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Characteristics of superior science students and some factors that were found in their background

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CHARACTERISTICS OF SUPERIOR SCIENCE STUDENTS AND SOME FACTORS THAT WERE FOUND IN THEIR BACKGROUND

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CHAPTER I

THE PROBLEM

1. The Purpose of the Study

The general goal.-- This study will attempt to identify characteristics of those superior science students who were winners and honorable mention winners of the Science Talent Search of 1952 and 1953, and will further attempt to isolate some factors that were found in their background. It is hoped that these identifications will be useful to teachers, who have responsibilities for the guidance of young people in our schools. These teachers also have the responsibility for continuing the supply of science-trained men and women in a highly technical environment. While there are many able students who are destined to enter the scientific world and who do not take part in the Science Talent Search, those who do enter go on to become, in general, science workers. Further, an attempt will be made to distinguish among the many characteristics and background factors of the respondents those which would be most useful to teachers for identification of superior science students. The characteristics and the

background factors of the superior science students will be compared with those of their contemporaries in the College of General Education at Boston University. If they are statistically significantly different they will be reported and in a manner thought to be useful to teachers.

The national shortage of scientists.-- That there is and will continue to be a national shortage of scientists is reported in the current literature. Trytten reported:[1/]

> "That the U. S. is already experiencing a shortage of scientists needs no elaborate proof.... Last spring 16 major employers of scientific personnel, each company a leader in its field, reported that after scouting the nation's graduating classes they were able to obtain on the average only 36 per cent of the new employees they needed."

A good place to start searching for more scientists is in the high schools where career choices are being made and educational plans are being jelled. Accordingly, much attention is being directed by many agencies toward the high-school students and their teachers and guidance counselors. Among these are the Westinghouse Corporation, the Bausch and Lomb Corporation, The Alfred P. Sloan Foundation, and The Ford Foundation. An effort is made to influence the opinion of the student by recognition, prizes, financial aid, guidance, appeals to their curiosity, patriotism and

1/ M. H. Trytten, "Scientists," The Scientific American (September, 1951), 185:71-76.

assurance of success in a career in science or engineering. This search for the science-talented high-school student has not yet produced enough science students. Trytten again reports:[1]

> "Since industry, government, and the universities were absorbing virtually all the available science graduates before the emergency, it is obvious that the supply will fall far short of the new demands. This would be true even if our colleges and universities continued to turn out as many scientists as they have in recent years. Actually the supply will be falling while the demand is rising. In the first place the number of college graduates will drop sharply in the next few years.... On the basis of present enrollments the number of science graduates will decline further to 36,000 in 1952, 33,500 in 1953, 29,000 in 1954. And this forecast does not take account of military obligations."

Reason for shortage of science students.-- The reasons why too few students are being guided and selected are many. They probably include factors in students' relationship to parents, home, school teachers, social setting, young people's activities and societies, the students' interests and attitudes and social-economic-political opinions.

We need to find ways to increase our supply of scientists and engineers. Senator Harley M. Kilgore says:[2]

> "The future of scientific research in this country is one of the pressing problems before the Senate today.

1/ Ibid., p. 72.

2/ Harley M. Kilgore, Hearings on Science Legislation, Tuesday, March 5, 1946, 79th Congress, S. 1297, Part 6.

> Together with a number of my colleagues I have spent a good deal of time in working out a National Science program which will assure the continued development of scientific research and development of our nation's welfare. We recognize particularly that we cannot have a strong healthy growth of scientific investigation in this country unless we develop our greatest scientific asset - the talented young people who are the new generation of scientists."

A study which would attempt to discover the characteristics of superior science students and some factors that were found in their background seems to be strongly indicated.

2. Justification of the Problem

Devices to identify scientific aptitude.-- There is a test of Scientific Aptitude but the world has changed much since its publication in 1929.[1] A most interesting and unusual device designed to discover and foster the scientific aptitude of boys and girls in high school made its appearance in 1942. This is the Science Talent Search. The originators were Harold A. Edgerton and Steuart H. Britt.[2] Some characteristics of the search are as follows:

> "The primary aim of the annual search - now in its third year - is to locate those boys and girls who seem

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1/ D. L. Zyve, Stanford Test of Scientific Aptitude, Stanford University Press, 1929.

2/ H. A. Edgerton and S. H. Britt, "The Science Talent Search," Occupations (December, 1943), 22:177-180.

to have the requisite aptitudes and interests to become first-rate scientists. A secondary purpose is to foster a greater interest in and a better understanding of science on the part of high school students. The organization of the Science Talent Search is carried out by Science Service, 1719 N Street N. W., Washington, D. C. and arranged as an activity of the Science Clubs of America. The entire program, including the awards to winners, is made financially possible by the Westinghouse Electrical Manufacturing Company as a contribution to a general program for the advancement of science in America....1/

Basis of Choice

The winners of the Science Talent Search are chosen each year on the basis of evidence selected to reflect this description.... (Our picture of the potential scientist suggests a person who is intellectually quite superior, interested in science, and a leader among his fellows. Potential scientists must be 'bright' and able to do high quality academic work. They should have shown by their records a strong interest in science, both in and out of school. In addition they should have exhibited over a period of time considerable resourcefulness, initiative, and social competence.) Six evidences of fitness are used. Four of these are:

1. Science aptitude examination. This examination helps to select those who have the aptitude to study science in colleges and universities, but the test does not place a heavy premium on previous knowledge of science.

2. High school record. A transcript of the high school record is required and also a statement of the contestant's rank in the senior class, indicating the number in the class.

3. Score on the recommendations furnished by the high school teachers. These recommendations are very specific.

4. Rating on the essay submitted. This essay is on some specified scientific subject.

Two further selectors are applied only to the

1/ Ibid., pp. 179-180.

forty trip winners, in order to furnish additional information to aid in the selection of scholarship winners. These hurdles are:

5. Personal interviews.

6. A test differing from year to year designed to measure some evidences of competence not measured by the above devices."

The Science Talent Search has resulted in the selection each year since 1942 of 40 Winners and 260 Honorable Mention Winners from the approximately 2500 contestants who have entered the contest each year. The parts of the "Basis of Choice" are difficult enough to discourage all but the determined students from making the effort to compete.

Many contests available.-- There are many contests which are designed to discover and to help potential scientists and engineers. Usually the teachers and students are desirous of the very favorable publicity and real rewards that accompany these contests and thus the conditions are challenging and stimulating for the students to enter the contests. Teachers are faced with these questions: who can win, who should enter, how can I help, who should not waste his time and heart in trying? It is difficult, if not impossible, to answer these questions at present. Some characteristics of the embryo scientist need to be defined so that attention and efforts can be focused on those persons most likely to succeed in scientific study and work.

Lives of embryo scientists.-- An examination into the

lives of the great contemporary scientists reveals that they did not lead ordinary lives. Their interests, activities, and family setting have not been like those of the multitude, as will be shown in a detailed description later. The kind of family in which the embryo scientist is most likely to be found, and what his interests and activities are through his school years, are most important problems to solve. A study of the literature shows that very little is known about the embryo scientist while he is in high school. There is a need to discover what activities are most stimulating, appealing, and conducive to the scientific advancement of the developing scientist so that these activities may be made available to future scientists. This study will attempt to do this task.

A search of the literature.-- The search of the literature has uncovered some helpful reports that relate to the problem. Anne Roe[1/] studied contemporary great American scientists and her study provided some data on the mature scientists. Goodrich, Knapp and Boehm of Wesleyan University[2/] studied several hundred contemporary adult scientists listed in American Men of Science. They uncovered some significant facts about their college or university life and

1/ Anne Roe, "A Psychologist Examines 64 Scientists," Scientific American (November, 1952), 187:21-25.

2/ H. B. Goodrich, R. H. Knapp and G. A. W. Boehm, "Origins of U. S. Scientists," Scientific American (July, 1951), 185:15-17.

training. Herbert S. Zim [1] studied the science interests and activities of students in the secondary schools.

Characteristics of superior science students.-- There is no study known to the writer which makes a careful examination of characteristics of the superior science student and some factors which have been found in his background while he was a student in high school. If such studies are being done they have either not been concluded nor have they been reported. There is a need for such a study, not only to complement the work of Roe, Goodrich and Knapp, and Zim, but also to determine, if possible, the relationship between the science student and the mature scientist in his characteristics and behavior. The high-school science student is like the pupa stage in the metamorphosis of the adult moth. He has been protected from our study by the hard shell of adolescence. It is during this stage of his maturation that he is making career choices and deciding whether to enter college or not.

Changes in the American way of life.-- Recent statistics shown by the U. S. Government [2] reveal that Americans are no longer an agricultural rural people, but that we have

1/ Herbert S. Zim, Science Interests and Activities of Adolescents, The Ethical Culture Schools, New York, 1928.

2/ U. S. Department of Commerce, Statistical Abstract of the United States, U. S. Government Printing Office, Washington, D. C., 1952, pp. 10, 23, 175.

become an industrial and urban civilization with the majority of our people living in cities and earning their living in non-agricultural pursuits:

Table 1. Changes in the American Way of Life [1/]

Conditions		The Year under Consideration		
Where they live	Group	1910	1930	1950
(1)	(2)	(3)	(4)	(5)
	Total Population	92,407,000	123,007,000	151,240,000
	Rural Population	49,973,000	53,820,000	54,669,000
	Urban Population	41,998,000	68,954,000	96,028,000
How they work	Group	1910	1930	1950
(1)	(2)	(3)	(4)	(5)
	Total Workers	37,370,000	48,828,000	59,957,000
	Agricultural Workers	11,591,000	10,471,000	7,507,000
	Non-Agricultural Workers	25,779,000	38,357,000	52,450,000

1/ Ibid., pp. 10, 23, 175.

Washington conference on scientist shortages.-- In contrast to this tremendous increase in dependence on industry, we are not producing the scientists and engineers that we need to keep it operating and to expand it as our population grows. Recently a conference was called in Washington, D. C. to discuss the problem of the shortage of scientists and engineers. Kenneth E. Brown and Philip Johnson,[1/] the leaders and spokesmen for the conference, report in part on this conference as follows:

> "More than one hundred educators including leaders in government and industry contributed to the conference through the presentation of short papers and participating in group discussions.... Our engineers and scientists for the next few years must come from the graduating classes in our colleges. There is not enough manpower in our colleges to meet the needs not seen.... The present graduating class is approximately three-fourths of the number graduated in 1950. Basing estimates on the population reaching college age and the normal increase in persons going to college, it seems fairly certain that for the next few years the supply of scientists and engineers cannot increase as it has during the past 5 years. Yet the survival of our democratic way of life may depend upon our increased technological progress. The battle for the freedoms we so fondly cherished may be lost in the laboratory. Our supply of engineers and scientists already is getting dangerously low."

These worried people stress the necessity of an early recognition and careful development of the potential scientist and engineer while he is still in high school.

1/ Kenneth E. Brown and Philip G. Johnson, Education for the Talented in Mathematics and Science, Bulletin 1952, Number 15, U. S. Department of Health, Education and Welfare, pp. 1-3.

3. The Scope of the Problem

Description of the test group.-- The reliability of this study depends on the source of the data. Can the respondents who will provide the data in this study qualify as "superior science students"? Some facts are known about them that will help to establish them as a suitable criterion group. The respondents are 600 students who are undergraduates in American colleges. Of this group 300 graduated from American high schools in the class of 1952 and thus are for the most part sophomores, and 300 graduated from American high schools in the class of 1953 and thus are for the most part freshmen. Each of the 300 was selected because he was in 1952 or 1953 the Winner or Honorable Mention Winner in the Science Talent Search. The basis of choice on which they were selected has been previously described in this chapter.[1/]

Analysis of the contestants.-- A few analyses have been made of these successful contestants. These reports reveal that about 50 per cent of the Winners and 40 per cent of the Honorable Mention Winners ranked first, second or third in their high-school graduating classes, which vary in size from 42 to 1000 members depending on the school. The members of both groups were from 15 to 18 years old at the time they graduated from high school. They graduated from private,

1/ H. A. Edgerton and S. H. Britt, op. cit., pp. 177-180.

public, and parochial schools. They represent 40 states of the Union. Girls were 22 per cent of the whole group. The proportion of boys and girls is determined by the ratio of boys and girls entering the contest. Most members of the group were members of some science club and all participated in extra-curricular activities. They all had taken many courses in science and mathematics in high school.

