$7.00 per volume
Single numbers $4.00

QUARTERLY
Two volumes per year

May, 1951
Volume 43, Second Half

(Founded in 1925 by Carl Murchison)

GENETIC PSYCHOLOGY MONOGRAPHS

Child Behavior, Animal Behavior, and Comparative Psychology

EDITED BY
CARL MURCHISON

Entered as second-class matter April 15, 1937, at the post-office at Provincetown, Mass., under Act of March 3, 1879

The Journal of Psychology

EDITED BY

Carl Murchison

The Journal of Psychology was founded at the request of many psychologists throughout the world for the purpose of establishing a medium in which publication shall be immediate and in which other publication experiments may be carried out.

(1). The subscription price will be $7 per volume.

(2). The format of each volume will be such that each subscriber may tear down the assembled volume into its component articles.

(3). Except through the fault of the author, the lag in publication should not be more than three or four weeks.

(4). The author will receive 200 reprints of his paper, and subscriber will receive the accumulated publications bound into half volume units. The second half of each volume will contain the title page and table of contents for that volume. Each half volume unit will be mailed to the subscribers at its stated date.

(5). Each author will be charged the actual manufacturing costs of any zinco or halftone cuts.

(6). The publication charges will be as follows:

4	page	signature	$35.00
8	"	"	48.00
12	"	"	72.00
16	"	"	96.00
20	"	"	120.00
24	"	"	144.00
28	"	"	168.00
32	"	"	192.00
36	"	"	216.00
40	"	"	240.00

These charges are tentative and will be adjusted as justified by the subscription list (especially by the effect of the war in China and in Europe).

(7). The accumulated units will be mailed to subscribers quarterly: January, April, July, and October. The units may vary in size, to accommodate publication needs.

Two volumes annually. Per annum $14.00; per volume $7.00; per half volume unit $4.00. Complete sets at $8.00 per volume, plus transportation.

THE JOURNAL PRESS
2 Commercial Street
Provincetown, Massachusetts
U. S. A.

$7.00 per volume
Single numbers $4.00

QUARTERLY
Two volumes per year

May, 1951
Volume 43, Second Half

(Founded in 1925 by Carl Murchison)

GENETIC PSYCHOLOGY MONOGRAPHS

Child Behavior, Animal Behavior, and Comparative Psychology

MAY, 1951

(Manuscripts are printed in the order of final acceptance)

Entered as second-class matter April 15, 1937, at the post-office at Provincetown, Mass., under Act of March 3, 1879

Genetic Psychology Monographs, 1951, **43**, 121-239.

A PSYCHOLOGICAL STUDY OF PHYSICAL SCIENTISTS*

La Jara, New Mexico

ANNE ROE

*Accepted for publication by Lewis M. Terman of the Editorial Board, received in the Editorial Office on February 8, 1951, and published immediately as a public service.

INTRODUCTION

This clinical psychological study of physical scientists follows a similar study of biologists (8). Like the former it has been supported wholly by a grant from the Division of Research Grants and Fellowships of the National Institutes of Health, U. S. Public Health Service.

The broad problem under investigation is that of the relationships between personality and vocation. At the present time, the work is focussed upon scientists in an attempt to learn whether there are any personality or life history patterns which are particularly characteristic of certain groups of scientists or of scientists in general.

Two main approaches have been used in the study. In the first, detailed clinical studies have been made of men of high eminence in the field. These have comprised interviews on life history, administration of the Rorschach, the Thematic Apperception Test, and a Verbal-Spatial test, and some brief discussion of the work of the subject. The second approach has been by Group Rorschachs of members of six university faculties.

The rationale back of this plan is explained in the monograph on biologists (8) and will not be discussed at length here. It may be stated, however, that the combination of projective tests, and tests of intellectual functions with life histories recorded verbatim in a minimally structured interview gives a very comprehensive clinical picture. The number of individuals studied this way is necessarily small, not only because of the time devoted to each one but also because they are widely dispersed geographically. The Group Rorschachs were collected in order to have some comparable data on a larger group in the same vocation.

It is obvious that the procedure in the individual studies is very time consuming for the subjects and their generosity in taking part in such a study as this is noteworthy. I cannot express my appreciation warmly or strongly enough. Any psychologist who has tried to get together a normal group at any level will particularly understand the difficulties of assembling so superior a one. Its importance for psychological theory in general as well as for this study is very great.

ANNE ROE

La Jara, New Mexico

1. SELECTION OF THE SAMPLE

Selection was a difficult job because of my lack of professional competence in physics, and the fact that the representation of physical scientists in the two major general national societies (the National Academy of Sciences and the American Philosophical Society) is apparently less adequate than the representation of biologists in these societies. The first difficulty was largely overcome by the wholehearted coöperation of Dr. Paul Epstein of the California Institute of Technology who spent a great deal of time constructing a preliminary list. This included the physicist members of the two societies named and in addition a large number of fellows of the American Physical Society. This original list was then pruned of men over 60 years of age, of those who were foreign born (an error was made in one instance, but as the subject came to this country as a very small child this was disregarded), and of those whose time was so taken up with administrative duties that they were not continuing research. (There are two administrators in the final list—one had been so for many years, but continued considerable research; the other had just changed over to full time administration.) These are the same criteria that were used for the study of biologists and their import is obvious.

The major concentration is in the field of physics proper, but there were included also men working in astrophysics, geophysics, physical chemistry, and theoretical engineering. The list derived as explained above included 39 physicists, 7 astrophysicists, 6 geophysicists, 9 physical chemists, and 8 engineers. Three of these were later dropped since it was learned that they were primarily administrators at the time, and four others were added at the suggestion of the men who were doing the rating. Several of those finally selected as subjects were later found to belong in other categories; this accounts for some imbalance in the final selection.

This list was then submitted to seven raters, selected to cover all of the fields. These were Dr. Paul Epstein, Dr. Hugh Dryden, Dr. George Kistiakowsky, Dr. W. V. Houston, Dr. Walter S. Adams, Dr. Beno Gutenberg, and a nuclear physicist who prefers not to be named. They were asked to rate only the men whose work they knew well enough to evaluate, and to rate them as 1, 2, or 3 in descending order of excellence. A few used intermediate ratings also, as 1-2 or 2-3. The final selection was made on the basis of these ratings. One man was included whose work was known to only two raters (and rated as 1 by both); all of the others were rated by at least three men. It was planned not to include any men in the

selection who received any rating of 3, but this would have eliminated too many men (because of the number of refusals) and three such men are included. In each instance there are at least three ratings for each (including at least one rating of 1) and the rating of 3 was given to each by the same rater, who was throughout very much more critical than any of the other raters. In all, 30 men were finally selected.

There are very interesting differences between the responses of the physical scientists and of the biologists to the letters which were sent out. The text was essentially the same. In the case of the biologists, there were only three refusals (two of which were thoroughly justified by special circumstances) although occasionally a second letter was necessary. With the physicists there were five who did not respond to either of two letters (three of them were later reached by phone or in person and readily agreed to take part); two refused on the plea of inadequate time and four wrote simply that they preferred not to be included. Similar difficulties were encountered in the group studies. Two of the studies of those who were seen are very incomplete, all test data being lacking. The tests secured from another subject have not been included because of special circumstances. The refusals, however, are not concentrated in those who received the highest ratings but are somewhat concentrated in theoretical physics. This does not materially affect the sampling. All of the men on the original list are at such a high level that differences among them are not very great. It had been hoped that there would be at least two from each of the more specialized groups but this did not work out. They are not separately designated. It should be pointed out in comparing the number of refusals for physicists and biologists that there is a considerable difference in the amount of free time available to them. The physicists are under much heavier pressure both in their regular work and in extra work.

Apart from the matter of numbers of refusals there are other differences between the biologists and physicists in their attitudes. Some of the biologists took the precaution of asking colleagues about me or checking up in some way, although this was apparently not common. It was much more common among the physicists, and in some instances the checking was quite complete. This is obviously a reasonable procedure and one which I am glad to have them follow since it makes for easier interviewing, but it is also indicative of certain differences in personality.

An additional difference is in the fact that with the biologists it was always possible to arrange two interviews and often three, which is much to be preferred, even though the elapsed time is no greater. Here, again,

the reality situation is a factor; it commonly happened with the physicists that only one interview could be obtained, although when this was the case it was usual to have a whole afternoon cleared for the purpose. In such instances there was generally not time to do the verbal spatial test, and then this was left with the subject. Of four tests left, two were not returned.

II. DESCRIPTION OF THE GROUP

The final group includes 9 theoretical physicists, 9 experimental physicists, and 4 physical chemists of whom 3 are theoretical and one experimental. Hence there are 12 who are classed as theorists and 10 classed as experimentalists. When there was any question as to classification I accepted the subject's statement.

Average age of the group is 44.7 ± 1.4. The range is 31 to 56 years. The theorists average 44.0 years and the experimentalists 45.7. Although selective criteria were similar, this group is younger than the biologists who averaged 51.2 ± 1.4 years, and this difference is significant at .001 *P*. This reflects the well-known fact that physical scientists achieve eminence at an earlier age than than do biological scientists, and this in turn, reflects certain differences in the two fields of study.[1]

A. Family Backgrounds

Some familial data were gathered for each man, enough to give an idea of the general social background of the family.

Birthplace by states is as follows: California, 4; Indiana, 2; New York, 2; Washington, 2; and 1 each in Connecticut, Kansas, Louisiana, Massachusetts, Minnesota, Oklahoma, Oregon, South Carolina, South Dakota, Texas, and Utah. Over half of them come from west of the Mississippi, in contrast to the biologists, only four of whom came from that part of the country. This may be in part due to the rather slight age difference. The period was one of rapid movement in the country, and this group is just enough younger that there had been considerable change in the population distribution and in the educational facilities available.

Occupations of the fathers of the subjects are given in Table 1. It is striking that 73 per cent of the fathers (84 per cent of fathers of theorists; 50 per cent of fathers of experimentalists) were in the professional class. This is even higher than in the case of the biologists, of whose fathers 45 per cent were professional men. Of the two business men, one was a designer and manufacturer, the other had studied law but owned his own small business and had never practiced law. Most of the mothers also came from families in which the men were in professions. Two mothers had

[1] As one physicist put it: "I think it's true that scientists reach distinction earlier, more or less in the ratio of the relative importance of intellectual effort to the experimental work. In pure mathematics you can have a smart idea and become a great man. In biology you essentially have to make experiments, you can't speculate about what an animal is doing and this is hard and takes a long time."

taught and one was a concert pianist; one had taught art and another was a graduate in music. The educational level of both parents is very much above the mean for the country at large.

TABLE 1
OCCUPATIONS OF FATHERS

Occupation	Number of fathers in occupation		
	Theorists	Experimentalists	Total
Research Scientist	0	1	1
College Teacher	3	0	3
Teacher, Primary or Secondary	0	2	2
Engineer	3	0	3
Physician	0	2	2
Minister	1	0	1
Lawyer	1	0	1
Optometrist	1	0	1
Pharmacist	1	0	1
Salesman	0	1	1
Businessman	2	0	2
Farmer	0	4	4
% professional	84%	50%	73%

In contrast to the biologists, only two of this group lost a parent by death under the age of 10 and the parents of only one were divorced.

Number of children in the parental family and position in the family (birth order) of these subjects are of some interest. The data are given in Table 2.

TABLE 2
NUMBER OF CHILDREN IN PARENTAL FAMILY AND BIRTH ORDER OF SUBJECTS

No. of children including subject	Number of subjects	Position in family	Number of subjects
1	5	1	16
2	4	2	3
3	4	3	0
4	2	4	0
5	4	5	1
6	0	6	0
7	3	7	2

Concentration of the men among the first born is very striking. Only five of these 16 were only children. It is also interesting that of the three who came from families of seven children, two were the youngest in the family. It should be noted that two of these subjects have stepsibs or half-sibs who are not included in the table.

Among the sibs of this group, most are themselves in professions, although some are in business. There are no unskilled or skilled workmen among them so far as my records go.

B. Marital Status

All of these men are married. Only one has been divorced, and one has remarried after the death of his first wife. Age at marriage and number of children for each subject are given in Table 3. Average age of marriage is 27.0. This is like the biologists—both are rather late. In part this is connected with the long educational histories. Some of these men are young enough that it is not unlikely there will be more children born to them in the future. I have only inferential data on marital adjustment in the group. I would judge it to be, on the whole, very good. Like the biologists, this is socially a very stable group.

TABLE 3
Age at Marriage and Number of Children

Age at marriage	No. of subjects	No. of children	No. of subjects
34	2	4	5
33	2	3	1
32	1	2	9
31	0	1	3
30	1	0	4
29	1		44
28	2		
27	1	Sons	19
26	4	Daughters	25
25	2		
24	1		
23	2		
22	1		
21	0		
20	1		
19	1		
Average	27.0		

Of the 44 children of the physicists, 19 are sons and 25 are daughters. This presents an interesting contrast with the biologists, whose 44 children include 30 sons and 14 daughters. X^2 is 5.56, P between .02 and .01. I have no interpretations to offer!) It also contrasts with Terman's (13) gifted group whose offspring had a high sex ratio.

C. College and Graduate School Histories

Ages at which these men completed various stages in their training are given in Table 4. Only nine took Master's degrees.

Average ages for receiving degrees are, for B.A. or B.S., theorists 20.5, experimentalists, 21.4, both 20.9; for earned Ph.D. or Sc.D., theorists 23.7, experimentalists 25.8, both 24.6. In part, the somewhat younger age at

TABLE 4
AGE AT RECEIVING COLLEGE DEGREES

Age at receiving degree	B.A. or B.S.			Earned Sc.D. or Ph.D.		
	Theor.	Exper.	Total	Theor.	Exper.	Total
30					1	1
29					1	1
28						
27					1	1
26				2	1	3
25				2	4	6
24		1	1	2		2
23	1	1	2	3	2	5
22	2	2	4	2		2
21	3	3	6	1		1
20	3	3	6			
19	2		2			
18	1		1			
N	12	10	22	12	10	22
Average	20.5	21.4	20.9	23.7	25.8	24.6

which the theorists finished reflects an economic difference in the parental families. It will be remembered that more of the fathers of the theorists were professional men, and as a result fewer of them had to work their way through college, or were severely hampered by lack of funds. They do not differ from the biologists in this respect.

There is little concentration in particular universities for doctoral work in this group. Only four universities gave degrees to more than one of the men in this group. These were Chicago University, 4; California Institute of Technology, 4; University of California, 3, and Princeton University 2.

Most of these men needed assistance in going through college; some of them had a very difficult time indeed financially. By the time they were in graduate school, however, those who needed financial help all had fellowships. Many of them also had post-doctoral fellowships: nine have had National Research Council fellowships, and two have had International Education Board fellowships in addition to others.

III. EARLY HISTORY RELEVANT TO OCCUPATIONAL CHOICE

In the life histories which follow, considerable differences in amount of detail are noticeable. Except for some editing, and a few changes made by the subjects when the personal material was submitted for their approval, the stories are essentially as they were told to me, and recorded almost verbatim. Presentation of them in this form gives a good deal of the "feel" of the personality not so easily conveyed in any other way. I did very little guiding of the interview after a preliminary statement of topics to be covered, asking questions only when it appeared that relevant data were being omitted, or to clarify some point (these questions are recorded in parentheses), so that the histories mainly include the things that the men themselves remember as of importance.

The clinical value of such life histories, particularly where the recording is verbatim, as here, has been adequately established by Allport (1). The pitfalls he mentions are largely absent in this material, except that of unconscious distortion. Here, however, some of the projective material provides a check, as on family relations. Furthermore, in an interview as little structured as this, the sequence of statements which has been preserved in the record is in itself something of a check, and the phraseology often provides useful clues to possible distortions. What is given here is what seems now to the men to be of importance, and this has its own significance.

The theoretical and experimental groups are presented separately, but the histories are not given in the order of presentation of other data, and the code numbers and letters assigned to each man for the test material have been omitted, since it is clear that some of the subjects can be identified by their close friends from these stories. The order of presentation of the life histories is roughly in accord with the lateness of the vocational choice. This bears no relation to the assignment of code numbers.

A. The Theorists

1. *Biographical*

1. This interview was very brief but a few salient facts were elicited. Some of the material was later deleted at the subject's request. He is the son and grandson of mathematicians. "I made up my mind that if there was anything I wasn't going to be it was a college professor, so here I am!" When pressed a bit, he said that he had to make a living and that was all he knew, and after he found he could make a living at physics

it would have been silly to change. He has never seriously considered doing anything else, although he had thought at times that he might have liked to be a lawyer but he supposed they had to spend a lot of time on very dull stuff. He had also thought of being a geologist but drawing pictures and graphic solutions didn't appeal to him.

2. His father was a college professor and his mother interested in art so that his background was a very specialized one intellectually. He says of high school:

> I liked school. I enjoyed nearly all subjects. They had a scientific course and another course, and I took the scientific. The reason was that there existed a scholarship fund for the nearest technical school covering tuition and train fare. That was why they had a scientific course at the high school.
>
> I suppose it was taken for granted I would go to college but this scholarship was available and it always appeared the family had no money, so no one would ever think of doing anything that would be expensive. I felt then and certainly felt afterwards that I didn't exercise the proper initiative with respect to trying to accomplish things that were not scheduled, and this has led to a conflict which remains. I was very much interested in scientific ideas and I was also very interested in other things. I remember once thinking of philosophy as a career and looked at books on the subject but saw that they all disagreed, and I gave up the idea; I suppose that was a sign of the scientific attitude. But I had also a great congeniality with the aesthetic. It was not so much an interest in music but in visual, two-dimensional things, and a great love of color.
>
> I had no early interests in gadgets. That was partly mother's influence. She was always talking about truth, beauty, and justice, and at that time I thought that mechanical gadgets weren't beautiful. Father was interested in carpentry and gardening but I didn't take to that. Before breakfast I used to go out on a bicycle, sometimes I would get up before the sun rosé, maybe at 4:00 on a May or June morning and ride 20 miles or so before school. I would go out and see the birds get up and the sun rise. I would go out and greet the dawn and enjoy it all in a very poetic manner. I never did anything in a positive or creative way in any of these fields of art but I had the passive side of it, the receptivity, a poetic reaction towards nature.
>
> At that time in the high school period I first read about the electron and previous to that I'd been taken to church regularly and had very considerable emotional reactions to it, the singing particularly, but I was never satisfied with it intellectually. I'm sure it was partly the result of the absence of any attitude on father's part or very much on mother's part in religious matters. Father didn't say anything or mother much. I read someone's book about the electron and I had for a moment an inspiration that maybe God was in the elec-

> tron, but this didn't last. Also about that time I gave a graduation essay as second in the class, on "The Electron, What It Is and What it Does." Of course the first in the class was a girl. She just worked hard, I suppose, and I didn't work quite so hard; up to that time my studies were quite easy.
>
> I read a great deal for two or three years and after that I didn't read so much. One reason was that I never learned to read fast enough. I was just learning about life at that period but it was a relatively short one. Some of it on my part was a result of lack of social contacts.

At college he took the general technical course, but some of the studies, such as projective geometry, didn't go so well, although he had had no difficulties in high school. One summer he did some extra work in chemical engineering which he particularly enjoyed because of his great interest in odors and colors. As a senior, in place of research he did a bibliographic job. During the war he worked in a research lab in Washington with poison gas. Although he worked out some theoretical ideas which would have been valuable, he kept them to himself, because he wasn't asked.

> I had a foolish feeling that other people ought to find out if there was something I could do. It didn't seem seemly for me to tell them. I think it should be a business of the professor to explore the potentialities but I think also that the chairman of a department should try to find out what people have done and are doing and try to help them.

"I don't know how I acquired the idea of going on in school but it just seemed the natural thing to do to acquire a Ph.D." At first, however, he took an industrial research job for money and experience.

> As I recall it, it seemed to me they were wasting their money on me, but this was partly because of my general attitude that there was no use in anything. I was just dragging myself around, there remained only a faint spark of interest in life which carried me through. Lack of social adjustment was one thing in this rational development of a scientific nature. It seemed to lead to the conclusion that there wasn't much point in anything. In school there was a great lack of training in the art of living. The reason that I was interested in physical sciences rather than biology was that life was a minor thing.
>
> Then I got a fellowship. I felt this was granted because they knew my father and not because of my own merits, but I took it anyway. For a long time I generally allowed fate to decide; and I usually made a habit of not doing what I really wanted to do. At first I started working in one field but then rebelled and shifted for my Ph.D. thesis to more nearly what I wanted to do. Then, following the path of least resistance as usual, I got recommended as a National Research

> fellow, and continued in the same field. After a year or two the NRC said they would renew the fellowship if I would do something different. It was then I went to another university and shifted to physics.

He is still working in the same general field in which he started at that time.

3. His father was a professional man and very scholarly and the whole family were very studious and all read a great deal. They were also rather poor, but every member of the large family went to college.

> I don't remember anything about my childhood, I am always surprised at the things people remember because I don't remember anything. The closest thing to physics in the sense of a somewhat early start that I recall is that the summer before I went to college I started reading physics books. I took it in high school but remember nothing of it. I think I was third or fourth in the class but I have no recollection whatever about it. There were some college texts about the house (apparently belonging to sibs) and for some crazy reason I started to read those. I vaguely recall that I presumably liked math. I got good grades in everything, I must have because I was high in the class. But I don't remember, and I didn't like or dislike anything especially.
>
> My older brother and I sold papers when we were in grade school. We used to get up at 4 on Sundays. That was the best day. I don't remember working in high school.
>
> It was just taken for granted that we would all go to college. That was part of the goal for my father. They would have felt disgraced if they hadn't sent us. There were no particularly strong outside interests for any of the children which would have made a conflict. Most are now in professions.
>
> We moved to a town where there was a small local college and we all went there. I started there and took physics. I haven't a ghost of an idea why I took it to start with. But after two years I had a really serious interest in it and then I changed to the state university. My father was willing to support me there but I insisted on doing it so I used to rake leaves, wash floors and so on and I had some sort of part-time job (at school) and the second year I had more support from the university. I lived by myself and ate sardines and things like that.
>
> (*When and why did you decide on graduate school?*) Perhaps it was just the observation that the faculty had advanced degrees so I continued and got my M.A. there. I had some kind of support, I don't remember just what it was. (*Were you interested in research or teaching?*) I didn't think about it much probably, but there must have been little else than teaching in my mind. I had no idea of research at that time.

Then he taught physics and chemistry for a year, and spent a summer

studying. With the savings from this year's teaching and a fellowship he was able to spend two years at another institution.

> For my M.A. I had done a minor experimental problem, the only experimental job I have ever done. I presume for some little time, without being able to put my finger on it, I had become aware of the fact that my interest was more in theoretical physics with a parallel interest in mathematics. Those go hand in hand. This stimulated my interest in theoretical physics. I felt more at home and was better. I went to Caltech because Epstein was the leading theoretical physicist there. The rest followed from that. I took courses from the mathematicians, too, of course, but I did my thesis there in theoretical physics.
>
> I think the idea of research is a gradual affair for most people. When you start the professor helps you out quite a lot and tells you what to do and you develop confidence. Then there is the matter of being conscious of the fact that most of your classmates are going into research so why can't you? I think at that time I wasn't thinking at all of industry. I think I was conscious of the fact that in such a profession as physics you have to go into research, pure teaching doesn't count. You have to keep going, if you don't do research you fall behind. It isn't a serious crusade but there is satisfaction in it. There is this other related thing—in graduate school you begin to study the work of contemporaries, some of them your own professors and people you know, and you see it draws respect so you follow. You think, maybe I can do it, too.
>
> My big plan was to get married so I grabbed the first job that came along. There was nothing fancy about that. And I have been here ever since.

4. This subject spent much of his early life in a suburb of a large city. His father was a bridge engineer.

> He was a very learned man, much more so than most engineers. I think he influenced me a great deal. At least he had a very high respect for scientific accuracy and the sort of intellectual honesty that scientists at least pretend to.
>
> When I was a kid we had a fairly large gang and played in the woods and skiied. Most of the kids were older than I; I had skipped one grade so I got licked regularly in the gang fights.
>
> I did comparatively little dabbling in chemistry as a child. I didn't have a lab or chemistry sets. I developed pictures a little more than most boys, but did practically no experiments with that. I had a Meccano set and this was a great joy, more perhaps than other boys who had Meccano sets. Otherwise I had no particular hobby. I did get extra parts for the set, it became quite a beautiful set before I was through with it. I never worked out of books. I found out by doing it. I probably did very little reading. Father did very

little playing with me. He made learned criticisms of the structural design which I was a little scornful of sometimes, of the theory of bridge construction at that level. Other boys had sets but I think I was a specialist.

I did fairly well in school, in fact I did really very well, I was first or second in the class all the time. One boy was better, usually. I rather liked arithmetic and I wasn't very fond of English. I did relatively poorly in languages. After the first year of high school we moved to the west, where I went for three years in high school.

I was very enthusiastic about woodsmanship as a boy; I should say my favorite book was Ernest Seton Thompson's *Two Litte Savages.* In California I was able to indulge this and even at the high school age I used to go off with one of the other boys on trips of three or four days with packs. Not real mountain climbing, though. We had no tendency to pick the cliff trail. E.g., one year about the end of high school we went off to Sequoia and a boy and I took a burro and went for one and a half or two weeks into the park.

As far as I can remember my plans were influenced by having a very good high school teacher who ran a rather good advanced course in chemistry. It was obvious I wanted to be a scientist. I had taken in high school an extra chemistry course, so I got a job in a sugar mill as a bench chemist in the summer. I made more money than I made for years afterwards. That experience was a bit unpleasant. There were some very pleasant boys who were chemists and I enjoyed their company, but the company I worked for cheated us thoroughly.

My father had retired and we were relatively well off, very modest but there was no question but they would send me to college. When I graduated from high school I had some slight prejudice against going to college. I knew I would go even then but I wanted to be a man suddenly. After the job as chemist there weren't jobs hanging on trees. One of the boys I had been with there was going to the college, so I went over with him and enrolled without telling my father. Perhaps because I was still being a man. I had a certain amount of resistance against being bossed. I was very conscious of the fact that my parents wanted me very badly to go to college and there was at least some point that I didn't want them to know I was thinking about it and then not do it.

I had no difficulty getting in and no difficulty staying with the class. It was a somewhat rough class, entering in February and going through without a vacation for two years and there was a large mortality; they stopped that system after that year. However I always knew I could make the grade. There was no chemical engineering as distinct from chemistry, or if so it was only in the senior year.

While I was there I went out for swimming. I tried the basket ball team but never got far with that. I was elected captain of the swimming team. It's probably significant that I didn't get a bid to a fraternity until the middle of my junior year and then got a bid to what

was probably the best. That's probably more or less characteristic, it was about that time I became rather popular.

By my senior year I was aware that what I wanted to do was research and I think that I thought I would prefer to stay in university work. I don't think I'm inclined to plan the future. After my graduation I got a teaching fellowship at the state university. The graduate department was one in which it was assumed you would go into academic work if you could. The department was a unique one at that time, there were practically no courses given. I did take at least two classes in physics, one of which I failed consistently because it came at 8 o'clock, but this just didn't count. We started research without the idea that the research one started in the first year would become a dissertation. We were encouraged to sort of play around in the lab.

This was followed by a trip to Europe and later on he spent some time there studying.

(*Research idea?*) At college, and I suppose the transfer wasn't very sudden. As an undergraduate I did a job of research; I was mostly the laborer but I understood moderately well what I was doing and I was very enthusiastic about it. I think I did it moderately well.

