

A PSYCHOLOGIST EXAMINES 64 EMINENT SCIENTISTS

The present shortage of qualified scientific workers raises the question of how they are made. Some interesting answers are given by the techniques of modern psychological testing

by Anne Roe

WHAT elements enter into the making of a scientist? Are there special qualities of personality, mind, intelligence, background or upbringing that mark a person for this calling? Besides the natural interest in these questions, they have a practical importance, because the recruitment of qualified young people into science is a growing problem in our society. Where and how shall we find them?

During the past five years I have been making a study of the attributes of a group of scientists and the reasons why they chose this field of work. The most eminent scientists in the U. S. were selected as subjects, since they are most likely to exemplify the special qualities, if any, that are associated with success in research science. They were selected by panels of experts in each field of sci-

ence. The study finally settled on a group of 64 eminent men who agreed to participate—20 biologists, 22 physicists and 22 social scientists (psychologists and anthropologists). A high percentage of them are members of the National Academy of Sciences or the American Philosophical Society or both, and among them they have received a staggering number of honorary degrees, prizes and other awards.

Each of the 64 individuals was then examined exhaustively by long personal interviews and tests: his life history, family background, professional and recreational interests, intelligence, achievements, personality, ways of thinking—any information that might have a bearing on the subject's choice of his vocation and his success in it. Each was given an intelligence test and was

examined by two of the modern techniques for the study of personality: the Rorschach and the Thematic Apperception Test (TAT). The Rorschach, popularly known as the inkblot test, gives information about such things as the way the subject deals with problems, his manner of approach to them, the extent and efficiency of his use of rational controls, his inner preoccupations, his responsiveness to outside stimuli. The TAT gives information about attitudes toward family and society and self, about expectations and needs and desires, and something about the development of these.

My study was financed during the first four years by grants from the National Institute of Mental Health and is being continued this year under a Guggenheim Fellowship. It has developed

FIELD	AGE AT TIME OF STUDY		AVERAGE AGE AT TIME OF RECEIVING COLLEGE DEGREES	
	Average	Range	B. A.	Ph. D., Sc. D., M. D.
Biologists	51.2	38-58	21.8	26.0
Physical scientists	44.7	31-56	20.9	24.6
Social scientists	47.7	35-60	21.8	26.8

AVERAGE AGE of the subjects at the time of the study and at the time they received their degrees is given in

this table. The upper age limit was set at 60; the lower limit was determined by the eminence of the subjects.



THE THEMATIC APPERCEPTION TEST

One of the projective psychological tests used by the author in her interviews with the 64 scientists is the Thematic Apperception Test, commonly called the TAT. In this test the subject is given a set of large cards, one blank and 19 bearing pictures. One of the pictures is shown above. The subject is asked to write a story about each of the cards; the stories are then studied by a trained interpreter as a method of revealing some of the subject's drives, emotions, sentiments, complexes and conflicts of personality.

The test was devised by Henry A. Murray of Harvard University, who observes about it: "The TAT will be found useful in any comprehensive study of personality, and in the interpretation of behavior disorders, psychosomatic illnesses, neuroses and psychoses. The fact that stories collected in this way often reveal significant components of personality is dependent on the prevalence of two psychological tendencies; the tendency of people to interpret an ambiguous human situation in conformity with their past experiences and present wants, and the tendency of those who write stories likewise to draw on the fund of their experiences and express their sentiments and needs, whether conscious or unconscious. The subject's interest, together with his need for approval, can be so involved in the task that he forgets his sensitive self and the necessity of defending it against the proings of the examiner, and, before he knows it, he has said things about an invented character that apply to himself, things which he would have been reluctant to confess in response to a direct question."

The picture, copyrighted in 1943 by the President and Fellows of Harvard College, is reproduced by permission of the Harvard University Press.

a great deal of material, much of which has been published in technical detail in special journals. In this brief article it is possible only to recapitulate the high points.

THERE IS no such thing, of course, as a "typical" scientist. Eminent scientists differ greatly as individuals, and there are well-marked group differences between the biologists and the physicists, and between the natural scientists and the social scientists. Certain common patterns do appear, however, in the group as a whole, and the most convenient way to summarize these generalizations is to try to draw a picture of what might be called the "average" eminent scientist.