Science Talent Search students become scientists.-- A study of their predecessors among previous groups of Winners has revealed some very significant information.[1/] Of the 240 who were Winners from 1942 through 1947, 93 per cent were trained scientists or engineers at the time of the survey which was taken in 1952. Of this group 221 had bachelor's degrees, 62 had master's degrees, 41 had doctor's degrees, 102 were in advanced study, 46 were in industry, 23 were in teaching or research at some college, and 18 were in the armed services. When these groups have been surveyed in the past by Science Clubs of America or Science Service, they have responded to inquiry forms and returned them to the extent of 98 per cent for the Winners and 88 per cent for the Honorable Mention Winners.

Such factors as illustrated in the preceding paragraphs qualify them as a very worthwhile group to study.

1/ Margaret Patterson, Unpublished data, Science Clubs of America, February 20, 1953.

4. Summary of the Aims of the Problem

The problem not a new one.-- People today consider the problem of the shortage of scientists to be a problem of these times only, particularly since the introduction of the atomic bomb. We think of the shortage of scientists and engineers as a new acute problem for our technology and times. Yet John M. Gillette wrote in 1915 as follows:[1/]

> "We must undoubtedly hold that if a larger supply of talent exists than is discovered and developed and put into use that, since, as we have seen, it is so valuable when estimated in terms of social progress, we are dealing wastefully with talent. We are allowing a great ability to go to waste since we are leaving it to lie in its undeveloped state. Therefore one of the problems of the proper conservation of talent consists in finding a method of discovery and releasing this valuable form of social energy. We shall be wise when we realize the worth of our workable talent and so establish its working conditions that it may secure the full measure of its productiveness. If scientific management for...laborers of a nation is worth while how much more serviceable would it be to extend its fructifying influence to the most able members of the community."

Science Foundation Bill.-- Since that time science and technology have moved to correct this situation. Yet in 1946 Senator Harley M. Kilgore[2/] in a speech before a committee on science legislation of the Senate spoke as follows:

> "The future of scientific research in this country is one of the pressing problems before the Senate today. We have with us today 40 young people, finalists in the Science Talent Search. They are exactly the sort of talented youths our country needs to assist and encourage. They have been chosen in national competition as

1/ John M. Gillette, "The Conservation of Talent through Utilization," The Scientific Monthly (1915), 1:151-164.

2/ Harley M. Kilgore, op. cit.

> the high school seniors with the greatest scientific potential. The objectives of the Science Talent Search match precisely the basic objectives of the National Science Foundation Bill which we have under consideration. These objectives are to discover and foster the education of boys and girls of scientific talent. The foundation would supplement the aid to scientific education given by such excellent private institutions as Science Talent Search, assuring the Nation of the best use of its greatest scientific resource, that is its young scientists."

Manpower Council report.-- Apparently the problems had not been solved as late as 1953, for the Research Staff of the National Manpower Council reported:[1/]

> "Persistent shortages of scientific and professional manpower cannot be generally relieved without efforts to increase the supply by expanding educational facilities and increasing the numbers who are financially and intellectually capable of completing training and have the desire to do so. There is always a shortage of first rate minds capable of making major scientific advances. The security of the Nation depends as never before upon creating the conditions which will encourage fruitful basic scientific research."

Goals for this study.-- This study could make the solution of this important persistent national problem much more rapid and certain, for by defining the characteristics of a superior science student it may help to determine the potential scientist. By pointing out some factors that were found in the background of the superior science student it could help to show how to create the correct conditions

1/ Research Staff of National Manpower Council, "A Policy for Scientific and Professional Manpower," Science (June, 1953), 117:617-622.

to stimulate and to guide more young scientists to the stage in maturity and experience where they add their numbers to our national pool of scientific manpower.

CHAPTER II

REVIEW OF RELEVANT RESEARCH

1. Scientists

Extent of study.-- This study is limited to the "Characteristics of Superior Science Students and Some Factors That Were Found in Their Background." Research in the literature has been limited to reports of studies that relate directly to the characteristics of great or near-great scientists and science students and some factors that were found in their background. Some studies of greatness will be reported which, in part, consider scientists.

Harlow Shapley writes:[1]

> "Scientists have never been good at explaining themselves and frustrated in this they tend to withdraw into the esoteric, refer to the public as 'laymen' and develop incomprehensible vocabularies from which they draw a naive, secret society feeling of superiority."

In the same book Oliver LaFarge is quoted as saying:[2]

> "The quality that sets the scientist apart is perhaps the persistence of his curiosity about the world. That is what causes him to bury himself in

1/ Harlow Shapley, Samuel Rapport, and Helen Wright, A Treasury of Science, Harper and Brothers, New York, 2nd edition, 1943, p. 9.

2/ Ibid., pp. 21-30.

his laboratory or travel to a remote corner of the globe."

These reports suggest scientists often were men who worked alone or in small groups apart from association with other teachers or learned men. This perhaps accounts for the study of scientists almost as strange individuals. Only recently, since science has been taught in universities, colleges and public schools, have they been studied as scholars and students.

Great scientists of the past.-- Since men have to learn in part from the contributions of their predecessors, it is natural for scholars interested in the generative force behind scientists to turn to the autobiographies of great scientists of the past. Wilbur K. Butts quotes Darwin in support of a theory of greatness:[1/]

> "My success as a man of science, whatever this may have amounted to, has been determined as far as I can judge by complex mental qualities and conditions. Of these the most important have been - the love of science, unbounded patience in long reflection over any subject, industry in observing and collecting facts, and a fair share of inventiveness as well as common sense. With such modest abilities as I possess it is truly surprising that I should have influenced to a considerable extent the belief of scientific men on important points."

Leta S. Hollingsworth[2/] presented a brief report on the findings of nine investigators all of whom read the

1/ Wilbur K. Butts, "Science and Personality," Bios (May, 1940), 2:83-92.

2/ Leta S. Hollingsworth, Gifted Children, The Macmillan Company, New York, 1926, pp. 4-20.

biographies of many men of greatness including genius and scientific eminence. The findings stressed the family background of these men in such terms as the following: "father in science," "from the middle class," "none came from artisans or peasants," "originated in the governing class or nobility." These reports are subject to variation in interpretation due to the use of terms that are not American and from backgrounds not found in America. Many of the men so studied and reported are not scientists, but are eminent in other ways. It is planned not to present further examples of either type of the background reports that have been illustrated above, but to present facts from first-hand studies about American scientists.

Sixty-four American scientists.-- Anne Roe [1/] presented a study of a group of 64 eminent men who agreed to participate--20 biologists, 22 physicists, and 22 social scientists (psychologists and anthropologists). These were some of the most eminent scientists in America. They were selected by a panel of experts in each field of science. Each of the 64 individuals was then examined exhaustively by means of a long personal interview searching each person's history, family background, professional and recreational interest, intelligence, achievements, personality and way of thinking.

1/ Anne Roe, "A Psychologist Examines 64 Scientists," Scientific American (November, 1952), 187:21-25.

Background factors of eminent scientists.-- In brief she reported that the family history showed:[1]

> "Geographical factors seem not to be particularly significant.... Economic level varied from poor to well-to-do.... There are no Catholics among this group of eminent scientists; five come from Jewish homes, the rest had Protestant background. Fifty-three per cent of the scientists were the sons of professional men: not one was the son of an unskilled laborer and only two were sons of skilled workmen...the operative factor is the value placed by these families and their associates on - learning for its own sake...many of them were their parents' first child...39 were first born; of the rest 5 were eldest sons and 2 became eldest sons through death of the first child. For most of the others there is a considerable difference in age between the subject and the next older brother (averaging five years).... One fourth of the biologists lost a parent by death."

Personality of scientists.-- Personality characteristics were revealing in that[2]

> "While the group as a whole is characterized by a very high average intelligence (163 verbal, 140 spatial, 160 mathematical), as would be expected, the range is wide.... It seems probable that this may point to the most important single factor in the making of a scientist - the need and ability to develop personal independence to a high degree.... The biologists and the experimental physicists tend strongly to dependence upon visual imagery in their thinking - images of concrete objects or elaborate diagrams and the like. The theoretical physicists and social scientists tend to verbalize in their thinking - a kind of talking to themselves. All groups report a considerable amount of imageless thinking particularly at critical points. Men whose fathers followed the talkative occupations (law, ministry, teaching) are more likely to think in words. On the Thematic Apperception Test the social scientists were characterized by verbal fluency. The biologists were inclined to be more factual.... The biologists and physical scientists manifested a quite remarkable independence of parental relations and were

1/ Ibid., p. 23.

2/ Ibid., p. 23.

without guilt feelings about it, while the social scientists showed many dependent attitudes, much rebelliousness and considerable helplessness along with intense concern over interpersonal relations generally.... He /the typical or average eminent scientist/ tended to feel lonely and 'different' and to be shy and aloof from his classmates. He had only a moderate interest in girls and did not begin dating them until college."

Activities of scientists.-- An examination of their activities revealed that these were quite specialized and limited, for example:[1]

"He says his work is his life and he has few recreations, those being restricted to fishing, sailing, walking, or some other individualistic activity. Movies bore him. He avoids social affairs and political activity and religion play no part in his life or thinking. Better than any other interest or activity scientific research seems to meet the inner need of his nature.... They have worked[2] long hours for many years, frequently with no vacations to speak of, because they would rather be doing their work than anything else.... Most of the scientists developed intellectual interests at an early age.... The early extracurricular interests of these men were varied, but here, too, there are some general patterns. More of the physicists than any other group showed early interests directly related to their later occupations but this seems quite clearly to be due to the common small-boy preoccupation in this country with physical gadgets - radio, mechano sets and so on. The theoretical physicists were omnivorous readers, the experimentalists much less so. Among the social scientists many went through a stage of considering or even working towards a literary career. Half the biologists showed an early interest in natural history, but for only five was it of an intense and serious sort.... Whereas the characteristic pattern among the biologists and the physicists is that of the shy, lonely, over-intellectualized boy, among the social scientists the characteristic picture is very different. They get into social activity and intensive and extensive dating at an early age. They were often presidents of their classes, editors of year-books and literary magazines, frequently big shots in college. This contrast between

1/ Ibid., p. 27. 2/ Ibid., p. 25.

the natural and the social scientist was still evident after they grew up. It is true only in general of course: even among the theoretical physicists there are some ardent party-goers.... He married at 27, has two children and finds security in family life."

A scientist's attitudes and opinions.-- Regarding their attitudes and opinions:[1]

"He avoids social affairs and political activity and religion plays no part in his life or thinking.... Only three of the 64 now have a serious interest in any church: only a few even maintain church memberships.... The biologists and physical scientists manifested a quite remarkable independence of parental relations and were without guilt feelings about it, while the social scientists showed many dependent attitudes, much rebelliousness and considerable helplessness, along with intense concern over interpersonal relations generally ....[2] The independence factor is emphasized by many other findings."

The scientists' schools and teachers.-- The influence of their schools and teachers was little:[3]

"The independence factor is emphasized by many findings: the subjects' preference for teachers who let them alone.... The discovery of the possibility of finding things out for oneself usually came through experience in school with a teacher who put the students pretty much on their own."

Their decision to become a scientist appears to have come late in their careers, for example:[4]

"....the final decision to become a scientist is the discovery of the joys of research.... Not until his junior or senior year in college did he decide on his vocation as a scientist. What decided him (almost invariably) was a college project in which he had occasion to do some independent research - to find out things for himself."

1/ Ibid., p. 22.

2/ Ibid., p. 25.

3/ Ibid., p. 25.

4/ Ibid., p. 25.

Conclusion.-- One conclusion of this study by Anne Roe[1] is as follows:

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

These studies of the 64 eminent scientists were made when the biologists' average age was 51.2 years, that of the physical scientists was 44.7 years and that of the social scientists was 47.7 years.