(*When did you decide to go to graduate school?*) I guess during my senior year at college, I'm not really sure at what stage I had decided to. I think my mother had sometime said, "It wouldn't be very bad for you to be a college professor." I didn't worry much about it.

(*Why your own line?*) I think at the university I had already to some extent picked my field. The work I finally did for my dissertation I think was somewhat the outgrowth of a talk in which I played at least some rôle. It may have been the professor's guiding hand that he let me think I suggested it. It was something that sort of grew up in discussions. At the time I went to work with *X* I definitely took a problem that he had suggested, although one I was quite interested in. Then later the experimental work I did was pretty much an outgrowth of that problem. I found that most of my research interests tended to branch out two ways from anything I'd done before. Usually there was an obvious connection, sometimes by way of an experimental trick you could put on a new problem. Sometimes a theoretical question which had arisen from the old problem.

(*Why did you go into theory?*) The reason I tended to become a theorist was that it was easier to work for a few hours on a theoretical problem and one could get somewhere in spite of the constant interruptions of classes, etc. And because of personal influences also I tended to go into theoretical work.

(*Did you read much?*) I wasn't very bookish, but at a certain stage I read an awful lot. The sort of thing of going all through Shaw and Ibsen and that.

5. He was born in a small midwestern town, the son of a minister. His

mother died when he was five and he was cared for by older sisters. He attended small town schools.

> I was an awfully bookish kid. Our family had more books than most in that part of the world, but I never remember having any children's books. I remember two or three books of nursery rhymes, with no illustrations, and *Alice-in-Wonderland*. And for a while I was a subscriber to the *American Boy*. Classes in school were always small and there would be one of my boy friends and I who were the bright boys of the class. There might be two or three girls who weren't so dumb but we didn't pay much attention to them and then I was always much discouraged by the fact that the teacher seemed to spend all her time on them (the dumb boys). We would be wildly shaking our hands and she would never see us.
>
> I had a friend whose aunt ran the switchboard and they had some peculiar gadgets, one called a pole-changer. It was a very impressive looking object with a large vibrator on it. This had on it the "gold point" and we used to get hold of that and put some dry cells to it, enough to make it flop back and forth satisfactorily and we could turn it on and off. There wasn't too great a variety of things you could do with it. My older brothers and sisters had school books including high school physics. At this age I didn't care much for that. I remember feeling I'd run out of stories and I got hold of an old Latin book with some stories so I started to learn Latin so I could read them. This didn't go far because I skipped the declensions, not knowing what they were, so my sister explained and I went a little further but never really learned to read the stories in the back. Later in high school I read theological material through scarcity of other reading. Father's health broke down badly so it was necessary for him to retire and we moved back to mother's old town but none of the family were there any more. In that school (8th grade) I made my debut with transferred grades, and was then placed at the head of the class. There were 24 that graduated from high school. I was at the head of it mostly but the situation was better there. There were at least four boys who were up to doing about the sort of standards of work it took to rank high and of the rest of the class I can't remember that there were any who were quite so bad as the ones before.
>
> It was a pretty lively group. The others were sturdy and took part in athletics (so didn't study as much). I was very skinny and frail. My faher was interested always in learning anything possible and he always encouraged us to use what books were around. He had an old encyclopedia, not too good, but only certain sections of it achieved my attention. We always had an unabridged dictionary. And the old tradition in that part of the country was that though education was scarce it was very highly valued. Anyway there was this tradition of not having much concept of what the higher kinds were about but having a great deal of ambition for what was available. At that time I

read heavily in math and physics. It was well begun by the time I was in high school. I hadn't decided to be one (a physicist), I only hoped to get a good education. When I was a sophomore in high school I found out there was a Ph.D. and I resolved to have one before I was 35. Late in the 8th grade I got acquainted with a kid no stronger than I and he asked me to come see some of his things and I went over and he had a collection of old dry cells, and Ford coils, etc., and he showed me how to make sparks and all. We had electric lights and the switchboard there used electrical current but it would fail off and on and they had to fall back on dry cells and they got heavy use so they discarded a lot that were still good. We'd get all types and so I soon had a bunch and was doing various things and I learned about the Cartesian diver. I took general science as a freshman and the teacher, who was one of the people with a similar attitude toward learning, did his best by us and he knew more physics than anything else. So by the time I was along in high school I knew I was very interested. I got hold of my brothers' and sisters' algebra books and studied some of the things in them, mostly like logarithms. Then I got hold of a calculus text and learned quite a little.

My sister's help and a scholarship provided me my college training. If I had been a very active robust type I could have worked as a thrasher, that's about all the work there was. I suffered a good deal mentally about this situation. I tried various things but got nowhere.

I went there with the ambition to major in chemistry because there had been a campaign to make people want to be chemists. Some outfit sent Slosson, Pasteur (books) etc., around to all the high schools; there was no chemistry in high school; the high school wasn't a good one, they gave only two years of Latin. I took part in an essay contest on the wonders in chemistry and I got second prize in the state, $5 in gold. I read the catalogue and it said you had to have high school chemistry to take the real course, otherwise you had to go into an inferior course. I didn't know much about it and I didn't abuse anyone's time and strength by locating anyone to ask questions about it. So I signed up for math, and then in my sophomore year I signed up for physics instead, having met some boys in it. Then a new physics professor took over, a Ph.D. from Illinois a number of years before, and he did various things for me, some good and some bad. His personality convinced me I wanted to major in physics instead of math. I had taken the dumb course in chemistry and nothing I experienced in it made me regret it. My college was probably better than a number of small colleges but it didn't provide the kind of training that an active student can pick up around a university, but I've always wondered if I would have been tough enough at that period to profit by a big university, I wasn't a strong type, either physically or emotionally probably. The professor admitted he might not understand some of the things too and that we should understand that it was very hard but I don't think that my inellectual development was pushed as hard as

it might have been. But I did a rather remarkable thing. There was a $100 prize for the person making the absolute top grade every year. My record for the four years was the best in the class, but not for any one year and I never got the prize.

You see I spent the full length of time all through my school years. I never took to suggestions of promotion. I'd overheard conversation about the unwisdom of pushing children. I was a good student generally. I think I have changed in some ways. I used to handle things much more by geometrical analogy; in recent years I have pretty much quit thinking of new points that can be handled that way. I frequently reproach myself for not having reflected more before beginning to scribble. On the other hand one of the things I had to learn was that you go ahead and do something rather than waiting in bafflement for an idea. In my earliest education doing a lot in one's head was regarded as the thing. Now this is replaced with operations.

(*Why did you choose your branch of physics?*) That developed more or less as a matter of circumstances. The situation was that I lapped everything up as I came to it to the limit of my ability. It was pretty thin stuff through high school and not the most nourishing through college. When I went to graduate school the first year was spent in a not too rewarding way but it wasn't wasted.

I decided to write a master's thesis although it wasn't required and had a most interesting time with an experimental problem. But my teacher was a theorist at heart and I eventually finished up doing a Ph.D. thesis on a theoretical subject. He assured me I could do experimental work but I never have.

It was of course a great wrench for many people to live down the transition from classic to quantum theory. I'm just young enough to have been able to do it but not young enough to have done it without difficulty. I had quantum mechanics in my third year of four years of graduate work, and the attitude of the whole class was one of outraged incredulity and indignation. The older teacher had had a phobia against quantum theory. The new man taught quantum theory, but not very well. There wasn't a very good supply of elementary books and we had an awful time. It wasn't until I was doing post-doctoral research that I began to get it and I don't think I became comfortable in it until about three years ago. Now in spite of the fact that a good deal of the teaching is still done by those who haven't grown up naturally in it we have a generation for whom this is the way things are.

I expected to go on and be a teacher but the idea of actually trying to enter the field of the country's leading institutions didn't play a rôle in my thinking in those days. The atmosphere was not intellectual. I spent one summer at Michigan and that trip was my first view of theoretical physicists and what they seemed to act like when they are working. They had a particularly good crew that year. This was quite a different atmosphere from that at my university.

Then I got an NRC fellowship and went to work with X. I'd never

been extended and he was calculated to extend anybody. It was the first time I had encountered a professor who obviously had a colossal amount more than I either had or had any prospect of having. It was a staggering experience. I was at sea and very low but after a few months it dawned on me the others didn't understand it either and by the time I had finished my second year he regarded me as a most valuable person because I would ask questions. But still he almost flattened me for my temerity.

At this time there was a great deal of pressure to get a job, and it was all very depressing. I had two years on the fellowship. I was abominably ignorant. This wasn't assuaged in the two years. I had a genuine deficit. Very interesting things were happening, the neutron, positron, etc. I only published one brief note at the end of the first year.

His second year, however, he produced a mathematical paper which made him a marked man and he was then offered an instructorship at the university where he still is.

6. His father was a professor of physics and mathematics at a state university, although he later left to go into industry for financial reasons. There was a good deal of dissension in the family and his parents were divorced when he was a sophomore, which was a great relief to him.

I think it's a series of coincidences to a large extent. As a youngster I became interested in airplanes at the time Lindbergh flew the ocean. That impressed me and I started making airplanes and won contests. I and a group of friends pretty well monopolized the business there in town and of course success is always attractive.

I took all of the science courses they offered in high school. In junior high school there was a course in general science and in the last three years of high school we had biology and chemistry and physics. I also had a course in qualitative analysis.

I read á terrific amount. I remember by the time I was ten I'd read all the books on the children's side of the public library and all the classics on the adult's side. I especially liked classical history, —this was in grade school and in high school. I've always read a lot, indiscriminately. I had no real favorites then. One thing I read a lot then I got interested in this pseudo-science, astounding science fiction, and stuff like Bell's thrillers. I got into that in high school and I still like it. I remember my wife hiding one of the magazines so people wouldn't come in and find it. I remember reading early American history too. Classical history because it was adventurous and far lands, I read the *Morte d'Arthur* and the *Idylls of the King*. I read lots of historical novels, I was always interested in history. Not so much in biography. I did very little general science. We didn't have a lot at home, the five-foot shelf which I read through completely and two or three encyclopedias. I probably read most of them eventually.

I spent lots of time on airplane models and later on radio. (*Did you work with your father?*) I had no help from father in this work. He was away from home lots with his work and when I later on became interested in radio he was a little of an inspiration there because during World War I he worked with the training of radio men for the army. There were still some odds and ends of pieces around I could use.

When I first started with model airplanes there was the *American Boy* which was the authoritative journal on airplanes and I kept the articles and used their designs. I didn't just copy the things. We built rocket ships and powered them with gun powder which we made. (*Were you the leader?*) Well, there was no real leader, there was a group of a half dozen of us and the sense of a leader was not strong, it was just the one who had been doing the most successful thing at that particular moment. We made planes individually and sold them to the other boys and that gave us enough money to make more planes. When I was a sophomore in high school we started flying gliders. There were never any strong objections, mom was sort of worried about it but she contained herself. It was almost impossible to get hurt. We didn't get much altitude. We usually ended up by taking the glider home and repairing it.

(*How about college?*) College was taken for granted except for the money. I went to a little church school and while they did not have regular engineering I took the science courses in chemistry and thought for a while I'd be a chemist. Then I went to the state university and took aeronautical engineering. I think the work I did there was very nearly standard but since I did have a basic interest in science I used my electives for math. I couldn't get into physics. When a senior I was stopped by a professor in the hall one day and he suggested I go on for graduate work. I'd thought vaguely of staying on there for another year or two but didn't have any very clear plans. I'd never heard of the place he suggested and so I looked it up, and applied and got in and so I came here and have been here ever since. When I was a second year graduate student I got a part-time job, and wrote my thesis on part of the work.

(*When did you get the research idea?*) I think that my high school chemistry teacher had quite a bit to do with that. He encouraged us to play around and we came back after school about three afternoons a week for an hour or so and spent the time working there. No research problems but we worked under our own steam. We did some quantitative procedures, it wasn't research but enough so I didn't have to take freshman chemistry in college. That gave me a little different level than just working with chemical sets at home. Later when I came out here and saw the field open up that was the first time I'd ever really done any research. That was the biggest thing I got out of my first year of graduate work. Until then the engineering course was designed to make routine engineers so when I came out here

and found there was something more to the business it was really quite an eye opener.

7. This subject was brought up in a large city. His father was a designer and manufacturer. There were no professional people on either side of the family, except for him and his brother. He went to public schools.

As a boy I spent a lot of time reading and building things like airplanes and electric trains. Also I did a good deal of playing baseball. I would say it wasn't until I got to high school that I began to ignore the more usual activities of a boy. I can recall always being interested in gadgets. I think I got started in science by reading *Astounding Science Fiction.* I had Meccano sets, and motors and so on. Mostly I built things on my own. The most ambitious thing was putting together a model plane, you bought a kit that had everything and just put it together and then I designed one of my own and built it. My brother built a radio, but I don't think we ever did any work together. At the time I was becoming interested in science he was going to college and so he had useful books lying around.

(*Did you do particular reading?*) Actually there is quite a good deal. I think actually at about this time just before going to high school I read a lot. Most of this was a development of my own. When I did start to high school I was wandering around libraries and reading popular books on science.

I first became convinced I was going to become a physicist and took a course in physics in high school. I remember thinking if I did well in this I would go on. I was fortunate to have a teacher who was doing research himself and he was a great help.

I recall going through a stage in my browsing when I picked up books in electrical engineering and then realized I wasn't interested in building dynamos but in the fundamental theory. I drifted through the stage of interest in making gadgets but it went fast. The thing that interested me was the discovery of the section in the text on the structure of the atom. The rest I knew pretty well anyhow.

(*When did you get the research idea?*) I think at this time I had begun to read fairly advanced books. I think it was clear to me what the nature of research was, it was just a matter of getting up to doing it and that didn't take very long, I began as a sophomore in college. It became an all-absorbing interest. Actually as I remember it the first time the idea of myself doing some research came when this high school teacher introduced me to someone at a local college and he raised the question of my helping him in some. I'm not quite sure I realized the distinction between learning from a book and finding out for myself, but it soon became clear where what was known ended and where I would have to take on. In mathematics also I was doing a great deal of reading. One fortunate thing was a copy of the *Encyclopedia Britannica* at home with some wonderful articles on mathematics and

physics, the 11th edition. Here the articles were pretty much written by the flower of the British school. Sometimes of course I flipped over the pages and read other parts, too. I had no course in chemistry in high school and was rather bored by it in college.

(*Family attitudes?*) Certainly the general family background was one in which the children should have the benefits the parents did not but I think also it was my own initiative in a way. My parents certainly put up no objection, although neither was interested in learning.

There were two classes of teachers at college, those who had been there for years and the young people on their way. Then also the student body was keenly interested. All in all I found it a highly stimulating place. There were no special good teachers.

When I was a sophomore I had already begun to do research. It was theoretical because theory was my outstanding interest. I think the thing I used the college for primarily was not so much that I took courses in any particular subject although I did some mathematics, but there were people there who were working in the current branches and there was a library so I spent the first two years in getting up-to-date.

After two years I switched to another college. This is an illustration of getting to know people who can really assist you. One of the people where I was became interested in me. He was doing his graduate work elsewhere and he introduced me to people there. He suggested I come down and listen to the theoretical seminar and I got to talking to the chairman and I guess I must have said something clever and this chap I knew sold him a bill of goods and they offered me a scholarship so I transferred. At the same time I began to do research at still another college and with a couple of others wrote a little note (at the age of 17). That's the beauty of physics. It's becoming less and less true that you can work in a very restricted field. After I transferred the tempo was rather different. Before everyone was in there fighting to learn something, but then I could take it slow and learn some other things. I guess I just kept busy learning things.

I had taken a number of years in French and at the time I could read and speak it fairly well. I don't think I have any particular talent in languages. I didn't do too badly in most subjects, I made Phi Beta Kappa. I have a pretty good memory and I think I have a reasonable interest in other subjects. At the time, of course, I rather ignored other things. I had no biology in college. Chemistry I pretty much ignored. I just took the general requirements. My only other special interest was in some philosophy course.

I stayed there and from that point on I had fellowships and so I had no financial worries and the path seemed to be clear. I worked pretty consistently in the theoretical field. I spend some time puttering around the lab but I never do any experimental work. My thesis was on a theoretical problem. I've had no experimental experience even. You are supposed to take a course in experimental physics, of course, but I squirmed my way out of it.

I took my Ph.D. slowly because in my second year they gave me a travelling fellowship. That was my first experience away from home. I can't say I ever wanted to go home after that. We drifted quite apart. The drifting began in high school when I was preoccupied, with no points of contact with my parents. I think they sort of sat back in awe at this wonder and didn't quite know what was going on. They were very helpful.

I was given a fellowship. This was an extremely fruitful period not only because I was beginning to do scientific work of some merit but I was placed in an interesting social atmosphere. There were all manner of people and all sexes so life became interesting. I was there for two years, first on the fellowship and the second year as research assistantship.

8. My father was a civil engineer who had very little formal education but had run away from home and apprenticed himself to an engineer and studied at the International Correspondence School. He had a good head and a great interest in engineering matters. I think that because of my worship of my father I became interested in engineering. Even when I was five or six years old I used to go around to his office and fool around with his drawing things and as I grew up, although he wasn't doting, he let me come around more. I was a very lazy student, I didn't study. I didn't dislike study but I did an enormous amount of reading. (*Of what?*) It's a little hard to recall, but such things as biography, the life of Napoleon, enormous quantities of Jules Verne, pretty near anything I could get hold of, technical and not; quite a bit of serious stuff. I remember in 1914 I was reading a history of the Boer war. I lived in a small town, the county seat where father was county engineer, of about 2,500 people in which there was an extremely remarkable lawyer. His wife and my mother were good friends and he had a son I used to chum around with and somehow I got to talking with the father about things and he invited me to come into his house and borrow any of his books. He had a very good library. I had the inclination to read to begin with and that pushed it very much up. He was one of the few men I've ever known who have really read everything we know about and should read and don't. I remember articles by Mill and Spencer, etc., and one on the logic of belief. I think part of this was compensation for the presumed physical defect. I was quite shocked when the doctor said I had this heart trouble. I still have a mitral murmur of some sort. About half the doctors catch it and about half don't. I couldn't get insurance when young but some time ago I did succeed in doing so.

One of my ambitions was to go to West Point, father was a veteran of the Spanish American war and retained a great interest in military matters and was at the time of his death (when the subject was 15) a major in the national guard. His death left us not well off. I was the oldest of five, the youngest was only one year old. The problem was

how I could go to college and this became very acute. During my high school I had planned to become a civil engineer and had spent all my vacations working in the lowlier jobs of civil engineering, both office and outside. That was my sophomore year. I skipped the junior year. So when he died the college business was only one year off. During that year my mother took me to the congressman of the district, father had a local reputation, and asked for an appointment to West Point, but I would have to wait until I was 17. Of course there was my arm, and at that time I had asthma, and the doctor couldn't cure it. The doctor's mother was a Christian Science practitioner and she cured it, she really did for about 10 years, so I thought the only way I could get into West Point was to use Christian Science on my arm. But the congressman advised me to go to the University and take ROTC.

This lawyer said he would be glad to help me go to college and he did. I took ROTC and hated it, I flunked two terms, I'd have been court-martialled in the army, I talked back to the major and everything. Mother was not terribly disappointed. It was assumed I would be an engineer. At the end of six weeks I discovered the only thing I liked about the whole business was mathematics, so I went around to the Dean and told him this and that I thought I'd like to go into mathematics. I guess I had talked to the mathematics department first and they said they'd be glad to see me transfer. I remember I asked the guy whom I had in mathematics, and he pointed to his cuffs and said "Do you want to go through life with a coat like that—all frayed?" The Dean thought I ought to transfer to the science faculty but was certain I would be back in engineering and asked me to keep up one course in it which I did for a year but I never returned. One of my objections was it was so cut and dried. I still object to engineering education, even here.

Once I thought of going into science, I thought the best I could hope to do was to be a high school teacher of mathematics. So when I decided to transfer this problem arose and I decided to go as far as possible in mathematics and protect myself by taking education courses, but I could only stand three sessions of the class in education and I was through. It was terrible stuff. A very distant relative heard about this and gave me the devil, he made me feel kind of bad but also made me mad. He thought I should be an engineer and support my mother.

I got a little job in the observatory showing the objects in the sky to the public. Mother was very much upset about it, she was pretty sure I was chasing moonbeams, but after I met *X* he became my spiritual guide. Mother was very much upset but by this time I saw what it meant to go on and get a doctor's degree. She thought it was a terrible thing. So *X* said to bring her up and I didn't know for a long time what they told her. They are enthusiastic people, everything is white or black and at the time I was the white-haired boy, so they told mother what a great genius I would be and they said in five years I

would have a job at $8,000 a year and that was in 1921! So with the aid of that whopper they quieted her down.

I still had some more undergraduate work. I had rushed through high school in three years. Then when I got to the university of course I didn't do any studying for a long time, I just raised hell, chased around, went down to the dance hall, and investigated what kind of prohibition booze one could get. The financial business was always something of a job although the pressure was relieved about this time because mother was appointed postmaster of the little town and that took care of her and the others. From that time on there was no pressure on me for money.

X told me there was a fellowship at the university which I should apply for but it was for graduate work. This was during my junior year so I got the idea, with his connivance, that by going to summer school I could graduate by Christmas and so would be eligible and so I applied for it in the spring and was granted it on condition I got my degree. I wasn't too conscientious about studying even then but my grade average was high. I made Phi Beta Kappa in my junior year and all that. I wasn't putting myself out.

So I doubled up and took as much as I could and did finish in time and got the fellowship. That was enough to get along on. By that time largely under the tutelage of *X* I knew the thing to do was to go on and get a doctor's degree. I decided I wanted to take my Ph.D. here. I was so bumptious, and sure I could do anything, I didn't apply anywhere else and they gave me a fellowship. So I came here and took my degree in two years, and taught some.

Well, here I was quite fortunate in the studies I took up and made a good showing although I still didn't work very hard. I got out with a summa cum laude, so I had everything in my way to be a spoiled brat. I was just cocky.

When I got my doctor's degree, then it was the style that the ones who were really good would be given a National Research Council fellowship. I went to Europe and spent two years. Then I really caught up with physics, I really started to study physics. I began late for this reason. I had it in high school from a woman teacher, she was lousy and killed it. I had been interested, went through the usual wireless stage. I then had to take it as a junior but I liked it fairly well. With chemistry I'd had to take that first term and I abhorred it. I didn't like the lab and also didn't like learning things that way. For many years all I could remember was that phosphorus was discovered in urine. I had to take two terms and postponed the second until the last term and then I liked it, I had had physics in the meantime and I began to see sense in it. Lab is the thing that I think shooed me off it. I really think it was because I didn't like physical work. I'd much rather read and sit down and cook up how the experiment should go. I took a minor in physics in graduate school and I paid attention, but no lab courses.

9. His father was a telephone engineer; his mother had worked on her father's paper before she married. He went to urban schools.

I can't remember much about grade school except the fact that I got reasonably decent grades right along and that I was fairly interested in science and mathematics. I had a friend in 7th or 8th grade who was the son of a druggist and we got a chemistry set between us and played around with it and almost blew up the house. We spent our spare time memorizing the table of elements.

I never got along in languages. I couldn't see any sense in memorizing grammar. In history I read so much I had many more facts than the rest, whether they were right or not. I think probably the interest in science was partly because of father. When he was home, he liked to do shop work and I used to do some with him. He was rather meticulous and in some ways this was discouraging for a beginner. There was one spell, I guess in high school, when I was sick for three months and decided I was going to go into history and I spent the time in drawing up a historical chart beginning with the Egyptians.

The first few years in high school I don't remember anything very special except that I managed to get fairly decent grades in mathematics. I took physics and didn't like it. I had taken chemistry before I got there but there was an extra course that sounded interesting so I took it and it turned out there were only four students in the course and a very interesting teacher. He sort of took personal charge and let us do pretty much what we wanted except that he was extremely insistent that we take care and do a good job. We worked through all of analytical chemistry there and I got a feeling for looking for small traces of elements, etc. This convinced me I wanted to be a chemist. A little earlier I had gotten a job with the phone company which was with a fellow studying to be a chemist. I read Slosson, *Creative Chemistry*. This was the romantic thing to be. I think that teacher had more individual influence on me than any other. My mother was quite worried about my staying indoors and reading so much and my lack of social contacts but more worried about my health, so we bought a place on the lake shore and put up cottages with father's brother and we went out as soon as school was over and lived in the open all summer so I built up a reasonably good health. We wore overalls and nothing else all the time. But I was never interested in the scientific or the natural side of the outdoors. Mother was and I absorbed a certain amount of it.

College was pretty much taken for granted. My mother was convinced from the beginning that all her children were going to college. I just went to college expecting to be a chemist. I had no very special idea about it. Two things happened in my freshman year. I took the college chemistry course plus the lab course. The lab course threw

me for a complete loss. I think it was taught by a poor teacher who was careless of the reagents and they weren't pure. I got traces of everything and reported it and I didn't like the way the course was taught because I was told everything I was supposed to do and it soured me on chemistry. The other thing was I heard Dayton C. Miller talk and then I got acquainted with a young man who had just come there as an astronomer and was teaching mathematics. He was perhaps the most inspiring teacher I had. He let you go if you wanted to go. I needed some money so I helped arrange the library and so I had a chance to look over the mathematics books. At the end of the year I decided the devil with chemistry, I'm going into physics. At that time the college had a course in physics which was not popular and the number of students in each year's class which started in the sophomore year was somewhere between two and four. My class had three and this gave us personal attention. My father was very dubious about it; he wasn't sure that physics was a thing you could get along with but he didn't push it very hard. He talked to me about it once and said, "You will have to go on in university work and won't make any money," and I said I knew that and he said "If you realize it that's all right." There was nothing special about the course except at the end of that year a prize exam was given. At that time physics was taught practically everywhere without the use of calculus and still is in many places. We didn't get calculus until our sophomore year in mathematics and I still can remember the annoyance and the feeling of being cheated out of an extra year or so of activity by not having had it earlier. At any rate the physics course was given with the calculus but didn't use it. So that about the middle of the second term I got disgusted and decided I wanted to learn physics the right way and asked Miller for a text. He smiled and gave me one and I studied that so when the exam came along I gave it all in calculus and got the prize. This confirmed me, of course, and the next two years were extremely pleasant. I divided my time pretty much between astronomy and physics. There were just three of us and we'd go to the professor and say we had finished up this and what shall we do next and he would say, "what do you want to do?" So we'd tell him and he would give us manuals and get the old apparatus out and usually it would have to be cleaned and fixed up, and he would tell us to work it up and we would have a fine time.

I spent a fair amount of time at an observatory during the summer when I did some assisting, so I had a chance to play on my own with the telescopes and the various astronomical instruments. During my junior year the professor was finishing some important experiments and I did the mathematical analyses of the data for him. At first the analyses showed that his hypothesis was correct but then I found I had made a mistake and it came out the other way. I found out the error just before he was to give a talk on it and it was a struggle

over whether to admit it or not, but I confessed and we spent nights and days for a couple of weeks doing it over. I did a thesis in astronomy for my B.A.

When I was in high school I had gotten acquainted with some radio amateurs and eventually we opened a small store which did very well. I also did some part-time writing. But neither appealed as a life work and I was convinced I wanted to go on in academic work.

