values, image of the scientist and self-image. For example, if he regards intellectual activity as intrinsically good, then he ought to perceive the scientist generally and himself particularly as being intellectually gifted. Similarly, if we find that prospective scientists do not value social relationships or income highly, then we should find that they do not emphasize these aspects in connection with their own self-image or their image of the mature scientist.

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1 See above pp. 79-81.

Chapter V: Outline of the Simon Fraser University Study

In the early months of 1966, a small scale investigation was made of the recruitment of potential scientists into Simon Fraser University. This study took the form of a postal questionnaire survey of a one in four random sample of males at S.F.U. At that time, no student had been at S.F.U. for more than one semester. The response rate for the survey was sixty-one percent: any tentative conclusions drawn from this research must be subject to the limitations implied by a non-response rate of thirty-nine percent. No attempt was made to include females within the survey, partly because so few women become scientists in North America, and partly because any fruitful treatment of the topic would have made this thesis too long. The aim of the survey was to gather responses relevant to occupational recruitment from two groups within the population of first-year undergraduate students, viz. those studying the natural sciences and those studying the humanities, etc., and to compare these responses so as to reveal whether the two groups differed in any significant respects. Any differences were to be evaluated in the light of the suggestions put forward so far. A copy of the questionnaire used in this investigation is given on the next five pages.

Where you are given a choice of alternatives, please indicate your answer by putting a circle around the figure next to the appropriate choice. For example, Catholics would circle 1 in question number one and Anglicans would circle 2.

1. Indicate which religious group you belong to:

    1. Catholic
    2. Anglican
    3. Other Protestant (please state)
    4. Other (please state)
    5. No religion

2. In which of these five groups do you consider your family to be?

    1. Upper middle class
    2. Middle class
    3. Lower middle class
    4. Working class
    5. Lower class

3. Within which of the following occupational groupings would you say your father's occupation falls (or fell)?

    1. Management
    2. Own Business
    3. Profession (please state which)
    4. Skilled manual work
    5. Unskilled labour
    6. Public service, e.g. police, busdriver, etc.
    7. Clerical
    8. Sales
    9. Other (please state)

4. Give a short description of your father's present job.

5. Did either of your parents graduate from a university?

    1. Father only
    2. Mother only
    3. Both
    4. Neither

6. If you could have voted at the last election (Nov. 1965), for which party would you have voted, assuming there had been candidates for all parties?

    1. Social Credit
    2. New Democratic Party
    3. Liberals
    4. Progressive Conservatives
    5. Communist
    6. Abstain

7. In which of the following broad academic areas will you be most likely to major?

   1. Natural sciences, e.g. physics, biology, chemistry, etc.
   2. Social sciences, e.g. economics, anthropology, etc.
   3. Humanities, e.g. English, History, etc.
   4. Education
   5. Other (please state)

8. Give a brief account of those factors which have been most influential in leading you to choose this area of study e.g. parents, teachers, own values, intellectual interest, etc.

9. Below are listed some of the requirements which students have said would have to characterize their IDEAL JOB or PROFESSION. As you read the list, consider to what extent an occupation would have to satisfy each of the requirements before you consider it IDEAL.

   Indicate your opinion by circling the figures next to the three requirements which you consider most important for yourself.

   1. Provide an opportunity to use my special abilities and aptitudes.
   2. Allow me to think and behave in a rational manner.
   3. Give me an opportunity to work with people rather than things.
   4. Give me social recognition and prestige.
   5. Allow me to do something creative.
   6. Give me a chance to exercise leadership.
   7. Provide me with an opportunity to be helpful to others.
   8. Permit me to avoid emotional involvement.
   9. Give me the chance to earn a good deal of money.
   10. Leave me relatively free of supervision by others.
   11. Give me a chance to help extend human knowledge.

10. If you had your choice which of the following would you like to be? (Choose only one)

  1. Independent
  2. Successful
  3. Well liked

11. We are interested in the ideas students have of certain occupations. Below are listed certain characteristics which we would like you to apply to NATURAL SCIENTISTS. On each line you will find two adjectives which are opposites, e.g. well paid and badly paid. Thus if you think that scientists are very well paid you should circle figure 3 on the left hand side of the first line. If you think that scientists tend to be slightly badly paid you should circle figure 1 on the right hand side of the first line. All the following lines should be completed in a similar fashion.

	Very	Quite	Slightly	Neither	Slightly	Quite	Very	
Well paid	3	2	1	0	1	2	3	Badly paid
Intelligent	3	2	1	0	1	2	3	Unintelligent
Religious	3	2	1	0	1	2	3	Irreligious
Interested in people	3	2	1	0	1	2	3	Not interested in people
Hard to convince	3	2	1	0	1	2	3	Easy to convince
Devoted to their work	3	2	1	0	1	2	3	Bored with their work
Indifferent to money	3	2	1	0	1	2	3	Concerned with money
Competitive	3	2	1	0	1	2	3	Uncompetitive
Rational	3	2	1	0	1	2	3	Irrational
Concerned with benefit of mankind	3	2	1	0	1	2	3	Unconcerned with benefit of mankind

12. List any clubs and societies to which you belonged at high school and any official positions held.

13. List any clubs and societies you have joined at S.F.U. and any official positions held.

14. How important is it for you to be well liked by different kinds of people?

    1. Very important
    2. Fairly important
    3. Fairly unimportant
    4. Very unimportant

15. Which of the following kinds of educational institutions did you attend?

    1. Church-supported high school
    2. Other independent high school
    3. Public high school

16. Have you attended any other university? (please state which)

17. Should a scientist withhold a discovery from the world when convinced that it would produce more evil than good?

    1. Yes
    2. No.
    3. Don't know

18. Should scientific knowledge discovered in Canada be passed on to all other countries?

    1. Yes
    2. No
    3. Don't know

19. Which of the following two goals do you think scientists should be most concerned with?

    1. Developing new knowledge for its own sake?
    2. Helping mankind achieve a better life?

20. People tend to be more gifted with respect to some abilities than others. Do you think you are most gifted intellectually, or with respect to personal relationships, or leadership ability, or artistic creativity?

    1. Intellectually
    2. Personal relationships
    3. Leadership
    4. Artistic creativity
    5. Other (please state)

21. In which of these areas do you think you are least gifted?

    1. Intellectually
    2. Personal relationships
    3. Leadership
    4. Artistic creativity
    5. Other (please state)

22. Assuming that you graduate successfully from S.F.U. which one of the following occupations do you at present think you would like to enter?

1. School Teacher
2. Physician
3. Lawyer
4. Scientist in industry
5. Scientist in government
6. University scientist
7. Engineer
8. Architect
9. University Professor (excluding Science)
10. Business management
11. Social Services, e.g. social worker
12. Accountant
13. Self-employed (business)
14. Commercial
15. Government Administrator
16. Politician
17. Other (please state)

At this point, an explicit statement must be made about the differences to be expected when comparing the responses of potential scientists and non-scientists. This is difficult however, in view of the fact that the organization of science in Canada is still to some extent undergoing the transition from academic to professional science. I have claimed in Chapters I to III that on the whole, science has become bureaucratized and professionalized but that university science, which plays a major role in the process of recruitment, retains considerable vestiges of 'academic' values and organization. If Canadian science has become 'professional' we would expect its recruitment process to diverge in no significant way from that of other professions and occupations which recruit primarily from the university. The degree of 'professionalization' of recruitment into science can be tested, therefore, by formulating a series of hypotheses based on the assumption that science is organized along 'academic' lines. To the extent that these hypotheses were validated it could be assumed that the process of recruitment was that characteristic of an academically organized science. To the extent that these hypotheses were not confirmed it could be assumed that the recruitment of scientists was probably much the same as that of any other professional group, at least with respect to entry into university. However the study undertaken at S.F.U. can be no more than exploratory. Research specifically into the recruitment of scientists is scarce in the U.S. and, to my knowledge, non-existent in Canada. It would be presumptuous, therefore, to formulate precise hypotheses in this study, particularly owing to the very limited scope of a sample survey within one small university. Consequently I shall do no more than describe in general terms what the survey was expected to reveal. Detailed discussion will be deferred until Chapter VI.

The questions contained in the questionnaire can be divided into two main groups depending upon the area which they were intended to investigate. Certain questions were concerned with what might be called general sociological variables such as social class, educational background, and religious and political affiliation. However, the majority of questions were concerned with investigating those factors put forward on page seventy-four as determining occupational choice. Existing studies of the social class origins of scientists are few in number and without convincing conclusions. Work by Knapp and Goodrich suggests that scientists may originate more frequently in 'lower' than in 'higher' socio-economic groups.[1] In contrast, the implications of a study by Holland are that socio-economic origin is not a primary factor in the recruitment of scientists, at least of those scientists who achieve some level of distinction.[2] There was no reason, therefore, to expect scientists to have

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1 R.H. Knapp and H.B. Goodrich: Origins of American Scientists.

2 J.L. Holland: Undergraduate Origins of American Scientists in Sociology of Science, eds. B. Barber and W. Hirsch.

a class background distinct from other would-be professionals. Similar reasoning applies to the educational experience of scientists and their political and religious affiliations. Although no specific differences were to be expected in relation to these factors it was worth including them in a survey which was essentially exploratory.

Much more specific expectations were available in relation to such factors as occupational values, personality, etc. Question No. 9 attempted to probe occupational values on the assumption that scientists would endorse self-expression oriented values and values associated with scientific groups to a greater extent than would non-scientists. Questions 17, 18 and 19 were designed to measure acceptance of specific scientific values such as emotional neutrality. Again it was assumed that potential scientists would be more favourable to such values than non-scientists. Certain questions were also included to examine personality, on the assumption that more scientists would be 'detached' personality types and/or would show a lesser interest in social activities. In the questions on self-image and image of the scientist (11, 20 and 21), it was expected that those elements characteristic of academic science would be stressed namely, intellectuality, devotion to work, scepticism, and so on.