Large-scale study of American scientists.-- Another group of American scientists has been studied in some detail by Goodrich, Knapp and Boehm.[2] The data for this study were obtained in the following manner. The biographies of eighteen thousand men who had received the Ph. D. and were listed in American Men of Science[3] (for the years 1944 and 1949), were searched to discover the undergraduate colleges most involved. This resulted in the listing of fifty colleges in America in rank of productiveness of this kind of individual. A personal visit was made to 22 of these

1/ Ibid., p. 22.

2/ H. B. Goodrich, R. H. Knapp and G. A. W. Boehm, "Origins of U. S. Scientists," Scientific American (July, 1951), 185: 15-17.

3/ Ibid., p. 15.

colleges and questionnaires were sent to their graduates who were on the list taken from American Men of Science. From the 800 questionnaires that were returned, the general traits, characteristics and factors of the men were determined. The personal visits to these colleges resulted in case histories of the colleges.

Characteristics of the scientist in the study showed that:[1]

> "He is rarely drawn from the homes of the wealthy.... They prefer [the wealthy] to maintain their economic standing by going into the law, medicine or business for the greater financial reward.... In general the scientific field that offers the brightest hope of employment and good pay especially through the opening of industrial applications attracted the most people."[2]

Characteristics of their teachers (in all cases college professors):[3]

> "....a successful teacher of science usually is not especially distinguished by his mastery of superficial pedagogic skills. Rather the successful teachers are marked by three cardinal traits: masterfulness, warmth and professional dignity. It would appear that the success of such teachers rests mainly upon their capacity to assume a father role to their students, in the best sense, and to inspire them to an emulation of the teachers' achievements."

Characteristics of the colleges are as follows:

> "These were found to be small liberal arts colleges in the middle west and the state supported agricultural colleges. These colleges were relatively inexpensive schools. Their student body shows high average I. Q.

1/ Ibid., p. 16.

2/ Ibid., p. 15.

3/ Ibid., p. 17.

> They are in the early stages of evolutionary growth as compared to other better known colleges. The top position was taken by the land grant agricultural colleges, second place in productiveness was earned by the private liberal arts colleges. Third place was achieved by the eminent universities. Fourth place was won by the leading engineering schools. Fifth and last place was accorded to the Catholic institutions. No data were presented to further explain all the rankings of these various groups."

Shift in source of science scholar.-- In another study Knapp and Greenbaum [1] showed that the undergraduate colleges of American scientists were quite different from those reported by Knapp and Goodrich in a previous study. [2] The results were so different that they called it a major change in the American education system of scientists:

> "A second matter...is the pattern...in the production of scientists. As with all types of scholars we have noted that those receiving awards in science tend to come in highly disproportionate number from institutions of high cost.... Four considerations may be advanced to account for the reversal of findings here noted. First, the method of sampling.... Second, is that eastern institutions of high cost have in the past two decades undergone something of a revolution with respect to intellectual climate and to student clientele .... Third, lies in the altered condition of science... dramatic achievement...increased prestige and financial returns...have made it an acceptable calling for economic and social classes which previously rarely selected this vocation. Finally...greater appeal to students of purely intellectual motivation...increase in recruitment among ranks of those dedicated to pure scholarship. It would appear that science now appeals to the student that formerly became a professional person or a business magnate."

1/ Robert H. Knapp and Joseph J. Greenbaum, The Young American Scholar: His Collegiate Origins, University of Chicago Press, Chicago, 1953, p. 94.

2/ Robert H. Knapp and H. B. Goodrich, Origins of American Scientists, University of Chicago Press, Chicago, 1952, p. 292.

Reasons scientists changed jobs.-- Theresa R. Shapiro [1] was the author of a study for the U. S. Department of Labor. She personally interviewed 407 scientists between December 1950 and June 1951. These scientists were located on the eastern seaboard from New York City to Washington, D. C. She wanted to discover in detail why scientists took jobs, kept them and changed them. Her findings were as follows:

Table 2. Reasons Scientists Changed Jobs Reported as Percentages

Reason	Take job	Keep job	Quit job
(1)	(2)	(3)	(4)
Interest in job	32.5	33.1	21.1
Working conditions a/	16.1	32.1	11.1
Earn advancement	24.1	18.5	23.5
Personal b/	8.8	10.0	9.0
Other reasons	17.0	2.0	27.0
Security	1.1	4.0	7.0

a/ Working conditions further clarified:

Seldom subject to close supervision
Freedom and independence in work (select own problem)
Good supervisors (they are competent scientists)
Pride in organizations' contribution to self and humanity
Facilities for efficient work.

b/ Personal reasons further clarified:

Further education
Change of locality
War effort
Personality clash
Family needs
Cultural opportunity

1/ Theresa R. Shapiro, "What Scientists Look for in Their Jobs," The Scientific Monthly (June, 1953), 76:335-340.

The general conclusions of the study were as follows: their job was important in extending science and to human welfare; it presented an opportunity for concrete achievement; it presented an opportunity to grow with a problem of importance; it presented a chance to grow and advance in their own special field; it presented chances for broader experiences in several specialties.

2. Superior Students

The high I. Q. of scientists.-- All studies heretofore reported indicate that scientists who were fully developed and recognized have a high I. Q. It is profitable to examine carefully the writings of two of the outstanding contributors to our knowledge of students with a high I. Q. to discover if there is a similarity of characteristics and factors found in their background that will aid in the identification and development of superior science students.

Leta S. Hollingsworth published in 1926 Gifted Children, Their Nature and Nurture.[1] Her study was concerned with observations of these children which covered her active lifetime. Some statements from the study follow:[2] "Others insisted that a positive relationship among all performances would ultimately be demonstrated, which would warrant use of

1/ Leta S. Hollingsworth, op. cit., p. 374.

2/ Ibid., p. 29.

the term general intelligence." Further:[1]

> "There are, however, certain abilities which show little or no correlation with others. It will be long before we know very much about these specialized aptitudes, but even at present we have identified some of them. Musical ability and ability of representative drawing are two important examples of aptitudes which do not correlate closely with general intelligence. In order to distinguish these special aptitudes from intellect in our discussion we shall call them talents."

Hollingsworth attempts to define clearly the term genius. She indicates that this is most difficult to do for:[2] "We cannot use a word which has lost its precision, as this word has done, though probably to everyone the real core of its meaning is 'capable of wonderful performance.'"

She defines the term "gifted" thus:[3]

> "In our present discussion we shall in general limit our interest to those who are so gifted that not more than one child in a hundred falls within their range. Thus we draw our line and arbitrarily choose to mean by 'intellectually gifted' the most intelligent one per cent of the juvenile population.... The best one per cent of children test at or above 130 I. Q.... These children we choose arbitrarily to discuss as gifted."

Family history of the gifted child.-- Hollingsworth, considering the influence of family history, stated:[4] "The values of the pedigree have long been recognized by those who deal in animals and plants, but it has not been popularly supposed that the same values apply in the case of human beings." Nonetheless, she reported some factors as coming

1/ Ibid., p. 30.
2/ Ibid., p. 31.
3/ Ibid., pp. 43-44.
4/ Ibid., p. 170.

from the family. She pointed out that [1] "The coefficients of correlation for twins hover around .80; those for siblings ...around .50; ...first cousins around .25. Of all kinships, that between twins is closest, according to mental tests so far made." She hastened to add, however, that [2]

> "Gifted children...do not have many siblings. Of 57 children included in the gifted group studied by Cobb and Hollingsworth, 18 were 'only' children. The group as a whole, at the median age of 10 years and 4 months, averaged not quite one sibling each...more than half were first born, including the 18 who were 'only' children."

Relationship between fathers' occupation and the gifted children.-- She showed that some relationship existed between the fathers' occupations and the gifted children: [3]

> "In Chapter III we have already called attention to the fact that fathers of gifted children in this country are largely professional men or proprietors. More than fifty per cent of all children testing above 140 I. Q. have fathers in these occupational groups in the United States where social-economic competition is relatively free for all. More than half the remainder have fathers in the semi-professional and clerical occupations. About ten per cent have fathers in the skilled trades, while fathers in unskilled labor and domestic service furnish only one per cent. The occupational group which is least numerous, the professions, furnishes by far the greatest proportion of gifted offspring, while the groups which are most numerous in the population furnish very few."

The professional or occupational status of the parents of the gifted child is not attained without education. Hollingsworth points out that [4]

1/ Ibid., p. 179.

2/ Ibid., p. 179.

3/ Ibid., p. 181.

4/ Ibid., p. 185.

"The educational equipment of parents of gifted children is far above the average of their generation, both for fathers and for mothers. In the majority of cases when the gifted child has been born since 1915 both parents are graduates of high school, and in far more cases than in the population at large both parents are college graduates."

She further showed the relationship between the fathers' occupation and the mean I. Q. of the child:[1]

"Occupation	Mean I. Q. of child
Professional men.....	115
Clerical workers.....	106
Business men.....	104
Skilled laborers.....	99
Semi-skilled laborers..	92
Unskilled laborers.....	89"

Environment of gifted child.-- The environmental status or home setting in which the child is growing and receiving his home training is mentioned.[2] "The great majority of them [gifted children] are born of parents who maintain comfortable or luxurious homes and...very probably the city yields more of them than does the country."

Personal characteristics of the gifted child.-- Personality may influence others to accept or reject children. Hollingsworth collected some data on the personal characteristics of the gifted child which she describes as follows:[3]

"We may summarize present data about the physique of the intellectually gifted children by saying that they tend to be tall and heavy and to maintain a high

1/ Ibid., p. 55.

2/ Ibid., p. 59.

3/ Ibid., p. 110.

> ratio between weight and height. In so far as this weight-height indicates nutrition, they are very well nourished as a group. However, it must not be forgotten that there are a few small, thin children among them."

Summarizing the personality of the gifted child under a heading of character, temperament and interests, the study says:[1]

> "The facts chiefly to be remembered about the character and temperament of gifted children...are rated above average in traits of character which make desirable citizens; usually underestimated by their parents and themselves;...rate above average in nervous stability...named as leaders more frequently than chance would allow...greatly interested in play... choose playmates of their own mental age...discrepancy between physical size and intelligence becomes so great as to render satisfactory choice of playmates difficult...often falls back on some form of solitary play, like puzzles, calculations, reading, chemical experiments, radio and the like.... Nearly all gifted children love to read and will read anything they can find. Discipline of the gifted may be accomplished by appeals to reason, by hero-worship, by presenting other people's point of view, and by constantly giving merit its just reward."

Talents and abilities of the gifted child.-- People frequently state that gifted people become artists or musicians because they have always had these talents. Hollingsworth reports that[2] "....generally unrelated capacities have been designated special talents. An intellectually gifted child may be of any status whatever in respect to one of these special talents for they are independent of general intelligence." But she further goes on to state contrariwise:[3]

1/ Ibid., p. 147.

2/ Ibid., p. 29.

3/ Ibid., p. 210.

"It is an unsettled question whether a person of low general intelligence can be highly gifted in arithmetic.... As for mathematical ability, including not only ability to calculate, but to solve problems, think in symbolic terms, and master the principles of algebra, geometry and other branches of mathematical science, there is no question but that it is not found in stupid persons. Between mathematical ability and I. Q. the correlation is extremely high."

School environment of gifted child.-- One might pause to wonder just what kind of teacher, teaching methods and school environment, in general, would be best to educate the gifted child. Hollingsworth has this to say of such influencing factors:[1/]

"The teacher must be free from unconscious jealousy...impersonal interest in educational problems, and have the ability to maintain an unbiased attitude even toward pupils whose grasp may in some instances exceed her own. Other personal traits are sense of humor, patience, love of truth for its own sake. The teacher should be a person of superior intelligence in order to gain and hold the respect of gifted pupils...should be well educated...wide range of information at his command if resources in this respect are not to be under a constant strain."

Teaching methods.-- Modification of teaching methods:[2/]

"It is generally agreed...certain modifications of methods are desirable...drill should be markedly reduced.... Gifted minds are especially amenable to instruction by the project method.... In recitation, the method of seminar is feasible even for very young gifted children, and is much enjoyed.... Projects in learning are particularly appreciated in which topics or parts can be assigned to individuals or groups who then report comprehensively to the class. However, certain features of equipment are particularly important for the gifted. Chief among these is a special library...dictionaries, collections...tables and

1/ Ibid., pp. 306-313. 2/ Ibid., p. 308.