My teacher felt I should go on to do graduate work. This was kind of a surprise to the family and a little bit of a worry because my brothers and sisters were coming along and there wasn't too much money. But I applied at three places, and took the second offer. My main danger the first year was to keep from galloping off in 24 different directions at once. I found it extremely interesting and exciting. I started work on an experimental problem but then I would get an idea for a theoretical paper and work on that for a while, and then go back to the other. So it turned out that the second year in addition to doing a number of odd jobs I did a job which was considered to be good enough for a Ph.D. but it was too early so they said I better stick around for another year and gave me the prize fellowship.

One summer I had a job at the observatory getting the telescope in shape and I had a very pleasant time of it. Next summer I got a summer job at the University of Michigan. I wasn't terribly interested but that was the first summer that Michigan had started its summer courses in theoretical physics. They got a grant to bring people over to give special lectures. I was boarding at a special boarding house the department had gotten ready and Kramers took the room right next to mine. This was during prohibition. I investigated the liquor situation around Detroit and this interested Kramers also. This was the first time I had gotten exposed to quantum mechanics when it was just beginning to crack. So while we were imbibing various things he would spout quantum mechanics and I listened to some of his lectures. So when I got back that fall I had finished my thesis and Condon had just come and he knew quantum mechanics. So we worked together.

(*Where did you get the research idea?*) I think my teacher in high school gave me a few nudges in that direction. Both the professors with whom I was in close personal contact and saw daily were active in research themselves and I just soaked that stuff up. It was a matter of digging into things. It's never bothered me if someone else has worked on it too. If something interests me I'm just as likely as not to stick at it and can't think of anything else. There are times then when I get sick of the whole thing and don't want to do anything but read history or something. But I find it hard to think back to the time when the idea of research and just spending all the time I had available on trying to understand anything wasn't just there.

10. He was born in the west and was brought up in a good-sized city.

His father was a pharmacist but died when he was nine. His mother came of a particularly able family.

I was often troubled by not having enough to read. One of the memories that I have of my father is that before he died he was concerned about doing what was best for me and he wrote a letter to the paper saying that he had a son who was a great reader and he would like to have advice as to what books to get for him to read. I believe I learned early, but not like John Stuart Mill. I always moved along very rapidly in school.

I remember I got rather interested in insects first, I believe when I was about 12, and in minerals. I don't remember how it happened, perhaps I ran across a book and began collecting minerals about the same age and in each case I did a lot of reading in books from the public library. My grandfather had made a collection of arrow heads and agates and miscellaneous rock specimens when he was young and mother had kept the collection and that interested me. It wasn't much of a collection but enough to give me an interest. When I was interested in rocks and minerals I got a book on mineralogy from the library and copied large amounts out of it and made myself a room in the basement and papered the walls with the sheets of paper on which I had copied tables and descriptions of minerals.

I saw my first chemistry experiment at the age of 13. A boy my age, a few months older, now a professor of psychology, showed me this experiment. I had seen him a few times in high school, I entered at 12, and as I was walking along one day home from school he said would I like to stop in. He conducted a few experiments. These interested me very much and I went home and got out an alcohol lamp and took some miscellaneous household things and set to it. I found a book from my father's library on elementary chemistry by Williams. I read that book, it was a beginning text in chemistry and I used that for my experimental work.

I don't think mother was very sympathetic but on the other hand I had a strong will, too, and I succeeded in doing what I wanted to do. She objected to some accidents but not too much. I was given some chemicals by a friend of the family, a druggist, and I ran across a cache of them in an abandoned smelter. I carried some of the chemicals home and used them. I did some dangerous experiments, spilled acid around, but I got along all right. Then in a couple of years I was able to study chemistry in high school and I learned a great deal from that. I liked it very much. I decided I would study chemical engineering which I knew was taught at the state college. It didn't occur to me that it was possible to be a professional chemist rather than an engineer and that I could have gone to a better college near by.

After the first two years of college I wasn't able to go back but they offered me a full time teaching job for a year and then I continued and took my bachelor's degree in chemical engineering.

Along about that year notices came around to the effect that fellowships for graduate students in chemistry were being given at a technical school and the head of the department said perhaps I should study for a master's degree. When I was a senior I applied at several places and took the first one offered me.

I was never tempted into any other field except related fields of science. I thought I might be a theoretical physicist, I received a good scientific training in physics and I might have continued as a physicist. My work has been very broad, it can hardly be called chemistry or physics.

I had the idea of doing experiments very early and I don't know when it was that it occurred to me that there were things people didn't yet know and could find by experiments. I remember when I was 18 just before I started teaching, during that summer I had a copy of the handbook of chemistry and physics that contained information about the properties of substances and I had an idea it might be possible to develop a theory. I thought it should be possible to discover something just by analyzing the known facts.

There was an extraordinary man as professor of chemical engineering there at college. He isn't a man of much intellectual ability but he had a very deep conviction about the importance of graduate work and research. He was responsible for sending perhaps 125 graduates in chemical engineering on to graduate work and often this involved his lending money to them. If I had had some good teachers I would have learned a great deal; as it was I learned something, but a small amount. But when I came on to graduate work I was full of enthusiasm for this great body of knowledge. I'm sure I could have learned mathematics in those years. I don't think that my mastery of mathematics is what it could have been if it had been taught properly during the early years. It's only the mathematical aspects that suffer when there is unsatisfactory training during the early years.

11. He was brought up in a small city in the midwest, where he attended elementary and high school. His father was a business man with a college education. They had a good library.

My father wasn't greatly interested in literature, never in science, more an outdoor sort of person. My mother in later years began to read a lot.

I began to take an interest in mathematics, I would say, outside of the routine about the 8th grade. This would be arithmetic. Things really began, as they usually do, in high school. My interest in science really grew from contact with my teachers in high school. I had some excellent ones, as a freshman a course in general science from a man with no high level of training but he was very inspiring and I began studying chemistry on my own before I took the courses. I had my own lab. I think I had a chemistry set once but I used to buy supplies

from the high school and used to go out and visit the elderly and only professor of chemistry at the local university. The chemistry teacher was very good. I think he encouraged me. (*Did you start doing problems on your own?*) I think so, and in high school too. I had managed to teach myself. My other main interest at that time was modern languages. I got French in high school but not German.

I decided on chemistry as a career when I was 13 or 14. I was firmly fixed on that and mathematics. I thought of it as a career in research. I always took it for granted I would go to college. My brothers and sisters went, too. (*What was your father's attitude?*) If anything he was discouraging about a scientific career, it was just the business man's point of view, but he was tolerant when it became apparent I knew what I wanted to do. Mother's view was similar.

I entered an engineering school and after two years I went to a university. The thing was that the undergraduate program is designed as in many engineering colleges in a very inflexible pattern. I began to decide at that time I would like to learn a little philosophy and a little more language and I had gone through most of the chemistry and mathematics and in two years of physics.

I suppose I really started setting my own research problems when I was doing graduate work. I knew about research early and knew that was what I wanted to do.

During my graduate work I began to study a lot of physics and became greatly interested in theoretical physics. It was a very exciting time, quantum mechanics had been developed a few years earlier and was diffusing to this country and it opened the possibility of clearing up many problems in chemistry. Nuclear physics has very little bearing on chemistry itself and I began to study applications of quantum mechanics to chemical physics.

12. Both his parents came from western pioneer families, but there were professional men on both sides. His mother's family was a decidedly artistic one, and she herself was of extraordinary energy and ambition but had very poor health.

When I was six years old my father retired although later he went back. We were comfortably off and mother wanted to go back to Europe so we did and spent two years chiefly in Germany. So my earliest recollections of school were there. I spoke the language fluently. We stayed for two and a half years. I think it served to accentuate my personal withdrawal in the conflict that has always persisted between myself as an individual and other people. To a large measure I've overcome it but only by a battle. It's an ordeal for me as far as public addresses go. It's something I've had to master. I developed the sort of personality that used to be called introspective. The fact that I lived with much older parents in a foreign land undoubtedly helped. (*Did you get along with the children?*) Yes, always, except

for the fact of not being pushing and tending to be somewhat shy and self-conscious and not having as good a time as other children would.

I've had a predilection for scientific things as far back as I can remember. I read books and I can remember everyone of those books as far back as I can think. I had Meccano, and engines, everything. The German toy shops were wonderful and I had everything from my days there. My family encouraged it. I became interested in wireless, they called it then, before I was 14, and haunted the store. And the public library, father was on the board. I read everything.

We returned to the west coast, and I went through grade school in about four years. I started late, of course. Out of that we spent a winter in California for my health. I went to the public high school for three years.

In high school this developed. There's a curious thing as I look back on it. I got interested first in electrical things. I think I wanted to be an electrical engineer. It got to be something I just knew I was going to be without having examined the other possibilities. I always had a literary bent and still have to this day. But it was primarily electricity although I had lots of tools and did do some carpentry. I have no great manual skill. I'm much more interested in the analytical. I would read up on things and try to make them but also I did them by myself. In high school I took chemistry and was utterly fascinated, I did it extremely well; I had a lab in the attic that was a living testimony to the need for laws against casual selling of dangerous chemicals and here I spent a large part of my time in the afternoon by myself. I had physics but there wasn't the excitement I felt with the chemistry. I never had any trouble. I took extra physics and I enjoyed the last term. Mathematics I did just a normal amount of. This is characteristic. Whenever I had too much to do I did well. I always enjoyed mathematics and, again a characteristic thing which persists to this day, I was much better at algebra than geometry. Trigonometry was easy. But I had no real difficulty in anything. But English and history were my best subjects. I was poor in Latin.

I had intended to go to Stanford and possibly to Yale but . . . the war came on then and I had learned to become a radio operator and I went out to China on a boat. I was about 17 and my parents were unhappy about it.

When I went into the state university I more or less without thought headed for electrical engineering. However I took more than was necessary and they had two kinds of courses in mathematics as many universities do, those for engineers and those in liberal arts, and I took five instead of three and the same in chemistry. Those were the courses I enjoyed most. I was bored to tears with the engineering, you did all sorts of practical problems so I didn't shine, but it was from lack of interest. It was that kind of thing that made me come back here. If I had gone on in chemistry or mathematics which I enjoyed . . . there was where I needed advice. Since I had always had the idea of engineering

it didn't occur to me to do anything else. But even to begin with I was more interested in science. I came here and entered electrical engineering, and was here three years. I lost the first year essentially because the school at that time indulged in the supercilious attitude that if you didn't have courses there you didn't have them. I took some exams, and made up the first two years in one year. By the time I was a senior I was ahead, I paid a very high price for it because I think I was just beginning to feel natural and enjoy people when I came here and had to work hard, and the atmosphere wasn't conducive to social intercourse. As it was, it was lonely, hard work, but uninspired.

When I got through I was disgusted with engineering. That really influenced my career and just about ruined me. My father sympathized with me and I had done well in school so he arranged for me to have a year abroad. I made a pretense that I was going abroad to study. That year was the high point in my life. I was away from home on my own and I got interested in history and philosophy. One of the important things I read was the life of Pasteur by his son. This concept of what scientific research really was, was important. That did stimulate me. One of the things that was going on was that there had been a poverty of any intellectual ideas here. I got to reading philosophy and talking to people and I got so far as to determine that that was what I was going to do. What was really happening was a sifting out of the material and interests from the business of storekeeping of materials (which is what a lot of engineering is) over into theoretical, intellectual and more mathematical ideas. I really worried about Kant, for instance, and I read all of them, Bergson, etc. What I was fascinated by was thought as opposed to the concrete.

I came back here to do research work with a professor from whom I got nothing. But I did make other associations here. What happened was I had a lot of time for graduate study, they were very generous, and I began to take all my work in mathematics and physics and I got completely interested in theoretical physics. My real professional interest is in theoretical phyics and applied mathematics. After I took my M.A. in engineering I had made up my mind to get a Ph.D. in physics but I wanted to get it abroad because I'd had too much of the university and I did like Europe, I was very drawn, I even thought of staying there. There was so much that appealed to me there. But I was perfectly clear that I didn't like the people and I didn't want to be an expatriate. So I went to Germany and stayed a year and a half and worked in mathematical physics.

2. *Summary*

As has been noted, most of this group come from families of professional men. In all but two instances, the desirability of college for the sons was taken for granted, although in several instances the problem of financing a college course was a serious one. In one exception it was more that it

hadn't occurred to the parents to send the son to college but there was no objection from them.

All of this group liked school, were interested in certain subjects, usually mathematics and science more than others, and all did well in school. More striking is the extent to which they were omnivorous readers. I do not have a comment on this from one, and one other said he wasn't bookish but went through a stage of extensive reading. He, incidentally, is the only one who mentions any specific interest in athletics. But all of the rest read, and most of them read almost anything they could get their hands on. A few of them soon concentrated on science, but a number were interested in biography and history. Two said that they got their first interest in science from reading science fiction. How much of this concentration on reading is due to the generally poor health of the group is not known but there may well be a connection.

This matter of health is a very interesting one. It was not mentioned spontaneously by 2, 6, 7, 10, and 11, but they were all asked about it later. These are the reports:

1. He stated that he had not been very strong as a child, but neither had he been sickly; he had just grown too fast.
2. I didn't have any unusual amount of illness, I probably had a good constitution.
3. Precise information is lacking here, but it is a fair inference from his story that there were some gastrointestinal problems as a child; he has a number of food difficulties now.
4. This subject had a very difficult time physically, with allergies, asthma, and migraine, and as a young man, an attack of glaucoma.
5. He was always skinny and frail and says: I was very puny and had a reputation as a cry baby and a weakling. I wasn't exactly weak, but I managed to be in a state of more or less unsatisfactory health until I'd been married for some time and was very weak muscularly until I had children. I guess there is nothing like continuously lifting an object that keeps getting heavier. I don't think there was anything wrong except not particularly good nourishment and the slightness and weakness was a constitutional trait.
6. I had all the usual childhood illnesses, and had pneumonia twice as an infant. While growing up my health was quite good except that I was always the smallest boy in the class.
7. In my case I was quite healthy. I don't remember anything else.
8. I was always fairly large for my age and at the age of three I had a very serious case of blood poisoning with the result that I had to stay in bed for a year with the threat I would lose my arm and maybe my life. I was climbing up a table after cookies, typical of me, and fell off. It made it so I couldn't use my arm for a year and

I became left-handed, but my parents trained it out of me. My arm is still bad, see? Sometimes people notice it but most don't. I think it had some effect because when I was in the eighth grade and big for my age and was urged to turn out for football, I did but the doctor said I had a mitral leak and that kept me out of athletics and I was always favoring myself.

9. I was rather sickly. I imagine it was more allergic than anything else, although it was not recognized at the time, and I was out sick two or three months each year. One term in high school I was only there for a month. I had to take make-up exams. I've snapped out of it since but then I spent a fair amount of time in bed. It was mostly troubles connected with the breathing tract. I had tonsils and adenoids and I still have hay fever to some extent, and I had a mastoid and an appendix. It was always something special; my brothers and sisters always had measles and things like that but those never bothered me, or anything like that. This meant that during most of the winter months I didn't get out and I got to reading fairly early and since I was in the eighth grade I've been in the habit of reading four books or more a week.

10. My health was not good. There was a period when I was about 12 when I seemed to be run down and my mother was somewhat worried about me. But actually there was no time when I had to stay in bed. There was perhaps a year or two when my mother felt that I wasn't doing very well, that I ought to eat more, and a friend of the family bought me a membership in the YMCA in order to get me more exercise. I don't remember any specific disabilities myself, I wouldn't have said I was sickly. I may have been a little slow to start growing and I was pale, perhaps partly as a result of malnutrition. Mother was sometimes a food faddist. I had rickets as a baby. My health has really been very good.

11. My health was always good. I never had a really serious illness except once at the age of 13. This was a glandular infection, a strep infection of some sort in the neck glands. I suppose I was seriously ill for a month or six weeks and several months convalescing. I was out of sechool for a term which I made up in summer school, this was just at the beginning of high school.

12. As far as I was concerned I had my mother's bad health. I had a poor start and from old parents. The trouble was bronchial asthma but it is better now.

Of this group of 12 men, only three reported generally good health and normal development; four more had no serious problems other than slow growth or general weakness; the other five all had real health problems. Both the obvious health problems, and the weakness and slowness in developing must have contributed to the difficulties in social integration experienced by this group.

Interest[2] in gadgets, Meccano, chemistry, sets, radio, model planes and so on is usual among them during their childhoods, although it was not true of Nos. 2 and 3, both of whom had somewhat specialized home atmospheres, the former being dominated by the aesthetic interests of the mother and the latter by the religious interests of the father. In a few the interest was not overwhelming, but in many it was a constant preoccupation, and carried well beyond the usual bounds.

In a few instances, these interests appeared before high school years, but with most of them the first specific interest in physics or chemistry or mathematics came with high school, and usually with a particular course. With the chemists and with four of the physicists this was a course in chemistry, but the early interests of five of them were physics (including much constructive work) and mathematics (often with a preference for algebra over geometry). Several shifted from one branch to another, often because of unsatisfactory experiences with college courses or because of the personal influence of a teacher. The usual decisive point seems to have been sophomore or junior year in college. This accords fairly well with studies of development of vocational interests (see, e.g., Super, 11).

Understanding of the nature of research and the fact that it could be done by them, seems to have come more gradually with this group than with the biologists. Perhaps the school work, particularly in mathematics, is closer to the work eventually to be done. The major problem is the shift to theory, and this apparently comes largely from working with men already in the field and observing what is to be done. The discovery that they could find out things for themselves which was so often a specific experience among the biologists, and of major importance in their choice of careers does not appear in the same dynamic way in this group at all.

A factor running through all of these histories and probably of the greatest significance is the single minded concentration on the field, once the subject got into it. This intense and continuous work is probably one of the most important factors in their present eminence. Some of them went to extraordinary lengths to get their education, and it is clear that the pressure came from within. These men are self-starters (with perhaps one exception), and needed none of what one of them calls "spoonfeeding."

[2]Interest, as used here, means that the subject spontaneously spent a lot of time on the activity. It is not necessarily the same thing measured by interest tests.

B. The Experimentalists

1. *Biographical*

13. This subject was born in the middle west. His father, who had been a school teacher, died when he was six, and his mother then married a farmer. He went to a rural grade school.

> I just can't remember that anything in grade school was important. I had very poor teachers except for one very good teacher who taught me how to study, but mostly this was a seven months a year school work. I think I passed out with a grade of 76 as I remember it. I was always studious; I read books all the time of some kind; liked arithmetic. Then I went on to high school and here I liked mathematics and I was very fond of Latin. I took a course in physics which I wasn't very fond of; I took a course in zoölogy and botany which I was fond of, in both cases there was lab work and book work. But when I got through high school I had an ambition to be a high school teacher of Latin, but I think only in college, which I didn't get to until I was 21, did I really get interested in science. I had none of the playing with Erector or chemical sets and did no carpentering. We always had an awful poor set of tools around the place.

He had been enabled to go through high school because of life insurance left by his father, but after that he spent some years teaching, before he was able to go to college.

> I was going to be a psychologist, and they said at college I had to be a zoölogist first so I took zoölogy. I had taught school and picked up some books on psychology. I don't know how it happened that I got an education. I taught school for a few years, and I saw some of these books, they were probably terrible, probably no good at all I don't remember the names now. Then in order to get anywhere with zoölogy I was advised to take chemistry. Of course I've always liked all the sciences, always was thrilled by them. Once I got into science there never was any question as to what I liked. I preferred it to English, languages, mathematics and everything. I thought I would be a zoölogist up till close to the end of my course but I had about as much chemistry as zoölogy and the war (1917) wanted a chemist, not a zoölogist so I went to a chemical works and worked there during the war.
>
> When I was thinking of being a zoölogist I thought of teaching and in chemistry I thought of industry. But my industrial experience in the first war convinced me that I didn't like it.
>
> I found out about industrial research during the war, I was in the research laboratory. My great drive for real research came from my graduate work. After the war the personnel of the factory was decreased. The job wasn't discontinued but I had an opportunity to

teach in my old college as an instructor and from there I got back to school by means of a fellowship. That was a real research lab, it was there I found out what research was really about. I began to realize there were very important things to be found in science, much more than the routine testing I had become accustomed to during the war. Any subject interesting to us in the department was defined as chemistry. There was no requirement in regard to courses to get a degree. I never learned what my grades were, it was all of no importance. We thought there were certain subjects we had better take courses in (because of exams) and then there were exams. I spent the bulk of my time on research.

(He was then able to go abroad to study.) By then it was quite certain that I was going on for an academic career. I wouldn't do anything else, I'm completely satisfied.

14. I was born in the midwest on a farm. My father was one of the pioneers in that section of the country, and had pioneered farther west. My grandfather had expected to be a doctor but this was interfered with by the Civil War. Both parents were interested in reading. I went to a small country school and then went four miles to high school.

I don't remember much from grade school. I think I was better in arithmetic than in most anything else. I always liked it. It was an eight months school, from the middle of September to the first of May.

It was encouragement from my parents that got me into high school. I was the first of the family to go through. There isn't much memorable except I made a pretty good record in science and mathematics. I had first year physics, not much lab but mainly mathematics, and a very good course in mathematics with an excellent teacher. I had physiology and psychology but no chemistry or biology. I'm not too good in languages. My memory isn't very good although I could cram for a while. I got a medal for scholarship, though; I was second in the class.

As a kid I did no extra reading. After school there were chores or I was chasing around with the boys. We had our own blacksmith and carpentry shops, and I worked in those to make anything I wanted to. I did some tinkering but I wasn't any better than my brothers. I could use my hands all right but I had no very special interest in it.

I sort of wanted to go on to college and father said I must and the high school principal said I should go and mother thought so, too. I had no clear idea except I wanted to take some more mathematics, and possibly go into medicine. I was very fond of the country doctor there but the war came up and that changed the whole thing. I took some advanced mathematics and the dean said I should go into mathematics or engineering instead of medicine.

I went to a small local college after a few months at a state agri-

cultural school. It was during the war and things were very confused. There was an excellent mathematics teacher in that college. To a great extent he was responsible for my going on. My first couple of years I just got a general background, and had some chemistry and geology. I got into physics in the third year. I took a major in mathematics and chemistry and got a fellowship to a university in mathematics. I knew only very little about the possibilities. I was just going on with the idea of seeing. I had an uncle who would have sent me to law school but I didn't want to go.

My fellowship took me to the university and I did a master's thesis in mathematics, at the same time taking some courses in physics. Then I wasn't quite sure but what I wanted to go into physics so I got a job for a year to make up my mind as instructor in mathematics and physics at a small college. After teaching both I got very much interested in physics and went on for my Ph.D. on a teaching fellowship. (*Where did you get the research idea?*) It began to dawn on me at the university. The dean was the professor of mathematics. He did a lot to impress the research spirit into me. I was very fortunate. I always had a feeling that physics was pretty close to nature and it seemed to be a sensible way of getting at it.

I think I just drifted into it. I always wanted to do something worth while in science, I always felt I would like to find out about things, I had a great deal of inquisitiveness about things. Research was sort of a gradual concept. I think really that came when I was working on my Ph.D. dissertation, that it wasn't such a superhuman job to get out a piece of research.

15. I'm not the first in the family in a scholarly profession. Father was a professor, too. My interests in school didn't particularly center in physics for a good many years, but I think I probably had a career in science or engineering in the back of my mind from an early age.

In grade school I had some tools, I liked manual work. I had two or three fairly close friends with whom I played. The usual amount of bicycling and I was in the Boy Scouts. As quite a young boy I had a Meccano set that interested me greatly and spent a lot of time with that as a youngster and Dad even fixed up a place that I could call my shop but I didn't put in an inordinate amount of time there. I wasn't greatly interested in athletics, except hiking and later tennis. Part of the activity in the shop was tinkering with radio and other electric things like silver plating and a certain amount of wood work. (*Ball games?*) Not much, I got a bad start on account of my eyes, I was nearsighted and had to wear glasses at ten so that set me back on ball games.

In high school the sciences attracted me, particularly the physical sciences. I had to work fairly hard to get mathematics and my record in it wasn't really outstanding. There was a small, loose group of us who were interested in technical subjects and did these things together. The element of competition was important.

It was always taken for granted I would go to college. At the one I went to the first two years are about the same for everyone including two years of mathematics. I began in my junior year by taking mathematical physics as I realized its value but I preferred experimental work. My inclinations were for physics in preference to chemistry.

When I got to college I was in a state of indecision about future work and although I went in for a science course I doubted my ability to do well enough in astronomy or physics and had difficulty deciding between science and engineering. In my junior year I changed to engineering and graduated in that. Science was not popular in my class and I felt it would give me too narrow a background.

After graduating in engineering, however, I decided I probably had been wrong so I went back to physics to really give it a whirl and entered the graduate school at Berkeley and got my degree there. I think it was a lack of sustained interest in engineering, feeling perhaps that though I could get a job I might not find the work engaging. I was more interested in fundamentals.

His father was an active research worker so his understanding of research came so gradually he didn't notice.

I think I recall two or three occasions when I was in high school when I attempted a small research problem on my own. Half in the nature of playing but I was trying to find out something. I tried to speed up the action of a photographic plate by applying an electric field to it. I used to play with electric motors of various kinds, I at one time had a very small printing press and rigged it up for continuous printing.

16. Father was a clerk and a farmer and quite unsuccessful financially, but except for money our parents were able to give us more than any parents ever did anyone. Things were disrupted after the Civil War and the family went from well-to-do to refugees. Financially we were always very insecure. (*Did you feel it?*) In a curious way. I sort of accepted the fact that a lot of nice things that were for other people were not for me. Took it as a man who has lost his leg would take it, well that's that. But we were very secure in the family. Father has read widely and is a modest, humble man but very wise. We look down on our friends as underprivileged. We all had music lessons even when we didn't have shoes.

I learned to read well before I started to school. There was a neighbor's girl a couple of years older. We always played together and so afternoons I learned her lessons. They found I could read as well as she could. The principal came by one day and heard it and said send him to school so I went, about six and then I skipped a grade, they thought I wasn't having enough to do. I went to high school in the same town (about 800 people).

In the grammar school I just loved the subject of grammar, that just was the apple of my eye. Arithmetic I couldn't do. The only way I

ever passed was father worked the problems and I learned them. There was no meaning and no intelligence in the subject for me. I now believe that had nothing at all to do with my interest or personal harmony with the subject but with the quality of the teachers. They weren't well trained themselves and probably couldn't do the arithmetic better than I so naturally they couldn't teach it. In the seventh grade we had a tall, red-headed teacher who taught agriculture. It was very good and my first contact with anything at all like science and I liked it fine. It just kept me on the edge of my chair all the time. Capillary action and photosynthesis and all that. Later in high school the county agent came around and was astonished to find that I knew about these things because I asked him questions. It was the first time I'd had a chance to ask anyone.

In high school I had a good teacher of algebra and a good teacher of geometry and general science, and a bad teacher in Latin. No trigonometry, and in the last year commercial arithmetic. The teacher of algebra was a wonderful man. Here was something independent of arithmetic and it was nice and clear and I had a new start, my past deficiencies were no problem. I liked that fine. Before this last year when the commercial arithmetic came along I had worked many summers in stores so the arithmetic was nice and easy. I had a course in physics taught by a man who didn't understand anything about it. He had come really as a football coach and he taught physics on the side. Our lab experiments there were quite awful to think about. We had long arguments about whether a falling tree in the forest would produce sound. For the experiments there was a cupboard full of apparatus most of the pieces of which no one could identify. There was a typical "experiment" with a Wheatstone bridge. We connected batteries and adjusted the plugs. Finally smoke came out. I was stimulated, I was tantalized by the lack of information perhaps more than I would have been by a well-taught course.