In general these expectations have been founded on the assumption that the natural scientist is a 'special' type of person able to derive a specific emotional and intellectual satisfaction from a life of isolated intellectual creativity; a life characterized by the distinct and interrelated values, and social and self-images of academic science. However, the main argument in the earlier part of this study was that as the academic organization of science comes to predominate, these peculiarities in the recruitment process will have been lessened, although probably not eliminated owing to the persistance of 'academic' elements within university science. If this analysis of professional science is correct we would expect to find few major differences between potential scientists and non-scientists. However, the small differences found should be consistently in the hypothesized direction as a consequence of the 'academic' organization of university science. One further point must be made here. The small differences between recruitment of scientists and non-scientists will be largely due to those persons oriented towards university science. We would expect, therefore, that such persons would remain within the university while the rest of the scientists tended to move out into employment in industry and government. This will be discussed more fully in the concluding chapter.

Chapter VI: Findings of the Simon Fraser University Study

The findings of the S.F.U. study in relation to general sociological variables are almost entirely negative; that is, potential scientists and non-scientists in the sample of students studied have much the same class background, educational experience, religious affiliations, and political views. Consequently, I have devoted little space to discussion of these variables and severable statistical tables have been relegated without comment to an appendix. In contrast, there are a number of interesting and statistically significant[1] differences between the two groups (scientists and non-scientists) with respect to occupational values, image of self, image of the scientist, and so on, and the discussion of these results is therefore rather more detailed.

Social Class Origins

On page ninety-two I suggested that existing work on the social class origins of scientists gave no grounds for formulating specific expectations in the S.F.U. study. On the basis of past research we could expect to find no differences in socio-economic background between prospective scientists and non-scientists. If tables 4 and 5 are examined it will be seen that no significant differences emerged. This remains so whether social class is measured 'subjectively'

1 Unless otherwise stated statistical significance was examined by use of the X^2 test. The test was used in all cases to reveal whether or not there was evidence of an association between the variable in question and membership of the two groupings i.e. scientists and non-scientists.

in terms of the respondents' perception of their own class position, or within the more 'objective' framework of the Blishen occupational class scale for Canada.

Table 4. Perception of Social Class (question 2)

	Scientists %		Non-scientists %	
Upper middle class	14		17	
Middle class	52		45	
Lower middle class	17		13	
Working class	16		24	
Lower class	1		1	
	100	N=77	100	N=161

X^2 test not significant at 95% level of confidence.

Table 5. Objective Social Class (questions 3 and 4)

		Scientists %		Non-scientists %	
Blishen social	1	6		9	
class category	2	43		37	
	3	10		15	
	4	13		11	
	5	17		21	
	6	8		6	
	7	3		1	
		100	N=77	100	N=157

X^2 test not significant at 95% level of confidence.

We must infer that socio-economic background is not an important determinant of whether university entrants will choose a scientific or non-scientific educational programme.

On the other hand, if this survey is at all representative, it is evident that the vast majority of scientists in Canada will be of middle class origins.[1] Over 70% of scientists were placed in the first four categories of the Blishen scale and over 80% identified themselves as being lower middle class or above. Some idea of the unrepresentativeness of this distribution can be gained by comparing Tables 4 and 5 with Table 6, for the latter table gives the percentage distribution of all occupations[2] in 1951. Expansion of service occupations since that date would tend to increase the proportion of middle class occupations but differential class birth rates would tend to increase the proportion of persons in the lower categories.

Table 6. Percentage Distribution of Occupations in Canada in 1951[3]

		%	
Blishen class	1	2.0	
	2	14.3	
	3	9.6	
	4	7.0	32.9
	5	32.9	
	6	24.4	
	7	8.7	

Source: Canadian Society eds. Blishen, Naegele, et al.

1 See G. Bancroft: Some Sociological Considerations on Education in Canada in Canadian Education and Research Digest Vol. 4, No. 1, March 1964. The implication of this article is that the situation at other Canadian universities is much the same as that at S.F.U.

2 Occupations but not persons.

3 Table 6 adds up to only 98.9 percent.

Although none of these figures are precise they are sufficiently accurate for my purposes. They serve to document the fact that professions in general, and science in particular, draw their recruits through the university overwhelmingly from middle class families. The practical implication here is self-evident. Canada has recently begun an attempt to stimulate its indigenous scientific research and development[1] and to move away from its position as possibly the lowest investor in research and development of any industrialized country of equivalent size and economic maturity.[2] This attempt cannot succeed without a great acceleration in the production of qualified scientists. To some extent the aim of accelerated production of scientists can be achieved by offering higher rewards, in terms of money and recognition, to those middle class adolescents who intend to become professionals of one kind or another. There is some evidence in this study to suggest that knowledge of the existence of expanding opportunities in science and technology is filtering through to the university entrant. For example, some of the potential scientists replied along the following lines when asked which factors had been most influential in leading them to choose their area of study:

> "I wish to be part of the growing industry of computers ... because of the challenges, opportunity, the dynamic nature of the industry in general."
> "The economy will demand more in the direction of science."

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1 e.g. The Sheridan Park scheme.

2 In Britain the government finances industrial research at the rate of sixty-seven cents per $100 of G.N.P., in France thirty-nine cents, in Sweden thirty-seven cents and in Canada six cents per $100 of G.N.P.

However, despite the possibility of expanding scientific manpower by drawing upon persons of middle class origin, the greatest reservoir of scientific talent lies among the families of lower socio-economic position. This latter source can be tapped only by recourse to greater government intervention in the process of educational selection, probably along the lines of more extensive financial assistance for poor students.

Educational Background

Some information with respect to the educational background of respondents in the S.F.U. study can be gleaned from Tables 7 and 8.

Table 7. University Graduation of Parents (question 5)

	Scientists %		Non-scientists %	
Father only	7		9	
Mother only	1		4	
Both parents	5		4	
Neither	87		83	
	100	N=77	100	N=162

X^2 test not significant at 95% level of confidence.

This table informs us of the proportion of parents who have completed a university education. Two facts stand out. Firstly, there is no significant difference between scientists and non-scientists. Secondly, in the great majority of instances, neither parent graduated from a university. This latter finding has a certain general interest in view of the fact that the Blishen occupational scale, on which the respondents' families were placed so highly, was computed on the basis of the average income and average number of years schooling associated with specific occupational categories. If parental education so seldom includes university graduation it would seem that class position was derived primarily from income. In the last generation attainment or maintenance of a middle class position seems to have been achieved largely through activity directly within the occupational sphere. For the present generation education, and particularly university graduation, is more important. This is a trend which has been documented in several industrial societies and which applies to many occupations in addition to those in the field of science and technology. However, we do find a significant difference between scientists and non-scientists when we examine the educational background of the respondents themselves. No difference is to be found with respect to the type of high school attended; neither independent nor public high schools seem to have a distinct advantage in the production of scientists. (Table 26. app.). But non-scientists do appear to be significantly more mobile at the university level, for 10% more non-scientists than scientists had attended at least one university other than S.F.U.

Table 8. Attendance at Other Universities (Question 16)

	Scientists %		Non-scientists %	
Yes	9	(7)	19	(30)
No	91	(69)	81	(125)
	100	N=76	100	N=155

X^2 test significant at 95% level of confidence.

It would be rash to place too much emphasis upon this divergence between the two groups which may, despite our being 95% certain of its significance, be no more than a chance fluctuation. Furthermore, it might well be no more than evidence of a strict admittance policy with respect to scientists at S.F.U., or some similar factor. On the other hand, it would accord more closely with other studies if we regarded this difference as being one aspect of a kind of 'intellectual parochialism' which is currently demanded of the scientist during his period of training. Rosenberg[1] found that natural science had a relatively low 'index of changeability', i.e. once an individual had chosen natural science as an occupational sphere and had begun the necessary training there was a relatively low likelihood that occupational choice would be transferred to a realm outside that of natural science. He attempts to explain this phenomenon in terms of intellectual and social <u>involvement</u> in the field and in terms of <u>investment</u> of time and energy in a <u>specialized</u> course of study. It seems to me that the degree of specialization is the primary factor, for involvement and investment may be just as extreme in fields which have a

1 op. cit.

much higher rate of change of occupational choice, e.g. social work. What prevents people from altering their occupational choice is involvement and investment in fields the skills of which have little transfer value, and it appears probable that the skills learned within science and technology are less transferable than those absorbed in a study of the humanities. It is being suggested here, then, that not only does this involvement and investment in specialized skills lower the tendency to alter occupational choice, but also perhaps the tendency to change educational institutions. It may be that a belief in the value of diversity of educational experience retains some hold upon a larger minority of those studying the humanities than those studying science, and that this is a consequence of the degree of specialization of skills entailed by the two intellectual areas. It must be emphasized that this interpretation is very tentative and is little more than a suggestion for further investigation. Such an investigation could take the form, for example, of an examination of the 'educational mobility' of three groups of occupations:

a) those with very low indices of changeability, e.g. medicine, engineering, architecture.

b) those with medium indices, e.g. natural science, teaching, law.

c) those with very high indices of changeability, e.g. advertising, social work, business.

The practical implications of this kind of study are perhaps a little vague, but are nevertheless important. For example, it may be that at a time when those with a scientific-technological background are achieving greater influence upon national policy making such persons are being forced into an increasingly restricted educational experience.

Endorsement of 'Scientific Values'

In the questionnaire used in the S.F.U. study questions 17, 18 and 19 (listed below), were designed to examine whether potential scientists expressed greater approval of certain putative 'scientific' values than did those who were potentially non-scientists. It was assumed that, if the acceptance of specific values was relevant to selection into science, then potential scientists would tend to display, as a group, a relative bias in favour of the values held by mature scientists.

17. Should a scientist withhold a discovery from the world when convinced that it would produce more evil than good?

It was assumed that any person who indicated 'no' to this question would be supporting the value of disinterestedness[1], i.e. the absence of emotional attachment in the search for knowledge. In 1948 exactly this question was put before a sample of American Ph.D's in the natural sciences[2] and eighty percent proposed that such a discovery should never be withheld.

Table 10. Whether or not Scientists should Withhold Evil Discovery (question 17)

	Scientists %		Non-scientists %	
Yes	45		41	
No	41		45	
Don't know	14		14	
	100	N=76	100	N=159

X^2 test not significant at 95% level of significance.

1 See p. 30 above.

2 See p. 34 above.

Reference to Table 10 will show that only forty-one percent of scientists in this study indicated approval of emotional or moral detachment while forty-five percent gave an entirely opposite answer. Furthermore, there is clearly no significant difference between the two groups.