> shelves...microscopes, piano, and a 'round table'... bulletin board...pictures on the walls...movable seats and desks...globes and phonographs.... In consideration of their liking for typewriters, one of these adds notably to classroom equipment.... Others can conserve, but only the gifted can originate. Therefore, should not the education of the gifted be education for initiative and originality? Originality depends first of all on knowledge of what has been done previously and of how it has been done. To take their places in civilization, therefore, it would seem that the intellectually gifted need especially to know the 'History and Evolution of the Life of Civilized Man.'"

The Terman and Oden study.-- Another study of the gifted child was done by Terman and Oden who state:[1]

> "Of the total 1,528 subjects 1,070 (70%) were selected for the study by the Stanford-Binet, 420 by the Terman Group Test, 24 by the National Intelligence Test, and 6 by the Army Alpha. The mean I. Q. for the Stanford Group is 151 - 10.6. The mean I. Q. for the Terman Group is 142.6 - 4.8.... The standard set was purely arbitrary and was intended to insure that the subjects included for the study should be in the highest one per cent of the school population in general intelligence as measured by the tests used."

Terman and Oden have here defined the gifted child and the subjects of their study.[2]

Influence of the family.-- They proceed further to describe in detail the gifted child. Relative to the influence of the family:[3]

> "Three fourths of the parents of our subjects were born in urban or semi-urban communities.... Classification of the occupation of fathers into the five grades of Taussig's scale gave:

1/ L. M. Terman and M. H. Oden, "Genetic Studies of Genius," Vol. IV, The Gifted Child Grows Up, Stanford University Press, Stanford, 1947, pp. 11-12.

2/ Ibid., p. 5.

3/ Ibid., p. 15.

Class I	Professional.....	31.4
Class II	Semiprofessional and business.....	50
Class III	Skilled work.....	11.8
Class IV	Semiskilled work and	
Class V	Unskilled labor.....	6.8"

1/

Also:

"The mean schooling of both fathers and mothers was twelve grades.... One third of the fathers and 15.5 per cent of the mothers had graduated from college.... The number of books in the home library as estimated by parents ranged from 6000 with a mean of 328. Only 6.4% reporting 500 or more.... Information on family income (as of 1921) was requested...these reported as follows:

4.4%	of	the	families	reported	$ 1,500	or	less
35.3%	"	"	"	"	2,500	"	"
average	"	"	"	"	4,705	"	"
14.0%	"	"	"	"	8,500	"	more
4.1%	"	"	"	"	12,500	"	"

2/

Further:

"The median was $3,333 which was twice as high as for the generality of families in California....

The incidence of parental divorce or separation is of interest in this connection. Up to 1922 the percentage of parents who have been divorced was 5.2% and of those separated 1.9% making a total of 7.1%. The incidence of broken families was definitely below that for the general population of comparable age in California in 1922 and has remained below since that date.... As a result of the combined influence of inheritance and environment the typical member of our group is a slightly better physical specimen than the average child of the generality....3/ Educationally the average gifted child is accelerated in grade placement about 14% of his age but in mastery of subject matter he is accelerated 44% of his age, thus...during the elementary school period they were kept at school tasks two or three full

1/ Ibid., p. 16.

2/ Ibid., p. 17.

3/ Ibid., pp. 55-56.

grades below the level of achievement they had reached...."

Interests of gifted children.-- Regarding the many-faceted interests of gifted children:[1]

"The interests of gifted children are many sided and spontaneous. They read easily, more and better books and largely educate themselves. The two months reading record kept by the children showed the average gifted child reading 10 books by age 7 and 15 by age 11, with little increase after 11. Few of the control group reported reading any books below 8 years and after 8 years the average reported for two months ranged between 40 and 50% of the average for the gifted. At the same time they make numerous collections and acquire far more knowledge of plays and games than the average child of their years.... Perhaps the most significant thing about the play preferences of gifted children is that they reveal a degree of interest maturity two or three years beyond the age norm...."

Character tests showed.-- Additional information was acquired from a series of character tests demonstrating:[2]

"A battery of character tests showed gifted children above average in every one. As compared to unselected children they are less inclined to boast or overstate their knowledge; they are more trustworthy... their reading preferences, character preferences and social attitudes are more wholesome; and they score higher on emotional stability. On total score of character tests the typical gifted child of nine years tests as high as the average child of twelve. The proportion of gifted subjects rated superior to unselected children of corresponding age was:

89% for 4 intellectual traits
82% for 4 volitional traits
67% for 2 aesthetic traits
64% for 4 moral traits
61% for 2 physical traits
51% for 5 social traits."

Deviation shown by composite portrait of gifted child.-- Summarizing the whole picture Terman and Oden conclude

1/ Ibid., p. 39.

2/ Ibid., p. 56.

that [1]

> "There are two facts that stand out clearly in the composite portrait: The deviation of the gifted subjects from the generality is in the upward direction for nearly all traits.... The amount of upward deviation is not the same in all traits.... Gifted children do not fall into a single pattern but into an infinite variety of patterns. One can find within the group individual examples of almost every type of personality defect, social maladjustment, behavior problem, and physical frailty; the only difference is that among gifted children the incidence of these deviations is, in varying degrees, lower than in the general population."

Significant follow-up study by Terman and Oden.-- Six years later (1927-28) a follow-up was performed on this group with results that are quite significant to the present writer's study for they apply to the high-school years. The results reported are as follows: [2]

> "Perhaps the most important outcome of the 1927-28 follow-up was the fact that the composite portrait of the group had changed only in minor respects in six years. As a whole the group was still highly superior intellectually, for the most part within the top 1% of the generality.... The showing in school achievement was in line with that for intelligence. There was less skipping of grades after the age of 11 or 12 years, but the quality of work for the group in general remained at an exceedingly high level. For example, nearly two-thirds of the high school grades of the girls and more than one half of the high school grades of the boys were A's. The significance of this is accentuated by the fact that the gifted group in the high school period averaged considerably younger than the generality of high school students."

Acceleration of the gifted child.-- The authors considered the whole problem of acceleration of the gifted

1/ Ibid., p. 57.

2/ Ibid., p. 64.

child and concluded:[1]

> "It is our opinion that children of 135 I. Q. or higher should be promoted sufficiently to permit college entrance by the age of 17 at latest and that a majority in this group would be better off to enter at 16. Acceleration to this extent is especially desirable for those who plan to complete two or more years of graduate study in preparation for a professional career."

Comparative success of subjects.-- The authors realized that there were possibilities of discovering those characteristics associated with vocational success. As children the subjects were all above the 99th percentile in I. Q. distribution; after twenty years they ranged considerably in vocational success. Terman and Oden proposed to read the careers of these men in reverse, so to speak. The plan was to compare the most successful with the least successful and then discover what variables discriminate between these two groups. The study was limited to men:[2]

> "The judges examined the records of 730 men who were 25 years of age or older from whom information on vocational status in 1940 was available and from these they selected the 150 most successful (A group) and the 150 least successful (C group).... In the classification that followed the A's included all the men listed in Who's Who or American Men of Science, a large majority of those who were teachers above the rank of instructor in universities or superior colleges, the men who were outstandingly successful in law, medicine, engineering, or business and a few who achieved most in literature, art, motion pictures of radio.... The C group is not composed of failures. It includes... unemployed, skilled trades, semi-skilled trades, clerical, minor business positions, civil service jobs, and some professional, semi-professional and managerial whose

1/ Ibid., p. 281.

2/ Ibid., p. 313.

records of accomplishment were among the least impressive among gifted subjects in such occupations."

A comparison of the A and C groups covers many pages in the reports. For economy of space it will be condensed in so far as possible:[1/]

Table 3. Comparisons between Groups A and C of 730 Men Who Were Gifted Children

Characteristic	Group A	Group C
(1)	(2)	(3)
Age:.....	Mean 30.8 yrs.	31.0 yrs.
Occupation:.....	Per cent	Per cent
Group I.....	68	9.3
Group II..... semiprofessional managerial.....	30.6	7.3
Group III..... clerical or skilled trades.....	0	48.6
Group IV (agriculture)...	0	1.3
Group V..... semi-skilled minor.....	0	22.0
Group VI..... slightly skilled.....	0	4.0
Student.....	.67	2.0
Unemployed.....	0	4.0
Incapacitated.....	0	.67
Unclassified.....	0	.67
Monthly earned income		
Mean.....	$387	$144.25
Range.....	$150-$1500	$ 50.00-$300

(concluded on next page)

1/ Adapted from ibid., pp. 315, 316, 318.

Table 3. (concluded)

Characteristic	Group A	Group C
(1)	(2)	(3)
Amount of education:.....	Per cent	Per cent
Doctor of Philosophy.....	33	1
Master's degree.....	25	3
Law degree.....	23	4
Doctor of Medicine.....	16	0
Bachelor of Theology.....	1	0
College graduation.....	90	37
One or more years P.G.....	76	14
One to four years - not graduated.....	7	31
High school plus special work.....	2	12
High school only.....	0	18.7

Deviation in high school.-- It was not until the two groups were going through high school that their records began to show a wide deviation. In the elementary grades there was no statistical difference between their performance or characteristics. We see that [1]

> "It was not until the high school period that the groups began to fall apart with respect to achievement. By the end of high school the difference had become very marked, for 95% of the A's had earned 15 or more recommended units as compared to 67% of the C's. At the college level the difference was still greater: fewer C's went to college and the average grades of those who did were relatively low.... At all educational levels the A's were reliably more accelerated than the C's. On the average they completed the eighth grade 4.8 months earlier, high school 9.6 months earlier, college 15.6 months earlier."

1/ L. M. Terman and M. H. Oden, op. cit., p. 320.

Analysis of vocational interests.-- An examination of the vocational interests gave a valuable clue:[1]

> "Of the 83 A's, 72.3% received an interest rating of A in their own vocation as against a marked rating of 52% for the 48 C's.... Strong has found that few men are successful in a vocation in which they scored a 'B-' or lower. These differences suggest one factor in the relative lack of success in the C group, though possibly not a major one, is that more of them are vocationally misplaced."

Avocational interests.-- Further study of the avocational interests was of less value and demonstrated[2]

> "There were few differences, none very reliable, in the population of A's and C's mentioning specific avocational interests. For example: sports were mentioned by 57.9% of the A's and by 50% of the C's; photography was mentioned by 32.4% of the A's and by 19.8% of the C's; reading or study was mentioned by 17.2% of the A's and by 13.5% of the C's. Strength of interest ratings showed the two groups to have equal interest in outdoor sports, religion and domestic arts. Higher mean ratings were given by A's on travel, science, music and art. The means were slightly higher for the C's on mechanics and pets. There was no field in which the mean was reliably higher for the C group but the means of A's were reliably higher for politics, social life and literature. These ratings suggest a greater breadth of interest among the A subjects and particularly more interest in politics, social life and literature."

Significant differences in family background.-- Additional examination of the family background of the two groups showed some significant differences:[3]

> "The occupational status of the family background of the fathers showed a marked contrast between the

1/ Ibid., p. 324.

2/ Ibid., p. 331.

3/ Ibid., p. 332.

two groups. In 1922 the fathers in Class (professional) Group I in A was 38% and in C was 18.5%; Classes IV to VII the A's were 25.3% and in the C's were 33.1%; deceased for Group A was 23% and for Group C was 38%."

Educational difference.-- The difference in parental education of the groups was even greater than the occupational classification:[1/]

Table 4. A Comparison of the Parental Education between Groups A and C of 730 Men Who Were Gifted Children

Parent: education	Group A Per cent	Group C Per cent
(1)	(2)	(3)
Father:		
College graduation or beyond.....	50	15
Less than high school graduation.....	32	57
Eighth grade or less..	15	29
Mother:		
College graduation or beyond.....	18	11
Less than high school graduation.....	38	60
Eighth grade or less..	10	26

Home library facilities.-- In a comparison of books in the home library the mean for A's was 427 books and for C's was 290 books.

Parents' marital status.-- The comparison of Group A

1/ Ibid., p. 333.

and C as to marital status of parents was:[1]

> "The incidence of separation or divorce in 1922 and 1928 was about twice as high for C parents as A parents. For both groups the incidence almost doubled between 1922 and 1928 and in 1940 was still much higher for C than for A parents.... The unstable marriage may be largely a symptom of ineffective social adjustment in general."