I had taken it for granted I would go to college, it was never in question, the only question was ways and means. As far as I know I had never met a college graduate, the teachers had mostly the minimum of two years at normal school. There was a young man older than me with whom I was friendly and he was enthusiastic about a college he knew of and he convinced me that I should go to that college. I graduated, I think I was valedictorian and they hand out scholarships but there was none from that college. I wrote to them in August asking about a scholarship and saying I had decided to go there. I blush. But I got a letter back saying I should have sent some credits. They had somehow gotten hold of them, and they thought I should go to a good high school to make up all my deficiencies first. Then later they said I could come. The president had a notion that they would do better to take the top kid from any school than the top 10 per cent from a big school. They had entered into correspondence with the principal of my school right away. They make no provision for those

with deficiencies, all take the same course. Everything is run on the basis of a minimum of trouble for the faculty. There is a complete refusal to inconvenience anyone for the benefit of the borderline student. The courses last a year, if you flunk the first half and pass the last you take the whole thing over. It's all run for the good student. That's actually my own philosophy of education.

I went to register for electrical engineering. I didn't know about science or technology, I just knew there were interesting things I wanted to know more about. I was not gifted as a child at making things. I just was attracted to the idea of machines and microscopes, just a vague romantic wish to know about them. I didn't know enough to have any reason back of it. There is a more or less set course for electrical engineering. I took it two years and then I moved out because many of the people who taught engineering were Yankees and had a sarcastic way of speaking and placed great emphasis on trivial things I considered to be petty foolishness and the people who taught mathematics and physics were scholars and gentlemen. It was the first time I had any notion of what scholars were. There were four or five people there who had great influence on me and thank God, I wouldn't probably have found them anywhere else. Some of it was so subtly done I don't know how it happened. There was a professor in mathematics and I wasn't in his freshman mathematics course but somehow I found myself acquainted with him which in itself was remarkable, and he invited four or five of us week-ends, he was a bachelor then, to a little camp he had. There aren't many places where teachers will bother with that . . . that was a wonderful help to me. It was my first acquaintance with a scholarly life. My physics teacher was nice. During my second year I met the head of the department there. As I look back on him today now from the standpoint of a colleague, I still have never met his equal. In all the advanced courses I read like mad, just read all the journals all the time. I would come to him with a question from my reading. If it had not been covered by the course he would stop the regular work of the course and teach to my question. I would pass through these odious sophomore stages where you would be contemptuous of the people who studied history and not mathematics, and he just said he had a hard time to decide between the two. That was more effective than anything else would have been. All of this happened to me in my first two years. Why they ever bothered to notice me I don't know. I had no clothes, I was washing my shirt in the sink. Somehow they just helped out. By the end of my second year I knew I wanted scholarship in physics or mathematics. The first year was quite rough. I ran out of money by Thanksgiving. There was another fellow as badly off as I and we heard of a job and we tossed a coin and he won. I felt as though it was the end. He went down and came back and said they wanted someone with experience (soda jerking). So I got busy and went down and said I had two years experience, and I meant to go

places and order things and see how it was done but I got busy and there wasn't time. My alternate was a Mexican girl, not too communicative, and I walked in and went to work. I worked from 5 to 12 every day, except from 11 in the morning to 12 at night on Sunday. Next afternoon a checker came in and asked for so and so and I said we were all out, so he asked for something else. The boss was there, there were always just two people on, and I knew that was all, so I went out and took off my apron and walked out, and said to the boss as I went I'm sorry I lied to you, and went on. I felt awful. I was about a block away when he caught up with me and he said where are you going, and I said I didn't know anything about it, and he said why did you say you did and I said I had to have a job, so he said, well come on back we'll teach you and they did. He was a very unhappy man and often we'd just say hello and goodbye but he was good to me. I had studied so hard I was well ahead, and I decided not to try to study at night, but to get some sleep and I depended on learning things in class. I made good enough grades for scholarships always after that and could do things that helped with my school work, grading papers, working in the library and so on. I worked the rest of that year.

For my Ph.D. thesis I was able to use data I gathered during the summers working for a big company.

17. I'll probably be a contradiction because I've always felt my getting into physics was a stroke of luck; not much thought contributed to it. My family, I would say, were moderately well-to-do farming class on both sides. In the early years I grew up as all other farm boys do, spending part of the time in the fields and going to school in the early years probably to a seven months school. I don't think I ever went to a nine months school until I was in high school.

My mother's education would be the equivalent today of about first year high school, she taught school for two or three years before marrying. No one in that generation as far as I knew went to college. In fact I think I was the first person on either side that ever went to college, although many of my cousins have gone since. Dad had about sixth grade education.

My father and mother were rather an exception in the community which can be pointed out in this way. We lived out in the country about seven or eight miles from a high school. The country school to which we went was very close but when I finished seventh grade the school was having its usual ups and downs and the high school was no good. So my father and mother agreed to send me to this school away from home and it required boarding me away from home and that was quite the talk of the area, that they would waste money boarding me.

My recreations were the usual ones, physical activity. Whereas most parents in that neighborhood believed that children when not in school should work along with the hired help, both father and mother adopted the attitude that they expected me to do that amount of work but

didn't care when I did it. They would lay out a certain amount per day and if I wanted to get up and work hard and be through with it that was up to me. That was always criticized because I was always enticing the other boys away when they were supposed to be at work. I earned the title of being one of the laziest boys. It was only necessary that I do it and do it well. He (father) did it with the other help as far as possible, too, like piece work. From that I learned how to make time on manual things and at the same time to do as well as required. But we had no tools and I did no carpentering. Up until I went to graduate school I never knew I had any ability in that respect at all. I didn't do a great deal of reading. In those days the books that were available were novels and I wasn't particularly interested.

(*Going to high school?*) I think I wanted to go to high school, at least I was perfectly willing to go. It came rather suddenly. I don't think very much was said about it until possibly a few days before I went. I suspect my mother had more to do with it, she had thought it out very well but I don't think she said much even to father. His reaction was that as long as you do well, I'll help you go to school. If you fail you can come home and work. Although he always thought farming too hard for anyone and that anyone who had intelligence would get off it. The first year or so was pretty rugged. It was difficult to find a satisfactory place to stay. We had one little course in physics in high school, not a lab course, and the usual mathematics. I think I was probably the top of the class in that. In mathematics there was one boy, we were usually about on a par. He had to be away a good deal or I think he would have been the top. In both physics and mathematics I never had any difficulty.

I think there is an incident there, it has always been an amusing one to me. The only time I had any trouble in school was with the physics teacher. About the middle of the year she was showing how the water level in the boilers was determined. She left the gauge open and I said all the water would go out. The argument got hotter and hotter and finally I volunteered to show her at which time I got thrown out of class. There again it was what father always said, you have to think things out for yourself. I think the study I had most trouble with was Latin. I'm not particularly good at languages. I have to work for it. If I have to I can.

When I went to college I thought I would go into medicine. That was because a young doctor boarded in our home about the time I was 12 and I used to drive a car for him. I got rather interested in it after I held a badly burnt child for him once and gave it ether when no one else there could manage him.

I went on to college, I just went to the nearest one. The medicine idea shifted rather gradually. Two things happened, I think, that caused a shift. One was that again purely by accident in the first year mathematics course, in the first week of the course I was lucky to be in the section of an exceedingly good teacher. I always liked to be

in the back of the room if I could. It seemed that during the first week this professor would start asking questions and begin at the front end, and by the time it came back to me I would have been able to get the answer, from the book or by working it out. Then he began to do another trick, if he didn't get the answer on the first three or four he would say "How about my old standby," and call on me so I felt I had to know it. From that he began to take quite an interest in my work and before the year was out began talking about didn't I want to work up the second year for myself during the summer. So I promised I'd try and he said he'd give me an examination in the fall and then I could go into the third year which he taught. I never have known if I passed it or he let me by, but I went on with him. He wanted me to specialize in mathematics and along with that there had happened another incident. I had become engaged to my wife, and she wasn't keen about being a doctor's wife and undoubtedly that had an influence on me. She wanted her husband at home a reasonable amount of the time. So I gradually drifted into the direction of mathematics. The second summer I worked up some other courses and in the first year I had carried 21 hours so at the end of the third year I had completed all the requirements and had completed four years of mathematics. Along with it I took one course in physics, but I wasn't particularly interested. I was taking a mathematics-science major so I had physics and one year of chemistry. The last year I found all I lacked for a B.A. instead of a B.S. which wasn't considered as good a degree, was a year of Greek so I took that. It was a kind of training that to my mind is lacking today. I even wound up with the highest grade in the class.

The idea of going to graduate school came from this mathematics professor. (*Were you thinking of teaching?*) I don't think I made a distinction. When I started I only intended to go through for an M.A., I didn't see my way clear further. This professor helped me to get a fellowship, and that plus father plus my wife made it possible for me to go. I started out intending to spend a year and a half and get an M.A. and go out teaching in mathematics.

Then again one of these things happened. The first summer I went there I took two courses in mathematics and for some strange reason I was assigned a course in physics. They said I should take a minor in physics and here's a course you might go down and take. The two courses in mathematics were taught by two foreigners and they were the two most discouraging courses I've ever had in my life. The fact that one in particular was taught by a famous English mathematician and was teaching completely over our heads. I thought it was my own dumbness. I worked as hard as I ever worked in my life and accomplished as little. A few days before the exam I happened to mention it to one of the other students and he was feeling the same way. So the next class he had the nerve to go in before the teacher came in and he went up front and asked and pretty soon he discovered most of us were in the same boat so when

the professor came in we stopped him and told him this. He asked around the class and they mostly said the same. He had assumed we had had two years of mathematics that we hadn't had and so he gave an exam I could have passed in high school. So I was thoroughly disgusted with mathematics. The only course that was half decent was the physics course but I wasn't prepared for that.

At the end of the summer I thought I wouldn't go on with graduate school and I decided to go down town and get a job and if I still felt the same way I'd just continue working instead of going back next term. So I got a job as a salesman. That was another lucky stroke. I went down and started putting the same effort into that. I began selling boys' shirts, and I'd never bought a shirt in my life, mother always did. So I went to the library and got out three books on cloth. I read two that night and by the second day I understood a little more. I thought that you wanted to be helpful in selling and it would be your job to learn what you were selling and it paid off as far as sales were concerned. Of course, then it was said I was a sales grabber so I was told to take my turn. I said that was all right and did take my turn but I still maintained the highest sales, but it was because by then I was selecting out the good quality. I got called down for that, they said there would be a lot of returns but I asked them to check it and there were hardly any. Then I had a run-in with the buyer and was transferred upstairs to sports goods and the same thing happened there. It was the same old trouble. No one ever bothered to study their stuff. At the end of the month I saw very clearly that in an industrial job you didn't get anywhere by knowing more or doing more than anyone else. By that time I was convinced that that side of the world was a pretty sorry one.

By then I had also decided I didn't want to go on in mathematics. That one course convinced me that physics was what I wanted. I had my fellowship transferred and had a long fuss with the dean who wanted to assign courses and I wanted to work up to them. So I started out from there and with essentially undergraduate courses.

I liked it very much better and I found I had somehow time on my hands and very soon I wanted to try my hand in the lab. I had never had any tools in my hand. Again a lucky break, I went down and told the professor and said I'd like to try, and I'd be glad to begin by opening boxes or anything else, and he laughed and said as it happened there were a lot of boxes to open, and so he put me to work. Presumably lying dormant in my fingers was an ability I didn't know I had. Within a month I challenged him I could make an electroscope work better than he and I won. I've always wondered if he let me do it; he never would admit it but I wouldn't expect him to.

I found that almost anything in experimental work I had no difficulty in doing. Glass blowing, and so on, just came to me overnight. I learned mainly just by doing it. Machine work was all pretty much the same way. Handling the tools just came naturally as if I had been

doing it for years. So much so that when I came here and took over the shop I said I'd never ask them to do anything I couldn't do myself. At first they sometimes said they couldn't do things, but I always showed them and since then there hasn't been any question.

(*When did you get the research idea?*) In college you were assigned something to do. In research you do another thing. If I have an idea on a research problem I often go ahead and do enough to know what I'm getting before I ever look up the literature. I suppose the first introduction might have been in *C*'s lectures. The idea I could find things out for myself came more gradually and apparently rather early. I became interested in thinking out things that ought to be done. There were two tolerant people who would listen to me. I would go to one of them with an idea and he would say yes, that would be a good thing to do and as a matter of fact so-and-so has done it and you will find it about the middle of a certain volume. I finally said apparently I can't think of anything to do that hasn't been done.

My choice of field was primarily due to a professor. My thesis was a problem that had been worked on before. I don't remember if I suggested I would like to work on it or whether he did. By that time we were working so closely together it would be hard to say. The first year I thought probably by the end of that year I'd have to go out and start teaching and I completed the requirements for an M.A. but by the time I had done that the university gave me an instructorship which paid all my university expenses.

18. He was brought up in a rather small town, where his father had a sectarian school, although he was not an ordained minister. His father was also a scout master, and a radio ordered for a minstrel show the troop was putting on was delayed so long in coming that the son and his chum (now also a famous physicist) "inherited" it, but it took them a year to get it working. Then a boy a mile away got some equipment and they received some local publicity when they carried out tests with an orphan five miles away in the orphans' home.

We played at it for a couple of years before we heard from any distance. I went far enough that I received the daily news dispatches from Germany during the first war and copied our declaration of war from Arlington. That and music were in competition for my interests.

When I was a freshman in high school we went to the nearest big town and visited a radio amateur there and he had a vacuum tube and I worked all the next summer to get money enough to buy my own tube. Once we got those things began to happen much more effectively.

When he was 19 a group of them set up some surplus tubes and transmitted music from a phonograph. He thinks this is probably the first broadcast in that state. They worked at it for some time but when it became a public thing he stepped out.

I think it's a fair statement that for me and I believe for most radio amateurs, the procedure is not to learn from books what people know about something but to get a small assembly of apparatus and then to see what you can do with it, then you read a book, and find out (*a*) how people have explained the things you knew, and (*b*) how much more they know about it. You have to know something in advance.

I took physics in my sophomore year in prep school. That was really a wonderful experience, that was excellent. Just like opening a cookbook when you can't cook. I felt much enriched by my experience in high school physics—that these things could be put into quite a simple framework. That you could understand all the things that happen and they were simple.

When father died just as I finished at the academy I did not have my career chosen. I thought of music, too. I worked for a year in a dry goods store to keep the home together. That gave me all the stimulus I needed to go into scholarship. I studied chemistry behind the counter. That gave me a chance to spend my working hours with something of significance.

I had finished high school in three years, and college also. At any time I was not sure I could stay in for more than three additional months. I started with $149 and a widowed mother. I started as a chemistry major but found it took too much memory work. Also I jumped into too advanced a course, so I went into engineering, not with the idea of studying physics but to keep my feet on the ground (so he could earn a living.) Then I took college physics and liked it still better but I wanted something of the training of the engineer, so I took my degree in electrical engineering. But I finished that course with the full knowledge that I was going into physics. (He had enjoyed mathematics and took a lot of it. He is facile in languages but took few in school.) I dislike memory work and highly complex subjects which lead to no reasonably firm conclusions. I have rather a disrespect for economics. I studied music theory, that has a satisfaction for me. But these argumentative subjects I haven't liked.

His Ph.D. thesis was a discovery by accident of some importance. Following that he was offered an NRC fellowship, but went to the research institution where he has been ever since.

(*When did you learn about research?*) It was no definite time. I suppose it had been pretty much an ideal even from my early days. I realized it in part in connection with the development of the vacuum tube. I guess the probability of doing it personally came as early as the idea that there are things to do. A radio amateur doesn't work through teaching at all. I don't think any actual teaching was a significant experience until I came to my Ph.D. The particular challenge which was my own, was exploring the things that were already known. I found sources for myself. I really tried to get the broad viewpoint ex-

pressed in a whole organized subject. (*a*) To imagine how could anyone do that the first time which left me baffled. I still feel baffled. (*b*) The way in which they have simplified the progress for us. Because facts relate so much more to each other.

Rather specifically I like to do something where a small number of people are doing things like it so I can know all of them and know what's happening. In nuclear physics today you just could not keep up with it. So much going on. It's a thing I do for private satisfaction, not for consequence, I feel out of place. (In public notice.)

19. His father was a farmer and active in church work. They had a home in a small town and one on a farm, four miles out.

I presume the early aptitude towards physical science and mathematics came with my very early interest in counting and telling time. I was exhibited by my parents (in counting) when I was about one year old and was regarded as somewhat of a phenomenon in the neighborhood. I could count and add and tell time before I was three years old. I don't remember how I got into this. I was the youngest of seven so I had the benefit of my older brothers and sisters. I was the baby and remained the baby so I was watched over by an older brother (10 years older) who protected me against some of the scraps kids get into; he wasn't going to have his baby brother picked on by the gang. I think he and my mother encouraged these early evidences of interest in counting and telling time. Throughout my early elementary grades arithmetic appealed to me more than other subjects. In my early childhood engineering appealed to me, I'd seen surveying work. My elder brothers took to the farm more than I did and very early I was set apart as one who wouldn't go on with the farm. I worked on the farm in the summer and looked on it as an unpleasant experience that took me away from school.

The first conscious efforts I can recall were associated with civil engineering because that was what I saw. I worked on the farm in summer until I was a senior in high school and about that period I got a job as assistant to a surveyor. I was more interested in the transit and level than I was in moving the chain and the computations were of more interest than the field work.

I went out to sell books between my sophomore and junior years in college, I wasn't adapted to that at all, it was a tortuous job. Some enterprising organizer came around and told us what a wonderful thing it would be. We were expected to sell a book called *Pushing to the Front,* in two volumes, a lot of sentiment on making a go. Quite a number of my classmates also were engaged for that summer work. My territory was in Eastern Oregon. After two weeks of *Pushing to the Front* I got a job with a survey party in Portland and spent the rest of the summer as a surveyor. I didn't want to go home and have it seem that I couldn't manage things, but I couldn't stand the book selling.

Very early my parents recognized I was not going to be a farmer. They were not only resigned but they encouraged it from the beginning. In that respect I was given some privileges my brothers didn't have such as not having to miss school for farm work except in case of an emergency. There was a definite effort on the part of my father to make it possible for me to go on with my schooling. I was interested in engineering until I met *X* who has influenced me more than any other person. He was then professor of physics and mathematics at the local university. Engineering as a department didn't exist and my association as a student with him convinced me as a freshman that I didn't want engineering. I wanted physics. It was his example more than anything else, it was the belief that that was the kind of man I wanted to be. If he had been in engineering I might not have gone on in physics. I think this early predisposition to engineering has manifested itself throughout my life; I've never wanted to be a pure physicist, I've always been on the borderland. Most of my research has been in applied physics. While I have some work in pure physics it came as a necessary part of an investigation in applied physics. I know that the early trend toward engineering has persisted throughout my life. (*Was there any particular person in that first survey party that influenced you?*) No.

In my junior year in college I was encouraged to pursue an academic career by an unusual experience that may be significant. The vice president in charge of faculty appointments called me in and told me he had watched with interest my career and said they hoped to have a chair of mathematics and they would like me to prepare for that. I wasn't a mathematical genius, I got *A*'s but I was no Richard Tolman, I had no feeling at any time that I belonged to the genius class. I knew I had the capacity to rise high but not to world eminence in mathematics or physics, my natural bent was more in between. But of course this gave me a lift.

In high school I had physics and chemistry, no biology. I had mathematics, trigonometry, and analytic geometry. I think geometry appealed to me more than algebra. I had all my upper division mathematics and all my physics from *H*. He was a one man department there. And he made me his research assistant. That was another potent influence. I got the research idea from him. I had no concept of research before then. It wasn't a faculty of great scholars, but it was one of good teachers. I think interest in research would have come earlier if the environment had been there. But once I met it I had no doubts. There was nothing of the sort in high school or in the town.

He then spent two years in church work, but combined this with studying, and from there went to work with a big industrial concern, to which *H* also had gone. After two years he went back to college, where he became interested in continuing the study of physics and undertook the

investigation of a problem in applied physics. When he finished there, jobs were plentiful and he selected a position at the university where he has been ever since.

20. As a kid I was very fascinated by mechanical things, as lots of children are in high school and I took all the science they gave and at that time I was quite sure I would be a scientist. I had decided on science or engineering as soon as the question came up. There was no struggle on my part. I did a lot of reading as a child, too.

Father was a physician and the family hoped I would go into that but it didn't interest me so much. We lived near a technical institute; they had lectures Friday evening and when I was in high school I started attending these things, I'd go down every Friday and hear all these wonderful things and that made me more certain. So I applied there, passed the exams and got in. The first year is about the same for everyone so I didn't have to decide but by the end of that year I was sure I wanted to be in a pure science because I liked it better and knew I wanted physics, not chemistry and pure science not engineering. So it seems quite simple. It started by being fascinated by gadgets and having contact, it just seemed natural that that was where I would go. College was always a matter of course.

This is very difficult because for one thing I have a very poor memory of past times. I know people who can remember everything but I can't. I'll just say that as far back as I can remember I've liked things like mechanics. I used to play around with stuff, I'd go to junk heaps and pick up stuff and try to fasten things together. I think I was pretty little. I'm not saying I was a boy mechanical genius, but somehow I've always had a liking for junk piles and bringing home all kinds of things.

About the only thing I can remember that I'd made quite early that worked was a buzzer and I can tell you how it was made but can't tell you how big I was . . . it must have been before I was 11. There was an old magnet, it came out of an old electric auto horn and a lid of a tin can and this was fastened to a stick which was pinned on a nail. I think I knew how buzzers worked before I made that.

Another thing I did which would be in early high school, I made various high frequency things, coils and bottles full of water for condensers. Just for fun. Probably read it in *Popular Mechanics* and things like that, there are ways of finding out things. There is a lot of lore going among high school kids you know. I was more or less solitary at that point. I just did this in my own bedroom, I had a pile of junk in the corner. Father had some discarded electric stuff which I pulled apart, but there was no concerted effort to provide me with stuff to fiddle with. Father wasn't mechanically minded. He had a lot of electrical stuff but he never understood how it worked. So I had no help at all in this. I was the only one in the family interested in this kind of playing around.

In high school I had one course called physical science, physics and chemistry, a long course. It was a very good course, a very good teacher. And a course in biology, which I liked but not as much as physics. It was interesting. We had a lot of taxonomy and since then I've liked to poke around the seashore and find these little beasts. I still remember from that the orders of insects and different kinds of things. Now the thing that interests me most in biology is biochemistry. If for some reason I couldn't do physics the next science I would choose is biochemistry, not physical chemistry which is no fun. I like the taxonomy. It's fun to find an animal and know what order it belongs to but it isn't important.

(*Why physics?*) I just thought that pure physics was more interesting. You work at the schools of engineering and you find that it's pretty much handbook stuff. What interested me was the principles, the research, the finding out. I've done some electrical designing since and I know how to use a handbook, too.

(*Where did you get the research idea?*) I suppose from the lectures I went to and from my teacher in high school who was a very good guy and had the true scientific spirit and from bothering research men at the college. I was not very advanced socially, I think, at that point and thought nothing of going down and bothering these people, I must have been an awful pest. That was while I was still in high school, I was just trying to find out what they were doing just trying to puzzle out what it was for. I'd see some things and I'd ask what does that mean? How do you do it? I never got thrown out.

I knew research existed before I went to college and I knew I wanted to do it and the first research I did was when I was a freshman. I actually did a problem and published it as a freshman. It probably helped my decision, to have gotten some published research and I got a great deal of satisfaction. I didn't do any more actually published work until my graduate work.

Chemistry as practiced there is close to physics anyhow and I liked the physical aspects more than the pure chemistry. I started out having this liking for the manual aspects. So far as I can remember the idea never occurred to me that I would sit down and work things out on paper. I like to study the theory but I never intended to do it on my own. I like to have some little thing that I can do with my hands, part of it is just that but there's also a pretty strong intellectual content in my case. I like to understand things, I like to know the theory. I like to talk, you've probably noticed that.

For my Ph.D. thesis I hunted around and decided on a very complicated problem, but my professor left and I finished up under a theoretician, so I was practically working on my own. I never published it, it turned out someone else came out just as I got mine done with about the same thing. They were always mad at me about it. But it would have involved writing it up and there was no point to it; it was too long, of course. I chose it out of a set of things. The idea

came originally from a professor; the design of the apparatus was my idea but the problem wasn't. That's the way those things go.

21. I really can't say when I got interested in things mechanical but it's just about as early as I can remember, about six or so I was interested in pretty much anything electrical, the usual things that kids are interested in, autos and so on. My father has a strong mechanical bent and I learned quite a bit from him, I guess, without realizing it. So I was just interested in that sort of thing as early as I can remember and by the time I was 12 or so there were several of us in it. We made a radio set. I was sort of leader and I did most of the designing and construction, the others did the operating. This was a transmitting and receiving station. I was always sure I wanted to be something of the engineering sort. I had never heard the word physicist, of course, and neither had either of my parents.

I had fairly large kinds of sets, Meccano and Erector at a rather early age. You can get a lot of action for a reasonable amount of time. (*Where did you get other equipment?*) I don't know. To begin with the folks would buy motors for toys and when I got to be old enough to be a radio amateur I was more organized and then it was mainly a question of making up my mind what I needed. We had all kinds of complicated arrangements. For a while we formed a small company to manufacture transformers. It was sort of a joke. The power company was putting in a lot of new transformers, and so we got any amount of stuff given us (one of the boys had a relative or something and he handed over a lot of the discontinued equipment to them), and then we cooked up a deal with another's uncle to dig a cellar for $20 or $30 worth of wire, and we made some transformers and sold them. I never worked so hard in my life. We sure found out things the hard way.

We had considerable instruction from books, but it was practically all of it from books, and we found out how to do it the wrong way first always. It just happened there were no radio amateurs around who knew more than we did so they learned from us.

Father was a traveling salesman and he ran an auto. From the age of ten or so I was entrusted with keeping the car serviced.

Father never helped me make anything. On the other hand if I asked him how to do something he always knew and he had tools around which he got for his own purposes and which I appropriated so it's hard to describe. He never gave me any formal instruction but I learned a lot. Not about electricity, but about mechanical things he was very, very good.

I got through high school quite young and my folks didn't think I ought to go to college quite so soon so they sent me for a year to the technical high school there, so I had perhaps better training than ordinary in that way. I still think that was a well run course. I spent most of my time in the machine shop. I took one or two of the

courses but it didn't amount to much and I spent most of my time in the shop.

(*Was college taken for granted?*) No, going to college wasn't taken for granted. It was mother's idea. Her father was a minister and she was of a fairly well educated family. Father was all for it, absolutely, but it was mother's idea in the first place. I liked anything scientific or mathematical and was all in favor of more school.

I got a scholarship and went to college intending to become an electrical engineer, that being the nearest thing we knew of to what I was interested in. Then my money ran out so I went home and continued in college there. About then I had to take sophomore courses in physics and the professor thought well of me and he said, "Why don't you go into physics?" and I said I'd never heard of it but it seemed a lot of fun and he thought he could stir me up a job here (his present institution) and said there wasn't much difference between the physics and the electrical engineering courses and I could change back if I wanted to. I guess he must have done some considerable wangling, but he got me a job as assistant when I was a junior and I came up and thought that was a lot of fun.