18. Should scientific knowledge discovered in Canada be passed on to all other countries?

Question 18 was designed to examine the value of communalism i.e. that all scientists have a right to share in existing knowledge[1]. Table 11 shows that over eighty percent of scientists endorsed this value but that, again, there was no significant difference between their response rate and that of the non-scientists.

Table 11. Whether or not Scientific Knowledge should be Shared Internationally (question 18)

	Scientists %		Non-scientists %	
Yes	81		76	
No	10		13	
Don't know	9		11	
	100	N=77	100	N=159

X^2 test not significant at 95% level of confidence.

19. Which of the following two goals do you think scientists should be most concerned with?

    1. Developing new knowledge for its own sake?
    2. Helping mankind achieve a better life?

This question was to some extent a check on the emotional attachment or intellectual detachment dimension probed by question 17, and also an attempt to measure concern with

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1 See p. 30 above.

what has often been supposed to be the major goal of scientific activity, at least of pure science, namely the extension of valid knowledge for its own sake[1].

Table 12. Perception of Primary Goal of Science (question 19)

	Scientists %		Non-scientists %	
Developing new knowledge for its own sake	19		14	
Helping mankind achieve a better life	81		86	
	100	N=74	100	N=160

X^2 test not significant at 95% level of confidence.

It can be seen that over eighty percent of potential scientists as well as non-scientists agreed that scientists should be primarily concerned with helping mankind achieve a better life. This finding is clearly contrary to what we would expect on the basis of Rosenberg's investigation in which potential scientists were found to stress 'instrumental' values much less than those centering around the intrinsic satisfaction of occupational activity, although it may be that such general questions as this are seen in an entirely different context from those concerned specifically with occupational choice.

In connection with two of the three questions considered so far differences in response rates are in the

1 e.g. Shepard op. cit.

expected direction. Yet these differences are small and are not statistically significant at the 95% level of confidence. Thus in general we can say that at the point of entry to the university, the scientists in this sample were probably no more likely than non-scientists to endorse these supposed scientific values of disinterestedness, communalism or the intrinsic value of scientific knowledge. Whether this is due to a change in the values of mature scientists towards convergence with those of other professions or whether it is due to the importance of the socialization process within the university, we are in no position to say with any certainty. On the one hand, it may be that potential scientists do endorse the values of their mature predecessors but that the values of scientists are those generally held among professionals. On the other hand, it may be that scientific values do diverge from those of other professionals in the expected direction, that the process of socialization within the university inculcates these values upon the neophytes, and that acceptance of such values is not an important aspect of the process of recruitment into science.

Occupational Values

In addition to agreement with relatively general values such as disinterestedness and so on, it was suggested above[1] that endorsement of specific occupational values was an important factor in determining occupational choice. The

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1 See p. 75 above.

rationale underlying this assumption is that when selecting out a specific occupation we have particular goals in mind which we imagine can be attained through entry into this occupational sphere. Rosenberg found[1] three groups of values relevant to choice of occupation: the people-oriented, the extrinsic reward-oriented, and the self-expression-oriented value complexes. He also discovered that potential scientists ranked the first two sets of values very low in relevance to their choice of occupation and the third group very high. In question number 9 of the S.F.U. study an attempt was made to investigate this same area once more, using Rosenberg's work as a basis but adding certain possible occupational values which were selected from other studies on the values of mature scientists.[2] Table 13 shows the results of this question in terms of percentages and crude response rates. As a test of the statistical significance of the differences of response rate between scientists and non-scientists the questions posed were divided into two groups. Questions included in group A were those which scientists were expected to check more frequently and those included in group B were expected to draw the attention of non-scientists to a greater extent. In general these expectations were borne out though response rates were not uniformly in the direction anticipated. The X^2 test of association was not applied to questions taken individually but to

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1 See p. 75 above for a fuller discussion of these value complexes.

2 See p. 30 above.

the two groups and was found to be highly significant at well above the 99% level of confidence. Spearman's rank correlation coefficient for the two lists of responses was +0.4 suggesting that, although there is a positive relationship between the ranking of occupational values by scientists and non-scientists, this relationship is only of moderate strength.

Table 13. Occupational Values (question 9)

		Scientists %		Non-scientists %	
Group A.					
Requirement 1.	Opportunity to use special aptitudes	20.5	(46)	15	(72)
Requirement 2.	Opportunity to behave rationally	12.5	(29)	8	(37)
Requirement 5	Opportunity to be creative	10	(23)	8	(37)
Requirement 8.	Avoidance of emotional involvement	-	-	1	(5)
Requirement 10.	Freedom from supervision	12	(28)	13	(60)
Requirement 11.	Opportunity to extend human knowledge	14	(32)	6	(30)
Group B.					
Requirement 3.	Opportunity to work with people	3	(6)	15	(71)
Requirement 4.	Social Recognition	4	(8)	4	(20)
Requirement 6.	Exercise of leadership	3	(7)	7	(34)
Requirement 7.	Chance to help others	6	(14)	12	(55)
Requirement 9.	Chance to earn money	15	(33)	11	(51)
		100	N=226*	100	N=472*

* more than one response required of each respondent.
X^2 test applied using Group A as one unit and Group B as one unit: test significant at 99% level of confidence.

Spearman's rank correlation coefficient P = +0.4

There is good evidence to believe, then, that potential scientists and non-scientists do diverge with respect to their occupational values. However, this value divergence can only be interpreted meaningfully after a discussion of response rates to the individual questions.

Question number 9 listed eleven possible requirements of which students were asked to indicate three as characterizing their ideal job. This question is reproduced below.

> Below are listed some of the requirements which students have said would have to characterize their IDEAL JOB or PROFESSION. As you read the list, consider to what extent an occupation would have to satisfy each of the requirements before you consider it IDEAL.
>
> Indicate your opinion by circling the figures next to the three requirements which you consider most important for yourself.
>
> 1. Provide an opportunity to use my special abilities and aptitudes.
> 2. Allow me to think and behave in a rational manner.
> 3. Give me an opportunity to work with people rather than things.
> 4. Give me social recognition and prestige.
> 5. Allow me to do something creative.
> 6. Give me a chance to exercise leadership.
> 7. Provide me with an opportunity to be helpful to others.
> 8. Permit me to avoid emotional involvement.
> 9. Give me the chance to earn a good deal of money.
> 10. Leave me relatively free of supervision by others.
> 11. Give me a chance to help extend human knowledge.

Requirement number 1 was taken directly from Rosenberg's study where it had been included within the self-expression-oriented value complex. As can be seen from Table 13 this ideal requirement was checked most frequently of all by scientists and somewhat more frequently than by non-scientists. This was in accordance with our expectations. Occupational requirement number 2 was based on the supposed high evaluation by scientists of rationality.[1] As expected a greater proportion of scientists than non-scientists indicated that the opportunity to think and behave rationally was an important characteristic of their ideal occupation. Rosenberg again provided requirement number 3, that of being able to work with people rather than things. This ideal had in Rosenberg's study been very little stressed by scientists and similarly in the S.F.U. study only three percent of scientists' responses indicated this choice as compared to fifteen percent of non-scientists' responses, thereby providing the largest divergence found in this question on occupational values. Requirement number 4, that of social recognition and prestige, was expected to be of little importance to scientists for it was one of the major elements in Rosenberg's extrinsic-reward-oriented value complex which had been endorsed minimally by scientists. This expectation was fulfilled; only four percent of scientists' responses indicated that recognition and prestige were important aspects of their ideal occupation. However, exactly the same proportion of non-scientists' responses were allocated to this requirement. Thus there is no evidence here that prospective scientists and other potential professionals differ in this respect. Item number 5 is concerned with the opportunity to be creative as an aspect of the respondents' ideal job. The difference between the two groups was in the expected direction, i.e. in favour of the scientists, but was in fact quite small viz. ten percent compared with eight percent. Requirement number 6 stressing opportunities for

1 See p. 30 above.

leadership was, as expected on the basis of Rosenberg's work, biased in favour of responses from non-scientists. Similarly item number 7 provided evidence along the lines anticipated, namely that considerably more non-scientists than scientists would prefer their jobs to supply opportunities for helping others. This finding accords with the slight tendency among scientists, discussed above,[1] to be more concerned with knowledge for its own sake than helping mankind achieve a better life. Requirement number 8 was based upon the expectation that potential scientists might favour the value of disinterestedness more than non-scientists and that they might tend to be persons wishing to avoid emotional attachments. If we can assume that this question did in fact probe this specific value then there is absolutely no evidence to support the initial contention. Neither potential scientists nor non-scientists appear to be at all anxious to avoid emotional attachments during the course of their intended professions. In contrast, both groups are in favour of deriving a good income from their professions (requirement number 9). Whereas Rosenberg included the desire for income within the extrinsic reward-oriented value complex and found that scientists were not, on the whole so oriented, in the S.F.U. study the desire for income was the second most favoured response of scientists, who stressed this element more than did non-scientists. Item number 10 was directed towards the 'scientific' value of individualism[2]. Table 13 provides no reason to suppose

1 See p. 105 above.

2 See p. 31 above.

that potential scientists are more emphatically individualists than non-scientists in relation to their occupational contexts. Finally, there is requirement number 11, the responses to which indicate, as has been proposed already, that scientists are more likely to be pursuing an opportunity to extend human knowledge.

The data gathered under question number 9 and listed in Table 13 is complex and its diverse implications are not easily summarized. Several points, however, do emerge clearly. Firstly, scientists do appear to have a bias in favour of those occupational values which Rosenberg calls self-expression-oriented (requirements 1 and 5). Secondly, scientists do not endorse people-oriented occupational values to any great extent (requirements 3 and 7). Thirdly, with respect to extrinsic reward-oriented values, scientists appear to make significant discriminations. Emphasis upon opportunities for leadership and for social recognition and prestige is minimal, and there is little divergence in rates of response between the two groups. However, acquisition of money is a primary value for both groups and ranks even higher among scientists than non-scientists (requirements 4, 6 and 9). Fourthly, while certain so-called scientific values do appear to be more frequently approved among scientists viz. rationality and extension of human knowledge, others appear to be held uniformly throughout the sample population viz. individualism, disinterestedness (requirements 2 and 11; requirements 10 and 8). In summary we can say that, on the basis of the S.F.U. study, occupational values of potential scientists show clear evidence of diverging from those of non-scientists in favour of values of self-expression and in favour of certain values thought to be characteristic of mature scientists. Negatively scientists show a bias against people-oriented values. Finally scientists do not appear to place low emphasis upon income as an occupational goal.