Social acceptance.-- Social adjustment was measured in another way:[2]

> "In 1940 the married subjects who were given the test of marital happiness were asked to report information on the various kinds of clubs or social organizations to which they belonged. Their response":

Table 5. Comparison in Their Social Memberships between Groups A and C of 730 Men Who Were Gifted Children

Organization	Group A Per Cent	Group C Per Cent
(1)	(2)	(3)
Labor union.....	6.4	42
Social club.....	48.7	29
Church club.....	43.6	30
Luncheon club.....	19.2	11.6

Personality.-- Traits of personality were measured by wives and selves and also by field workers. The results were significant:[3]

> "We may repeat the outstanding fact...is the marked agreement among the different sets of judges

1/ Ibid., p. 333.

2/ Ibid., p. 337.

3/ Ibid., p. 341.

with regard to four sets of traits which best discriminate between A and C men. These are: integration toward goals, perseverance, self confidence, and absence of inferiority feelings."

The field workers' ratings showed that

"There were seven traits which yielded very high critical ratios of differences between A and C men. They were in order of magnitude: appearance, alertness, poise, attractiveness, curiosity, originality and attentiveness. Traits only slightly below these in reliability of difference in favor of the A's were speech and friendliness."

Terman and Oden summarize the differences between the two groups.-- In summation of the differences between Groups A and C the authors conclude:[1]

"Turning to the childhood records and test scores of the two groups we note first that during the elementary school years the A and C groups were almost equally successful.... In high school the groups began to draw apart as a result of lower grades in the C group, but it was not until the college period that the slump of this group assumed alarming proportions. The slump cannot be blamed on extra curricular activities for these were almost twice as common among the A's as among the C's.... The family background of the two groups differed markedly.... The important point here is that the educational tradition was strongest in families of the A group.... Evidence of social maladjustment in the C group increases steadily with the years. Both in high school and in college, leadership was far more often displayed by members of the A group .... Everything considered, there is nothing in which A and C groups present a greater contrast than in drive to achieve an all around social adjustment...in short with well balanced temperament and with freedom from excessive frustration.... At any rate, we have seen that intellect and achievement are far from perfectly correlated. Why this is so, what circumstances affect the fruition of human talent, are questions of such transcendental importance that they should be investigated by every method that promises the slightest

1/ Ibid., p. 350.

reduction of our present ignorance. So little do we know about our available supply of potential genius, the environmental factors that favor or hinder its expression, the emotional compulsions that give it dynamic quality or the personality distortions that make it dangerous."

3. Science Students

Science interests and activities of students.-- In 1940 Herbert S. Zim reported a study in which he probed the science interests and activities of students in grades 7 through 12.[1] His study is of particular interest at this time because it was performed on 230 boys and girls from several public and private schools in New York City. These young people all participated in Science Fairs. They voluntarily prepared and submitted exhibits. At the close of the Fairs in 1936 and 1937 questionnaires were sent to all who had participated. Then in the words of Zim:[2]

"From the data in these questionnaires an attempt has been made to picture activities and characteristics of young people who are interested in some phase of science.

The number of replies received from exhibitors at the fair was as follows:

	1936		1937	
Grades	Boys	Girls	Boys	Girls
7, 8, 9,	53	6	39	3
10, 11, 12	44	16	55	14
Total	97	22	94	17

This data gathered from 191 boys and 39 girls (230) is of unusual interest.... It is expected that this

1/ Herbert S. Zim, Science Interests and Activities of Adolescents, The Ethical Culture Schools, New York, 19 , p. 256.

2/ Ibid., p. 129.

> data will give some clues as to the role of the science interest in the lives of the exhibitors. This picture cannot be complete. It must be synthesized from the answers to...questions. It must be inferred from the wording of the replies...."

Characteristics of science-interested students as reported by Zim.-- The author has reported what appear to be characteristics of science-interested students and some activities in which they engage. Parts of his findings will be reported in an effort to show the relationship between these students and the gifted student. In the conclusion of his study of Science Fair participants he states:[1]

> (Family History) "The adolescent interested in science may come from a variety of social or economic backgrounds. His interests may have no relation to the family background or the occupations of his parents. Family conditions may be such that the adolescent soon realizes that he cannot carry on his education to the extent he desires and that he must compromise both his vocational ambition and his hobbies.... They may work alone or with a friend. Often this work goes on in spite of the objections of distracted parents who are unaware of its significance to their children."
>
> (Personality) "In many ways the science interested adolescents appear to be normal growing young people who exhibit the same pattern of behavior and have the same problems, fears and needs as other young people. Even within the area of science there are many similarities between all adolescents.... Those interested in science and those who are not wonder about similar scientific topics."[2]
>
> (Associates) "They may work science activity alone or with a friend.... Their heroes are mostly scientists and it is frequently that the emulation of these men has guided their activities."
>
> (Activities) "The most outstanding characteristic

1/ Ibid., p. 150.

2/ Ibid., p. 149.

is that the interested adolescent works long and continuously on the topic which has his interest. He gives freely of his time and energy often to the extent of curtailing other desirable activities. He prefers school subjects associated with his interest.... Science is preferred by these adolescents.... These adolescents spend a great deal of time in the science laboratories outside class hours. They assist the teachers, work on special projects, or just 'hang around.' Often they are members of 'laboratory squads'...these adolescents are members of science clubs. Frequently they are elected to office and take on additional responsibilities in this regard. At meetings they give talks and demonstrations, prepare exhibits, participate in research projects.... Many carry on their work at home or in clubs connected with museums and other organizations .... They are constantly 1/ reading scientific books and magazines, visiting museums, taking field trips. Many find the opportunity to build a laboratory or work bench at home."

(Science teacher) "These adolescents feel that their science teachers are the ones who help them most with their interest. This help and guidance are often of vital significance to the adolescent. Others beside the science teacher give assistance but usually in a minor role outside the school."

(Interests and hobbies) "The interested group like all adolescents have a wide range of other interests beside the one which makes them 'interested in science.'"

(Decision to be a scientist) "The ambitions, hopes, ideals and wishes of these young people are affected by their interest in science. Many express a strong urge to benefit mankind through their participation in some branch of science. They feel that science can accomplish great things in the future and that it can do much to improve the conditions of man."

Now we come to one of the most important findings of this study, for according to Zim 2/

"Most of the adolescents who are interested in science have become interested before the age of 12

1/ Ibid., p. 150.

2/ Ibid., p. 150.

> and have been persistently interested since. They do not usually shift from one field of science to another. Both boys and girls collect scientific specimens and tend to develop their collections over several years. These young people do not exhibit a general interest in science. The focus of their attention is directed at specific topics or problems which they are trying to understand and with which they desire to experiment.... The interest in science which differentiates these adolescents from others brings with it deeper and different satisfactions than other adolescents may feel. It may bring the adolescent closer to adult life in some respects."

Study by Mallinson and Van Dragt compared to the Zim study.-- A very interesting situation arises when a comparison is made of the study by Zim with that of George Mallinson and Harold Van Dragt.[1/] In this study 240 students in grade 9 were given Kuder Preference Tests. Again, after grade 12 was nearly finished, they were given a repeat test. The study compared the science and mathematics on both testings and found as follows:

> "....the following implications seem reasonable. 1. The data indicates that to a great extent if interest in science or interest in mathematics ranks high in Grade IX it is still likely to rank high in Grade XII. However, one is not justified in assuming that it will remain in the same rank. Students who are guided into science in Grade IX...may find themselves more interested in music, social study or some other study in Grade XII. 2. Over-all predictability is not high in so far as scores or ranks at Grade IX are related to those at Grade XII. Coefficients of alienation are greater than correlation. 3. This study fails to substantiate claims that interest is likely to be a reliable predictor of talent in individuals."

1/ George Mallinson and Harold Van Dragt, "Stability of High School Interest in Science and Mathematics," School Review (September, 1952), 362-367.

Study that covers a whole generation by Harrington.-- A very practical study was reported by E. R. Harrington. Here is the experience of a classroom teacher that covers a period of a whole generation. He states:[1/]

> "After I had been teaching I had a chance to make some observations on the subject, and I soon began to doubt the oft-heard statements which had placed the professional man's children in a higher scholastic bracket than the children of tradesmen.
>
> During the 19 years of the study I have had 4500 students in my classes of physics, chemistry, meteorology, air navigation and geology. During that time 420 have been listed with a grade of A. From the school records we determined the parent's profession.
>
> These conclusions to the study can be drawn. It is apparent that (family history) intelligence, and the will to use it are in no way monopolized by any one economic or social group. Not all students get an education geared to their capacity. A number fall by the wayside. Some compromise to lesser goals.
>
> Our chief resource is our people. It is poor economy to deny education to those who could really handle it. Scholarships are too little so the student cannot afford them. We as a people give more money to athletics than to scholarship. In the atomic age we shall need all the bright young people we have. The time is short and we had better look down the road that once great nations have traveled in the past. We had better look while we still can."

Science adjustments as criteria.-- Schools and teachers have long associated science with mathematics. A search of the literature also suggests a close association of these two subjects. It may be that in these activities "things equal to the same things are equal to each other." A study

1/ E. R. Harrington, "Who Made That A in Science," The American School Board Journal (August, 1949), 119:2.

by Lenore B. Schmitt,[1/] who examined the background factors of 150 high-school senior boys and girls who were in the college course and had elected senior-year mathematics, contrasted this with another group similar in every way except that they had not elected mathematics. Items of particular importance to this study have been marked by a star. The data for this table have been selected from different portions of her study but in such a way that the truth is unimpaired:

Table 6. Comparison in Background Factors between Two Groups of High-School Students: Those Who Did and Those Who Declined to Elect Mathematics

The Factors	Mathematics Group Per cent	Non-Mathematics Group Per cent
(1)	(2)	(3)
Family History:		
Religious faith:		
Protestant	28.8	★ 47.7
Jewish	14.4	6.0
Catholic	14.4	★ 39.3
Others	4.5	12.0
Marital Status:		
Married (still)	91.0	86.6
Separated or divorced	1.8	6.7
Father's occupation		
Mathematics	11.7	7.3
Science	6.3	1.3
Other	82.0	89.4
Professional	★ 27.9	13.3
Business manager	28.0	21.3
Business manufacturer	10.8	8.7
Skilled	13.5	14.7
Supervisor	6.3	8.7
Buying and selling	9.9	8.0
Unskilled	11.7	★ 22.3
Father owns his business	★ 38.7	22.7

(continued on next page)

1/ Lenore B. Schmitt, An Investigation into the Backgrounds of Senior High School Students to Discover Factors in the Backgrounds of Girls Who Elect Mathematics, Unpublished Master's Thesis, Boston University, 1948.