Then I, well I was pretty young and I guess not any too noticing about some things. I didn't realize there was such a thing as research either at that time but one fine day I was downstairs and saw someone wandering down the hall with a soldering iron, something I recognized. He was a student and didn't look like he knew what he was going to do so I went with him to help and spent most of my junior year working on his research and had a high old time working on it, but never published it, I suppose I should.

The boy (above) was a graduate student working for his Master's degree. This was a small place in those days. You see no one told me how things ran. I didn't know about any of the places where people gathered. I'd seen this fellow around the teaching labs but . . . I'd never heard of the idea of research. I'd taken courses and I thought that teaching was what professors did. The fellow I assisted for was one of the few that did not do research and I just saw him in his teaching laboratory.

By the time I got to be a senior it got to be recognized that I was pretty useful in the lab so they gave me to an International Research Fellow for research associate. He went to another university and talked of taking me with him, and I told the department head this, and after a couple of weeks I got an offer of an instructorship at my college and so I stayed here to get a Ph.D. I just hadn't thought much about it, I was kind of unconscious I guess. I was only 20 and just had hardly grown up yet. I took chemistry and got along well in it and had a good time and I'm sure I would have been happy as a chemist only I just had more background and experience of thinking mechanically that made me seem to fit into physics better.

As it happened I worked on several problems at once, but the one

I did my thesis on was a joint paper with the head, so he really suggested the problem and I just worked with him. It's a very rare student that can tell a good problem when he sees one, can start it off and carry it through. I certainly couldn't have.

Then I got an NRC fellowship and went to another college for a couple of years and spent one summer at Michigan. I had a whack at theoretical physics for a while as a change from being an experimenter. I liked it quite well. . . . I did fairly well at it but I'm a better experimenter than theorist so I learned a lot and did some work that has stuck. It was valuable training, it sort of broadened me out. I always liked mathematics and there hadn't been much opportunity to learn it here. At the time I went to school they hadn't anyone in mathematical physics and I have more training for the experimental end, so I felt there was a big gap there and I lacked mathematics so I thought I better learn some mathematical physics. I didn't do any experimental work at the other college at all.

22. Of course I've always been interested in mechanical things, that's one of the things that an experimental physicist has to have competence in. I did all the things that boys do who are mechanically inclined. Erector sets, taking things apart and sometimes putting them together again. I haven't any memory of when I wasn't interested in mechanical things. We always had tools around the house, and I got blocks and construction sets for gifts.

Father was a physician and spent half his time in research and he had a laboratory. I went over and played in his laboratory on Sundays. He had lots of experimental animals and all sorts of electrical gadgets. I didn't pay any attention to the dogs, I liked the electrical stimulators and had no interest at all in the biological side. So I think that's one thing that indicated an early interest. Also I had some chemical interests, but just mixing up blue and white powders and that sort of thing. I can't remember a time when I didn't know how to fix electrical plugs and do things with tools.

I tinkered with radio when I was in the sixth grade but not much. I just didn't have any friends in amateur radio. Most of my friends, we spent our time playing tennis and having a good time. When I was a senior in high school, I built a model of a Spanish galleon and that took a year and a half and I worked a lot on it. The galleon was out of *Popular Science*. I really have always been sorry that I didn't get into amateur radio because I had to pick it up the hard way.

The first time I ever heard of a physicist was when I was a sophomore in high school. Father was wondering what I should be and had been reading about individual physicists, the phonograph development was new and he had read about how it was the result of the basic physics of sound reproduction. So he told me about this.

When I was a sophomore in high school I said I was going to be a physicist. (All he knew at that time was the industrial end of it.) I think my father must have had a pretty good idea I was going into

something like that because when I was a junior and senior in high school, he arranged for me to be a shop helper in the clinic so I had two summers of marvellous training, learning to use precision tools. He also apprenticed me to the glass blower at the shop so I had a pretty good background in that before I got into science, a thing physicists used to have to know but don't need to any more. I read popular science and the biographies of scientists at that time.

I always assumed I'd go to college, and that I'd do graduate work. It's a professional family. Both grandfathers and my uncles have graduate degrees, and all my aunts and uncles are college graduates except one.

In high school when I was a junior or senior I decided to be a chemist, so when I went to college I decided to major in chemistry and I took chemistry for two and a half years, I always had chemistry courses but I got only *B*'s, solid *B*'s in all the courses. When I was a junior I took physics and could get *A*'s without trying and found it much more interesting and I found I was falling behind in chemistry and realized there was no future in that for me if I had to think about studying, whereas in physics I liked to study.

(*Do you know what the things were about chemistry that you didn't like?*) Chemistry was sort of like cooking, you spent all your time mixing up solutions in bottles and making dirty messes all over the table top, whereas in physics you work with nice clean apparatus and get nice clean results. It just fits in with my nature, that's all, there is no other way to explain it. Chemistry is a dirty business, I didn't like it and the finer points of the theory left me cold. In physics I dug into the literature, and spent a lot of my time reading the original articles; in chemistry I just read the textbooks.

In my junior year I decided to be a physicist. It was a combination of the fact that I was obviously not a first rate man in chemistry and physics became so much fun so the two things were coming together.

As an undergraduate I built some apparatus for one of the professors and got to know the head of the department personally, it's always a good thing for a student to get to know a man of his status. I did a problem I thought up for myself for an M.A. No one paid much attention to the students there, you floundered around or you did your work yourself. I think it was the best thing that happened to me, it was much better than being spoon fed like a lot of graduate students are now. I had spent a fair amount of time learning things not required in the courses. I never learned the stuff that was in the lectures because I was always off doing experiments in the basement. To get a Ph.D. you didn't have to attend courses, you had to pass a long oral examination and that was a good thing because I had to learn the stuff myself to pass it.

I'm not very good at languages. I was reasonably good at mathematics, and made Phi Beta Kappa by the skin of my teeth, if any grade had been one point lower I wouldn't have made it. I got my letter in athletics and I was in some dramatics. I didn't really study very hard

the first two years, just had a good time. I played bridge and baseball and things like that. I can't remember doing anything serious the first two years.

Geometry in high school was completely effortless. I could look at the proof and know it at once. It's been interesting to notice as I went further along in college mathematics and classes got smaller, I dropped behind and as a senior I got my first *B*. It was very funny, you could just see this. (That as more and more people who had been like him at the top of their class began to come in, he didn't maintain his lead, but dropped down.) Right now I feel I'm not a very good mathematician, I feel that my mathematics is a weak point. Mathematical minds are very special things. I got good grades in high school, I was second or third in my class including everything.

I took piano lessons for five years and didn't learn a thing (under pressure? Yes). And then when I was a graduate student I became interested in playing again. (*What?*) Almost entirely Chopin. I don't play well enough for anyone to hear me. I occasionally play four-hand with my wife and when I was a graduate student used to play a lot until the rest of the people where we lived presented me with a petition.

I think I've done things in more fields than a lot of physicists have. One thing that characterizes my work is that it isn't a narrow field. I've done what you might call pioneer work in a number of fields and as soon as it's been developed I've gone off into something else. That suits my temperament better than cleaning up odds and ends.

I think one thing worth while knowing in a study like this: I've consciously spent a lot of time thinking about problems. My father advised me to when I was young. He said he had often thought that he would have gotten much farther if he had just stopped working at problems and sat and thought about them a while, about which ones to pick and so on. He said, "You ought to consciously spend time sitting down, just sit down in an easy chair and let your mind wander," so I do consciously and often sit down and see what comes in mind.

I think my creative thinking probably started when I was in my first year of graduate school or thereabouts. I used to write down ideas in a notebook, most weren't any good or had been done by someone else but at least it shows I was thinking up ideas of experiments and ways of looking at things.

2. *Summary*

The general difference in family background between the experimentalists and theorists is quite noticeable. There are fewer professional men among the fathers of the experimentalists, and while in the case of three of them it was taken for granted that the children would go to college, for the others it was a matter of special planning, often on the part of the parents, and sometimes quite contrary to the usual social custom of the group.

Although these subjects, too, liked school, there is less spontaneous mention of it and only two said that they did a good deal of reading. It seems probable that the others did do some reading, particularly of such things as popular science journals but with none was it so important a factor as it quite usually was with the group of theorists.

There is rather less early interest in and experience with gadgets, or with Meccano sets, or radio, and so on in this group than in the other. This may be because of the number brought up on farms and in small towns where such things are not so common. Only four of them, Nos. 6, 8, 9, and 10 mention a good deal of work of this sort, and with these it has been a considerable preoccupation.

Most of them had some early interest in mathematics or science, which was usually stimulated further by high school courses, but the interests of this group were much more definitely mechanical and engineering than those of most of the theorists. Two of them originally planned to be physicians, several originally took work in engineering. This was in each instance because these were conceived of as the only ways in which to study science, the possibilities of careers in research or in physics or chemistry or mathematics not being understood by them. Again the interest had usually crystallized by the second or third year of college, although with several the final choice was not made until graduate school.

With most, also, the idea of research came rather gradually, and without any particular incident to clarify it.

Not one of this group made any spontaneous mention of poor health as a child. One was nearsighted which interfered with his playing ball; one said he had always felt inferior physically but didn't know why. Later one remembered, when asked about it, that at four or five he had been thought to have had heart trouble and been kept in bed, but there seem to have been no later difficulties; and one had lost most of his first year in school because of measles and other childhood diseases. One other spoke of being weak, large for his age, and not athletic.

Like the theorists, there is striking evidence of intense concentration upon the vocation from a relatively early age in these men, and even more of them than in the other group had to get an education the hard way. Again it is striking that the pressure comes from within. Since I do not have comparable data on the least successful scientists I cannot say that this devotion to work is not characteristic of them also, but I think it unlikely. Certainly in the case of the men who are less obviously endowed with high intellectual capacity, this constant preoccupation with professional problems must have been a highly important factor.

IV. PROFESSIONAL HISTORY

This group has changed from one institution to another somewhat less than the biologists but it should be remembered that they are younger on the whole. The number of institutions at which each man has worked since receiving his doctorate, not including fellowships, brief lectureships, etc., is shown in Table 5. If he left one institution and later returned to it, it is recorded twice.

TABLE 5
NUMBER OF INSTITUTIONS WITH WHICH SUBJECT HAS BEEN CONNECTED SINCE DOCTORATE

No. of institutions	No. subjects
4	5
3	2
2	7
1	8
Mean	2.18

A few of the men had quite a bad time during the depression, and several who were at no time out of a job felt extremely insecure during this period, because of the fact that departments were being cut down. In general, however, this was not the case, and the younger men, who got into the field just before its sudden rapid expansion have no acquaintance with this situation.

Most of them have been able to carry on research without any serious difficulties. Of course, before the war, they were frequently not as well financed as they are now, so that equipment was short, but in general they were in situations where research was a normal part of the work. This was not true of one of them, whose academic history for some years was one of the most intense frustration of his research interests; even he, however, is now well situated.

So far as I can tell, individual research interests have generally shifted comparatively little in this group, except as the field itself has changed. One of them remarked: "This lack of shift in interests may be correlated with the manner in which the science has been developing. Perhaps because it has been developing so rapidly people stayed on the things they started out with." Most of the men had settled into a general field by the finish of their doctorate work, and few have left it, but this is not invariably true. One says: "My research has changed too much for my own good. I get bored sticking with one line for very long. I think that I jump around more than I should but I find that in about five years I get

sick of it. . . . When the cream is skum I'm not terribly interested." Several others also remarked that once they had started a new line and others had moved in they lost interest and wanted to go on to something new, but this of course does not always involve a change of field. Only a few of them have had several main lines of research. One of the theorists became a theorist after considerable experimental work, and two of them have done experimental work but spend most of their time on theory.

All of them were involved in various war projects and with most of them this meant considerable interruption of their own work, sometimes for a period of years. Most still have some governmental connections in the way of consulting jobs, but the majority have gotten rid of as many of these as they can. Two have completely changed their research interests, largely as a result of their war experiences:

"I had had enough of my ideas classified. . . . I don't want any more of my ideas in the clutches of these arbitrary men who run war projects."

"I wanted to do problems which had no conceivable practical importance but were only dedicated to philosophical interests."

V. PSYCHOSOCIAL DEVELOPMENT

In very general terms, the psychosocial development of most of this group was slow and in its major outlines often much like that of the majority of the biologists. And for the most part, they are not now very interested or at ease in social activities. In tracing the development of patterns of interpersonal relations, it was sometimes possible to get some direct information about parent-child relationships, and in some cases to make inferences from the test material.

Very few of them speak of or give any indication of closeness to their fathers as children, but there are none among the physical scientists who did not respect their fathers even though they may have rebelled against them. (One with a stepfather seems to have identified strongly with his own father in some respects and with his mother's family, but clearly had little regard for his stepfather with whom he was in frequent conflict, although he admitted that no distinction was made between him and his step sibs.) Of those who seem not to have been close, it nevertheless appears in three instances that the father took a very real interest in the son.

In six instances, it is clear that there were covert or open rebellions on the part of the sons, there being occasional sharp conflicts although these are relatively rare. The more usual pattern is that of concealed rebelliousness, where it seems to occur at all. One said his father was an independent thinker, and he himself had been a rebel from the age of ten, perhaps because of his father's urging him to think for himself, and disagreed violently with his father's views. Nevertheless it is clear that he was allowed considerable freedom and apparently his disagreement did not result in disciplinary action. Another spoke of his father as being a great inspiration to him, but that the father made a point of not interfering. As a result he did not ask his help and advice, and went through a period of what seems to have been an unsuccessful attempt at getting away from fairly close identification with his father. In another instance, there was severe, concealed rebelliousness on the part of the subject, who, knowing his parents dearly wanted him to go to college, concealed his intention of doing so until after he had enrolled, "perhaps because I was still being a man." In this instance, the test material shows continued suppressed rebelliousness. Another received, he felt, some preference in the matter of fellowships because of his father's connections and definitely resented this,—but accepted it. Another has concealed his present family life from his parents because of religious differences. Still another reports having had severe, open conflicts

with his father during adolescence, but some understanding was later achieved.

On the other side of the picture is one of the experimentalists who was especially privileged by both parents from the start, and excused from much of the work expected of his older sibs. Another spoke of having been quite close to his father in understanding. Two others speak of great admiration for their fathers, apparently receiving from them, if not great warmth, considerable attention and trust. One of these who had put it that he worshipped his father until his death (when the subject was 15) clearly identified with him closely in many ways. There is one other who spoke very warmly of the close family life; they were very poor but felt other children were underprivileged, because they didn't have the same sort of parents. Nevertheless, the test results do not give any similar picture.

There is less information about the relationship to the mother. In general there seems to have been somewhat more warmth, for most of them, and more closeness, at least during the early years. A number rather grew away. Only one subject spoke in such a manner as to indicate very great warmth and approval. Two, however, said there were considerable clashes, one remarking he always disagreed with his mother and always had, although not too unpleasantly. (This had appeared so clearly in the *TAT* that he was asked specifically about it.) Another said, "Mother is a fuss budget.... I've been taught wrong by a lot of women." Another said, "Mother and I used to have awful fights over anything and then she would go around shouting about what a model son I was which made others mad because they knew I wasn't. She was very emotional about things, she was a sketch."

In summary, very great closeness or serious disagreement is not very common with respect to either parent, during childhood, and there is little evidence of any present problems here. The general attitude of respect for the father, even among those who went through a rebellious period, should be emphasized.

Like the biologists, most of this group did very little dating until well along in college or even graduate school, and speak of having been very shy and ill at ease. A few thought this was largely a result of financial problems, and it is true that some of them had so little money they could hardly have done much dating, and that in these instances the poverty had been present from the start and certainly could have been an inhibiting factor. But there are others with the same sort of late interest or late freedom to express interest who had no serious financial difficulties. I think there may have been two or three who did not follow this course. One suddenly

became interested in girls half way through college, and then had intermittent periods of much dating, alternating with periods of concentrating on his studies. Only one could say, "I've been going with girls ever since I was six. I always had one. Of course I had several serious ones in college. When I got to the university I didn't do any studying for a long time, I just raised hell, chased around, went down to the dance hall and investigated what kind of prohibition booze one could get." At least three of them have serious sexual problems at the present time, on the basis of test evidence and general observation, but all of them seem, as one of the others put it, to have learned to adjust. The fact that only one of the group has been divorced is probably significant here.

The more general social development was also very slow, and with many of them there is still very little interest in other persons generally. In the case of many of the theorists, particularly, this was in part associated with the physical disabilities of various sorts which have already been discussed. Under these circumstances many of them had considerable isolation as children. On the other hand, certain of these difficulties were clearly psychosomatic. Whatever the cause, the incidence of feeling alone, or outside is very high, but the feeling of apartness is not always accompanied by feelings of inferiority, e.g., one remarked, "I soon became clear where what was known ended and where I would have to take on." Among the theorists, these situations obtained:

"I have always felt like a minority member."

"I developed the sort of personality that used to be called introspective. . . . I got along with other children except for the fact of not being pushing and tending to be somewhat shy and self-conscious and not having as good a time as other children would . . ." (in college). "I slipped back to lonely isolation." This was later much relieved.

"My mother was quite worried about my staying indoors and reading so much and my lack of social contacts, but more worried about my health. . . ."

"I carried on what seemed like a perpetual flight from two or three overgrown louts who like to catch us and twist our wrists."

"I was very much an isolated person."

Among the experimentalists, there are fewer with such obvious difficulties, and some of them seem to have gotten along very well generally. But some had problems:

"I always felt inferior physically but I could run. . . ."

"I was always a couple of years younger, I was never one of the group."

"I was always lonesome, the other children didn't like me, I didn't have

friends, I was always out of the group. Neither the boys nor the girls liked me, I don't know why but it was always that way. I can see the remnants now. . . ."

There was somewhat more tendency among the experimentalists to have one or two friends interested in the same things, and with whom they shared quite a little, although general social adaptation might not have been very broad. Also several of them spoke of relatively brief periods of difficulty, due usually to particular circumstances, which did not persist. Nevertheless, it is clear that both groups were slow developing socially. It is also clear that many of them are still somewhat non-participant socially although most have worked out acceptable techniques.

VI. RELIGION

The present religious attitudes of this group are of considerable interest, particularly in view of the current campaign of a well-known newspaper publisher whose Sunday supplement carries quotations from well-known scientists. (His carefully undescribed sampling procedure is such as to make it inevitable that all the scientists he quotes are fairly orthodox, or at least favorably disposed towards the established churches.) Such information as I have refers to religious attitudes as manifested in attendance at or interest in established churches. (Two of the men come from Jewish, the others from Protestant families.) Of religious sentiments, mention was made by very few and my impression is that probably only one of the group has more than a very vague feeling of the sort, and I doubt that his is very developed. I do not have the information for two of the subjects. I usually inquired about present recreational and social interests, and had church affiliations had any significance they would pretty surely have been mentioned.

Two of the men had no early religious training to speak of and have no religious interests now. Apparently such problems just do not exist for them.

The other 18 for whom there is positive information had varying amounts of religious experience. Of these, 13 are now indifferent. Some who are personally indifferent, are, however, uncertain of what to do about the training of their children.

> I've had no church activities since I have been an adult.
>
> I don't go to church even occasionally.
>
> We were Episcopalian. Like most people in science I abandoned that many years ago.
>
> I went to church when I was a boy every Sunday and a couple of times a week. But I think I did enough of that. My kids go if they want to, it's a very occasional business with the family all the way around. (*Do you have any strong convictions?*) No.
>
> My life was too easy. There weren't any crises. Some people seem to have crises over religion and things but I never did. Mother was and still is a Presbyterian I guess; father was originally a Methodist but is now a Presbyterian. It's not a very churchly family. I went to Sunday school as a kid. Sometimes children have a great emotional crisis, I never took it seriously. I drifted away. I suppose I should go now, our kids will grow up. I think it's right they should have some religion but I haven't done anything about it.
>
> No, I never go to church. I'm afraid I don't believe in it in the first place and there doesn't need to be any second place. I was ex-

posed to it very mildly and tentatively at an early age and didn't like it and my parents never insisted, so—.

I have no church interests now. I went to church as a youngster, I never joined a church, it has no interest for me. I've never seen my father in a church and the only time I've ever seen my mother in one was when I was married. When I was a child a neighbor lady got upset about us and got us started going, and I was a model scholar and got prizes. There is one thing that I don't understand in this attitude of mind. As near as I can make out the religious is the same attitude as in lots of political groups, Nazis and so on and lots of scientists go in for advanced political groups but don't get taken in by religion. I can see some purpose for the church, our culture is based on the importance of a moral idea, and the churches have been the place to pass this on. I don't know what we'll do about the children.

I'd been taken to church regularly and had a very considerable emotional reaction to it, the singing particularly, but I was never very well satisfied. I'm sure that was partly the result of the absence of any attitude on father's part or very much on mother's part in religious matters. They went to support the minister and to show a little interest for his sake. It was a Unitarian church. The aesthetic elements were strong and that's the principal value for me. . . . I gradually developed a very mechanistic view of life and of people. . . . I often thought I would have been a fine preacher if I had had some faith.

As a boy I went to the Baptist church. I sort of quit about the time I went to college. I think it was rather accidental. My parents were devout but they don't practice formally, they don't attend church regularly and see through the hypocrisy of so many who go. Mother was more disturbed when the kids got religion than when they lost it. One of my children was christened because the grandmother insisted on it and the preacher was so nice. I have a lot of reverence for something.

Father took care of all our religious teaching and was quite active in the church. He gave us all a very intense religious training which unfortunately hasn't done much good. I threw things overboard. There was no conflict or planning about it. I had no disturbance over it personally but I have kept it from my parents.

I was exposed to religion constantly. In high school I went through misery with the revival meetings and conviction of sin. There was a backsliding at the age of nine to worry about. The religious practices of the region were orgiastic. A severe emotional crisis at conversion was essential to salvation. I was in a worse state than some. I backslid several times and then there was the necessity for public confession. I managed to get through with considerable doubt as to what my position was. I was never besieged by overwhelming doubts about God but I just gradually picked up the idea. My freshman year at college I took a course in evolution of morals and in social psychology and I've always had a peculiar tolerance about the things you are sup-

posed to be frightened of. I had the interesting thought early in the class that this was that awful higher criticism some visiting minister would fulminate about. Just the constant preoccupation with a set of reality that clicked and which just didn't have anything to do with those superstitions seems to have done the job. My more religious colleagues seem to have water tight compartments. I'd as soon call myself a materialist but not an atheist. I've not become violently anti-religious. I think that kind of religion served a purpose on the frontier, one had to be a drunken wretch or one had to be one of the godly. I am pretty completely agnostic as to what is behind the scene of things. I'm willing to take my chances on its being a fundamentalist or Catholic god. If such a being should turn out to be in charge I think the only self-respecting thing is to be damned but I suppose I have a vague humanisic attitude towards the situation.

I am nominally an Episcopalian but haven't particular convictions. Except that people who say there is nothing in it have no more evidence than those that say there is. I haven't found religion much comfort. In the face of a great loss you just have to take it there is nothing to do, but religion isn't a comfort. I don't attend church but I sent the children, partly for social reasons and partly because I felt it was a part of life that they should experience.

I suppose I'm a very religious man. (But he does not go to church.) I found the church far too arrogant. The Protestant attitude is to make poetic statements and then to interpret them as literal statements of actual fact. I went through a phase of rebellion, but I have reached a surprising point of complacency and even affection in dealing with the religious people. I know they are dealing with poetry but they don't know it. This is recent. I went through a revulsion for 20 years of my life. In my early twenties. I avoided it for about five years. I had one earlier experience where I gave up. I decided I must have committed the unforgivable sin. I was a little disturbed then for two weeks. From 20 to 40 I was pretty much against the church, an allergic reaction I now feel more comfortable about. Arrogance is the thing that bothers me most. I have always felt even during the years of revulsion that my whole life is a worship in my way.

The other five (four of them experimentalists) have maintained some church connections for various reasons, but as the quotations show, none of them is personally of very strong convictions.

"My family were Baptists and it was just accepted that you would go to church. Both my parents were quite tolerant. I was a rebel since I was 10 or 11, but I've no idea where I got those ideas. Perhaps because father was an independent thinker and from my earliest childhood on, whatever he said he would say there are many things you learn in life and there are many things you have to think out for yourself. It might have been it came out in that way although I'm sure we disagreed

violently on our views." In the second interview, when I asked about his other activities, he said, "We are rather active in the Baptist church here." I asked how this had followed his earlier rebellion, and he explained, "My feeling is that what I think internally doesn't matter to anyone else. Some of my closest friends have been ministers even though they knew we disagree. I have no sympathy at all for some of the ideas. I don't advertise what I think on some things. I have found as a practical expedient that the friends I pick up there are more interesting to me than others. Jealousies creep out in the university. Outside of the church so many friendships are based on how people can use you. This is a fairly exceptional church. It grew out of several churches who didn't subscribe too literally."

I'm not very much of a church goer. I'm a great believer in church but don't get around to it. I always went as a boy. Mother was a very good church woman. I'm not attached to any church but I go occasionally. I usually go where my wife wants to go. I had no sort of religious crisis, if anything science strengthened me on that. It was so clear that one doesn't understand things. There is this business of checking back on nature and finding you were wrong in your ideas. I've had so many clear cut ideas and set up the apparatus and it came out a different way, it makes you pretty humble when you think about it.

I occasionally go to the Presbyterian church. I go largely because of my wife although I have attended it most of my life. We like to have our children go there. I would say I'm not particularly interested in the religious aspects. If I go it's in hopes that the minister will have something to say. (I asked him if he is a theist and his reply was that he did not wish to be pushed about it.)

I drifted from orthodoxy on such matters as evolution. I wouldn't like to give the impression that the church influence was not important I don't think there is any substitute for these things of character. Our children were confirmed in the church but they do not go. I still belong. It's a strict regime that they are taught to follow. I've not severed my connection and they haven't excommunicated me.

I go to chapel once a month. I come from a churchgoing family. I just get a little lazy but when there is a good speaker I go. I definitely go more than the average.

VII. RECREATION

In respect to activities outside of their work they are a varied group. I do not have the information for three of them. They range all the way from one who says, "I have none, my work is my life," and means this quite literally (although he spends as much time as he can with his children whom he adores, and he reads *Time*), to one who not only reads a good bit of non-science as well as of other fields of science, but likes camping and skiing, plays some bridge, goes to occasional concerts and is extremely fond of parties and social gatherings,—so much so that sometimes they are out or have people in seven nights a week.

There are three others who like parties and have fairly active social lives and two more whose liking for social living is more limited, but who enjoy small gatherings, dinners with another couple or two rather than parties. The others seem to have very little social life. They are like the biologists, none of whom cared for parties. It is the more interesting because from the Rorschachs of most of this group who go in for parties I would not have expected this activity. All but one of this group had been or were then at a particular university where one or two unusually socially inclined professors had started what is almost a tradition of partying among the physicists which is still maintained.

Only two of them play cards regularly with pleasure; a few others play because it is the custom with their particular groups, but the rest do not care for them.

Five of them are interested in some form of sports,—skiing, camping, swimming, climbing, tennis, fishing, and sailing were mentioned, but such activities are curtailed somewhat because of lack of time.

Nine of them say that they read a great deal. The subjects may vary, but a number mentioned biography and travel, three mentioned detective stories, two included specifically Astounding Science fiction, a few read other fiction, and a few read science in other fields. A number of them said that they read chiefly magazines. Three of them do practically no reading outside of their professional work, and the rest read a little now and then but it is not a major activity with them.