Personality

In his study of occupations and values Rosenberg sees values and personality as being related in the following way:

> ... our argument is that the selection of certain occupational values is partly an expression of certain personality characteristics which are not in themselves values.[1]

He concentrates in his study of personality upon 'self-other' attitudes, i.e. upon the ways in which an individual relates himself to others, and makes use of a three-fold typology of personalities derived from Karen Horney; namely the compliant type, the aggressive type and the detached type. Rosenberg claims that each of these three personality types finds expression in the three kinds of occupational values. Thus scientists are seen as primarily detached personalities, they try to avoid social contact with other persons, and this gives rise to their occupational values which stress concern with intellectual and creative processes rather than with people.[2]

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1 M. Rosenberg, op. cit. p. 41.

2 See above pp. 76-78.

We have seen already that Rosenberg's account of potential scientists' values, although perhaps somewhat oversimplified is not without support from the S.F.U. study. However, the investigation of the personality dimension in this study provides only very tentative vindication of Rosenberg's claims.[1] I did not feel justified in the kind of pre-coded, postal survey undertaken at S.F.U. in attempting any meaningful analysis of personality for this requires much more an 'approach in depth'. What I did, therefore, was to include certain questions used by Rosenberg as indices of personality type but to add two questions concerned with the behavioral implications of personality. More specifically, it was assumed that if scientists were characterized by detached personalities they would indulge in social activities rather less frequently than those personalities oriented towards interpersonal relationships. Thus some indication of the required dimension of personality could be gained by gathering information on membership of and participation in clubs and societies. Reference to Tables 14 and 15 will show that the questions designed to examine personality dimensions directly produced no significant differences between the two groups.

Table 14. Importance of Being Well Liked (question 14)

	Scientists %		Non-scientists %	
Very important	12		19	
Fairly important	61		59	
Fairly unimportant	23		19	
Very unimportant	4		3	
	100	N=77	100	N=158

X^2 test not significant at 95% level of confidence.

1 These reservations apply equally to the findings of Anne Roe mentioned above p. 75.

Table 15. Proportions Choosing to be Independent, Successful or Well-Liked (question 10)

	Scientists %	Non-scientists %
Independent	25	31
Successful	58	45
Well Liked	17	24
	100	100

X^2 test not significant at 95% level of confidence.

Furthermore, the terms used in question 10 (Table 15) are so ambiguous as to make interpretation of responses virtually useless; and in question 14 (Table 14) so many respondents chose the two moderate categories that, again, interpretation of results would be of little value. It would seem that prior doubts as to the utility of questions of this nature were fully justified. However, the results of the questions on membership of clubs and societies are more concrete. They can be examined in Tables 16 and 17 and 18.

Table 16. Membership of Clubs and Societies at High School (question 12)

	Scientists %		Non-scientists %	
Membership of no clubs	30		27	
" " one club	22		18	
" " two clubs	22		19.5	
" " three clubs	13		14.5	
" " four clubs	6		12	
" " five clubs	4		5	
" " six clubs	3		4	
	100	N=77	100	N=160

Scientists: average of 1.7 clubs per person
Non-scientists: average of 2.0 clubs per person
X^2 test not significant at 95% level of confidence.

Table 17. Membership of Clubs and Societies at University (question 13)

	Scientists %		Non-scientists %	
Membership of no clubs	52		48	
" " one club	29		33	
" " two clubs	13		13	
" " three clubs	5		4	
" " four clubs	1		1	
" " five clubs	0		1	
	100	N=77	100	N=160

Scientists: average of 0.75 clubs per person

Non-scientists: average of 0.8 clubs per person

X^2 test not significant at 95% level of confidence.

Table 18. Official Positions Held in Clubs and Societies at University (question 13, 2nd part)

	Scientists Persons	Non-scientists Persons
One official position	4	15
Two official positions	-	3
Three official positions	-	-
Four official positions	-	2
	4 official posts	20 official posts

X^2 test not significant at 95% level of confidence.

Table 16 shows that, at high school, more scientists belonged to no clubs, one club or two clubs than did non-scientists; but that more non-scientists than scientists belong to three, four, five or six clubs. Non-scientists, then have a slight edge over scientists with respect to average number of clubs and societies per person. Membership of clubs at university (Table 17) does not have so regular a pattern but once again it shows non-scientists as slightly more likely to be members of clubs and societies. Finally, there is Table 18 which gives details of official positions held in clubs and societies at S.F.U. by members of the two groups. Thus one hundred and sixty-two non-scientists indicate tenure of twenty-nine official positions while seventy-seven scientists provide tenants of only four such posts. None of these differences is statistically significant, that is we can only be less than ninety-five percent certain that they have not occurred by chance. Yet, unlike those questions framed to investigate personality directly, the differences between the two groups are consistently in the expected direction. Consequently, we can summarize the findings of the S.F.U. study with respect to personality differences as follows: There is no direct evidence of personality differences between the two groups; however, some evidence does exist which implies that scientists may be just marginally less prone to engage in formal social activities than non-scientists.

Image of Self

In prior studies of the recruitment of scientists into their profession no examination has been made of the image which potential recruits have of themselves. Yet it would seem self-evident that if occupational values and image of occupation enter into the process of selection some act of self-definition and evaluation in terms of these values and images is essential. In view of the fact that there was no previous research on this aspect of the problem it would have been usual to make use of a completely unstructured question in the questionnaire in order to avoid introducing too much bias on the part of the researcher. However, in this instance it was thought that such an 'open' question would be virtually meaningless to the respondent, for example: 'People tend to be more gifted with respect to some abilities than others. In which areas do you think you are most gifted?' Given that this kind of question was not to be used, the only viable alternative was to structure students' responses within the framework derived from past research on other aspects of the recruitment process while at the same time leaving the respondent at least some opportunity of answering within his own frame of reference. This approach gave rise to questions twenty and twenty-one, the first of which is reproduced below.

> People tend to be more gifted with respect to some abilities than others. Do you think you are most gifted intellectually, or with respect to personal relationships, or leadership ability, or artistic creativity?
>
> 1. Intellectually
> 2. Personal relationships
> 3. Leadership
> 4. Artistic creativity
> 5. Other (please state)

It can be seen that the categories of intellectuality, personal relationships, and leadership derive directly from Rosenberg's study.

Tables 19 and 20 show the responses to these questions; 'positive self-image' refers to those areas in which respondents perceived themselves as most gifted and 'negative self-image' to those respects in which they thought they were least gifted.

Table 19. Positive Self-image (question 20)

	Scientists %		Non-scientists %	
Most gifted intellectually	44	(31)	25	(38)
Most gifted in personal relationships	27	(19)	38	(58)
Most gifted in leadership	6	(4)	14.5	(23)
Most gifted in artistic creativity	10	(7)	14.5	(23)
Other	13	(9)	8	(12)
	100	N=70	100	N=154

X^2 test significant at 95% level of confidence.

X^2 test applied to first two sets of responses, i.e. "intellectuality gifted" and "gifted with respect to personal relationships" proved significant at 99% level of confidence.

Table 20. Negative Self -image (question 21)

	Scientists %		Non-scientists %	
Least gifted intellectually	4		10	
Least gifted in personal relationships	17		9	
Least gifted in leadership	25		20	
Least gifted in artistic creativity	49		54	
Other	5		7	
	100	N=76	100	N=158

X^2 test significant at 95% level of confidence only with respect to first two sets of responses.

It is evident that the positive self-image of the scientists stresses intellectuality while that of the non-scientists lays emphasis more upon personal relationships. The question on negative self-image was less discriminating largely owing to the inclusion of the category 'artistic creativity' into which some fifty percent of responses were placed. Allowing for the 'distortion' introduced by this category the pattern of the negative self-images of the two groups closely resembles the obverse of the positive image. Virtually all of these differences are statistically significant and in addition they are consistent with those divergences discussed above in relation to values and those which will be discussed next in connection with the social image of the scientist. As less than ten percent of responses indicated some sphere of ability other than intellectuality, personal relationships, leadership and artistic creativity it can be assumed that these categories were meaningful for the respondents. Thus we can interpret the responses as showing that this group of scientists valued itself highly in terms of intellectuality, much less highly with respect to personal relationships, and minimally in relation to leadership ability and artistic creativity. In contrast, the non-scientists judged themselves to be most gifted with respect to personal relationships, rather less gifted intellectually and in terms of leadership potentiality, and like the scientists least proficient in relation to artistic creativity.

Social Image of the Scientist

Question number 11 of the S.F.U. questionnaire examined the image respondents had of 'the natural scientist' with respect to ten factors, e.g. his income, his intelligence, his interest in people and so on. With respect to each of these factors it was possible for the respondent to give any one of seven responses ranging from highly favourable to highly unfavourable, e.g. the scientists could be seen as anything from very highly paid to very badly paid. In analysing the data the three moderate responses in the middle of the continuum have been consistently ignored with respect to all ten factors, as providing no indication of any definite image. The rationale behind this procedure was that of trying to avoid the creation of a spurious social image. By concentrating solely upon extreme responses we can be reasonably certain that we are dealing with definite, and perhaps behaviorally significant aspects of the students' perceptions of natural scientists.

If the factors composing the positive and negative images of scientists and non-scientists are placed in rank order[1] we find that there is almost complete agreement between the two groups.

Positive Image

	Scientists	Non-scientists
1.	Intelligent	Intelligent
2.	Rational	Devoted to their work
3.	Concerned with benefit of mankind	Rational
4.	Well paid	Well paid
5.	Hard to convince	Concerned with benefit of mankind
6.	Devoted to their work	Hard to convince
7.	Competitive	Competitive
8.	Interested in people	Interested in people
9.	Religious	Religious
10.	Indifferent to money	Indifferent to money

1 i.e. those factors with the largest proportions of responses are placed at the head of the list.

Negative Image

Scientists	Non-scientists
1. Competitive	Indifferent to money
2. Indifferent to money	Religious
3. Religious	Competitive

Number of respondents too small to make completion of the list meaningful.

There appears to be general agreement that natural scientists are intelligent, rational, well paid and concerned with the benefit of mankind; and that scientists are not indifferent to money, religious or competitive. However, despite this almost complete consensus in general terms between the two groups there are certain very interesting divergences and differences of emphasis which are worth examining in some detail.