Table 6. (continued)

The Factors	Mathematics Group Per cent	Non-Mathematics Group Per cent
(1)	(2)	(3)
Father's Education:		
Beyond college	8.1	0.0
College graduate	★ 30.6	24.0
Beyond high school	1.8	2.0
High school	23.4	★ 50.7
Elementary	27.9	19.3
None	1.8	2.0
Foreign	2.7	0.0
Mother's Education:		
Beyond college	1.8	0.0
College graduate	26.4	19.3
Beyond high school	.9	3.3
High school	43.0	50.0
Elementary	25.5	22.0
None	0.0	4.0
Foreign	0.0	0.0
Father's College Major:		
Science - Medicine	6.3	3.3
Engineering - Mathematics	★ 17.3	6.0
Law	3.6	2.0
Education	.9	1.3
Mother's College Major:		
Science - Medicine	2.7	0.0
Engineering - Mathematics	1.8	.7
Law	0.0	0.0
Education	5.4	1.3
Language	2.7	.7
Social Studies	3.6	1.3
Home Economics	1.8	5.3
Siblings of Respondent:		
Brothers (none)	★ 40.5	30.0
Brothers (one)	39.6	40.0
Sisters (none)	44.2	43.3
Sisters (one)	39.6	36.0
Family Hobbies:		
Sewing	35.1	★ 50.7
Cooking	10.8	5.3
Mechanics - craft	19.8	24.7
Social clubs	★ 18.9	6.0

(continued on next page)

Table 6. (continued)

The Factors	Mathematics Group Per cent	Non-Mathematics Group Per cent
(1)	(2)	(3)
Family Hobbies: (continued)		
Arts	29.7	22.0
Photography	✱ 18.9	4.7
Games	18.9	10.0
Dancing	3.6	9.3
Nature	.9	3.3
Foreign Language at Home:		
Russian	1.8	0.0
Jewish	7.2	0.0
German	1.8	0.0
Polish	2.7	0.0
French	1.8	3.3
Greek	2.7	10.0
Italian	.9	0.0
Portuguese	0.0	1.3
Student activities:		
All subject grades:		
A or B	✱ 45.9	✱ 30.0
C, D, or F	49.6	✱ 61.4
Not given	4.5	8.7
Mathematics grades:		
A or B	✱ 71.2	46.8
C, D, or F	22.5	✱ 43.1
Not given	6.3	10.1
Science elected two years	✱ 72.8	51.4
Foreign language courses taken:		
None	7.2	8.0
One	36.0	34.7
Two	54.0	54.0
Three	2.7	3.3
Course in which most time spent:		
Mathematics	✱ 59.5	14.0
Science	48.7	42.7
Social studies	35.2	28.7
English	21.6	✱ 64.7
Language	13.5	18.0
Commercial	11.3	10.0
At school:		
Sports	✱ 47.8	32.7

(continued on next page)

Table 6. (continued)

The Factors	Mathematics Group Per cent	Non-Mathematics Group Per cent
(1)	(2)	(3)
At school: (continued)		
Honor	36.0	13.3
Student government	13.5	8.0
Photography	3.6	.7
Mathematics	12.6	0.0
Language	11.7	26.0
Music	18.9	28.0
Science	18.9	20.0
Social	10.8	16.7
Arts	1.8	3.3
Jobs held by respondents:		
Clerk	28.8	46.7
Baby sitter	1.8	13.3
Office	8.1	12.7
Hospital aid	0.0	2.0
Camp	14.4	7.3
Unskilled	18.9	8.0
Skilled	11.7	6.0
Tutor	4.5	0.0
Laboratory	.9	0.0
Books read per month:		
None	18.0	22.0
1-2	58.5	46.0
3-4	10.8	17.3
5-6	7.2	5.3
More	1.8	4.0
Attendance at dances and parties:		
0 times a month	9.9	5.3
1-2 times a month	42.4	28.7
3-4 times a month	30.6	36.0
5-6 times a month	9.0	14.7
7-8 times a month	1.8	2.7
9-10 times a month	.9	1.3
More times a month	0.0	2.7
Hobbies and interests:		
Collecting	62.2	44.7
Crafts	34.2	14.7
Arts	36.0	30.0

(continued on next page)

Table 6. (continued)

The Factors	Mathematics Group Per cent	Non-Mathematics Group Per cent
(1)	(2)	(3)
Hobbies, interests: (continued)		
Gardening	7.2	1.3
Science	8.1	1.3
Photography	✱ 17.1	6.0
Magic	2.7	0.0
Reading	18.9	25.3
Sewing	6.3	✱ 22.7
Social	2.7	4.0
Games	1.8	6.0
Dancing	8.1	✱ 24.7
Dramatics	0.0	2.7
Debates	.9	1.3
Language	0.0	0.7
Social work	0.0	1.3
Occupational choice and intentions:		
Future education:		
College	✱ 99.1	80.7
Business school	0.0	5.3
Vocational school	0.0	1.3
Work	0.9	5.3
Armed forces	0.0	3.3
Nursing	0.0	2.0
College Major selected:		
Liberal Arts	19.8	14.7
Science or Engineering	✱ 34.2	5.3
Medicine or Dentistry	15.3	16.0
Business	11.7	12.7
Education	5.4	12.7
Junior College	2.7	4.7
Undecided	9.0	12.7
Vocational aims in major field:		
Mathematics	✱ 14.4	3.3
Pure and applied science	10.8	5.3
Medicine and Nursing	8.1	13.3
Others	36.0	✱ 48.0
Vocational aims in specific job:		
Undecided	11.7	9.3
Engineer	✱ 11.7	1.3

(concluded on next page)

Table 6. (concluded)

The Factors	Mathematics Group Per cent	Non-Mathematics Group Per cent
(1)	(2)	(3)
Vocational aims in specific job: (continued)		
Medicine	7.2	4.7
Lawyer	4.5	0.0
Business man	8.1	6.7
Accountant	2.7	2.0
Scientist	6.3	0.7
Educator - Teacher	5.4	11.3
Nurse	0.9	8.0
Secretary	0.0	8.0
Salesman	0.9	1.3
Journalist	0.9	2.0
Laboratory Technician	0.9	2.7
Music and Art	0.0	4.7
Pharmacist	0.0	1.3

Data from a high school of science.-- Morris Meister has been principal of the Bronx High School of Science for many years. He has kept careful records and follow-up progress notes on pupils after graduation. In many ways this school and its students represent an ideal teaching-learning situation for science. Here in brief is a picture of its students and its staff over the years as reported by Meister:[1/]

"The upper segment of high school students find in

1/ Morris Meister, "A High School of Science for Gifted Students," The Gifted Child, Chap. 10. Edited by Paul Witty for the American Association for Gifted Children. D. C. Heath and Company, Boston, 1951, p. 219.

the appropriate special school a realization of purpose which they cannot find in the general high school. They can do the work required in the general high school in much less time than it takes the other students. When this extra time is not wasted it is rarely employed at levels which bring the maximum return. In a specialized high school this extra time is used to better advantage. For example in a high school of science the students are those who have demonstrated a more-than-passing interest in science and who will later become physicists, doctors, engineers, chemists, biologists, psychologists, research workers and the like....

Typical student profile.-- Here then is a brief and generalized profile of a typical student in the High School of Science.2/ His parents may come from any one of many economic levels and be engaged in one of many types of work or professional activities. In any event they are keenly interested in his school and in his progress there....

(Personality) He wants to go to college and make science his career; however, he is not too definite in his interest. He is a year younger than the average high school student of the same grade; but he knows the fundamentals of arithmetic and spelling. He reads extensively in many kinds of books and periodicals. He is alert to current issues and is capable of profound loyalties.... He spends much spare time in his home laboratory and on other hobbies. Because he is eager and vocal he is difficult to control in class.... He has achieved an early sophistication in the importance of marks and is aware of short cuts to high grades. His mental and physical health is excellent. He welcomes the advent of girls with typical adolescent enthusiasm. Though young, he is proficient in athletics, participating in and supporting basketball, soccer, swimming, baseball, tennis, handball and track. He may work after school and during the summer. He joins many clubs. His I. Q. is exactly at the median for the school; it is 140! He offers his teachers the greatest possible challenge, spiritually and professionally.

The extra curricular work in the High School of Science occurs both during school hours and after; within the school building as well as outside.... A

1/ Ibid., p. 222.

large number of school clubs concentrate their interests in related science activities such as: radio, aeronautics, mathematics, bacteriology, engineering, natural history, architecture, astronomy, seamanship, the science explorers club of the freshman year and others. Nevertheless, the spontaneous interest in the humanities reflects the broadest scope of the school's objective. Large groups of boys are attracted to the Creative Writing Club, the Dramatic Society, the staff of Science Survey (the school newspaper), the Forum, the school orchestra and chorus, the Chess Club, the language societies, as well as the athletic teams. Included, too, in extra curricular activities are the large number of 'squads' that serve in the functioning of departmental offices, libraries, laboratories, preparation rooms, supply depots, gymnasium and medical rooms and school offices."

Career categories.--

"Surveys,[1] interviews and follow-up questionnaires have shown that students in the High School of Science are interested mostly in careers that fall roughly into the categories of medicine, engineering, dentistry, science research, allied technologies, teaching, pharmacy, mathematics, biology, chemistry and physics. Nevertheless there are some who ultimately enter business, law, journalism, accounting and other fields."

Qualifications of the teacher of the gifted child.--

"(The Science Teacher) Nevertheless, not all the present faculty are equally suited for the task of guiding gifted children.[2] In this connection we wish to endorse the point of view of the N. E. A. Policies Commission that the qualities especially needed in a teacher of gifted children are: superior intelligence, a rich fund of information, versatility of interest, an inquiring mind, ability to stimulate and inspire, modesty, a sense of social and professional responsibility, freedom from jealousy, freedom from excessive sensitivity to criticism, understanding of educational psychology, with special knowledge of the psychology of the gifted children. To these we would add a love for

1/ Ibid., p. 224. 2/ Ibid., p. 227.

and understanding of the adolescent and mastery of the subject matter. While all high school teachers should possess most, if not all, of these qualities, the lack of any one of them is a distinct handicap to a teacher of the gifted."

Departmental success.-- Paul F. Brandwein of Forest Hills, New York, has made several contributions to the partial solution of the problem of the embryo scientist. His first contribution states:[1/]

"In an earlier paper a plan was set forth wherein young people on the high school level were given the opportunity to develop their interest in science....

Since 1945 when the first group of students trained in the program...were graduated, 13 of these 52 students have been Finalists and 21 have been awarded Honorable Mention in the Westinghouse National Science Talent Search....

Preliminary indications as far as the Westinghouse Science Talent Search is concerned are that the 34 'winners' (finalists and honorable mention) of the 52 have yielded no more individuals to scientific research than the 21 who did not 'win'...."

Questions "science talent" as a quantity.--

"The writer's hypothesis is that there is no such quantity as 'science talent' but that very high intelligence (as measured by high I. Q., high mathematical ability, high verbal ability) coupled with an environment favorable to interesting work in science, may produce the individual who is successful in scientific research....

It is quite clear from a study of the 52 students that theirs was a variety of interests as far back as their memories go. Only 24 of the 52 indicated that their interest in science went back before the age of 14. Ten had no recollection that their science interest

1/ Paul F. Brandwein, "Selection and Training of Future Scientists--II, Origin of Science Interests," Science Education (December, 1951), 35:251-253.

was more important than any other interest; 18 indicated that a major interest in science had been really awakened by the opportunities in high school.... There is a good indication that for many of the students prior to the age of 14, such activities as sports, music, general reading, art were of equal or of greater interest.

But as they began to select vocational interests, the opportunities available for exploration of these interests and their success (honors) played a greater part in choosing their interest of greatest concentration in this case - science....

It may be that further study will lend support to the writer's present conception of the situation, namely, that in our present society, youngsters before 14 are interested in science much as they are interested in sports, or music, or reading, or collecting stamps. Then as they get into high school or college, their teachers, the opportunities for prosecution of scientific work and their success in science, determine, at least in part, who will go into science....

Furthermore each one of these students was clear in his notion that some adult had kindled and maintained his interest in science: 14 of the 52 named parents, relatives or friends; 38 names school teachers ....

From a preliminary study it is also clear that certain teachers are much more successful in kindling science interests than others. The students in this study were consistent in mentioning the same teachers time and time again.

This preliminary study of original science interest indicated that, given proper opportunity and specially trained teachers, the high school can stimulate and sustain the science interest of qualified students. There is no indication at the present state of the investigation that there is a special 'science talent' per se. There is every indication that young people with 'science potential' can be recognized early in their high school careers...."

The "science potential."-- Brandwein also observes that:

"Four PATENT FACTORS seem to affect the origin of interest in science in students with 'science potential': (1) high intelligence of the type which results

in high success on tests of intelligence and of mathematical and verbal skills, (2) well trained teachers, (3) the opportunities for work in science, (4) success in science over and above success in other intellectual or artistic endeavors.

A latent factor which seems to be present is a science interest early in youth.... Whether there is another latent factor to be called 'science talent' remains to be determined and defined by continued investigation as do, indeed, the preliminary and tentative summarizations made here."

Further hypothesis.-- A second contribution of Paul Brandwein concerns his "Hypothesis on the Nature of 'Science Talent.'" He appears to be unwilling to accept "science talent" as a high-level ability that is unrelated to any other human ability. He says:[1/]

"In the attempt to clarify problems which would be useful in determining the direction of investigations on the nature of the high level ability which has been called 'science talent' one is struck with the paucity of published observation which would serve to define the trait, if indeed, there be one.... Be that as it may, to investigate a trait, or better an element in behavior which we may call 'science talent' we need to be able to define it so that we may observe it.... We are on relatively safe ground to begin with if we admit that we are operating in an ambiguous area, that an investigator may at least state his hypotheses to his own satisfaction provided they are not ambiguous to him and proceed to test them in the light of clearly understood operations.... Hypothesis Two might be stated this way: There is no single trait called 'science talent'; high level ability in science (science talent) is a function of high general intelligence....