He was the first-born child of a middle-class family, the son of a professional man. He is likely to have been a sickly child or to have lost a parent at an early age. He has a very high I.Q. and in boyhood began to do a great deal of reading. He tended to feel lonely and "different" and to be shy and aloof from his classmates. He had only a moderate interest in girls and did not begin dating them until college. He married late (at 27), has two children and finds security in family life; his marriage is more stable than the average. Not until his junior or senior year in college did he decide on his vocation as a scientist. What decided him (almost invariably) was a college project in which he had occasion to do some independent research—to find out things for himself. Once he discovered the pleasures of this kind of work, he never turned back. He is completely satisfied with his chosen vocation. (Only one of the 64 eminent scientists—a Nobel prize winner—says he would have preferred to do something else: he wanted to be a farmer, but could not make a living at it.) He works hard and devotedly in his laboratory, often seven days a week. He says his work is his life, and he has few recreations, those being restricted to fishing, sailing, walking or some other individualistic activity. The movies bore him. He avoids social affairs and political activity, and religion plays no part in his life or thinking. Better than any other interest or activity, scientific research seems to meet the inner need of his nature.

This generalized picture represents only majority traits; there are, of course, many exceptions to it, not only in individual cases but by groups; the social scientists, for instance, tend to be by no means shy but highly gregarious and social. Let us now consider the differences between groups. I have separated the physicists into the theorists (12) and the experimentalists (10), because these two groups differ sharply. The biologists (physiologists, botanists, geneticists, biochemists and so on) are

sufficiently alike to be grouped together, and so are the social scientists.

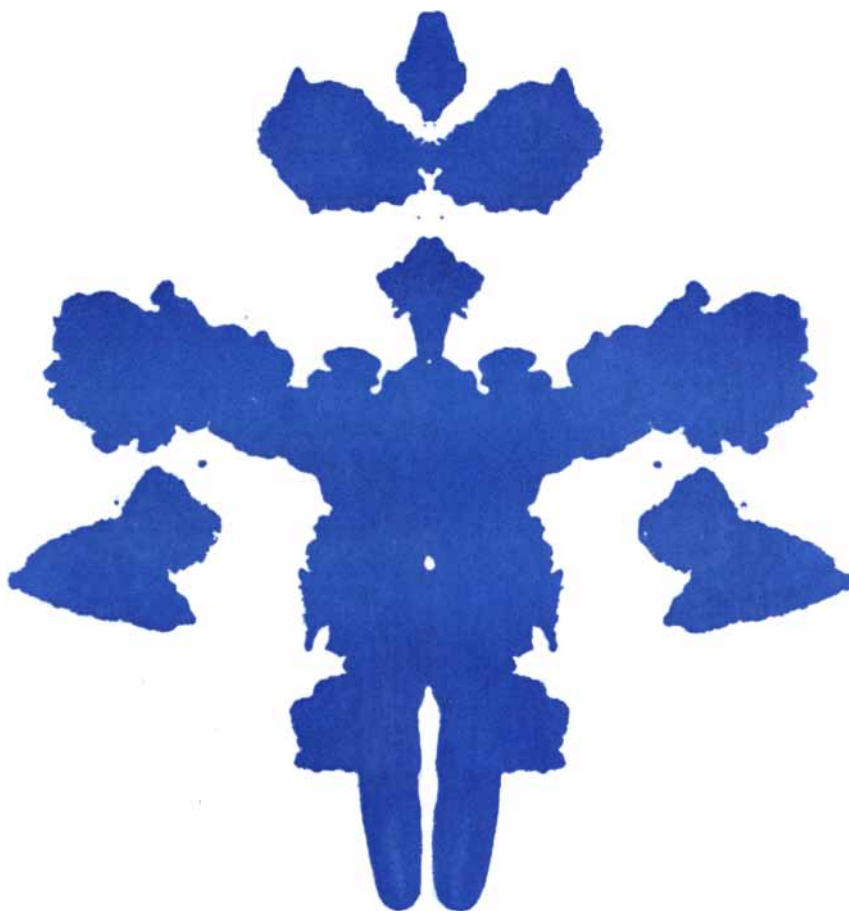
NO STANDARDIZED intelligence test was sufficiently difficult for these eminent scientists; hence a special test was constructed by the Educational Testing Service. To provide ratings on particular intellectual factors, the test was divided into three parts: verbal (79 items), spatial (24 items) and mathematical (39). (The mathematical test used was not difficult enough for the physicists, and several of them did not take it.)

While the group as a whole is characterized by very high average intelligence, as would be expected, the range is wide (*see table on page 24*). Among the biologists, the geneticists and biochemists do relatively better on the non-verbal tests than on the verbal, and the other biologists tend to do relatively better on the verbal. Among the physicists there is some tendency for theorists to do relatively better on the verbal and for the experimentalists to do relatively better on the spatial test. Among the social scientists the experimental psychologists do relatively better on the spatial or mathematical than on the verbal test, and the reverse is true of the other psychologists and the anthropologists.

On the TAT the social scientists tended to give much longer stories than the other groups did—verbal fluency is characteristic of them. The biologists were inclined to be much more factual, less interested in feelings and, in general, unwilling to commit themselves. This was true to a lesser extent of the physical scientists. The biologists and physical scientists manifested a quite remarkable independence of parental relations and were without guilt feelings about it, while the social scientists showed many dependent attitudes, much rebelliousness and considerable helplessness, along with intense concern over interpersonal relations generally. The biologists were the least aggressive (but rather stubborn) and the social scientists the most aggressive. The most striking thing about the TAT results for the total group, however, is the rarity of any indication of the drive for achievement that all of these subjects have actually shown in their lives.