Table 21. Image of Natural Scientist (question 11)

Scientists

	Positive (responses 3 & 2)	Neutral (responses 1,0&1)	Negative (responses 2 & 3)	
1. Well paid	70% (53)*	27.5% (21)	2.5% (2)	=100 N=76
2. Intelligent	100% (77)*	-	-	=100 N=77
3. Religious	15% (11)	69% (51)	16% (12)	=100 N=74
4. Interested in people	35% (27)	60% (46)	5% (4)	=100 N=77
5. Hard to convince	45% (34)	49% (37)	6% (4)	=100 N=75
6. Devoted to their work	44% (34)*	56% (43)	-	=100 N=77
7. Indifferent to money	5% (4)	79% (50)	16% (12)*	=100 N=66
8. Competitive	42% (31)	41% (30)	17% (13)	=100 N=74
9. Rational	92% (70)*	7% (5)	1% (1)	=100 N=76
10. Concerned with benefit of mankind	80% (61)*	19% (15)	1% (1)	=100 N=77

X^2 test used on positive responses to sections 1, 2, 6, 9 & 10, plus negative responses to section 7 with respect to scientists and non-scientists: significant association at above 99% level of significance. Even when highly significant section is omitted, X^2 test remains significant at 95% level of confidence.

Spearman's rank correlation coefficients with respect to positive image of the scientists and with respect to negative image held by the two groups was + 0.9.

Non-scientists

		Positive (responses 3 & 2)	Neutral (responses 1, 0 & 1)	Negative (responses 2 & 3)	
1.	Well paid	59% (93)*	40% (63)	1% (2)	=100 N=158
2.	Intelligent	92% (146)	7% (11)	1% (1)	=100 N=158
3.	Religious	10% (15)	72% (114)	18% (29)	=100 N=158
4.	Interested in people	30% (48)	59% (92)	11% (17)	=100 N=157
5.	Hard to convince	49% (77)	47% (74)	4% (7)	=100 N=158
6.	Devoted to their work	89% (141)	10% (16)	1% (1)	=100 N=158
7.	Indifferent to money	8% (13)	63% (100)	29% (45)*	=100 N=158
8.	Competitive	40% (64)	47% (74)	13% (20)	=100 N=158
9.	Rational	70% (110)*	27% (42)	3% (5)	=100 N=157
10.	Concerned with benefit of mankind	58% (92)*	38% (60)	4% (6)	=100 N=158

*X^2 test used on positive responses to sections 1, 2, 6, 9 & 10, plus negative responses to section 7 with respect to scientists and non-scientists: significant association at above the 99% level of confidence. Even when highly significant section 6 is omitted, X^2 test remains significant at 95% level of confidence.

Spearman's rank correlation coefficients with respect to positive image of the scientist and with respect to negative image held by the two groups was + 0.9.

Non-scientists have what we might call a 'traditional' image of the scientist presumably deriving from the period when science was primarily academic; they perceive the scientist as being a highly intelligent, rational, sceptical individual who is largely unconcerned about specific people or about religion but who is devoted firstly to his own intellectual endeavours and perhaps secondarily to the benefit of mankind in general.

Potential scientists accept these general contours but they are very much less certain about the scientist's devotion to his work; whereas 89% of non-scientists' responses depicted the scientist as very devoted only 44% of scientists' responses indicated a belief in this extreme devotion on the part of the natural scientist to his research. This is statistically a highly significant divergence between the two groups. If I am to offer on interpretation within the terms of the framework provided above I would suggest that the image held by potential scientists is more realistic, less stereotyped, in this respect. It has been claimed in this paper that modern science has tended to become larger, more specialized and organized around rewards less esoteric than pure intellectual satisfaction. If this is in fact so then potential scientists appear to be more aware of these changes than non-scientists; they underplay the scientists' devotion to his work and stress his concern with financial rewards[1]. We have seen that the occupational values of our prospective scientists emphasize income. Thus their image of the scientist is perhaps partly derived from their own occupational values and self-perception; they wish to have a high income, they are only moderately devoted to scientific knowledge, consequently they believe that mature scientists are probably much the same. Significantly, there is a considerable divergence between the two groups in their perception of the actual income of the

1 Whereas non-scientists stress the scientist's interest in money, they emphasize even more his devotion to his work.

scientist: whereas 59% of non-scientists see the scientist as being very highly paid fully 70% of scientists enjoy this image of affluence.

It is of interest to note that potential scientists are significantly more likely than non-scientists to perceive the scientist as being highly intelligent, very rational, notably concerned with the benefit of mankind. These differences of emphasis are important because they show the prospective scientist to hold a rather more favourable image of the scientist, favourable in terms of his own values and self-perceptions, than does the non-scientist. The potential scientist sees himself as being intellectually gifted and perceives the mature scientist as being highly intelligent; his own occupational values stress the desire to behave rationally and the scientist is perceived as a very rational person; he supports overwhelmingly the proposition that scientists ought to help mankind achieve a better life[1], and he perceives scientists as doing just that.

These findings demonstrate clearly a convergence between, on the one hand, the values and self-image of prospective scientists and, on the other hand, their perceptions of the characteristics of mature scientists. Convergence occurs notably in connection with the intellectuality of the scientist, his rationality and its positive evaluation, the character of the ultimate goal of science, viz. the benefit of mankind, and the nature of the rewards to be derived from science, viz. income rather more than intellectual satisfaction.

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1 See Table 12, p. 105.

It would seem likely that this convergence can be used in explaining the selection of certain persons rather than others into science. This whole problem of the recruitment process will be dealt with more fully in the next chapter.

One last point, not directly related to the process of recruitment, is worth making. On the whole those aspects of the social image of the scientist dealt with so far appear to be more or less in accordance with reality. Yet at the same time scientists are seen as being not religious and not competitive; and there is evidence to suggest that these elements of the stereotype may be unfounded in fact. Firstly, there is Reif's study which demonstrates an immense rivalry among scientists related to the stress upon originality and the prevailing criterion of originality namely, prior publication.[1] Furthermore, there is the thesis of Caplow and McGee[2] which generalizes this element of competition in claiming that it applies to the whole academic world. Secondly, with respect to religion, this S.F.U. survey shows only a slightly higher tendency among potential scientists when compared with non-scientists towards a lack of religious affiliation (Table 28, Appendix). It is true that this data is derived not from mature scientists but from prospective scientists only. However, it must make us doubtful about the validity of defining the scientist as irreligious. The general point to be drawn from this is that the potential scientist

1 F. Reif: The Competitive World of the Pure Scientist in Science, 134, (1961).

2 T. Caplow and R. McGee: The Academic Marketplace.

stresses, and perhaps acts upon, those aspects of the social image which can claim some basis in fact. What remains totally unclarified is how this social image is formed and how it is transmitted.

Some Aspects of the Respondents' Perception of the Recruitment Process

Question number 8 of the questionnaire was an uncoded question which asked students which factors had been most influential in leading them to choose their particular area of study. The responses were read by two persons who agreed upon coding them in terms of six categories, viz. school, family, economic interest, intellectual interest, benefit to society and self-development. The results can be seen from Table 23. Differences between the two sets of responses were not statistically significant. However, it is worth devoting a little space to reproduce some of the responses and to offer limited comment for this may help to generate greater understanding of the students' view of the recruitment process.

Table 23. Factors Perceived as Influencing Choice of Area of Study at University (question 8)

	Scientists %		Non-scientists %	
School	25	(34)	20	(49)
Family	12	(16)	10	(23)
Economic advantage	13	(17)	18	(42)
Intellectual interest	43	(58)	36	(86)
Benefit to society	6	(8)	9	(21)
Self-development	1	(2)	7	(18)
	100	N=135*	100	N=239*

*more than one response possible from each respondent.

X^2 test not significant at 95% level of significance.

It is clear that high school provides an important influence in the moulding of choice of study area at university and consequently of occupational choice. This influence is almost certainly undervalued in Table 23 for the school clearly helps to determine such factors as intellectual interest and ideas about self-development and the benefit of society. There is a slight suggestion in Table 23 that scientists are more affected by school influences than non-scientists and certainly they make greater explicit mention of the contribution of specific teachers to their development, sometimes answering question 8 with one short reference, e.g. "High school physics teacher." None of the non-scientists replied in this fashion.

More scientists than non-scientists perceived intellectual interest as being the predominant influence in their choice of area of study. This was clearly in harmony with our expectations and with the scientists' self-image and image of the mature scientist. In fact, some of the responses were classic expressions of this dichotomy between concern with objects and ideas and interest in people:

> Scientist: .. entire life revolves around physical sciences - never taken a broad interest in people.

> Non-scientist: .. I have found people and their behaviour more interesting than inanimate objects such as those studied in the physical sciences.

At the same time those responses which suggested economic gain as a major influence in this context showed a bias in favour of non-scientists. However, when we recall the scientists' stress upon income in relation to occupational values (Table 13) and image of the scientist (Table 21) our general conclusion must be that, almost certainly, there is no difference between the two groups with respect to their concern with monetary rewards.

Non-scientist: I chose economics because it is the field which large businesses look towards for advice; hence it is a field in which a fairly tidy bundle of money can be earned ..

Scientist: The economy will demand more, in the direction of science.

Scientist: .. a systems man on a computer is not likely to be replaced through automation for a long time.

Non-scientist: Want money (lots of it).

These are examples of some of the economic reasons given for choosing a particular field of study.

The other categories which emerged were family influences, benefit to society and self-development. A few examples of these will now be given:

Benefit to society -

Non-scientist: .. fact that all (technological?) knowledge in the world is no good unless people know how to use it. I feel this can be best imparted in the humanities.

Scientist: I have been interested in the benefits of scientific research to the growth of civilization.

Scientist: I can see a use for the natural sciences but no use for English, etc. ..

Self-development -

Non-scientist: English and History give me an account of man and his motives (past and present). In studying these subjects I hope to find how to best improve myself as well as to learn how to deal with certain situations (political or emotional) as they arise.

Scientist: I see more concrete understanding in science. In the humanities education can sometimes be a handicap in living.