I usually asked specifically about music, because one hears so often of an association between musical talent and mathematical interests. Six had had music lessons as children, two on the clarinet, and others on the piano. The pianists all play some still, the other two do not. One said he hadn't learned anything with five years of lessons on the piano when he was a

child, but had resumed playing in graduate school and had then learned much more. One of the clarinetists said he had played a good deal until he was in college but then gave it up because he got a sore throat every time he played. One other has picked up the piano himself; another now spends most of his spare time studying it. Most of these have also an interest in listening to music and spend some time with radio or phonograph programs. Of the others, four are mildly interested and five have a considerable interest and spend quite a little time listening to radio programs or have amassed large record libraries. Interest in music is clearly stronger in this group than it was in the biologists.

Only two of the men mentioned a particular interest in art.

One of them had in the past been active politically; one is active now. Another has done a good deal of speaking on international problems. None of the others has ever been very interested, although I gather that most of them do vote.

Four of them mentioned a special interest in travel.

A few of them go to the movies occasionally, but often it is to take their children unless there is some very special program. Most of them find movies dull.

Few of them are really active in professional organizations.

Two of them mentioned that they occasionally studied another language for amusement; one has a special interest in dictionaries and encyclopedias, and one does some photography. Two of them do a little gardening.

Two of them said that they spent all of their spare time writing. One says his only recreation is loafing. Another says: "Actually my greatest enjoyment of life comes from being alone. Very frequently at home I prefer to be in a room by myself. It's kind of a dream state. There seems to be an enjoyment in it."

Several of them mentioned spending time with their families and children. This was less marked than with the biologists, but I think it may be because their children are younger on the whole and problems seem somewhat less acute.

There are no noticeable differences between these theorists and experimentalists in their recreational interests.

VIII. THE VERBAL-SPATIAL TEST

This test comprises the first two sections of the Verbal-Spatial-Mathematical Test which was compiled for the biologists by the College Educational Testing Service. The mathematical section is not difficult enough for this group and it was shortly dropped. The verbal section comprises 79 items, the task being the selection of antonyms. Time limit was 15 minutes. The spatial section comprises 24 items. Each item consists of four views of solid figures, the problem being to select the two views of the same figure. The time limit was 20 minutes. Examples of both are given in Figure 1.

Verbal: Decide which two words in each group are most nearly opposite, and underline them.

1. Predictable 2. Precarious 3. Stable 4. Laborious

Spatial: Each set of four drawings contains two views, and only two views, of one solid figure, taken from different angles. The other two drawings represent solid figures which differ in some particular from the one solid of which two views are shown. You are to identify the two drawings of the same solid figure and underline them.

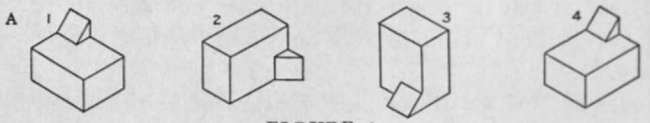

FIGURE 1

Several expressed considerable difficulty while taking the test, and great dislike for the task. This more often happened with the spatial test. A number completed the task in considerably less than the allotted time; most of them used the rest of it to check but a few did not. One gave up altogether after 10 minutes.

The test results are given in Table 6. The experimental and theoretical groups are listed separately. It is evident that the experimentalists had considerably more difficulty with the verbal test than the theorists did: the difference between the means is significant at the 5 per cent level. Although the experimentalists are also lower on the spatial test in terms of number right, this difference is not significant.

TABLE 6
VERBAL-SPATIAL TEST

Theoretical Physicists	Sigma Score*		Experimental Physicists	Sigma Score	
Subject	*V*	*S*	Subject	*V*	*S*
TP1	+.16	—1.63	EP3**	—2.90	—2.04
TP3	+.86	—.20	EP4	+.81	+.20
TP4	+1.04	+.82	EP6	—2.08	—1.63
TP5	+.57	+1.22	EP7	—.49	+1.84
TP6	+.92	—.20	EP8	+.28	+.41
TP7	—.08	—.20	EP9	+.22	0
TP8	+.45	—.20	EPC3	+.25	—.61
TP9	—.19	+1.02			
TPC1	+.63	0			
TPC2	+.39	+.82			
TPC4	—.31	+.41			
Mean Score	64.2±2.4	13.8±1.2	Mean Score	46.6±8.8	11.7±2.4

*Computed on the distribution for all the physicists.
**This test is probably representative but not valid.

Comparisons with the group of biologists previously reported are given in Table 7.

Means for the two groups on the verbal test are almost the same. On the spatial, however, the mean for the physicists is significantly higher ($p = .02$).

TABLE 7

COMPARISON WITH BIOLOGISTS ON VERBAL-SPATIAL TEST

	Biologists	Physicists
Verbal:		
N right, range	28-73	8-75
mean	56.6±2.8	57.3±4.1
Spatial:		
N right, range	3-20	3-22
mean	9.4±1.0	13.0±1.2

In both groups the ranges are extremely wide, and the lower limit unexpectedly low. Intelligence is unquestionably a factor in the eminence of these men, but clearly it is not the only one, nor does an extraordinarily high level (of the kind of intelligence measured by these tests) seem to be a *sine qua non*.

The groups are too small for much discussion of this point, but because of its theoretical interest correlations were run between the tests. For the theoretical physicists r is +.091; for the experimentalists, r is +.72 (for both .55). For the biologists it was +.445. The narrower range on the verbal test of the theoretical physicists must be noted.

I usually inquired as to how they had done the spatial test, and almost invariably the response indicated an attempt to shift the pictured figures in imagination and then to compare them with the others. A typical statement was: "My procedure was to actually carry out in my mind, keeping one figure fixed, the operation of rotation and reflexion. I can do that, but then the comparison of the two figures is sometimes baffling. I didn't check when I got an approximate figure."

Another remarked that when he had difficulty with the rotation he sometimes had recourse to verbalization. Another said, "In some cases I tried to stand on my head. In some cases I was visually following these things" (particular bits); "in some I turned them around in my mind. In several you could rule one of them out quickly and that was a help."

One of them, however, reported very differently, "I just moved myself around. Look at this one. I just walked down here and the narrow part was on my left. Then I came over here and this is on the left, so . . ." (he demonstrated on one example. Apparently he had a kinaesthetic image of walking around the structure, which was larger than he).

I made some inquiries as to techniques of handling size, in view of the fact that many of these subjects shift from dealing with atoms to dealing with galaxies. The data are not altogether satisfactory, and will be reported elsewhere. They are mentioned here with the comment that it may be a significant point to investigate.

IX. THE THEMATIC APPERCEPTION TEST

The Thematic Apperception Test, devised by Murray and his associates (4), is a technique for personality analysis. It consists of a set of pictures, the task of the subject being to tell a story about each picture, which includes the events leading up to the picture, what is going on, including what the characters are thinking and feeling, and what is going to happen in the future. Only nine of the usual 20 cards in the series were used for this research. They are Cards 1, 2, 4, 6, 7, 10, 13, 15, and 11, from the male series of 1943, presented in that order.

Card 1 shows a boy, seated, looking at a violin on a table in front of him.

Card 2 is a farm scene, with a man plowing in the background, a woman leaning against a tree, and a young girl carrying books in the foreground.

Card 4 shows a young man and woman, the woman facing the man, with her hands on his arms and the man looking away from her. There is a picture behind them, showing a partially dressed woman.

Card 6 shows an elderly woman looking out of a window, a young man, hat in hand, looking away from her.

Card 7 is a close-up of an older and younger man, the boy looking away.

Card 10 is a close-up of two heads, incomplete, the forehead of one against the chin of the other, and one hand as though on the other's chest. They are usually interpreted as a man and woman.

Card 13 shows a girl lying on her back on a narrow cot, her breasts exposed, a man standing turned away from her with his arm over his face.

Card 15 is a stylized picture of a man standing in a graveyard with his hands together, pointing down in front of him.

Card 11 is a vaguely delineated scene, apparently in a deep canyon, with some indefinite figures at the edge of a bridge, and a web-footed long-necked creature emerging from a hole in the canyon wall. None of the details is very clear.

A. Analysis of the Protocols

Interpretation of the *TAT* protocols (the responses to the cards) has not been codified. Clinically it is particularly of value in giving hints as to the genesis of any difficulties that may be present, which the Rorschach does not do. It is also useful for getting at attitudes toward family, etc., which may be of significance.

The stories were scored formally, following Wyatt (14) with some

emendations, and the data[3] are given in Tables 8 through 12. In all of the tables, the entries in the columns are the numbers designating particular pictures. Numbers are placed in parentheses when the column heading applies to part of the story but not to all of it. Three subjects declined to give stories to one or two of the cards.

In Table 8, the first aspect considered is the relative amounts of narration (*S*) and description (*D*) which are given in the stories. The task is set as narration. Some subjects, however, give a good deal of description, either accompanying a narrative or by itself. The latter, if general throughout, is usually a form of non-compliance, often on a subconscious basis. Subjects who have difficulty thinking of a story to a particular card will also often resort to description as a way out instead of refusing the card. Responses limited to description (*D*) or dominantly description but with some story (*DS*) are not common except in the protocol of *EP* 8, who had great difficulty with both this and the Rorschach tests. It occurs most often with the others in response to Card 11, which is the vaguest of the cards.

The first column under perception refers to the amount of notice of particular details in the picture, which is only common with *TP* 3 and *TPC* 1. Perceptual distortions were so rare in this group that they have not been tabled.

The column headed Deviation refers to unusual stories or (listed in parentheses) stories with unusual twists to them. It is clear that Card 15 provokes more unusual stories from this group than any other card, and that Cards 10 and 13 are next. These stories often relate to the aftermath of aggression. (It was interesting in administering the test to find that a number of this group recognized this picture.)

Time trend is given in the last section of Table 8. It can be seen that about a third of all the stories are limited to the present, but that nearly a third include all dimensions of time. It seems to be a little easier for this group to project a story into the future than to infer the past.

Outcome for the stories which have a future is recorded in Table 9. It often happens, as in Card 4, that success for one character means defeat for another, and in this case the card will be entered under both headings. It is noteworthy that the incidence of endings involving defeat for one character or another is much higher among the experimentalists than among the theorists and that the theorists are considerably more certain in their statements. Other entries in this table are self-explanatory.

[3] In addition, Miss Betty Aron scored all of the protocols using her own new technique. Her analysis has contributed to the general discussion here.

TABLE 8

TAT SUMMARY: PHYSICISTS

	Story					Perception		Time Trend			
Subject	Refused	*S*	*SD*	*DS*	*D*	Detail description	Deviation	Past, Present Future	Past, Present	Present, Future	Present Only
TP 1	2	6, 15, 11	1, 4, 7, 10	13				4, 6		7, 13, 11	1, 10, 15
TP 3		all				1,2,4,6,7,11	(1) (4) 7, 10, 13, 15, 11	1, 2, 4, 7	6, 10, 13, 15, 11		
TP 4		1, 4, 6, 10, 13, 15	2, 7, 11				7 (10) 11		1	2	4, 6, 7, 10, 13, 15, 11
TP 5		1, 2, 6, 7, 13, 11	15			15		1, 10, 13, 11	6	4, 7	2, 15
TP 6		1, 4b, 6a, b, 7, 10, 15	4a, 13	2, 11			4a (6b) (7)	1,6a	10, 13, 11	2, 4a, 6b	4b, 7, 15
TP 7		1, 2, 4, 6, 7, 10, 13, 15			11		15	10		1, 2, 4, 6, 7	13, 15
TP 8		all					(4) 6, 7, (10), 13, 15, (11)	4, 13, 15, 11	6	1, 2, 7	10
TP 9		all					(1), 15, 11	2, 6	4, 15	1, 7, 10	13, 11
TPC 1		1, 2, 4, 6, 7 10, 13, 15			11	all	(1) (7) (10) 15	2, 4, 6, 7, 15	10, 13		1, 11
TPC 2		1, 11	2, 4, 6, 7, 13, 15	10		10	(15)	1, 6, 7, 15, 11	10, 13		2, 4
TPC 4		1, 2, 6, 7, 10, 13, 15	4, 11				(13) (15)	2, 13		4, 6, 10	1, 7, 15, 11
EP 2	4	all					1, 2, 10 (13) 15	1, 6, 7	2, 13		10, 15, 11
EP 3		1, 2, 13, 15	4, 6, 7	10, 11			(1) (4) 15	1		2, 4, 6, 7, 13	10, 15, 11
EP 4		2, 4, 6, 10, 13, 15	1, 7, 11			11	(7) (15)	6	10, 13	2, 4	1, 7, 15, 11
EP 6		all					(1) (2) 10 (11)	11	1, 15		2, 4, 6, 7, 10, 13
EP 7		1, 2, 4, 6, 7, 10, 13, 15	11			2	(1) (2) 10, 13, 11	2, 6, 10, 13	1, 15, 7	4, 11	
EP 8	2, 15	1,6		4, 11	2,7,10,13	2			1	6	4, 7, 10, 13, 11
EP 9		1, 4, 6, 7, 10 13, 11				1, 2, 4	(2) (4) (6) (13) (11)	2, 7, 13, 11	1	4	10, 15
EPC 3		1, 2, 6, 10, 15	4, 7	13, 11		(4) 7 (13)		1	13	2, 4, 6	7, 10, 15, 11

TABLE 9

TAT SUMMARY: PHYSICISTS

Subject	Outcome: None possible	Outcome: Success	Outcome: Defeat	Outcome: Unresolved Tension	Certainty of Outcome: By rule	Certainty of Outcome: None given or ?	Certainty of Outcome: Certain	Certainty of Outcome: Probable	Certainty of Outcome: Possible	Overt: Personal Reference	Personal Opinion
TP 1	10, 15	4? 7?	6			1, 13, 11	4	6, 7		1, 4, 6	
TP 3		1, 2	2, 4, 10? 11?	13		7, 15	1, 2, 4, 11			1, 6	13
TP 4		2				1, 4, 6, 7, 10, 13, 15, 11		2		1, 4, 6, 7, 13	
TP 5		4? 10?	4? 7?	2, 6, 15, 11		1, 13		4, 7, 10			
TP 6	11	2, 4a	1, 15	10	6a, 6b	4b, 7, 13	1, 4a, 6a, 6b, 15	2		1, 4a	15
TP 7		1? 2, 6, 7?	4	10, 15		13	2, 6, 7	1, 4			
TP 8		1, 2, 4, 7	6, 15, 11	13		7, 10	4, 6, 13, 15, 11	2	1		
TP 9		1, 2, 4, 7	6, 15		10	13, 11	2, 6, 10, 15	1, 4, 7			
TPC 1		2, 4, 7	1, 2, 4, 6, 7, 10, 15	13		11	1, 2, 4, 6, 7, 10 15				
TPC 2		4, 6	1?	7, 10, 15		2, 13, 11		1, 4, 6			
TPC 4		2, 4, 6	4, 10, 13	1, 15		7, 11	2, 4, 6, 10	7, 13			15
EP 2	2, 15	1, 7	6, 13	10	11		6, 7, 10, 13, 11	1		(1), 2, 4	
EP 3		1, 2, 4? 7			10, 13	6, 11	13	1, 2, 7, 10?	4	15?	1, 2
EP 4		2, 6	4?	15, 11		1, 7, 10, 13	2, 6	4			
EP 6		11		2, 4, 6, 7, 13		1, 10, 15	11				
EP 7		2, 4, 6, 7, 10	4	1		13, 15, 11	2, 10	4, 6, 7		15, 11	
EP 8		1		6, 7, 10, 13, 11		4		1		2	
EP 9		2, 4, 6, 13	7?		11	1, 10, 15	2, 4, 6, 13	7		(10) 15	1
EPC 3	15	1, 2, 4, 6		13	1	7, 10	2, 6	1, 4		1, 7, 15	2

TABLE 10

TAT SUMMARY: PHYSICISTS

Subject	Level: Concrete-factual	Level: Endopsychic	Level: Symbolic	Level: Mythical	Level: Make-Believe	Level: Conditional	Tone: Indifferent	Tone: Detached	Tone: Contemplative	Tone: Cheerful	Tone: Serene	Tone: Melodramatic	Tone: Unhappy	Tone: Tense	Tone: Anxious	Tone: Morbid	Tone: Aggressive	Tone: Sardonic
TP 1	4, 6, 7	1, 13	15			(1) 10, 11	1, 7, 10, 13, 15		6?	11					4			
TP 3	1, 4 (6)	2, 6, 7, 10			13, 15, 11								1		11	4, 7	15	1, 2, 10, 13
TP 4	1, 11	4, 6, 7, 10, 13, 15	2			(1) (6) (13)	1, 7				10			15	4, 6, 13, 11			
TP 5	6, 7, 10, 13, 11	1, 2 (6), 15			4, 15					10		4, 13	1	2	6, 15, 11			7
TP 6	2, 4a, 4b, 7, 11	1, (4a) (4b) 6a, b, 10, 13	15			4, 6	7			2?			1, 6b, 10, 13 15, 11		4a, 4b, 6a			
TP 7	1, 2, 4, 6, 7, 10	13, 15					4			2, 6, 7			10, 15	13	1			
TP 8	2, 4, 6, 15, 11	1, (6) 7, 10, 13 (15) (11)	(2)							1, 7			6, 13	10	2, 4	15?	11?	
TP 9	1, 2, 4, 6, 10, 13, 15, 11	7 (15)								1, 2, 7, 11			6, 15		4, 10, 13			
TPC 1	1, 4, 6, 7, 10, 13	2 (13)		11	15		11					4, 15	1, 6, 10	13	2, 7			
TPC 2	13, 11	1, 6, 7, 10, 15	2										15	4	1, 2, 6, 7, 10 13, 11			
TPC 4	4, 6, 7, 10, 13, 11	1, 2, (13) 15				(1)				4		10, 15, 11	13	1, 2, 7	6			
EP 2	6	1, (6), 7, 10, 13	2, (10), 15, 11			(13)			1, 2, 15		6, 7	13, 11		10				
EP 3		1, 2, 4, 6, 7, 10, 13		11	15	(10)		15? 11?		1	6, 7, 10		13	2, 4				
EP 4	2, 4, 6, 7, 10, 13	1 (6) (13)	11			15				10			15	2, 11	1, 4, 6, 7, 13			
EP 6	(1), 13, 11	1, 2, 6, 7, 10, 15			4	6				11	10		15	2, 4, 6, 7	1, 13			
EP 7	2, 4, 13	1 (2), 6, 7, 10, 15		11		(6)				7, 10, 11			6, 15		1, 2, 4, 13			
EP 8	4, 6	1			11	(4) 7, 10, 13, 11				1			6, 7, 10, 13				4, 11	
EP 9	2, 4, 6, 7, 10, 13, 15	1, (6)			(15) 11			15		2	1, 4, 6, 10		7		11		13	
EPC 3	1, 2, 4, 6, 7, 10, 15, 11	(6), 13							15	6, 10, 11	1				4, 13		7	

In Table 10, the general level of interpretation and the feeling-tone of the story are recorded. There are no great differences in level between the experimentalists and theorists—both tend somewhat more to stick to the concrete-factual, but also give a fairly high incidence of stories (recorded as endopsychic) in which the thoughts and feelings of the characters are of major importance. The somewhat larger number of conditional stories among the experimentalists reflects their greater uncertainty about outcome. Feeling-tone of the stories is quite varied. Comparison is somewhat easier if the groups are combined, as is done in Table 11.

TABLE 11
TONE OF *TAT* STORIES

	Indifferent Detached Contemplative	Cheerful Serene	Unhappy Tense Anxious	Morbid Aggressive	Melo-dramatic Sardonic
Theorists	11	14	28	5	12
Experimentalists	7	22	19	4	2

Table 12 summarizes the choice of languages and diction, the style of the story under the heading Quality, and the nature of the personal relations and the presses in the stories. Clearly a generally literate style is the most common. There are very few instances in which the subject has resort to clichés, but an excessively critical attitude is somewhat more common. There is some evasiveness, that is, the subject apparently made a determined effort to produce a non-committal reponse.

Personal relations are most often formal for both groups, that is, they fall into recognized social structures, husband and wife, father and son, etc. It is notable, however, that emotional relations are relatively commoner in the stories of the theorists. These appear particularly in response to Cards 4 and 13 for both groups and to Card 15 for the theorists. In both Cards 4 and 13, the protagonists are a man and a woman; Card 15 is the graveyard scene, and the relationship is to the person buried there.

The sources of pressures exerted upon the central figures in the stories are classed as friendly, unfriendly, impersonal and internal, where these can be determined. Highest incidence is in the impersonal group with friendly a close second. But friendly presses are relatively more important in the protocols of the experimentalists and impersonal ones in those of the theorists. It is noticeable, too, that certain cards are particularly differentiating. Card 10 (a couple embracing) is interpreted with friendly presses significantly more frequently by the experimentalists and a similar trend is noticeable in Card 4. To the theorist, Card 10 most often represents a couple under pressure of

TABLE 12

TAT SUMMARY: PHYSICISTS

(1/9/61)

Pressures

	Quality				Personal Relations				Presses				
Subject	Literate	Cliché	Critical	Evasive	Formal	Emotional	Not Stated	None	Friendly	Un-friendly	Imper-sonal	Internal	?
TP 1	all		7	1, 6, 7, 10, 15	6	7	4, 10, 13	1, 15, 11	7? 10				1,4,6,13,15,11
TP 3	all	6	10		2, 6	4,7, 13,15,11		1, 10	6		1, 7, 15, 11	2, 4, 10	13
TP 4	all			all	1, 2, 6, 10?		4,7,13,11	15	1, 4, 10		7, 15, 11		2, 6, 13
TP 5	all			4	6, 10	4, 7, 13	11	1, 2, 15	1? 10	2, 7	13? 11		4, 6, 15
TP 6	all		2	2	1, 2, 4a, 6a, 10, 13, 15	4b, 6b, 7		11	1? 4a	6a?	4b, 6b, 10, 13, 15, 11	4a	2, 7
TP 7	all(S→6)		2, 11		1, 2, 7, 10	4, 6, 15?	13		1? 6, 7		10		2, 4, 13, 15
TP 8	all				1, 2, 4, 7, 10	6, 13, 15, 11			1, 2, 7	4, 15	6, 10, 13, 11		
TP 9	all				1, 2, 6, 7, 10	13, 15, 11			1, 4, 7, 11		10	15	2, 6, 13
TPC 1	all				1, 2, 6, 7, 10	4, 13		15, 11	1, 4	13	10	2, 7	6, 15
TPC 2	all				2, 6, 7, 10, 15	4, 13	11	1			4, 6,10,15,11	1, 2, 13	1, 7
TPC 4	all		10	7	2, 6, 10, 13	4, 7, 15	11	1	4? 6		10, 15, 11	1, 2, 13	7
EP 2	1,2,7,10,13 15, 11	6, (11)		10? 15?	6, 7, 10		2, 13	1, 15, 11	7, 10	11?	2	1, 13?	6, 15
EP 3	all	10	2, 4	15	1, 2, 4, 6, 7, 10, 13			15, 11	1? 6, 7	2? 4?	10? 13, 15, 11		
EP 4	all			4? 7? 11?	2, 4, 6	7, 13	10?	1, 11	2, 10	4?	7, 13, 11	1, 6, 15	
EP 6	all			4, 6	2, 4, 6, 10, 15		1, 7, 13	11	2, 7, 10		13, 15, 11	1, 2, 15	4,6
EP 7	all				1, 2, 6, 7	2, 4, 10, 13, 15		11	1,2,4,7,10, 13		15, 11		6
EP 8	all		2	4	7	4, 10	6, 13	1, 11		4, 11		1, 13	6, 7, 10
EP 9	all			4, 13	2, 4, 10, 13, 15	6, 7		1, 11	2, 4, 10	13	6, 15, 11	1	7
EPC 3	all		2		1, 2, 6, 7, 10 13, 15	4	11		1, 4? 6? 10	7	2, 13, 15		

a death or other misfortune. For the other group it is a scene of reconciliation or pleasure.

This sort of formal analysis does not give much information by itself to the non-expert, and is particularly lacking in content analysis. In general, this group give quite satisfactory stories, which are rich and meaningful.

The attitude they manifest with regard to family relations is rather an unusual one. Its chief aspect is of independence of parents, usually without conflict over it. In a few instances there is some indication of feelings of succorance and warmth in the family relationship but these are rather rare. The duty of the parent toward the child is rather taken for granted, and quite broadly conceived, but it is also taken for granted that the child should go off on his own.

A similar independence of other personal relations is generally noticeable. But here, particularly with respect to sexual relations, there is a strong tendency to evade an emotional situation, to give it distance in some way. These are relations in which for the most part they seem not to be at ease. There is more apparent conventional morality among them than there is independence of thought in this area. There is almost complete absence of any feeling of need for or the naturalness of warmth and closeness to other persons.

A number of them give evidence of a considerable passivity, which often overlies an unexpressed rebelliousness, and over which there may be conflict, although obvious conflict is not very common. On the other hand, some free aggression is present. But there is an interesting factor here. In most of the stories where aggression is clearly apparent, it is relegated to a fairly distant past, and as a rule the aggressor suffers severely for it. At the same time, there is a sort of acceptance of aggression as an admissible form of behavior.

B. Responses to Card 10

It is impossible, because of limitations of space, to reproduce all of the protocols here.[4] In order to give some idea of the nature of the differences between these groups and for a comparison with the biologists (6) the responses to Card 10 are given below: (?) indicates a question by the experimenter.

> *TP* 1: I should think this was happening in France, and as to what it is I'd say comfort in sorrow would be a possibility. Or reunion. Well, not knowing what it is I don't know what will happen but this seems

[4]Copies will be made available to other workers on request.

to be the thing that is happening here is the end and so there is no need of anything else to happen. The satisfactory culmination of an episode in so far as it can be satisfactory.

TP 3: Oh, my God. All I can think of is mush. There was once an artist who yearned to be a great architect and to build churches and other monuments which would be a true decoration to the Mediterranean civilization in which he lived. As he studied more and more he became interested in the details of the great edifices which he had planned to erect and finally discovered that these meant more to him than the cold architectural drawings in which he had been originally most interested. He ended up by designing statues of saints who were of a particular nature which stood in the corners of the churches built to his plan by someone else and gradually became covered with dust which was to the best interests of the people who came there. As for himself he realized that this was the inexorable working of the second law of the thermodynamics which stated Murphy's law "If anything can go wrong it will." I always liked Murphy's law, I was told that by an architect. (Are the figures in the picture the saints?) These were saints in a niche, at first I thought they were two men then possibly the man who did it, but they are the saints.

TP 4: Well, this could very well be the reunion of two people who have a great deal of affection for each other. I should say a young man and his mother probably or some older woman. There is a suggestion that they are both very content to be back together and whatever it is that has separated them it isn't evident whether that's over or not or that they may be separated again, but at least there is no indication of any spiritual separation or any failure to be perfectly content at the time with the reunion. (?) Man on the left.

TP 5: This is definitely mother and son I guess although it's a little hard. I guess it's mother and son. The boy has just come back from a lengthy trip, the mother evidently wasn't sure that he would either come back or would greet her as exuberantly as he seems to be doing because she has a slight expression of triumph or pleasure or something in her face. The boy is definitely a weak character, he's glad to get back, I think he's going to say that he's going to stay a while. Even the hand is rather weak, in fact practically a child's hand. The woman's had a hard life. (?) He hasn't helped her.