On the Rorschach the social scientists show themselves to be enormously productive and intensely concerned with human beings; the biologists are deeply concerned with form, and rely strongly upon a non-emotional approach to problems; the physicists show a good deal of free anxiety and concern with space and inanimate motion. Again the social scientists, particularly the anthropologists, are the most freely aggressive.

Early in the course of the work it became apparent that there were some



RORSCHACH TEST, in which the subject describes the pictures he is able to perceive in a standard set of inkblots, also was used in the study.

differences in habits of thinking, and a special inquiry was instituted along these lines. The data are unsatisfactory from many standpoints—there are no objective tests for such material, and I had to ask many leading questions in order to convey any idea of what I was after. Nevertheless rather definite and meaningful patterns did appear. The biologists and the experimental physicists tend strongly to dependence upon visual imagery in their thinking—images of concrete objects or elaborate diagrams or the like. The theoretical physicists and social scientists tend to verbalization in their thinking—a kind of talking to themselves. All groups report a considerable amount of imageless thinking, particularly at crucial points. Men whose fathers followed talkative occupations (law, ministry, teaching) are more likely to think in words.

THE LIFE histories of these 64 men show some general similarities, and there are patterns characterizing some of the subgroups. Geographical factors seem not to be particularly significant, except that only a few came from the South. The economic level was varied, ranging from very poor to well-to-do; among the anthropologists and the theo-

retical physicists a somewhat higher percentage came from well-to-do homes.

In several respects the scientists' backgrounds differ very much from the population at large. There are no Catholics among this group of eminent scientists; five come from Jewish homes and the rest had Protestant backgrounds. Only three of the 64 now have a serious interest in any church; only a few even maintain church memberships.

Another striking fact is that 53 per cent of the scientists were the sons of professional men; not one was the son of an unskilled laborer and only two were sons of skilled workmen. Why do more than half of our leading scientists come from the families of professional men? It seems to me most probable, from more knowledge of the family situations of these men than I can summarize here, that the operative factor is the value placed by these families and their associates on learning—learning for its own sake. Most of the scientists developed intellectual interests at an early age.

Another remarkable finding is how many of them were their parents' first children. This proportion is higher than chance expectancy in all of the subgroups. Thirty-nine were first born; of the rest five were eldest sons and two

	Biologists	Experimental physicists	Theoretical physicists	Psychologists	Anthropologists	TOTALS
PROFESSIONS	9	5	10	7	3	34
Research Science	0	1	0	0	0	1
Physician	0	2	1	2	0	5
Lawyer	0	0	1	1	3	5
Engineer	0	0	3	2	0	5
Clergyman	2	0	1	0	0	3
Editor	2	0	0	0	0	2
College teacher	4	0	3	2	0	9
School teacher	0	2	0	0	0	2
School superintendent	1	0	0	0	0	1
Pharmacist	0	0	1	0	0	1
BUSINESS	8	1	2	4	5	20
Own business	4	0	2	2	4	12
Clerk, agent, salesman	4	1	0	2	1	8
FARMER	2	4	0	2	0	8
SKILLED LABOR	1	0	0	1	0	2
TOTALS	20	10	12	14	8	64
PER CENT PROFESSIONAL	45	50	84	50	38	53

OCCUPATIONS OF THE FATHERS of the 64 eminent scientists showed a strong bias in favor of the professions. This was especially true of the 12 theoretical physicists, 10 of whose fathers had been professionals.

The anthropologists were an exception: five out of eight came from business backgrounds. Four of the 10 experimental physicists were the sons of farmers. None of the scientists were the sons of unskilled laborers.

	Number	VERBAL TEST		SPATIAL TEST		MATHEMATICAL TEST	
		Average	Range	Average	Range	Average	Range
Biologists	19	56.6	28-73	9.4	3-20	16.8	6-27
Experimental physicists	7	46.6	8-71	11.7	3-22		
Theoretical physicists	11	64.2	52-75	13.8	5-19		
Psychologists	14	57.7	23-73	11.3	5-19	15.6	8-27
Anthropologists	8	61.1	43-72	8.2	3-15	9.2	4-13
TOTAL	59	57.7	8-75	10.9	3-22	15.9	4-27
APPROXIMATE IQ EQUIVALENTS		163	121-177	140	123-164	160	128-194

INTELLIGENCE TEST RESULTS revealed minor variations among the specialties of the scientists. The theoretical physicists did best in the verbal test; the experimental physicists rated lowest. Both theoretical

and experimental physicists did not take the mathematical test because it was not sufficiently difficult. Two anthropologists who took the verbal test did not take the other tests on the ground that they could not do them.