In summary we can say that the respondents in the S.F.U. study perceive themselves as having been influenced primarily by two institutional areas; in the first instance by the high school and, rather less significantly, by the family. These influences appear to make themselves felt by structuring the students' intellectual interests and their perception of the financial returns associated with specific areas of study. There are probably no differences between scientists and non-scientists with respect to the general contours of this process.

Occupational Intentions of those Studying Natural Science

In addition to investigating the entry of prospective scientists into university the S.F.U. study gathered information as to the occupational intentions of the respondents. This data is reproduced in Tables 24 and 25. For purposes of comparison, Table 25 also shows the distribution of natural scientists between employment sectors at January 1, 1962 and also the estimated rates of increase for the following five years.

Table 24. Occupational Intentions of Students Studying Natural Science

	%		
Engineering	21.25	(17)	
Industrial scientist	18.75	(15)	
Government scientist	18.75	(15)	
University scientist	15	(12)	)
			) - 23.75%
Teacher (outside university)	8.75	(7)	)
Physician or Dentist	5	(4)	
Other	12.5	(10)	
	100	(80)*	

*more than one response possible

Table 25. Occupational Intentions of S.F.U. Science Students compared with Percentage Distribution of Scientists at January 1, 1962 and estimated rates of increase from January 1962 to January 1967 [1]

	Intentions %		Actual Distribution %	Rate of Increase %
Industry	30	(15)	37.8	+ 29
Government	30	(15)	48.0	+ 32
Education	40	(19)	14.2	+ 34
	100	(49)	100	

It is evident that there is considerable divergence between the actual occupational intentions of science students at S.F.U. and the opportunities open to them. Whereas some 40% of those who intend to remain within the field of natural science wish to work within an educational milieu, only 14% of jobs are to be found in this sphere. Similarly, whereas exactly equal proportions of respondents wish to enter

1 Sources: S.F.U. Study and Professional Manpower Report No. 13, 1962, Department of Labour.

industry and government, in the economy there is a large bias in favour of government employment. These figures suggest therefore, that within the period of university training a large section of prospective natural scientists learn to orient themselves away from the university and teaching, and towards occupational activity within government and industry.[1] Estimates of future requirements of scientists make no significant alteration to the situation. However, too much reliance should not be placed upon the figures underlying this analysis. Firstly, the number of respondents is even smaller than to other questions. Secondly, the distribution of scientists in industry, government and so on differs in relation to various areas of study, e.g. biologists are more frequently employed by government than are other varieties of scientist; and we cannot be sure that the distribution of disciplines among the would-be scientists in the sample is at all representative. Nevertheless this divergence between occupational intentions and opportunities remains as a possibility and is worthy of further study.

<u>Conclusions Drawn from the S.F.U. Study</u>

At this point it is worth summarizing the findings of the S.F.U. study before passing on in the next chapter to a discussion of the general character of recruitment into

1 In the final chapter I shall examine this process in greater detail.

professional science.

1. General sociological factors such as social class can be relevant to the recruitment of scientists. Yet there is little evidence in this study of any significant difference between scientists and non-scientists with respect to religious affiliation, social class, educational experience or political belief. We must conclude therefore that such effects as these factors have apply equally to the two groups. We cannot infer from social class or educational background whether or not a person is likely to become a scientist rather than any other professional occupation.

2. Scientists appear to be less 'educationally mobile' than non-scientists. It is possible that this is a consequence of increasing specialization within science, of decreasing transferability of skills, and of a declining acceptance of the value of diversity of educational experience.

3. When they enter university scientists are only marginally more likely to endorse such supposedly 'scientific' values as disinterestedness, universalism and the intrinsic worth of knowledge. It is clear that the last value, namely, the intrinsic worth of knowledge, comes a very poor second for scientists as well as non-scientists to the benefit of mankind as a fundamental goal of scientific activity. The significance of these findings will vary, depending on the assumptions we make. If we assume that the values of mature scientists are much the same as those of other professional groupings, then we would not expect the values of potential

scientists to differ from those of non-scientists, and the findings will cause us no surprise. If, in contrast, we assume that the values of scientists and other professionals do diverge, then we must also assume that the values of scientific neophytes are changed by an efficient process of socialization within the university. Whichever assumption we make it would seem that anticipatory socialization in terms of the values of disinterestedness, universalism and the intrinsic worth of knowledge plays no significant part in the process of scientific recruitment.

4. Other 'scientific' values, viz. those of rationality and the extension of human knowledge (perhaps the latter is valued instrumentally in view of the preceding conclusion) are endorsed more frequently by scientists and may, therefore, play a part in recruitment of scientific personnel.

5. Scientists are more likely to endorse self-expression-oriented occupational values than are non-scientists and are less likely to express acceptance of people-oriented occupational values. They are, however, no less likely to be concerned with financial gain in the course of their occupational choice.

6. There is no direct evidence to suggest that a population of scientists will contain a larger proportion of 'detached personalities' than an equivalent population of non-scientists. On the other hand, there is a little evidence to suggest that scientists may be less socially active.

7. The self-image of prospective scientists agrees closely

with their occupational values. Whereas the latter stress rationality positively and people-oriented values negatively, their self-image emphasises that they are most gifted intellectually and least gifted as regards personal relationships.

8. At the same time their conception of the natural scientist runs along parallel lines accentuating such features as intelligence, rationality, high income, and concern with the benefit of mankind.

9. There appears to be a considerable divergence between the occupational <u>intentions</u> of scientists at the point of entry into university training and the <u>opportunities</u> open to them upon graduation.

10. The general implication of the study seems to be that potential scientists can be most readily distinguished from non-scientists by reference to the following factors:

A) occupational values
B) acceptance of certain 'scientific' values
C) self-image
D) image of the natural scientist.

In the next chapter I shall attempt to show how these factors can be used as part of an explanation of how the process of recruitment into professional science operates.

Chapter VII: The Recruitment of Scientists in Canada

Occupational recruitment into science and into other fields of employment is a developmental process. The sequence of acts which determines occupational choice begins in the family and continues within the school. The process consists in the gradual formation of values, self-images and occupational images through interaction with significant others.[1] These early experiences within primary groups are important because they channel later developments; more specifically they determine which institutional contexts the individual will enter. On the one hand, early experiences determine the kinds of social contexts the individual will choose. On the other hand, they limit the kinds of qualities the individual can offer in the process of selection into various institutions. The importance of mass media in the formation of occupational values, occupational images, and so on, has not been examined in any detail in connection with science.[2] However, there is a whole body of research which indicates that the values and images put forth by television, radio and films are perceived selectively so as to strengthen the values and perceptions absorbed within such primary groups as the family.[3]

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1 Significant others are basically those who control rewards and punishment for the developing person. " ... the person, through his social experiences, becomes aware of the expectations and appraisals of others. He acts one way and others reward him ... he acts another way and they punish him ..." H. Gerth and C.W. Mills: Character and Social Structure.

2 One of few such studies is 'The Image of the Scientist in Science Fiction' in Barber and Hirsch eds. The Sociology of Science.

3 e.g. H. Himmelweit et al: Television and the Child.

The process of occupational recruitment is intimately involved with educational institutions. It may be that the influence of the family is more 'basic' in the sense that it precedes and helps structure the effects of being at school. The S.F.U. study, however, indicates that the school may play a slightly more active part in this process than the family.[1] This makes sense in relation to science because few children will have had direct contact with any kind of scientist until they reach high school. Thus the high school science teacher occupies a crucial position within the sequence of acts leading to final occupational commitment, for he offers what are probably perceived as definitive accounts of science and the activities of scientists. The process of occupational choice has certain major points of commitment. Perhaps the most important of these for professionals is that of choice of a particular kind of higher education. At this juncture the determining factors are:

a) occupational values and values in general;
b) images of occupations (including the kinds of rewards associated with these occupations);
c) self-image; and
d) the selective orientation of the university.[2]

The high school teacher will have some influence with respect to each of these categories. He will provide definitions of the student's academic ability and thereby affect the latter's self-image. He will also influence the kind of educational

1 See above p. 127.

2 See above p. 74.

qualifications gained and in this way help to determine which students satisfy the selective requirements of the university.

University education is essential for most professionals including scientists. And entry into university depends formally upon the attainment of academic qualifications. But as we have noted above[1], the achievement of such educational qualifications and entry into university are closely related to social class origins. Thus the ability to satisfy the requirements for entry into university can be explained largely in terms of certain students' having that complex of values, attitudes, selective perceptions, economic opportunities, etc., characteristic of middle class groups. It is not for this study to investigate these factors any further, partly because there is no difference here between science and other professions. I shall turn therefore to an examination of the remaining elements relevant to occupational choice namely, occupational rewards and images, self-images and occupational values.

The nature of the rewards awarded to scientists plays an important part in the recruitment process. Small scale, academic science tended to absorb persons who endorsed values stressing the self-justifying character of objective, rational and socially isolated thought about the natural world. The rewards offered to such individuals were primarily the

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1 See above pp. 67-8.

intellectual satisfaction of problem-solving and recognition of intellectual worth by other qualified persons. It can be assumed that persons capable of deriving satisfaction from such rewards are few in number. But contemporary science is relatively large scale and growing quickly; it is impossible to recruit enough scientists for large scale science while the whole process of recruitment is geared to academic science. Small scale, academic science offered 'peculiar' rewards valued only by a few. Large scale, professional science offers more widely valued rewards such as high income and social prestige. There was evidence in the S.F.U. study that scientists are now generally perceived as being very well paid and that this is important for potential scientists.[1] Until such rewards are offered, and seen to be offered, in 'sufficient measure' professional science will continue to experience its current manpower shortages. However, as I suggested in Chapter I, the offer of new rewards will not alone solve the long term manpower problem of science, for this problem is built into the transition from exponential to logistic growth.[2]

Despite the emphasis by potential scientists on income as a major reward and as an important element in their image of the scientist, there remain distinct and consistent

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1 See above pages 110-2.