TP 7: What sort of a Russian is that? Well, this wife presumably is being consoled by her husband following some tragedy in the family, all my stories are pretty sour, aren't they? Perhaps the drafting of a son into the service.

TP 8: The difficulty is only because there are just an infinite variety of gushy stories and I'm trying to pick out something that I don't bore myself with. Let's see. Well, to pick out a standard sort of topic here we have a soldier returning from war after three or four years absence and his faithful wife clasps him fondly and this essentially suggests the hopeful life in the future and the possibility of

going on together although the possibility of irreparable damage as far as they can see at the moment it hasn't been done and they can look forward. Only they are four years older, for the happiness they have planned on. Of course they don't know how much mental damage may have been done to him but at the moment they feel they can go on as they have planned. Is writing scenarios as easy as this?

TP 9: There is a certain sad cast to this picture. A couple, say their child is very sick. The man has come home to find his wife frantic and worried and the child very ill and he is comforting her the best he can under the circumstances and as many things happen it passes away and everything recovers.

TPC 1: You can do almost anything with this. Let's make this a man and his wife. They are not newly married but they are relatively young and they have no children. Let's see where we'll put them? I think I better make this a parting rather than a reunion. Let us make them Russian. He is an engineer who has been brought up in the Soviet tradition being young at the time of the revolution, in fact both of them have. And through his ability and industry he has become the factory manager. We'll make it in the Urals. However he possesses an independent mind and has been unable to accept certain changes in policy which came during the years. He has at times been indiscreet in expressing his divergent opinions and has been betrayed by his subordinates one of whom wishes to displace him. This has resulted in a denunciation and he is on his way to a labor camp and this is the parting. This was very one sided because I have left the wife out but I think I have said enough. I could have him going off to war.

TPC 2: Well that is a rather small hand. These noses suggest you see they aren't Japanese I would say but central European, perhaps possibly Polish and yet the woman's hair it's hard to be sure about her age, it gives the impression of being blond rather than black. It's very difficult for me to ascribe a geographical location to this scene. The woman's hand is small and dainty and not what I would expect from what I see of her face. She isn't a pianist, I think more a working girl. There isn't grief indicated in the man's face but rather pleasure and tenderness. I don't think that there is a parting occurring here. There isn't a feeling of joy expressed on the woman's face so I don't think there is a reunion either with some . . . with a loved person. I would think that this indicated that this showed husband and wife after an accident or illness to one of their children or perhaps to their child. The man is clearly young, about 30, and the woman may be probably is somewhat younger still. This illness is such as to have made them sad and the husband is consoling his wife about it. It seems clear to me that he is sad, too, but also full of affection and I don't think his expression is such as to indicate that they are parting. That eyebrow doesn't look like Poland.

TPC 4: This is kitchig. (?) Kitchig is to sentimentality as saccharine is to sugar. I don't know, I mean this is a woman and a

man approximately the same age I suppose, perhaps husband and wife and it looks like it's . . . it doesn't look like it's a story, it looks like the artist was trying to tell a story and doing it poorly. Maybe she's telling him they are just going to have a baby or else she's bidding him good-bye for years, it would fit either way. (?) It would, no the story for which this sort of picture is appropriate must have a sad ending. She at least dies in childbirth and he gets killed in the war.

EP 2: This again is one of the things which is foreign to my mental processes and I find it very difficult to make any sort of story. This doesn't seem to be a starting point for fiction, it's an abstraction. It has to be a tale of woe. (?) Probably one that a father senses for a fallen woman, probably his daughter here his wife even, in which there is forgiveness and understanding and infinite remorse that would be the general thing. The girl? Yes. Remorse but can't reverse things. That would have to be the motive in the fiction.

EP 3: This looks like a soldier's farewell although, wait a minute, that's an older man. I can't make up my mind whether it's a farewell, it doesn't look like the clear cut features of youth, it looks like an older person. I can give you one either way you can either have a soldier's farewell or a consolation. (*Which do you prefer?*) I think looking at the actual ages of the faces it's a husband consoling his wife that some sadness has come into the lives, this is the photograph of the consolation. I take it that that is the case because her expression and the way her hand is placed and all, indicates that she is not too conscious of what she is doing, as well as the rather firm determination of his face indicates that his is an hour of strength rather than weakness. I suppose all you can say is that those hours are the hours that build homes.

EP 4: Well, this is quite a conventional scene I would say. A pair of lovers, I can't say what the relation between them is, whether married or not; could be, could not be. I think they possibly have had a quarrel and are just in the act of making up but it's nothing serious. I can't make much more than that.

EP 7: I suppose you might say that this young couple were dancing but their expressions look too serious for that. He looks as though he were telling the girl that he loves her and wants to marry her and she looks as though she had been hoping he would say that and wonders just what sort of reaction she should have. She's obviously very happy at what he's saying since she's always wanted him to say that. Her past training tells her she shouldn't be too enthusiastic but should be a little bit coy, which is very hard for her in view of her strong feelings about the matter. I'm sure she will, it's just how she will say it.

EP 8: Well, there . . . gosh, I don't get any feeling out of these pictures. Oh. I can't tell if someone is in love with someone or if it's his daughter-in-law. I have no idea who's young or old.

EP 9: Well, this must be a father and daughter, small hands suggest

a young person here. And they are happy, I guess she's really just telling him good-night. In the immediate future she will have to, well after all this daughter isn't so very young, so she has probably reached the age of responsibility and will go to bed without fuss. Which is a very good thing.

EPC 3: This is hard to interpret, I suppose mother and daughter, or father and daughter, I can't make out, surely this is a daughter over here. Well, or is it husband and wife? I rather think husband and wife probably. It represents a very happy and congenial union. He's just returned from a trip I should judge and they are glad to see each other. Or else he's just left, one of the two. It doesn't quite look that way. I think he's coming home.

C. Comparison With Biologists

On the whole this group gave rather longer stories than the biologists did. Too, the biologists gave more description, and less straight narration than the physicists did, and many fewer stories with full time sequence. The biologists more often gave incidents in which no future was possible, and the physicists more often interpreted the future as a defeat or with unresolved tensions, and were more certain in offering these outcomes than the biologists were. In addition the physicists, while also much given to interpretation at the concrete-factual level, were less so than were the biologists and more inclined to show interest in the thoughts and feelings of the protagonists. There are also some over-all differences in the "tone" of the stories, as Table 13 shows.

TABLE 13
Tone of *TAT* Stories:
Comparison of Physicists and Biologists

	Indifferent Detached Contemplative	Cheerful Serene	Unhappy Tense Anxious	Morbid Aggressive	Melodramatic Sardonic
Physicists	18	36	89	14	9
Biologists	12	15	110	9	25

These differences in tone, combined with those noted earlier would suggest that the physicists have found it easier to accept the fact of difficulties in life, and less inclined to gloss them over or to put distance between themselves and the problem. Nevertheless, they are a group in which anxiety is easily mobilized, as the Rorschach shows, and as may be indicated also by their greater acceptance of situations of unresolved tension. Any further generalizations in this extremely intricate situation are unwarranted

on these data, particularly since not every member in each group follows the line characteristic of the group as a whole.

Both groups are dominantly literate in expression. They show no particular differences in types of personal relations, but do show slight differences in regard to type of presses, with the physicists using somewhat fewer unfriendly and internal ones, and leaving more unanalyzable ones. There are a few differences on particular cards, for example for the physicists presses in Card 10 are more often friendly, for the biologists more often impersonal. Again on Card 10, the biologists give the greatest number of deviations in the story, but for the physicists it is Card 15 that evokes the most deviations (and sometimes the freest aggression).

In content, the biologists, like the physicists, show considerable lack of need for interpersonal relations, and somewhat more facility in avoiding them, as well as somewhat more incidence of guilt feelings. In the field of interpersonal relations there is one very striking difference—the biologists appear much more concerned about their children. To some extent this is an age factor, their children are older, more of them are adolescent, and more problems are apparent. This relationship which is one in which the biologists feel at ease, and which has particular value for them, has perhaps a larger independent element in it than any other close one, at least for the parent. Even here, however, the general independence of the physicists is stronger.

Aggression is much freer in expression among the physicists, with the biologists it is more likely to be a form of stubbornness.

X. THE RORSCHACH

Results of the Rorschach Method of Personality Diagnosis are available for 19 of the subjects. This test employs a set of 10 standardized cards, each bearing an ink blot. The subject's task is to tell what the ink blot, or any part of it, looks like to him, or reminds him of. Responses were recorded verbatim. The cards are run through a second time, in order to make certain of just how and where each response was seen, and what features of the blot were significant for the concept. The tests were scored according to Klopfer's system (3) and again by the use of the Munroe Inspection Technique (5). This technique makes the results easier to handle as a group and makes allowance for variation in total number of responses.

A. Analysis of the Protocols

The test data are presented in Tables 14, 15, 16, and 17.

Discussion will be limited chiefly to the Inspection Technique, from Table 17. Throughout the table minus entries indicate a relative deficiency and plus entries a relative excess of the item, the number of each indicating degree. Excessively poor or vague forms are noted by *B* or *V*, either with respect to whole or original responses in particular or to all responses in general. Checks indicate refusal of a card or cards or the presence of shading or color shock. Other entries are explained in the discussion of the particular item.

The number of responses (*R*) varies from 10 to 81, with a mean of 33.7. The theoretical and experimental groups are quite different in this respect, mean for the former being 40.9 and the latter 23.8, a significant difference. Number of responses may be taken to indicate something about the energy available to the subject for more or less intellectual effort.

The next line, T/R refers to the amount of time required per response, minus entries indicating that it is less than 30″ and plus entries that it is more than 60″. Reaction time (see Table 15), that is, the time elapsed between presentation of a card and the first response, averages 11.9″ for the theorists and 17.0″ for the experimentalists. The differences are not great, but it would seem that the theorists are a little quicker, and perhaps a little freer to react in this situation than the experimentalists.

1. *Location*

These entries refer to the portion of the blot chosen for each concept, W indicating that the whole blot was used, Dd, an unusual portion of the blot, and *S* the white space. The entry → 100 indicates that whole responses

TABLE 14
RORSCHACH DATA

Subject	R	W	D	d	Dr	S	M	FM	m	k	K	FK	F	Fc	c	C′	FC	CF	C	P	O	T
TP 1	29	7	16	1	5	0	4	2	0	0	0	0	12	3	2	0	2	4	0	7	2	0
TP 3	81	11	36	7	23	4	7	7	3	4	0	3	39	6	0	1	7	3	1	9	24	0
TP 4	18	9	8	0	1	0	1	4	0	0	0	0	9	0	1	0	1	2	0	3	2	0
TP 5	51	10	23	2	12	4	4	3	5	4	0	1	20	7	1	2	3	1	0	5	16	7
TP 6	32	14	12	3	3	0	4	3	1	2	0	2	8	6	1	1	1	3	0	5	4	0
TP 7	15	9	6	0	0	0	1	2	0	0	0	0	9	0	0	0	1	2	0	5	2	0
TP 8	61	4	26	13	17	0	4	7	2	3	0	1	31	2	1	1	3	5	1	5	15	4
TP 9	14	9	3	1	1	0	1	1	0	0	1	1	4	1	1	0	1	3	0	3	0	0
PC 1	62	9	29	4	20	0	2	4	2	0	0	2	34	7	0	0	8	3	0	10	16	1
PC 2	70	20	28	5	17	0	6	5	5	0	1	0	28	10	3	1	6	4	1	7	21	5
PC 4	17	11	6	0	0	0	2	2	0	0	0	0	3	2	0	0	2	6	0	7	0	0
EP 2	20	12	8	0	0	0	1	4	1	1	1	0	3	2	1	0	2	4	0	3	1	0
EP 3	21	12	7	0	2	0	1	2	1	1	1	0	3	1	2	4	2	3	0	2	2	0
EP 4	18	9	7	0	2	0	5	2	0	0	0	0	6	1	0	0	2	1	0	4	1	0
EP 6	34	12	22	0	0	0	3	5	2	0	2	0	16	0	2	0	0	5	0	2	4	3
EP 7	44	5	17	5	8	9	5	8	2	0	0	0	21	4	0	0	3	1	0	7	10	2
EP 8	10	7	1	0	2	0	1	1	0	0	0	0	8	0	0	0	0	0	0	2	1	0
EP 9	28	11	11	2	4	0	2	5	0	0	2	0	11	1	1	0	2	3	0	4	5	2
PC 3	15	7	6	0	2	0	2	1	0	0	1	0	7	2	0	0	0	2	0	3	1	0

TABLE 15

RORSCHACH DATA: PERCENTAGES

	R	W%	D%	d%	Dr%	S%	F%	$F^1+\%$[a]	$F^2+\%$[b]	A%	Last 3	Turning	T /R	Ave. RT	RT Range
TP 1	29	24	16	3	17	0	41	100	83	31	45	V only	35″	9.3	1 - 17
TP 3	81	13	44	8	29	5	46	90	86	24	55	once on IX	30″	2.6	1 - 11
TP 4	18	50	45	0	6	0	50	67	62	61	39	no	17″	9.8	5 - 28
TP 5	51	19	45	4	23	8	39	95	86	35	41	much	37″	3.7	1 - 7
TP 6	32	44	37	9	9	0	25	71	72	22	22	no	44″	22.2	3 - 60
TP 7	15	60	40	0	0	0	60	78	73	60	27	no	32″	21.6	6 - 63
TP 8	61	6	43	21	29	0	51	87	80	32	50	much	31″	19.8	10 - 35
TP 9	14	64	21	7	7	0	29	100	71	43	29	no	47″	7.7	4 - 20
PC 1	62	15	47	6	32	0	55	91	92	39	32	much	28″	14.0	4 - 36
PC 2	70	28	41	7	25	0	40	82	77	40	41	no	28″	4.4	2 - 8
PC 4	17	65	35	0	0	0	18	100	59	47	47	some	42″	16.6	3 - 37
EP 2	20	60	40	0	0	0	15	100	60	35	35	no	45″	10.0	1 - 32
EP 3	21	57	33	0	10	0	14	100	52	42	38	no	60″	24.5	6 - 62
EP 4	18	50	39	0	11	0	39	86	88	55	59	no	97″	18.4	5 - 46
EP 6	34	35	65	0	0	0	47	88	71	32	44	little	32″	27.0	3 - 80
EP 7	44	11	40	11	18	20	48	100	98	48	41	little	22″	10.7	5 - 28
EP 8	10	70	10	0	20	0	80	75	80	30	30	no	22″	9.5	1 - 24
EP 9	28	39	39	7	14	0	39	82	68	29	25	little	47″	25.4	9 - 60
PC 3	15	47	40	0	13	0	47	71	67	47	20	some	44″	10.8	1 - 24

[a] $F^1+\%$ refers to form level of F responses only.

[b] $F^2+\%$ refers to form level of all responses.

TABLE 16

RORSCHACH DATA: CONTENT

	H	Hd	A	Ad	Aobj.	At	AAt	Sex	Sci.	Obj.	Pl.	N.	Geo.	Art Des.	Embl. Mask	Blood	Expl. fire	Cloud Wind	Micro photo aerial photo X-ray	
TP 1	4		7	2	3	5				3	4									Other groove
TP 3	7	2	14	6	5	8		5		8	1	5	14		1			1	1	2 whirling spray
TP 4	2		10	1		1				2	1				1					
TP 5	6		12	6	2	2		2	3	6		3	2	4		1			1	1 light; 1 hole
TP 6	3	1	6	1	5	4		2	1	1	1	1	2	1	1				2	
TP 7	1	2	8	1							2									1 food
TP 8	3	4	10	10	2	1			4	7	1	5	4			1		1	2	1 water
TP 9	1		5	1		1					1	2		1	1	1				
PC 1	4	11	21	3		6	1	2		4	6	2	1			1				
PC 2	8		19	8	4	5		2	1	10	2	2	2	1		2	1			food 1; ink 1; sine curve 1
PC 4	2		7	1	1	3			1		2									
EP 2	2		7		3		1		2	1		1		1				1	1	
EP 3	2		7	2		2			2		1		1	1	1			1	1	
EP 4	4		10		1		1							1	1					
EP 6	3	2	11			1				6	5		1		2			1		2 rocks
EP 7	6	4	12	9	2	2		2	1	4	2									
EP 8	2		3		2					1	1			1						
EP 9	2	1	5	3	1	2			1	3	2			2	1			2		1 rock; 2 food
PC 3	2		4	3	1	2						1			1		1			

TABLE 17

MUNROE INSPECTION TECHNIQUE RECORD

	Group: Subject	TP1	TP3	TP4	TP5	TP6	TP7	TP8	TP9	PC1	PC2	PC4	EP2	EP3	EP4	EP6	EP7	EP8	EP9	PC3
	Sex																			
	Age																			
	R	29	81	18	51	32	15	61	14	62	70	17	20	21	18	34	44	10	28	15
	T/R			—						—	—						—	—		
	Refusal						√								+			√ √		√√√
Location	W		—	+			+	—	+			+→100	+V	+BV	+			+→100		
Location	Dd	+	++		+			++		++	++				+		+	+	+	+
Location	S		+		+												+++			
Location	Suc		ll		ll	l		ll		l	ll						l			
Content	P							—					—			—				
Content	O				+									B						
Content	At	+	++			++				++		+								
Content	Range		t		+	t	—	+		t	t	t			—					
Form	F%			+			+	+		+			—	—				++		+
Form	F			B		V			B			*VB*	*VB*	*BV*					*VB*	
Shading	ShSh			√		√√	√√		√√	√		√	√	√√		√			√	√√
Shading	FK, Fc			—			——									——		——	—	
Shading	c	+							+					+		+				
Shading	C													+						
Shading	K, k		+		+			+	+				+	+					+	
Movement	M		r	—			—		—	—		—	——	——			r	—	—	
Movement	FM			++									+					—	+	—
Movement	m				+						+					+				
Movement	ΣM								—											
Color	C Sh	√	√√	√√			√	√	√√		√	√√√	√√		√	√√	√			√√
Color	FC						—		—									——		——
Color	CF	+					+	+	+			+				+		—		+
Color	C																			
Color	ΣC		+	+								++	+		+			——		
	C:M	+	+						++U	+		++	+				——	——		
	ITS	7	14	12	8	9	12	11	15	11	8	15	14	13	6	9	10	18	7	13

were given to nearly every card. Succession (Suc) refers to the order in which these were used in the responses to each card. If responses are first to the whole blot, then to large and small usual details, to unusual details and to the white space in that order the succession is regular. An entry of 1 indicates considerable relaxation of this order, and of 11 that responses followed no order at all in this respect.

The relative frequency with which different portions of the blot are used is associated with the usual manner of approach to problems. For example, according to usual Rorschach theory, the subject who gives a preponderance of W responses is likely to view problems in a large setting, not to bother about details but to be more concerned with abstracting and generalizing, and the converse is true. The quality of the W responses is very important here, however, vague sweeping Ws being much less significant of high order work than Ws in which the separate parts are carefully related to the whole. A high incidence of use of unusual aspects of the blots is evident, and this seems an important factor in the success of these men—ability to look at things a little differently than other people do, to see what others miss. Very often, in this group, the Drs are unusual combinations of usual small details. White space responses have usually been taken to indicate oppositional tendencies. Even more than the Drs they indicate ways of regarding problems which are very different from the usual ones.

It is possible, from the intricate balance of these factors to deduce with some accuracy the manner in which each man goes about his professional work, such as his relative interest and competence in broad or more restricted theorizing, and what his more special sort of contribution has been.

One of the striking things is that the theoretical group does not tend particularly to high W. It is true that very few of them do much in the way of abstracting on a really *broad* scale. One of them, for example, remarked, "I haven't created any basic theory, and you will find no one on the campus who has." TP 8 who had an unusually low number of W, said, "Yes, my type of understanding is not the over-all comprehensive sort."

The precise meaning of the W response needs clarifying. It is far from accurate to suppose that high W% by itself can be taken as an indicator of a tendency to abstract thought and preference for generalizations. It is of some significance in this respect, but the necessary qualifications are not limited to those deducible from the sorts of W given. It appears also to be true that some types of abstract thinking (if not of generalizing, which is a different process) do not seem to be reflected in W responses of any sort. Certainly it is of considerable importance for Rorschach theory that W activity is *not* what theoretical physicists characteristically do.

EP 7, who had an extraordinary number of white space responses, most of them original ones, said, "I don't like to make small improvements. If I can't do something quite different I'd rather not work at all. . . . People are always saying, 'How do you think up these things?' I have that ability to think up unusual things in odd fields." This is amply confirmed by his colleagues.

Other aspects, such as freedom in shifting concepts, or their stickiness, and the presence or absence of general attitudes of criticalness are also quite clearly shown in the Rorschach.

There is considerable difference between the theoretical and experimental group in succession, although this is not statistically significant with these small groups. To some extent this difference is just a function of the difference in total number of responses—where few responses or few types of response are given it is not possible to judge succession. Nevertheless it is noteworthy that the theorists are much less rigid, and show not only greater variety in their responses but also less orderliness.

2. *Content*

(See also Table 16.) The entries in this section refer to the content of the responses, humans, animals, plants, and so on. P refers to the number of Popular responses, that is, responses most commonly given. Subjects who have very few of these are likely to be unable to see things as other people do. Only three of this group have fewer than the desirable minimum of these but none of them lacks such responses altogether.

Entries under O refer to unusually large numbers (over 35 per cent) of original responses, which are defined as responses given by fewer than one person in a hundred. Only one subject, *TP* 5, has an unusually high number of these, and only one, *EP* 3, gave original responses with particularly poor form.

Five of the theorists had an excessive number of anatomy and sex responses (At), but none of the experimentalists. I think this may reflect a real difference although it is not statistically significant. It will be remembered that many of the theorists have been ill a good deal; several seem presently somewhat concerned over physical problems; and there is probably a higher incidence of sexual problems in this group. In one case at least, this seems to be a definitely physical problem.

Range is very wide in two instances—that is, the content of the responses is distributed through a very large number of categories. In two other instances categories are very limited (minus entry). In both of these the

number of animal responses was very high. The entry *t* was given only to theorists, but to five of these. This means that the same response was given to at least three cards, and indicates some concept domination. The particular concept varies—for *TP* 3 it was maps, of harbors, lakes, etc.; for *TP* 6, it was central canals; for *TPC* 1 and *TPC* 2 it was pelves; for *TPC* 4, it was bats. The specific content has only individual significance, but the fact that there are persistent concepts for so many in the group might mean a general tendency for concept domination, which is not pathological, but which means in this setting that the men are relatively little constrained by external reality. This does not seem inappropriate to a theoretical physicist.

The responses were also scored for technical content. There are relatively few of these—the only one that occurs with any frequency is the response, governor, to Detail 12 in Card X (the wishbone), always seen in motion.

3. *Form*

Responses determined solely by the form of the blot, or blot area, and not at all by shading or color or apparent movement are scored as F responses. High numbers of responses of this type indicate greater reliance on intellectual control—if extremely excessive (as they are not in any of this group), they tend to show a very pedantic, limited sort of approach to life. Another factor of importance is the clarity of the forms perceived, and the care with which the details of the blot are worked into the concept. A few of these subjects are not particularly concerned with or critical of form, as is shown by the B and V entries. The double entry, VB indicates that 30 to 40 per cent of the responses are either poor or vague (such as cloud formations) in nature.

4. *Shading*

The first item in this group is "shading shock," a not very precise term. It is supposed to be quite uncommon in normal groups. The entry is given when the reaction to the more differentially shaded cards is notably different in any respect from the reaction to other cards. This is manifested chiefly in increased time before a response, change in manner of response or content, or in decrease of form level. Beck says, "It signalizes that anxiety which, because its roots lie deep in the very early experiences of the individual, has become a central character force diffusing his energies and paralyzing him in almost all of life's crises . . . It signifies a low threshold sensitivity to events bearing potency of danger . . . it bespeaks a chronic readiness to

be upset" (2). It is shown clearly by over half of this group, and in addition to those noted, five more showed some indications of it but not quite sufficient to warrant a check. There seems to be no difference between the theorists and experimentalists in this respect.

There is no discernible relation in this group between early traumatic experiences and presence of this characteristic. It seems to be common in groups of high achievement, and it is probable that it is related to the presence of enough drive to carry the person to the top. In groups such as this, with few exceptions, vocational activity has been intense and concentrated over many years and tremendously strong drive is necessary to maintain this. It is important that recovery from the shock is fairly good in most of the group.

The entries for FK, Fc refer to the presence or absence of responses conditioned primarily by the form, secondarily by the shading. Absence of FK responses, in which the shading is interpreted as light or vista does not indicate any particular hazard; absence of Fc responses, in which the shading has textural qualities, is more serious and a number of this group are lacking in them. These responses seem to indicate capacity for sensitive appreciation of others which is important in mediating interpersonal reactions, particularly where the type of adjustment indicated by Fc responses is not well developed.

The few entries for *c* indicate too many responses in which the main determinant is texture, with form secondary or lacking. These are indicators of excessive sensitivity, anxiety and poor control. C′ responses are those determined by the blackness or grayness of the blot areas; they are rare in this group.

Entries for K, and k are unusually high. These are considered to be open indicators of anxiety which is very prevalent, and unstructured. They are of considerable importance in this group. The theorists and experimentalists show some difference here as can be seen from Table 14: the theorists tend more to k and the experimentalists to K. The k responses are a sort of toned-down, intellectualized form of K responses, and indicate somewhat more efficient controls. This may be due to greater awareness of problems, which would seem to be indicated by the fact that FK responses occur among many of the theorists and among none of the experimentalists. Presence of FK always indicates awareness of problems and that the subject is to a considerable extent able to cope with his anxieties.

5. *Movement*

This group of responses refers to concepts into which movement is projected. These may be human movement (M), animal movement (FM), or inanimate movement (m). Movement responses as a whole are considered indicative of the richness and intensity of the inner life of the subject, as well as its level of maturity (ratio of M to FM), and the subject's ease with his instinctual drives (relatively few m).

A large number of human movement responses have usually been taken as indicative of creative ability, but this apparently is not necessarily the case. It would seem that the primary meaning of good M responses is that the subject has developed an adequate concept of human personality and its functions and has been able to accept this concept as applied to himself. In addition, production of M responses requires not only good natural endowment, but also the ability to delay response in order to achieve an integration of the elements. It requires a rich and active ideation, but I think this may be present without being manifested in M responses. As can be seen, this group tends to underproduction of these responses. The r entries indicate that, although there are a sufficient number of such responses, the action of the figures is very restricted—a modified form of limitation. FM responses are not consistently high, or lacking, and m responses, although commoner in the group than usual, are not of great significance in the whole group. Their greater frequency among the theorists ties in with the greater awareness of conflict in these men.

The last row in this set, for sum of movement responses indicates that it is generally adequate, neither too many nor too few.

6. *Color*

Color shock is analogous to shading shock, but very much commoner, and in mild forms not indicative of serious disturbance, but rather of some unease in emotionally toned situations. It is about as frequent in this group as in most professional groups which have been reported.