Certain observations made since describing earlier ones tend to support the hypothesis stated therein (similar to Number Two stated here).

1/ Paul F. Brandwein, "Selection and Training of Future Scientists. III, Hypothesis on the Nature of 'Science Talent,'" Science Education (February, 1952), 36:25-26.

> It seems that those who tend to favor scientific research per se by seeking, or declaring their intentions of seeking, a doctorate of philosophy in science rather than work in the applied sciences such as engineering, medicine, and dentistry tend generally to give a picture of introversion rather than extroversion. They tend generally to have selected science as a career earlier than those who go into the applied sciences, tend generally to have higher scholastic records (ranking in class), tend generally to be able to need less assistance in selecting problems for project work, tend generally to show higher ability in mathematics, tend to show a generally greater preferment for classical music, chess, and individual rather than team sports than those who go into the applied sciences. They also tend to show high level ability earlier than those who tend to go into the applied sciences.... These are clearly observable trends in an increasing number of cases already studied through graduate work but the number is not sufficiently high (about 60 of the 400 students mentioned) for the report of the observations to be conclusive.
>
> The place of the scientist in our society being what it is a study of what underlies high level ability in science should occupy a high priority in our investigations."

The "developed aptitude."-- A third contribution of Paul Brandwein's appeared recently [1/] in which he clarifies his own hypothesis and defines what he believes to be a better term to describe "science talent." He states as follows:

> "The limited working hypothesis which keeps me from straying from the firing line is this: High level ability in science is a function of high general ability and cannot, at present, be isolated as a separate hereditary factor arbitrarily called 'science talent.' Furthermore, young students with high achievement in verbal

1/ Paul F. Brandwein, "Selection and Training of Future Scientists. IV, Developed Aptitude in Science and Mathematics," The Science Teacher (April, 1953), 20:111-112.

and mathematical skills can develop a high level ability in science (a developed aptitude) if given appropriate opportunities (skilled teaching and wide training in laboratory science).

Developed aptitude is arbitrarily defined as aptitude (or ability) which is based on training as shown by increase in knowledge and skills....

This hypothesis is based on continuing observations of some 400 students: 60 of these have already proceeded through high school, college and post-college work, into research in science and productivity in other scientific areas....

Observations on two entire freshmen classes numbering approximately 1340 students, in addition to the 400 special students mentioned above, indicate that under the present educational opportunities obtained in Forest Hills High School the great majority of students who developed science aptitude, or high level ability in science and whose science interests were sustained to the point where major training in science is selected in college, are typically students with high I. Q., high verbal ability, and high mathematical ability....

Observations on the group above indicate that a clear relationship cannot be established between developed aptitudes in science and a science interest expressed before the ninth grade. Whether the science or mathematics interest establishes itself as a developed aptitude in science depends on two presently identifiable characteristics: (a) the presence of high general ability and (b) the nature of the opportunities offered to develop the aptitude.... The difficulty of maintaining formalized, dry programs often destroys the interest. Also there is difficulty in distinguishing between a temporary and pervasive interest....

Subsequent experience of different kinds leads me to the notion that youngsters of high level ability need the most competent care; they cannot be left to expediency but require a carefully devised program."

The methods of the Science Talent Search.-- A very different effort has been made to discover and describe in part

the characteristics of the superior science student and to expose some of the factors that were found in his background. This work has been done over a period of years through the mechanism of the Science Talent Search (described in Chapter I) by its two authors, Harold A. Edgerton and Steuart H. Britt. It is interesting to note that those few common characteristics and factors that have been found by them are reported in but three of a series of articles that they have written about the Search. These will be reported here. In the first report, Edgerton and Britt state:[1]

> "It is significant to note that of the first 40 (winners of the Washington trip), ages varied from 15 to 18 and averaged 16.5 years. They came from 31 localities in 13 states. Fifty-two and four tenths per cent stood at the head of their graduating classes. Twenty-two were members of science clubs. Six were class presidents. In their career plans 14 were heading for chemistry, 10 for engineering, 8 for physics, 7 for medicine or biology and 1 for astronomy."

In the second report, Edgerton and Britt describe the kind of young person which they conclude that the Science Talent Search selects. It follows:[2]

> "From the point of view of the Science Talent Search, it is necessary to know the 'earmarks' of such persons, before they become scientists. Our picture of the potential scientist suggests a person who is intellectually quite superior, interested in science, and a leader among his fellows. Potential scientists

1/ Harold A. Edgerton and Steuart H. Britt, "The First Annual Science Talent Search," American Scientist (January, 1943), 31:55-68.

2/ Harold A. Edgerton and Steuart H. Britt, "The Science Talent Search," Occupations (December, 1943), 22:177-178.

must be 'bright' and able to do high quality academic work. They should have shown by their records a strong interest in science, both in and out of school. In addition, they should have exhibited over a period of time considerable resourcefulness, initiative, and social competence."

In the third report Edgerton and Britt were joined by R. D. Norman. They made a careful study of the Winners and Honorable Mention Winners and the non-winning contestants. The data have been regrouped and are presented here as follows:[1/]

Table 7. Comparison between Award Winners and Non-Winning Contestants in the Science Talent Search in Their Scholastic Achievements.

The Achievement	Award Winners	Non-Winning Contestants
(1)	(2)	(3)
Major in Science.....	More	Less
Go to College.....	More	Less
Scholarships.....	More	Less
Choose Scientific Professional Occupation.....	73%	55%
In Honor Societies:		
Trip Winners.....	49%	5%
Honorable Mention Winners...	17%	
College Marks:		
Trip Winners.....	3.55	2.99
Honorable Mention Winners...	3.48	

Summary and a look ahead.-- The studies reported in

1/ Harold A. Edgerton, Steuart H. Britt, and Ralph D. Norman, "Later Achievements of Male Contestants in the First Annual Science Talent Search," American Scientist (July, 1948), 36: 403-414.

this chapter represent the situation as seen by the writer in January of 1954. These studies reaffirm the necessity for doing the research of this dissertation. The investigators quoted show many characteristics of scientists and science students and gifted people, and some factors that were found in their background. When they are examined as an integrated group of reports they reveal great gaps in the picture of what is known about the development of a scientist. The writer's study should supplement and complement the work of the above-mentioned investigators and add many new facts to what is known in this field: characteristics of superior science students and some factors that were found in their background.

Studies of unlike samples.-- The investigators whose studies are reported in this review for the most part did not study data from the same source. The samples from which they drew conclusions were different from each other's and from that of this study. Anne Roe [1] studied the present characteristics of 64 of the most eminent scientists in America whose age varied at the time of the study, but who were above 39 years old. Goodrich and Knapp [2] studied the collegiate backgrounds only of Ph.D. scientists who were listed in the 1944 edition of American Men of Science.

1/ Anne Roe, op. cit., p. 21.

2/ H. B. Goodrich et al., op. cit., p. 15.

Theresa R. Shapiro [1] studied the present attitudes of professional scientists. This was a study of adults. Leta S. Hollingsworth [2] studied the background characteristics of gifted children who were not selected as science students. Terman and Oden [3] also studied gifted children, but continued to study them later as adults. These were not segregated and studied as scientists. Herbert S. Zim [4] studied 81 science students in grades 7, 8, and 9 and 129 science students in grades 10, 11, and 12. These students were science fair contestants and were not selected as superior science students. Mallinson and Van Dragt [5] studied ordinary unselected science students in grade 9 and the same again in grade 12. They measured changes in the students' interest in science as shown by the Kuder test. E. S. Harrington [6] studied only the family background of his 420 high-school students who had earned an "A" in his science courses. This "A" group was not identified as being superior science students. Lenore B. Schmitt [7] studied the families, hobbies, activities, and future intentions of 150 seniors in high

1/ Theresa R. Shapiro, op. cit., p. 335.

2/ Leta S. Hollingsworth, op. cit., p. 29.

3/ L. M. Terman and M. H. Oden, op. cit., p. 11.

4/ Herbert S. Zim, op. cit., p. 129.

5/ George Mallinson and Harold Van Dragt, op. cit., p. 362.

6/ E. S. Harrington, op. cit., p. 25.

7/ Lenore B. Schmitt, op. cit., p. 20.

school who had elected mathematics. Morris Meister [1] reported a generalized profile of the typical student in the Bronx High School of Science. Superior science students selected by the Science Talent Search from this group would differ from the generalized profile of the typical student that he studied. Paul F. Brandwein [2] studied superior science students, but in his own words "the number [of cases] is not sufficiently high (about 60 of the 400 students mentioned) for the report of the observations to be conclusive." Edgerton and Britt [3] studied superior science students [Science Talent Search winners] but they reported very few details. They reported items of personality, interest, school activities, and also conducted a follow-up study. These studies were helpful to the writer for they suggested possible characteristics and factors for productive study.

Portrait of a "gifted-student-scientist."-- Here is an attempt to present a composite portrait of the "gifted-student-scientist" as painted by the research reported in this chapter. Later in this study the writer's conclusions will be presented as similar portraits.

(Family) His family is of a high cultural level and economic level. His father is a professional man or a business

1/ Morris Meister, op. cit., p. 222.

2/ Paul F. Brandwein, op. cit., p. 25.

3/ H. A. Edgerton and S. H. Britt, op. cit., p. 177.

executive.

(Personality) He has very high intelligence, he is independent, stable, vocal, often solitary, curious, enjoys leadership, likes society, is sophisticated, healthy and physically active.

(Interests) His interests are wide with a concentration on non-team outdoor sports. He also enjoys fishing, hunting, radio, science, reading, collecting, courses, walking, laboratory work, mathematics, puzzles, crafts, art, photography, magic and music.

(Activities) His activities are many. He works at his hobbies, enjoys his family, joins societies and is an avid reader.

(Teacher) His teacher of science and his teaching methods are as follows. His teacher taught with a loose rein and allowed great freedom for the student to find out for himself, he inspired his students by a personal example, he used projects, seminars and visual aids. He had high intelligence and a wide range of information. He had a sense of responsibility and ability to handle the unusual student. He had a love for students and mastery of his subject matter. He gave his students much guidance and assistance.

(Occupational Choice) The vocational plans of the "gifted-student-scientist" were very closely bound to his interests. They were generally in science, engineering, or business

management. He wanted to be a professor, lawyer, physician, journalist, or a mathematician.

Usefulness of the portrait.-- The portrait just painted is based on the facts which were common to at least five of the eleven studies. The writer has included every type of item found in the 11 studies and added others (with the help of the advisers listed in the appendix) in order to enrich his inquiry form. Specifically the study undertaken by the writer utilizes certain procedures and findings reported by the authors listed above in the recapitulation, but does this on a special population, the superior science student.

Checklist of the "gifted-student-scientist."-- Here an attempt has been made to reduce the many characteristics of that hypothetical person known as the "gifted-student-scientist" to a list that can be checked against a real person.

1. The family background is one of culture and leisure.
2. The father is a business executive or professional man.
3. The student's personality is one of high intelligence, high mathematical and verbal ability and keen curiosity about his world.
4. The student enjoys and respects the society of man.
5. The student has wide interests that center about science and the out-of-doors.
6. The student's hobbies frequently include radio, crafts,

photography, and collecting.

7. The student is an avid reader.
8. The student enjoyed a wide variety of school activities, in and out of classes.
9. The teacher of this student handled him with a loose rein and inspired him by splendid example.
10. The student followed a career in science, engineering, one of the professions, journalism, or as a social service worker.

CHAPTER III

RESEARCH PROCEDURE AND TECHNIQUES TO BE USED IN THE SOLUTION OF THE PROBLEM

1. Preparation of the Survey Packet

Restatement of the problem.-- There is a need to discover the characteristics of some superior science students [1] and some factors that were found in their background. That is the title and purpose of this study. It is hoped that the solution of this study will result in some new guideposts for the use of the teacher, guidance counselor and scientists who want to help young science students along their way to fruitful maturity.