2 See above pages 25-8.

traces of academic science in the recruitment process today.

a) Potential scientists stress such scientific values as rationality and the importance of extending human knowledge.

b) They emphasise self-expression oriented occupational values.

c) They stress the intellectuality and rationality of the mature scientist.

d) They stress their own rationality and intellectual capacities.[1]

These features are characteristic of prospective scientists at the point of entry to university. They are probably derived from the presentation of science in schools which is clearly 'academic' in nature. One way of investigating the presentation of science in schools would be to undertake an exhaustive content-analysis of science textbooks and teachers manuals. It has not been possible to include such an analysis as part of this study. However, a cursory examination seems to indicate that little mention is made either directly or indirectly of the character of science as a career or of the extrinsic rewards associated with such a career. School textbooks tend to emphasise the validity of scientific thought, the intellectual satisfaction involved in thinking scientifically, and to some extent the practical utility of scientific knowledge.[2] One basic aim of science textbooks is that of encouraging the attitudes of 'academic' science. This is stated openly in at least one teacher's manual:[3]

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1 See above p. 120.

2 e.g. Limpus, Reid & Shore: Explorations in Science, Craig, Roche and Navarra: Experimenting in Science

3 Craig, Roche and Navarra: Teacher's Manual for Experimenting in Science.

> ... the scientific method is a method of honesty, and neither teacher nor child should be penalized in any way for being honest. The learner should never be humiliated for the admission of ignorance. The implications of science for mental hygience and human relations are profound.
> It could be well for the teacher to consider the implications of science in the development of such behaviour patterns as open-mindedness, critical-mindedness, and the avoidance of gullibility.

We have come across these latter virtues before in the writings of Oppenheimer and Bronowski, Merton and Barber; they embody many of those values which I have suggested above have been characteristic of academic science in the past and university science at the present time, and they clearly imply the company of equals pattern of social relations as an ideal. In short, science is presented in the school as essentially an intellectual activity which is intrinsically satisfying but which is to be valued in addition for its technological utility. Consequently, those persons are drawn into science who can firstly satisfy the university's financial and educational requirements and secondly whose self-image and occupational values converge with this social image of science. The values of those entering science emphasise the desire for high income but also for rationality, creativity, self-expression, individualism and the wish to extend human knowledge. At the same time the potential scientist's self-image lays overwhelming stress upon his intellectuality. Thus it is in terms of a convergence between social image and self-image that we can begin to explain the unique features of the process of recruitment of potential scientists into the university.

The account so far stresses the differences which exist between recruitment into science and recruitment into other professions. Yet there are, as the S.F.U. study demonstrated, many potential scientists who differ in no marked way from other prospective professionals. How do these persons fit into scientific recruitment? The simplest answer to this question is that there are further processes of selection within science itself which operate along lines similar to those which govern selection into the university; at the same time there is an effective system of socialization within science which moulds recruits in the required direction. The only available studies of selection within scientific groups are those of R. Krohn. His findings are consistent with the main thesis of the present study. They indicate that recruitment and selection within science are a continuation of the process whereby scientists are drawn to study science as undergraduates. To begin with Krohn studied scientists in American industry, government and university, primarily with respect to divergences in values and attitudes towards science. His study revealed that university scientists:

a) had a less practical conception of the nature of science;

b) had a specifically intellectual conception of the scientific role rather than a generalized professional conception; and

c) were more favourable to the individual investigator as the appropriate unit of research, as opposed to the organized team.[1]

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1 R. Krohn: The Institutional Location of the Scientist and His Scientific Values in IRE Transactions of Engineering Management, Vol. EM-8, No. 3, Sept. 1961.

The values particularly emphasised by university scientists were individualism i.e. personal independence and reliance upon one's own judgment, and intellectuality, i.e. reliance upon reason and enjoyment of the life of the mind. After having examined the different patterns of scientific values found in varying institutional locations, Krohn went on to investigate whether different types of person are attracted to and encouraged by the different institutional contexts. Once again he found that university scientists were a distinct group. Significantly more university scientists had chosen science out of intellectual interest rather than as a result of concern with attaining some kind of professional status; more university scientists had been influenced by their professors and had respected them as men and as scientists; and more university scientists traced their interest in science back into their childhood thereby demonstrating, according to Krohn's interpretation, a stronger motivation in favour of science.[1] The main implication of Krohn's work is that the minority of persons who stress 'academic' aspects of science at the point of entry into university make their lasting occupational commitment in favour of university research, while the larger proportion of prospective scientists who differ in no marked way from other would-be professionals move away from the university into industrial and government science. At the same time there is evidence to suggest that scientists

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1 R. Krohn: The Scientist: A Changing Social Type in <u>American Behavioral Scientist</u>, Dec. 1962.

who are favoured by high levels of ability are likely to be selected into university science and basic research in general.

> Attrition in graduate schools tends to be high, and only the more competent and highly motivated students obtain the doctorate. Among those who do obtain doctorates in science, only a fraction are permitted to enter careers in basic research (university science); the rest become teachers, administrators, and applied scientists. Basic scientists then are a highly selected and highly socialized elite group.[1]

The general contours, then, of recruitment within science can be described as follows. The majority of science students entering university differ in no major respects from other undergraduates. Only a small proportion of potential scientists endorse 'academic' occupational values, self-image, etc. It is this small minority which, by laying particular emphasis upon the rationality and intellectuality of science and of themselves, provided the consistent findings of the S.F.U. study. During the period of undergraduate and graduate study there is a process of selective drop-out and effective socialization in terms of the values and norms of university science. Virtually all science graduates and even more those who achieve the doctorate will have been moulded by the social environment of university science. However, only those who give evidence of the highest ability and who most embody the values of university science will be recruited into university research. Furthermore, within university science the various disciplines and specialisms are ordered hierarchically in accordance with scientific values and those students defined as 'better' scientists will tend to be recruited into higher

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1 W. Hagstrom: The Scientific Community.

prestige disciplines.

> Specialties with high prestige usually find it easy to recruit scientists and succeed in recruiting those with most talent. In specialties with low prestige, on the other hand, the recruitment problem may be ... most serious. [1]

Those students not selected into university science will move out into industry and government. On the whole these persons will endorse the values of university science less fully and they will be defined as less academically gifted. Once within industry and government the motives and values of these scientists will be further moulded away from the academic pattern by their new institutional environment. Many of these scientists, however, will retain role-behaviours characteristic of university science;[2] in particular they will continue publishing research in return for recognition by the scientific community even though publication may be totally irrelevant to advancement within their non-scientific bureaucracy.[3] In short there is a process whereby the majority of qualified scientists are channelled away from university science into industry and government. There is evidence to suggest that persons remaining in the university are 'academic' scientists; while the majority, whose motivation is basically similar to that of other prospective professionals,

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1 Ibid.

2 See above p.49.

3 L. Meltzer: Scientific Productivity in Organizational Settings in Journal of Social Issues, 12 (1956).

move into more professional-bureaucratic surroundings. Recruitment into science differs from that into other profession, within the framework of this study, in that there are more recruits who endorse the values and social images of an 'academically' organized science. These recruits tend to be absorbed into university science while those expressing more usual values and images enter, in the long run, employment in government and industry.[1]

The account of scientific recruitment offered so far in this chapter is very general and applies equally to Canada and the United States. However, there is in fact one important difference between the organization of science in these two countries which affects the pattern of recruitment. In the U.S. research and development takes place predominantly within privately owned industry; in Canada research is performed largely within government establishments (Table 26). Whereas in the U.K. and even more in the U.S. the majority of scientists spend most of their professional life in industry, the greater proportion of Canadian scientists are destined to work in government.

Table 26. Amount of Research and Development Performed by Government and Industry in Three Societies[2]

	Canada - 1959 Millions of Dollars	U.K. - 1958/9 Millions of Pounds Sterling	U.S. - 1959 Millions of Dollars
Performed by Government	126	159	1780
Performed by Industry	97	280	9438

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1 The evidence supporting this account of recruitment within science is very slender. It can never be more than tentative until a 'longditudinal' study is undertaken which follows the same batch of scientists through the relevant parts of their careers.

2 Source: The Royal Commission on Government Organization in Canada 1963 Special Area of Administration 23: Scientific Research and Development.

Furthermore, the organization of certain sections of government science in Canada is unlike that in other societies, for government science in Canada includes the National Research Council which is credited by all commentators with having a most 'academic' form of organization.

> ... while there is little distinction between the types of activity in various government laboratories, there is considerable dissimilarity in the administrative and environmental conditions under which research is conducted. The general view of scientists is that the National Research Council's laboratories provide a model environment in terms of facilities, employment and personnel practices, as well as in the degree of financial autonomy enjoyed.[1, 2]

Consequently it seems likely that recruitment into the laboratories of the N.R.C. will be similar to recruitment into university science. However, the actual character of recruitment will depend upon the image of the N.R.C. held by university scientists in Canada and on this point there is no direct evidence available.

Scientific recruitment then, in Canada today, operates along the lines described above. Any changes in this pattern to be expected in the near future will derive from the rapid expansion of science which is already underway. The expansion of university science, which at present absorbs around 14% of scientists, is of course a prerequisite for scientific growth in general and its occurrence is foreshadowed in the Bladen Report. This Commission on the

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1 Ibid.

2 See above p. 62.

Financing of Higher Education in Canada proposed that government support of research and graduate studies be increased quickly and by a considerable amount. One estimate of increase in expenditure on graduate studies in science and engineering quoted by the Commission was as follows:

Table 27. Estimated Expenditure on Graduate Studies in Science and Engineering[1]

Year	Amount
1964/5	65 million dollars
1970/1	220 million dollars
1975/6	331 million dollars.

University science will grow during the next decade because it provides a training ground for government and industrial scientists, and because it is generally recognized as the best environment for basic research. It is difficult to decide whether university science will expand at a rate faster than that of science in general. We can be sure however that the rate of growth of university science must at least approximate that of science in industry and government taken together. In contrast, it does seem evident that science in industry will expand more quickly than government science. There are several reasons for this. To begin with, the recent re-organization of government science indicates that future policy will reassert the once basic goal of government science policy, namely that of helping generate growth in Canadian industry. One of the original purposes for which the central government devoted money for research was to stimulate

1 The Royal Commission on Government Organization. This estimate was presented to the Commission by the Canadian Association of Graduate Schools.

industry. However, in the course of time government policy lost sight of this goal, partly because of an underestimation of the research potential of Canadian industry, partly owing to the existence of scientific colonialism in Canada, and partly because of the tendency of an established bureaucracy to extend its own organization whenever an entirely new research project came under consideration. The recent formation of a Science Council for Canada is part of an attempt to remedy this situation. The Council is designed to constitute a senior policy making group with direct access to the highest echelons of government. Of its twenty-seven members, seven are business representatives, nine came from the universities, and eleven are public servants. It is hoped that this body, including as it does representatives of all major scientific groups, will coordinate government policy particularly with respect to the acceleration of economic growth through advances in science and technology. Formal government control over research with respect to certain basic industries such as timber is already at a maximum in Canada. At the same time government policy has been reorganized so as to stimulate research within industry and industrial expansion. Consequently we can expect that there will be a swing in the distribution of scientists away from government employment and in favour of industry, at least for the next decade or so. Thus during this period recruitment of scientists will tend to have a rather different pattern from that existing at present.