The FC responses are those in which form is a main determinant, but color is also important. The number and adequacy of these indicate capacity for emotional adaptation, particularly social adaptivity. They should outnumber CF responses (responses in which color is the dominant element, but some element of form is also present), which are indicative of egocentric emotional responsiveness, and large numbers of which show considerable affective reactivity. Rorschach remarked: "The greater the preponderance of FC over CF the

more stable the affect and the greater the adaptability and capacity for formation of rapport. The closer CF comes to FC the greater the moodiness, instability and egocentricity" (10). In 11 of this group (about the same in the theorists and experimentalists), CF are more numerous than FC. In this group there seems to be present a tendency to impulsiveness, to emotional responsiveness when logical considerations are not effective and for poor tolerance of delay in reaching satisfactions and a tendency to disregard the emotional needs of others. All of these make for difficulties in socialization, and for some self-centeredness.

The total number of color responses tends to be high, and to be larger than the number of movement responses. This suggests greater tendency to responsiveness to environmental than to internal stimulation.

7. *Inspection Technique Score*

This score is a rough indication of the general clinical adjustment of the individual, the higher scores indicating greater degrees of maladjustment. Averages are 11.1 for the theorists and 11.3 for the experimentalists, 11.2 for the total group. The two groups of physicists seem to be equally well adjusted, on this very course measure, but the nature of the adjustment is somewhat different.

B. General Discussion

The data given above do not give a clear picture of the quite varied individuals that compose this group of subjects. These men, although they have much in common, range in personality from the rather blunt and determinedly practical to the sensuous aesthete. Some attempt at fuller summary, from the qualitative as well as quantitative aspects of the protocols will be given here.

The theorists, on the Rorschach, seem to break down into two well-separated groups. The larger number (six) are characterized by large numbers of responses, generally loose or confused succession, low per cent of whole responses, very high per cent of responses seen in unusual areas, and wide use of determinants and content categories. They give rich protocols, with much evidence of high intelligence and a considerable amount of emotional and intellectual energy. This energy, however, is not very well disciplined, for the most part, although it is generally readily available. They are likely to go at things in a somewhat hit or miss fashion, rather than in a highly ordered, logical one. With this much energy available, however, this is not serious, and in fact it is very possible that it is an element

in their creative thinking. On the other hand, not the method of attack on problems, but the concept once developed, may be a little sticky, either hard to drop, or recurring from time to time with little appropriateness. The formal aspects of reality do not concern them very much. Almost all of them show much concern for space and space-filling things—three dimensional perceptions come easily to them. The fact that psychologically this is an indication of anxiety is mitigated in this group by their fair ability to control its expression. The bilateral symmetry generally means to them an insistence of biological responses—for a number of them these are unpleasant. In a few "biology" is specifically equated to "sex," but it is not clear if this is true of all of them. They are rather likely to give technical responses, not in large numbers, but of other than the "governor" type, and of a sort unique in my experience. For example, to Card I (apparently meant as W) "It suggests to me a repeating figure in that there is enough symmetry between the two pairs of white spots to indicate there might be a symmetrical translation that might produce an infinitely long figure but I see the upper pair is not identical so I would have to abandon this. . . . It's the repetition of a unit with a symmetrical operation." There is usually evidence of conflicts, which are not as a rule too repressed or too badly handled. They seem, for the most part, to be rather mature socially. Those who have apparently not developed good socially adaptive techniques have considerable sensitivity which probably serves moderately well where it isn't more irritability than sensitivity. In most of this group, too, aggressive tendencies are plain but are usually adequately controlled, even though they may be the source of some anxiety.

The other four present a strikingly different picture. Their protocols are usually very limited. They have very high per cent of whole responses and use practically no unusual areas. As a rule the whole responses are sweeping and form is often poor. They come to conclusions quickly and quite uncritically. With the smaller number of responses, variety of determinants is naturally much curtailed, and so is content. There are practically no clear indications of conflict or anxiety as they appear in determinants but the picture as a whole is in each instance one of a man who has protected himself by withdrawal. This way of handling problems probably works pretty well for them, but they are, as a group, rather irritable, likely to be impatient and jumpy, and they are rather insensitive to other people. It should be stressed that these restricted protocols, while not without meaningfullness are nevertheless by no means satisfactory representations of these subjects. That men of such extraordinarily high achievement can give

protocols which are so flat raises another note of caution with regard to the Rorschach. Absence in the protocol of any indications of capacity for high achievement does not mean necessarily lack of the capacity. It will be interesting, when other groups of scientists have been added, to make a special study of those who give this sort of protocol.

The experimental physicists do not divide so neatly into subgroups, and there is quite a little variation in most factors. With two exceptions, however, they seem to have developed few adequate social techniques, and in general although they are far from lacking in aggressiveness, they tend to handle it by getting out of the situation as far as possible or by resorting to a superficial passivity. One or two of them, however, may have explosive outbursts.

C. Comparison With The Biologists

Comparative quantitative data are given in Tables 18 and 19. The differences are very striking. The individual physicists generally used more determinants than did the biologists—this in part is due to the greater number of responses offered by the physicists but only in part. The major differences are in the use by the physicists of k and K responses, which were extremely rare among the biologists, the differences in the amount and balance of color responses and in the domination of form. These are consistent with the general summary that the biologists, who manifested considerable basic anxiety as shown by the incidence of shading shock (high in both groups, but somewhat higher in the biologists) have this anxiety pretty well structured for the most part. Their general control is better; they are less interested in other people and the social environment but they have developed better techniques for coping with it than the physicists have. The physicists, on the other hand, are severely burdened with a considerable

TABLE 18
Comparison of Rorschachs of Physicists and Biologists

	χ^2	P
N > 1 for main Fk, kF, k, K or KF	5.41	.02 — .01
N > 1 for main m	3.47	.1 — .05
N > 2 for m including additionals as ½	4.34	.05 — .02
N > 1 for de, dd or di	5.41	.02 — .01
N > 1 for object as content	4.61	.02 — .05
N > 1 for Fc	6.57	.01 — .02
FC > CF + C	9.53	< .01
ΣC not over 2½	13.8	< .01
ΣC > M	4.71	.05 — .02
Check list entries:		
K, k	4.33	.05 — .02
CF +, no entry, —	10.80	< .01

TABLE 19
COMPARISON OF RORSCHACHS OF PHYSICISTS AND BIOLOGISTS

	Physicists Mean	Biologists Mean	P of difference
Number of responses	33.7	22.1	.02—.05
Inspection Technique Score	11.2	8.9	.02—.05
W%	39.8	44.5	>.05
F%	40.9	43.1	>.05
F^1 + %[a]	85.6	83.8	>.05
F^2 + %[b]	75.3	80.3	>.05
% non-F-dominated responses[c]	17.4	7.0	<.01
A%	39.6	42.6	>.05
Number of M	2.9	2.6	>.05
Sum of C	4.3	1.9	<.01
Number of Technical responses	1.3	3.1	.02—.05

[a] F^1 + % refers to form level of F responses only.
[b] F^2 + % refers to form level of all responses.
[c] This is the per cent of responses in which form does not enter or enters secondarily.

amount of free anxiety, mobilized with the greatest readiness (this was striking not only in the greater difficulty of making arrangements with the physicists but also in the interviews); their affects are relatively strong and their social techniques are often not very good. The contrast between the two groups is very like that between obsessive-compulsives and anxiety-hysterics among the neurotics.[5]

There are also some differences in content of the responses. The biologists gave more technical responses than did the physicists. The blots lend themselves so readily to interpretation as animals or animal structures that it is not surprising that the biologists do give more responses which are classed as technical, although such responses only receive the designation technical if specific scientific knowledge is involved. The physicists gave more responses the content of which was objects of various sorts, such as pliers (not technical) or governor of a gasoline engine (technical), although even their total of these is not very high (9 per cent of all responses). One of them explained it very well—"Why didn't he make some with four-fold symmetry? There would be a lot more possibilities in it. This two-fold symmetry gives an unfair advantage to animal likenesses. If you were after mechanical or abstract things this doesn't do."

The physicists are also a generally more aggressive group, although this may be masked under a superficial passivity in some instances. As a rule, however, it is more open and stronger in this group than in the biologists, in whom it is characteristically expressed more as stubbornness.

[5] I do not want to be misunderstood as having implied that biologists are generally obsessive-compulsive neurotics and physicists anxiety-hysterics, which is not true. It is to the difference between these groups that the analogy is drawn.

XI. COMPARISON WITH RORSCHACH STUDIES OF OTHER PHYSICISTS

In addition to the individual studies so far reported, the faculties in physics and physical chemistry in six institutions were asked to take a Group Rorschach. In making the comparison it must be remembered that there are some differences between the individual and group administration of the Rorschach and that the nature of these has not been clearly established experimentally. This point is more fully discussed in the monograph on the biologists. It would seem, however, from such evidence as is available, that these are less than would be expected by anyone who has not seen many group protocols. These have as much variety of response as the individual protocols do, and in my experience are very nearly as useful clinically. It is not direct evidence, but certainly merits consideration, that the differences shown on the Rorschachs individually administered to biologists and physicists are precisely the differences which appear on the group administration.

Considerable difficulties were encountered in securing subjects for this, but eventually 65 subjects took part. These records have been analyzed in detail and are reported elsewhere (7). The subjects included (there is only one woman) are of all university ranks. A few of them are extremely well known but were not considered for the individual studies because of age or foreign birth.

These subjects were requested to record a preference for teaching or research, and the field of research. Those who did not specify a research field, or who reported a decided preference for teaching are not included in the subgroup selected for comparison with these individual records. This subgroup, reported below, includes 11 men doing theoretical research and 37 doing experimental research. Comparative data are given in Table 20.

That the groups studied individually are older than the others is a natural result of the process of selection. The difference is statistically significant for the total groups. No mean comparisons between individual and group Rorschachs for the theoretical, experimental, or total groups are significant, although differences between the means in some instances are present.

A table of Check List entries for the groups has not been included; there are no significant differences between individual and group Rorschachs for the theorists, the experimentalists, or the total groups.

The major finding here is that the physicists teaching in universities, in general, do not differ on the Rorschach from their most eminent colleagues. There is in these data no clue as to what brought the men studied individually to a higher level of professional success than many of the others.

TABLE 20
COMPARISON OF INDIVIDUAL AND GROUP RORSCHACHS

		Theoretical		Experimental		All	All
		Group	Indiv.	Group	Indiv.	Group	Individual
N		11	11	37	8	48	19
Age	Range	24-65	31-53	28-56	38-56	24-65	31-56
	Mean	39.3	44.0	36.8	45.7	37.3	44.6
	S.D.	11.9	6.0	7.7	7.0	8.9	6.6
R	Range	15-48	14-81	13-68	10-44	13-68	10-81
	Mean	32.3	40.9	34.0	23.8	33.6	33.7
	S.D.	9.0	23.6	14.8	10.3	13.7	20.9
ITS	Range	6-17	7-15	2-25	6-19	2-25	6-19
	Mean	11.3	11.1	11.3	11.3	11.3	11.7
	S.D.	3.1	2.6	5.0	4.0	4.7	3.3
W%	Range	7-67	6-65	8-68	11-70	7-68	6-70
	Mean	35.6	35.3	37.0	46.1	36.7	40.4
	S.D.	18.6	20.9	18.0	17.0	18.2	20.1
F%	Range	14-63	18-60	4-72	14-80	4-72	14-80
	Mean	40.4	41.1	35.8	41.1	36.9	41.2
	S.D.	14.6	12.4	17.8	19.5	17.2	15.8

XII. DISCUSSION

This study is part of an attempt to find out whether there are factors in life history, in level of intelligence, or in personality structure which are relevant to vocational choice or success. The data would indicate that there are certain factors which, because of their higher incidence in this group than in others, probably do have such relevance, although a directly causal relation cannot be demonstrated. Only one, sustained devotion to work, is present in all of this group and in all of the group of biologists previously reported. For such sustained interest, it is required, psychologically, that the activity somehow be satisfying to strong basic drives. They must be strong to account for the depth of the absorption; they must be basic to account for their constancy. It is of course evident that most vocational activities beyond a mechanical level, may satisfy the autonomous drives, at least in our cultural setting. What is unique here is the extent to which the vocation is called upon for these satisfactions. It is very probable that the creative nature of much of the work of these men carries also homononymous satisfactions and that this furthers the extent to which their lives are dominated by their work.

The reasons for the development of such a channel of satisfactions to the near exclusion of others seem to vary. Some special situations appear to recur in these life histories. It does not follow that they are causal, but it seems improbable that they are not relevant. Dependence on intellectualized forms of satisfactions may develop when other channels are not continuously clear, and this one is available, either in the family setting or elsewhere. With the biologists a recurring situation was loss of a parent at an early age; this did not appear in this group. Among the theoretical physicists a common situation was early severe illness, or generally "poor constitution" which obviously would function to increase social isolation and in certain settings, increase recourse to intellectual satisfactions. Illness was not commonly a factor among the experimentalists, and although there were various isolating factors among them, and although the incidence of feelings of apartness is high, the elements contributing to this are more varied.

That physical science took the lead over other forms of scientific activities in these men is only in part, I think, due to obvious environmental situations. It was usually the case that the only science courses available in high school were physics or chemistry, but this was also true of the biologists. I suspect that subtle differences in modes of thinking may have already developed in these two broad groups, so that for some form was important and for others

not, and that this played a part, but the origin of these differences is still unknown. (Data on this point are given elsewhere, 9.)

Intellectual functions, so far as these have been tested, and so far as these tests are a measure of them, do differ somewhat in the groups so far studied, but most striking is the very wide range in all of them. Physicists, however, are generally better at a space test, although the differences are not great.

Differences in personality structure are more marked, but are in line with the others reported. The general indifference to close personal relations is striking in both groups of scientists, with the physicists being remarkably free of any guilt in this respect. It is very probable that identification with the father was relatively easier in this group than in the biologists and this, too, may be related to a choice of a profession which has a more definitely "masculine" tone than has biology.

It is as yet too early to develop any general theories on these data, but as noted above, some hints are beginning to emerge. When other groups have been studied it should be possible to construct a number of hypotheses which can be tested on larger samples.

It is not too early, however, to point out some of the pedagogical implications of the data. These derive chiefly from the life histories. It is clear that early opportunity to become acquainted with the field and work in it is a great help but is by no means an essential to final success, and that the boy who is entering college may well not know what he is interested in, or his final interests (as expressed in his behavior) may change completely.

Several things are of major importance in any attempt to increase the number of students interested in research in a physical science. Perhaps the first and most important is high school teaching. Here it is not just the fact of having a course in physical science available, but the manner of teaching the course, and this applies equally well to college teaching. The vital point is to give the student the opportunity to find things out for himself. It makes no difference if the fact is well known or not at this level, what is important is that the student not learn it by rote, but learn it by discovery. Admittedly this may often be pedagogically very difficult—but it is part of the way research scientists become research scientists, and it is a factor susceptible to control. The students who can't work on their own may be in the majority, although I doubt it, but it is essential that the others be given a chance to learn that they can work on their own. A good many boys learn this through gadgeteering, but not all have this opportunity. Even at a quite different level this general principle seems to apply. A re-

port on "Productivity, Supervision and Employee Morale" (12) states that: "The findings suggested that persons are more effectively motivated when they are given some degree of freedom in the way in which they do their work." Certainly top-level research scientists have an extraordinarily large degree of such freedom, but it was certainly not *given* all of them at first. They took it.

The personal influence of a teacher or someone else may be of great importance also, although I think it secondary. And it should be noted that the final effect on the student may not be so different whether a teacher leaves his students alone to work on their own because he doesn't want to be bothered or whether he stimulates them to work on their own because he is personally interested in them. (I refer only to the effect on vocational development.)

Once, however, a boy learns the satisfactions of research, good pedagogy may be a help, but bad pedagogy, unless it is completely stultifying probably won't be much of a hindrance. Given the drive and even the faintest chance at it, the devoted student will carry on, on his own. I strongly suspect that some of the new programs of assistance are defeating their own ends by giving too much assistance.

XIII. SUMMARY

This monograph reports a study of the personalities of physical scientists. The major portion is devoted to individual study of 22 men selected, by a group of their peers, for their eminence in research. This is supplemented by a brief Rorschach study of 48 other research physical scientists now on faculties at large universities.

The men studied individually include nine theoretical physicists, nine experimental physicists, three physical chemists primarily engaged in theoretical research, and one physical chemist primarily engaged in experimental research. As presented here the major division retained for the study is that of theoretical or experimental work. In a few instances the subjects have worked in both fields.

The number of physicists who would qualify for this study is not large. Of the 30 physicists who were selected, 22 were willing to be interviewed, but the data from one of these are very curtailed. Although the absolute sample size is small, it is a relatively very large sample of a very small universe.

The age range of the subjects studied individually is 31 to 56, with an average of 45. All but one were American born; that one came here at a very early age. They have all received the major part of their training in this country and have done their major work here. All of the men are married; only one has been divorced. This is socially a very stable group.

Data on family backgrounds show that the group as a whole is very unlike the population at large and that there are marked differences between the theorists and the experimentalists. The major difference here is in the occupations of the fathers of the subjects: 84 per cent of the fathers of the theorists were professional men, and 50 per cent of the fathers of the experimentalists. Four of the experimentalists, and none of the theorists were the sons of farmers. Among the theorists, also, most of the mothers came from families which included a number of professional men, and this was not true to the same extent of the experimentalists. It follows, too, that the educational level of the parents of both groups, and in particular of the theorists is considerably above that of the population at large. Furthermore, so far as I could determine, none of the sibs of any of this group are unskilled or skilled workmen. It is clear, then, that a family background of learning is generally present.

It seems probably of considerable importance that, among the theorists, but not among the experimentalists, there are a number who reported early

very poor health, frequently of a repeatedly disabling sort, or generally poor constitution, often necessitating long interruptions in schooling.

For all but two of the theorists, a college course was taken for granted; this was true of only three of the experimentalists. This is not to say that the parents of the others did not spontaneously wish their sons to go to college or did not plan for it—a number of them did—but it was a matter which required debate and special planning, and this was not necessarily entirely financial. There is a great difference between the two groups in the amount of early liking for and interest in school and particularly in reading. It is characteristic of the theorists that they were early and omnivorous readers, and while some of the experimentalists also were, it is unusual. They showed little more than the average interest in gadgetry, on the whole, although here the range is very wide.

The school course for the theorists was somewhat more accelerated than that for the experimentalists. In part, of course, this reflects an economic difference, since more of the experimentalists had to work their way through. With most in both groups, there was no crystallization of scientific interests before high school, and here it was likely to come with a particular course, very often a course in chemistry, which was more generally available then. The usual point of decision to enter physics as a career was about the junior year of college, although with several it was later than this. There seems in general to have been no sudden understanding of the nature of research and the possibility of a research career. On the contrary this developed somewhat gradually. Entrance into theory as a field was necessarily delayed until some situation arose—such as working with a teacher interested in theory rather than in experimentation—in which the possibility of such a choice became clear; it was not known as a vocational possibility before the college level, usually not before the later years in college.

For the most part their histories after receiving their doctorates have been of steady development, with relatively few changes in research interests, except as the field itself has changed. All of them, of course, were involved in war projects. With some this meant continuing with their old work under new circumstances, with others, a considerable shift in the work itself.

In very general terms, their psychosocial development followed the course which appears to be the pattern with educated men in this country. That is, intellectualization of interests usually was sufficiently developed at an early age that it seems to have inhibited free development of social interests, particularly of sexual ones, with the result, among others, that marriages are generally late in this group. Furthermore, social interest, in

general, is not the rule in the group. Most of them don't particularly like to be with people socially, outside of the family, although there is a small group who are much given to parties. It is very probable that early illness contributed to the comparative isolation of some, but with others it seems to have been a matter of preference for books. Among the experimentalists this is not so true. But the spontaneous expressions of feelings of isolation in childhood and continuing to the present time are numerous and striking. In some measure I think this is due to a probably greater awareness of the self which, it would seem, must inevitably promote consciousness of isolation. As regards parental relations, neither great closeness nor great distance is common, but it is noteworthy that genuine and continuing respect for the father is characteristic.

Only a very few of this group are church goers; perhaps not more than two of them are emotionally involved in an established church in any way.

In their general intellectual and social development they are quite like the group of biologists previously reported. The incidence of illness was not noted to any significant extent among the biologists but it was found that 40 per cent of them suffered the loss of a parent before the age of ten. This was not true of the physicists. Incidence of professional fathers among the biologists was 45 per cent, about that among the experimentalists in this group. Resemblances throughout between the experimental physicists and the biologists are close.

The Verbal-Spatial test is the same that was used for the biologists. The mathematical subtest had to be discarded for this group as it was not difficult enough for most of them. On the verbal test, the theorists average 64.2 correct and the experimentalists 46.6, a difference not quite at the 5 per cent level of significance. On the spatial test the averages are 13.8 and 11.7 respectively. This difference is not significant. The experimentalists tended to have a higher sigma score on the spatial test and the theorists on the verbal test, but this was not consistent. For the biologists, the verbal average is 56.6 and the spatial is 9.4. The physicists as a group are significantly higher on the spatial test. In both biologists and physicists the ranges are extremely wide and the lower limit unexpectedly low. Clearly intelligence, as shown in these tests, while a factor in the eminence of these men, is by no means the decisive one, and this particularly applies to verbal intelligence.

In the results of the Thematic Apperception Test, some differences appear with regard to particular details, but on the whole the protocols for the two groups of physicists are very like. The stories do not differ in length or in degree of narration and description. But the theorists are more certain

in their statements of outcome, and give many fewer stories involving defeat of the protagonist or stories with conditional endings than the experimentalists do. Both tend to stick to stories that are dominantly concrete-factual, but to a considerably greater extent than did the biologists; they also consider the thoughts and feelings of the subjects. The theorists also seem considerably freer in their construction of personal relations, and less insistent that presses be friendly.

Perhaps the most striking aspect of the protocols in general is, for both groups, the feeling of independence of parents that is so strongly present, and in addition, the lack of feelings of guilt over this. This is accompanied by a similar independence of personal relations generally, although with some, particularly sexual situations, there is present a definite attempt to get distance, hence this independence is achieved with some difficulty, and there is more conventional morality among them than there is independence of thought in this area. There is a general acceptance of aggression as a permissible element in behavior, although not a great deal of obvious aggression is present, and where it is, it is generally relegated to the past.

They gave longer stories than the biologists, with more narration and less description, and with more stories of full time sequence (i.e., including past and future as well as present). They also gave many more stories involving unresolved tension or defeat than the biologists did, and were more interested in the feelings of the characters. The biologists, like the physicists, showed considerable independence of need for personal relations, except for the fact that they were remarkably concerned over their children, a feature which did not appear at all in the stories of the physicists, and may be in part associated with age differences in the children. The expression of aggression was much freer among the physicists than among the biologists as was the acceptance of aggressive elements in behavior.

In general the Rorschach protocols were rich and most of these men use many determinants and many content categories, although there are a few restricted ones among them. The major findings for both are the evidences of great and often not too well controlled intellectual and emotional energy, the very high percentage of responses seen in unusual areas, the very general use of some form of shading response involving three-dimensional perception, and the unusual extent to which they use inanimate movement responses. There is also a high incidence of shading shock and a low incidence of human movement responses. The theorists seem to be classifiable into two quite homogeneous groups,[6] but the experimentalists are rather hetero-

[6]The work of these two groups should be analyzed for common factors. As a start,

geneous by comparison. In general the theorists show somewhat greater awareness of personal problems, and a more controlled handling of anxiety. The theorists also show some inability to get away from concepts, once devised. Socially, both theorists and experimentalists are usually somewhat poorly adjusted. This is in some instances due to considerable impulsiveness and egocentricity and in others to general apathy with regrd to social relations.

The physicists gave many more responses than the biologists did, and differ markedly from them in some other respects, although both groups share the only slightly higher than average W%, the much greater than average use of rare details, and the restriction in use of human movement responses. They differ primarily in the relative emphasis on form and shading responses. The biologists in general are more concerned with form, more careful about it and more likely to embody it as a main determinant; they show very little concern with shading in three-dimensional terms. The latter is common to the physicists who also use much more inanimate movement than the biologists do. In conventional Rorschach terms, one would infer that the biologists, while having considerable basic anxiety have this anxiety pretty well structured and rely heavily and effectively upon intellectual control of behavior, and that the physicists have a strikingly large amount of free anxiety, readily mobilized, and have considerably more emotional responsiveness than the biologists do. Perhaps, however, the vocationally relevant point is a simpler one. Biologists are deeply concerned with form, to an extent that permeates their whole personality development; physicists have relatively little concern with form as such, but they are much concerned with space, and with inanimate motion, and this, too, is deeply ingrained in them. These aspects are so much a part of the personalities of the two groups that I doubt very much that they can be the result of vocational interests, although it cannot be said on these data that this is impossible. It would, however, seem much more likely that the possession of such personality structures as these men have would be important factors in their choice of vocations.

It would seem that various factors contribute to choice of and eminence in physical science as a vocation, but there is only one thing which seems to characterize the total group and that is absorption in their work, over

---

I might note that the smaller group of theorists is more like the experimentalists generally, and that it includes the two theorists who have done considerable experimental work. Further analysis would require a considerable technical knowledge of physics.

long years, and frequently to the exclusion of everything else. This was also true of the biologists. This one thing alone is probably not of itself sufficient to account for the success enjoyed by these men but it appears to be a *sine qua non*. It needs to be accompanied by a certain amount of intelligence, and by sufficient emotional and social adjustment that it is possible to maintain a position in which the work can be done. I think, too, that some early success or encouragement is a potent factor in maintaining this work level, as it often must be maintained, in the face of continued incomplete closure.

The psychological dynamics are probably somewhat different in different instances. What must be common is a channeling of emotional energy into intellectualized forms of satisfaction, and a considerable amount of energy to be channeled. What may vary is the source of the energy, but that in most instances it derives from basic insecurities is clear. It seems possible that the unusual amount of free anxiety, which seems characteristic of this group, is related to the extent to which symbolization is part of their vocational activity.

REFERENCES

1. ALLPORT, G. The use of personal documents in psychological science. New York, Social Science Research Council, 1942.
2. BECK, S. J. Rorschach's Test: II. A Variety of Personality Pictures. New York, Grune & Stratton, 1945.
3. KLOPFER, B., & KELLY, D. M. The Rorschach Technique. Yonkers-on-Hudson, New York: World Book, 1942.
4. MORGAN, D. D., & MURRAY, H. A. A method for investigating phantasies: The Thematic Apperception Test. *Arch Neur. & Psychiat.*, 1935, **34**, 289-306.
5. MUNROE, R. The Inspection Technique: A method of rapid evaluation of the Rorschach protocol. *Rorsch. Res. Exch.*, 1944, **8**, 46-69.
6. ROE, A. Psychological examinations of eminent biologists. *J. Consult. Psychol.*, 1949, **13**, 225-246.
7. ———. Analysis of group Rorschachs of physical scientists. *Rorsch. Res. Exch.*, 1950 (in press).
8. ———. A psychological study of eminent biologists. *Psych. Monog.* (in press).
9. ———. A study of imagery in research scientists. *J. Personal.* (in press).
10. RORSCHACH, H. Psychodiagnostics. Berne: Huber, 1942.
11. SUPER, D. E. Appraising Vocational Fitness. New York, Harper, 1949.
12. Survey Res. Center, Univ. Michigan. Productivity, Supervision, and Employee Morale. Human Rel. Series 1, Rept. 1. Ann Arbor, Michigan, 1948.
13. TERMAN, L. M., & ODEN, M. H. The Gifted Child Grows Up. Stanford: Stanford Univ. Press, 1947.
14. WYATT, F. The scoring and analysis of the Thematic Apperception Test. *J. of Psychol.*, 1947, **24**, 319-330.