who were second born were effectively the eldest because of the early death of the first child. For most of the others there is a considerable difference in age between the subject and the next older brother (averaging five years). It seems probable that all this may point to the most important single factor in the making of a scientist—the need and ability to develop personal independence to a high degree. The independence factor is emphasized by many other findings: the subjects' preference for teachers who let them alone, their attitudes toward religion, their attitudes toward personal relations, their satisfaction in a career in which, for the most part, they follow their own interests without direction or interference. It is possible that oldest sons in our culture have a greater amount of independence or more indulgence in the pursuit of their own interests than other children have. On the other hand, there is some psychological evidence that first-born tend to be more dependent, on the average, than other children, and a good case could be made out for a hypothesis that reaction to this overdependence produced the scientists' strong drive to independence.

The early extracurricular interests of these men were varied, but here, too, there are some general patterns. More of the physicists than of the other groups showed early interests directly related to their later occupations, but this seems quite clearly to be due to the common small-boy preoccupation in this country with physical gadgets—radio, Meccano sets and so on. The theoretical physicists were omnivorous readers, the experimentalists much less so. Among the social scientists many went through a stage of considering or even working toward a literary career. Half of the biologists showed some early interest in natural history, but for only five was it of an intense and serious sort, involving keeping field records of birds and flowers, and so on. Many of the biologists did not know during childhood of the possibility of a career in biology. This was even more true of the psychologists and anthropologists, since there are almost no boyhood activities related to professional social science.

IT IS of considerable interest that over half of these men did not decide upon their vocations until they were juniors or seniors in college. More important, perhaps, than when they decided, is why they decided. It certainly was not just a matter of always following an early bent. From fiddling with gadgets to becoming a physicist may be no great leap, but the attractions of theoretical physics are not so obvious or well known, nor are those of the social sciences or advanced biology. In the stories of the social scientists and of the biologists it becomes clear that the most important factor in

FIELD	Visual	Verbal	Imageless	TOTALS
Biologists	10	4	3	17
Physicists	10	4	4	18
Psychologists and anthropologists	2	11	6	19
TOTALS	22	19	13	54

IMAGERY OF THE SCIENTISTS was correlated with specialty. The natural scientists were strong in visual imagery; the social scientists, in verbal.

the final decision to become a scientist is the discovery of the joys of research. In physics the discovery may come so gradually as not to be noticed as such, but in the other sciences it often came as a revelation of unique moment, and many of these men know just when and how they found it out. A couple of quotations will illustrate this:

"I had no course in biology until my senior year in college. It was a small college and the teacher was about the first on the faculty with a Ph.D. It was about my first contact with the idea that not everything was known, my first contact with research. In that course I think my final decision was really taken. It was mainly that I wanted to do something in the way of research though I didn't know just what, but working out something new."

"One of the professors took a group of us and thought if we wanted to learn about things, the way to do it was to do research. My senior year I carried through some research. That really sent me, that was the thing that trapped me. After that there was no getting out."

That research experience is so often decisive is a fact of very considerable importance for educational practice. The discovery of the possibility of finding things out for oneself usually came through experience in school with a teacher who put the students pretty much on their own.

There are other things in the general process of growing up that may have influenced the choice of career in subtle ways. One fourth of the biologists lost a parent by death or divorce at an early age. This may have tended to shove them to greater independence. Among

the theoretical physicists there was a high incidence of serious illness or physical handicaps during childhood, which certainly contributed to the feelings of isolation characteristic of them. Among the social scientists there is an unusually intense concern with personal relationships, which often goes back to family conflicts during childhood. A relatively large proportion of them seem to have come from homes in which the mother was dominant and the father inadequate in some way. The divorce rate among the social scientists in this study was remarkably high—41 per cent.

Whereas the characteristic pattern among the biologists and physicists is that of the shy, lonely, over-intellectualized boy, among the social scientists the characteristic picture is very different. They got into social activity and intensive and extensive dating at an early age. They were often presidents of their classes, editors of yearbooks and literary magazines, frequently big shots in college. This contrast between the natural and social scientists was still evident after they grew up. It is true only in general, of course; even among the theoretical physicists there are some ardent party-goers.

The one thing that all of these 64 scientists have in common is their driving absorption in their work. They have worked long hours for many years, frequently with no vacations to speak of, because they would rather be doing their work than anything else.

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PROFESSION OF FATHER	Visual	Verbal	Imageless	TOTALS
Verbal	5	10	3	18
Non-verbal	8	2	2	12
TOTALS	13	12	5	30

IMAGERY OF THE FATHER'S PROFESSION was strongly influential. The numbers on the right side of this table refer to the imagery of the sons.