There are several different ways in which government can assist the expansion of industrial research. For example, specific applied research projects can be contracted out to Canadian industry by means of special research funds. This pattern of cooperation between government and private industry with respect to scientific research is the one commonly found in the U.S. In general it involves no change in the normal organization of industrial research. There is, however, another form of organization which is emerging in Canada which is something of a new departure. It is exemplified in the Sheridan Park scheme. A short description of this project will give some idea of the organization involved and of how, increasingly, government and industry may combine to accelerate research and development in Canada.

The Sheridan Park Research Community is a massive research centre now being built outside Toronto. It is sponsored by the Ontario Provincial Government and by private industry, on the assumption that indigenous research will stimulate Canadian industry and free it from undue dependence upon developments in the United States. Within a few years Sheridan Park will have 100 million dollars worth of buildings, plus more research equipment than can at present be estimated; it will be occupied by research establishments from many of the world's largest companies; and it will house six thousand scientists and technicians who will be paid at least forty-two million dollars annually.[1] The Sheridan Park scheme is under the control of the Ontario Research Foundation which has been in operation for thirty-five years and which obtains

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1 Macleans, Dec.1st, 1965.

six-tenths of its funds from private industry, three-tenths from the provincial government, and one-tenth from interest on investments. The funds from industry and government are on the whole payments for specific assignments. Research at Sheridan Park will not revolve around the university, although the site has clearly been chosen to facilitate access to the numerous universities in the Toronto area. Furthermore, the attitude to payment of scientists will not be that of the usual Canadian university. The aim of the organizations occupying Sheridan Park will be to attract and hold the best research scientists available by offering high salaries, lavish research equipment and pleasant surroundings.[1] If this kind of establishment, based on the cooperation of industry and provincial government, spreads it will tend to complete the professionalization of science in Canada. It is also expressly designed to attract scientists away from government and university into industry and is likely to play a prominent role in emphasising the swing from government science to science in industry.

In the near future, then, government science in Canada will be relatively stable while science in the university and industry will expand rapidly. This double expansion will tend to create difficulties particularly because, in the minds of the planners of Canadian science the central concern is that of industrial growth. As a result of this stress upon technological and economic pay-off it is inevitable that the social

1 Ibid.

image of the scientist will change so as to mirror this aspect of scientific research. This change in image will be produced both informally and by direct manipulation on the part of government and industrial agencies. But it seems unlikely that the emphasis upon industrial science can operate without distorting the academic image of the scientist which has played such an important part in scientific recruitment up to the present day. As the academic aspects of the scientist's image decline in prominence it seems probable that recruitment of 'academically' inclined scientists will be reduced. Thus the question arises of whether it is possible to increase recruitment into industrial science without adversely affecting recruitment into university science. Furthermore, is the 'academic' scientist essential to creative, innovating research? Is Steacie correct in the remarks quoted as an introduction to this study?

> In a research organization a few people make all the difference. If five percent of the staff of a research laboratory are really first-rate, with imagination and initiative, all is well. Without this five percent very little that is worth while will emerge from the laboratory. If we are going to expand, these are the essential people. <u>This is where the shortage will develop</u>.

The expansion of Canadian science into a 'mature' science will have to be fostered by government. It will also involve increasing bureaucratization, extrinsic rewards such as high income, and the emergence of an appropriate social image. Yet if these changes take place it may be necessary to take specific measures to encourage the potential 'academic' scientist, if we make the assumption that the latter is essential to the maintenance of creative scientific innovation.[1] If we can assume that the academic scientist provides a necessary dynamic element in science and that professional science will find it increasingly difficult to recruit such men, it follows that the reconciliation of scientific growth in Canada with the maintenance of high standards of research will be difficult to achieve.

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1 Many commentators claim that precisely this problem of maintaining scientific quality already faces the bureaucratic science of the United States.

Appendix: Additional Statistical Tables

Table 28. Types of High School Attended (question 15)

	Scientists %		Non-scientists %	
Church supported high school	3		6	
Other independent high school	8		6	
Public high school	89		88	
	100	N=77	100	N=154

Table 29. Political Affiliation (question 6)

	Scientists %		Non-scientists %	
Social Credit	11		6	
New Democratic Party	33		31	
Liberal	43		44	
Progressive Conservative	5		12	
Communist	-		-	
Abstain	8		7	
	100	N=76	100	N=162

Table 30. Religious Affiliation (question 1)

	Scientists %		Non-scientists %	
Catholic	11		15	
Anglican	17		22	
Other Protestant	37		34	
Other	3		4	
No religion	32		25	
	100	N=75	100	N=161

X^2 test not significant at 95% level of confidence for any of these sets of figures.

BIBLIOGRAPHY:

J. D. Babbitt: Science in Canada: Selections from the Speeches of E.W.R. Steacie.

G. Bancroft: Some Sociological Considerations on Education in Canada in Canadian Education and Research Digest Vol.4, no.1, March 1964.

B. Barber: Science and the Social Order.

B. Barber and W. Hirsch. The Sociology of Science.

D. C. Beardslee and D. D. O'Dowd: The College-Student Image of the Scientist in The Sociology of Science eds. Barber and Hirsch.

H. S. Becker: An Analytical Model for Studies of the Recruitment of Scientific Manpower in Scientific Manpower 1958.

J. Beer and W. Lewis: Aspects of the Professionalization of Science in Daedalus, Fall 1963, Vol. 92 no.4

J. Ben-David: Scientific Productivity and Academic Organization in Nineteenth Century Medicine in Sociology of Science eds. Barber and Hirsch.

J. Ben-David: Professions in the Class System of Present-Day Societies in Current Sociology Vol. XII, no. 3, 1963-4.

P. Blau: Bureaucracy in Modern Society.

B. Blishen:et al. Canadian Society.

B. Blishen: The Construction and Use of an Occupational Class Scale in Canadian Society eds Blishen et al..

J. Bronowski: Science & Human Values.

Paula Brown: Bureaucracy in a Government Laboratory In Social Forces 32, 1954.

H. Butterfield: The Origins of Modern Science.

T. Caplow and R. McGee: The Academic Marketplace.

J. W. Carper and H. S. Becker: Adjustments to Conflicting Expectations in the Development of Identification with an Occupation in Social Forces, 36, 1957.

A. M. Carr-Saunders and P. A. Wilson: The Professions.

L. Coser: Men of Ideas.

Craig, Roche and Navarra: Experimenting in Science

Craig, Roche and Navarra: Teacher's Manual for Experimenting in Science.

G. DeGre: Science as a Social Institution.

Department of Labour: After Graduation: Plans of Final Year Students in Engineering and Science, 1958-1963.

Department of Labour: Professional Manpower Bulletin No. 10.

Department of Labour: Professional Manpower Report No. 13, 1962.

Department of Labour: Skilled and Professional Manpower in Canada, 1945-1965.

H. Gerth and C. W. Mills: Character and Social Structure.

E. Ginzbergot al. Occupational Choice.

W. Hagstrom: The Scientific Community.

H. S. Hall: Scientists and Politicians in Sociology of Science eds Barber and Hirsch.

H. Himmelweit et al. Television and the Child.

W. Hirsch: The Image of the Scientist in Science Fiction in Sociology of Science eds. Barber and Hirsch.

W. Hirsch: The Autonomy of Science in Totalitarian Societies in Social Forces, 40, 1961

J. L. Holland: Undergraduate Origins of American Scientists in Sociology of Science eds. Barber and Hirsch.

G. Holton: Models for Understanding the Growth and Excellence of Science in Excellence and Leadership in a Democracy eds. Graubard and Holton.

N. Kaplan: The Western European Scientific Establishment in Transition in American Behavioral Scientist, December 1962.

R. H. Knapp and H. B. Goodrich: Origins of American Scientists.

R. H. Knapp and J. J. Greenbaum: The Younger American Scholar: His Collegiate Origins.

R. Krohn: The Institutional Location of the Scientist and His Scientific Values in IRE Transactions of Engineering Management, Vol. EM-8, No.3 1961.

R. Krohn: The Scientist: A Changing Social Type in American Behavioral Scientist, December 1962.

Limpus, Reid and Shore: Explorations in Science.

Macleans, December 1st, 1965.

S. Marcson: Decision-Making in a University Physics Department in the American Behavioral Scientist, December 1962.

T. H. Marshall: The Recent History of Professionalism in relation to Social Structure in Citizenship and Social Class.

M.Mead and R. Metraux: The Image of the Scientist among High School Students in Sociology of Science eds. Barber and Hirsch.

N. H. Meltz: Changes in the Occupational Composition of the Labour Force.

L. Meltzer: Scientific Productivity in Organizational Settings in Journal of Social Issues, 12, 1956.

R. K. Merton: Priorities in Scientific Discovery in Sociology of Science eds. Barber and Hirsch.

R. K. Merton: Science and Democratic Social Structure in Social Theory and Social Structure

In the Matter of J. Robert Oppenheimer: U.S.G.P.P. 1954, Washington D.C.,

J. Robert Oppenheimer: The Open Mind

J. Porter: The Vertical Mosaic.

D. J. de Solla Price: Little Science Big Science.

F. Reif: The Competitive World of the Pure Scientist in Science, 134, 1961.

A. Roe: The Making of a Scientist.

The Royal Commission on Government Organization in Canada, 1963. Special Area of Administration 23: Scientific Research and Development.

M. Rosenberg: Occupations and Values.

D. Rueschemeyer: Doctors and Lawyers--A Comment on the Theory of Professions in Canadian Review of Sociology and Anthropology, February 1964.

H. Shepard: Basic Research and Social System of Pure Science in Philosophy of Science, 23, 1956.

S. West: The Ideology of Academic Scientists in IRE Transactions of Engineering Management, June 1960.