Source of possible characteristics and factors.-- In the body of literature there are many books, pamphlets, articles and tests that have some helpful suggestions leading toward a solution of this problem. This literature was examined and has been reported in Chapter II. The possible characteristics and background factors that were found in the search of the literature were set aside in a list to be developed as questions for an inquiry form. The authors of these writings were contacted by correspondence. In many

1/ The total group examined in this study numbers 504.

cases they replied and gave helpful suggestions. Personal interviews were conducted with prominent scientists, science professors and teachers, science students, guidance counselors, students and professors of education.[1] They discussed the problem and added many helpful items to the growing list of possible characteristics and development factors. The writer also added items drawn from his own experience. From the list of possible characteristics and development factors an inquiry form of five hundred questions was prepared. The questions were grouped under eight major headings with matching blanks for each question in which to check the chosen answer. This preparation resulted in the First Trial Form.

Pretest of the trial forms.-- After the First Trial Form had been duplicated and assembled it was tested on local science students who by their performance as Science Fair winners or by other achievements in science showed that they were unusually good science students. Their comments and responses were noted and on the basis of this experience the inquiry form was revised and rebuilt. This resulted in a Second Trial Form. The Second Trial Form was submitted for comment and criticism to many mature people who had professional interest or training related to this problem and who had been corresponding with the writer on this problem. They returned many helpful suggestions for possible improvements. These suggestions were employed in the next

1/ See Advisers for the Study, Appendix.

revision of the inquiry form. This revision resulted in the Third Trial Form which was done using the multilith process.

Approval of the inquiry form.-- The Third Trial Form of the inquiry form was submitted to Science Clubs of America where the administrators and designers of the Westinghouse Science Talent Search gave it a thorough examination. Their many helpful suggestions were incorporated in changes on the stencils and the final form of the inquiry form was duplicated by the multilith process. A copy of the inquiry form in its final state has been included in the appendix.

Assembly of the survey packet.-- To the inquiry form were added the following materials: printed and stamped envelopes, an electrographic pencil, an I.B.M. answer sheet, and a "Biographical Facts About You" answer sheet. Science Clubs of America provided several hundred printed letters of transmittal and six hundred printed, gummed labels of the names and addresses of the Winners and Honorable Mention Award Winners of the Westinghouse Science Talent Search who had been selected to receive the survey packets. All of these materials were assembled and on November 1, 1953 they were placed in the U. S. mails for delivery to the respondents. A sample of these materials without the envelopes or the pencil has been included in the appendix.

2. Returns on the Survey

Description of the respondents.-- The respondents who received the survey packets were scattered about the United States. They were 600 young men and women who were the Winners and Honorable Mention Winners in the Science Talent Search in 1952 and 1953. A copy of the instrument similar to that which selected them for this honor has been included in the appendix. Some facts were known about them before they received the survey packets. These have been reported in Chapter II and are again included here in compact form:

1. Winners (80)

Age:	mean 16.6; range 15-18 years
I. Q.:	unknown, but 58 per cent ranked first, second or third in their graduating classes
Sex:	girls constitute 22 per cent of the group
Distribution:	residents of 22 states

2. Honorable Mention Winners (520)

Age:	mean 16.8; range 15-18 years
I. Q.:	unknown, but 39 per cent of the boys and 53 per cent of the girls ranked first, second or third in their graduating classes
Sex:	girls constitute 19.5 per cent of the group
Distribution:	residents of 40 states.

Previous surveys of other groups of Science Talent Search Award Winners indicated that a high rate of returns

could be expected and that the questions would be answered thoughtfully, speedily and honestly.

Receipt of the returns.-- Five days after the survey had been mailed the first return was received. The data showing the details of the return pattern have been presented in Table 8 which follows. On December 15 a small "follow-up" was mailed. This consisted of 20 post cards to the 20 Winners whose responses had not yet been received. By January 8, 1954, when 512 returns had been received, the survey was closed and processing began.

Table 8. Response of 600 Students to a Survey [1/]

Week Number	Date	Returns this day	Returns this week	Cumulative total returns
(1)	(2)	(3)	(4)	(5)
1....	Nov. 5	1	1	1
2....	9	8		9
	10	8		17
	12	37		54
	13	12	65	66
3....	16	56		122
	17	20		142
	18	34		176
	19	33		209
	20	38	171	237
4....	23	61		298
	24	28		326
	25	5		331
	27	23	117	354

(concluded on next page)

1/ This table is included so that future investigators who study these groups will know what to expect.

Table 8. (concluded)

Week Number	Date	Returns this day	Returns this week	Cumulative total returns
(1)	(2)	(3)	(4)	(5)
5....	Nov.30	29		383
	Dec. 1	20		403
	2	20		423
	3	10		433
	4	7	94	440
6....	6	11		451
	9	12		463
	10	8		471
	11	1	32	472
7....	14	5		477
	15	3	(Sent out follow-up)	480
	17	5		485
	18		13	485
8....	21	4		489
	22	3		492
	23	5		497
	24	2	14	499
9....	28	9		508
	30	1	10	509
10....	Jan. 4, '54	1		510
	6	1		511
	8	1	3	512

3. Treatment of the Returns

Processing the returns.-- Five hundred and twelve survey packets were opened and the contents sorted. The first examination revealed that eight were not usable because they had not been completed or identified, or that one of the answer sheets was missing, or that they were returned unopened because of a post-office stamp listing "address

unknown." There were many personal notes attached. These were set aside for further correspondence. All the I.B.M. answer sheets were examined to make certain that all pencil marks were large and dark enough, and all stray marks were removed. The names were checked against the master list. The extra materials were set aside and the two answer sheets from each packet (I.B.M. and "Biographical") were examined. The mechanical process of machine-scoring utilized I.B.M. answer sheets in packets of one hundred sheets, approximately, in each packet. It was therefore necessary to separate the 504 I.B.M. answer sheets into 5 or 6 bundles. It was suggested that instead of an even distribution of sheets into bundles, they be piled according to some common factor and then the analysis might reveal additional and more useful data. A search of the answer sheets was made to try to discover some common factors that would separate the total stock of 504 pairs of answer sheets into 5 or 6 groups. The answers to several questions on the "Biographical Facts About You" were read and as a result of these answers the two answer sheets in a pair were piled into one of several piles as follows: Winners; Honorable Mention Winners who wanted to become scientists or engineers; Honorable Mention Winners who were women; and the last group later to be called Prospective Members of Professions. It was considered that it might be possible that the respondents of the sub-groups

would respond differently to the questions and would select a different pattern of occupational choices. This information could be a valuable tool for guiding prospective students of science. The sorting process actually did result in five sub-groups. The sub-groups were rechecked several times to eliminate errors in sorting them; they were counted and the numbers translated to percentages. All of the figures are shown on Table 9 which follows:

Table 9. Distribution of 504 Respondents in the Study into Sub-Groups of Common Characteristics

Group Names	75 Winners		429 Honorable Mention Winners		504 Superior Science Students	
	No.	Per Cent	No.	Per Cent	No.	Per Cent
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Winners.....	75	100			75	15
Scientists...			164	38	164	33
Engineers....			110	26	110	22
Women.....			83	19	83	16
Others*.....			72	16	72	14
Total.....	75	100	429	100	504	100

* Prospective Members of the Professions.

Tabulation of the occupational choices.-- The sorting process resulted in five sub-groups each of which could be processed separately or all could be pooled together and processed as one group called Superior Science Students. The I.B.M. answer sheets were now removed from their companion

"Biographical" answer sheets and placed in separate packages with their sub-group labels on each package. The remaining "Biographical" answer sheets were placed in piles according to their sub-group title. Each sub-group was then hand sorted into smaller lots according to the respondent's first choice for his preferred occupation. These lots were totaled, percentages found, and are reported in the Appendix.

Processing the I.B.M. answer sheets.-- The I.B.M. answer sheets were taken in their separate packages to the Statistical Research Department of Boston University where they were processed by item-analysis machines. The result of the work done by the machine was a total for each sub-group of all the respondents who selected every possible response for every question. Each total and the grand total were then reported as percentages (slide-rule accuracy). When a percentage was greater than 0.49 per cent it was increased to the next whole number. When it was 0.49 per cent or less it was reduced to the previous whole number. In some cases the percentages did not total 100 per cent. This is because some respondents did not answer all questions; also some selected more than one or two of the multiple-choice responses; lastly, "rounding off" the percentages into whole numbers introduced some small errors in percentages. The divisor used for calculating all percentages was the total number of respondents in a sub-group or in the grand total irrespective of a

respondent's decision to answer a question or not. The choices of answers to all questions by sub-groups and the grand totals by the Superior Science Students were recorded on I.B.M. answer sheets and further analyzed for their meaning. This work is reported in Chapter IV.

4. Assumptions Made

Normality of the group and reliability of the respondents.--

1. Because of the nature of the group, it is assumed that they answered honestly and with careful regard for the importance of the study and its value to society.

2. The respondents who though they were in 1952 and 1953 the winners and honorable mention winners are not significantly unlike all the past and, perhaps, the future winners and honorable mention winners of the Science Talent Search. If this is true a significant sample of able science students has been analyzed. Reiterating the limitation of the study stated in the purpose of the study, not all superior science students are in the Science Talent Search. Many superior science students have no interest in this competition, or have not heard of it, or have been too occupied with their own studies to give time to entering the Search. Nevertheless, the assumption may be made because of the achievements of these students that those who comprise this group are a significant if not statistical portion of all superior science students.

CHAPTER IV

ANALYSIS AND INTERPRETATION OF DATA

1. Superior Science Students

Occupational choices of 504 superior science students.-- This study has attempted to discover the characteristics of superior science students and some factors that were found in their background. Five hundred and four such students completed an inquiry form and their responses were recorded on two answer sheets for each student. One sheet labeled "Biographical Facts About You" contained an item (number 11) called, "What is your choice of a permanent occupation?" All of the "Biographical" answer sheets for the 504 respondents were sorted and piled according to their first preference for a permanent occupation. Each lot was further subdivided by sex. All the responses in each lot were listed in order of frequency and percentages were calculated for each occupational title. The results are shown in Table 10 which follows:

Table 10. Occupational Choices--504 Superior Science Students (75 Winners and 429 Honorable Mention Winners)

Occupational Title of Chosen Occupation	No. Women	No. Men	Total Number	Choices in per cents
(1)	(2)	(3)	(4)	(5)
Physicist, research.....	6	69	75	14.8
Doctor Medical Practice...	2	44	46	9.1
Chemist, research.....	8	31	39	7.7
Engineers, chemical.....		30	30	5.9
Mathematician.....	3	29	32	5.7
Chemist, general.....	9	19	28	5.5
Physicist, general.....	1	21	22	4.3
Biologist, research.....	14	8	22	4.3
Doctor Medical Research...	10	11	21	4.1
Engineers, electronic.....		21	21	4.1
Undecided.....	5	13	18	3.5
Engineers, electrical.....		15	15	2.9
Engineers, aeronautical...		11	11	2.1
Engineers, mechanical.....		9	9	1.7
Engineers, physics.....		8	8	1.5
Teacher.....	7	1	8	1.5
Astronomer-Astrophysicist.		7	7	1.3
Psychologist.....	5	2	7	1.3
Writer-Journalist.....	4	3	7	1.3
Science Professor and Research Worker.....		6	6	1.1
Medical Service.....	6		6	1.1
Engineers, unspecialized..		6	6	1.1
Biologist, general.....	5	1	6	1.1
Engineers, automatic control.....		5	5	0.9
Engineers, nuclear.....		5	5	0.9
Lawyer.....	2	3	5	0.9
Theologist.....		4	4	0.8
Engineers, architecture (general).....		3	3	0.5
Engineers, industrial (general).....		3	3	0.5
Radio-Television Entertainer.....		3	3	0.5
Business.....		3	3	0.5
Homemaker.....	3		3	0.5

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Table 10. (concluded)

Occupational Title of Chosen Occupation	No. Women	No. Men	Total Number	Choices in per cents
(1)	(2)	(3)	(4)	(5)
Home economics.....	3		3	0.5
Geologist-Meteorologist....		3	3	0.5
Engineers, architecture (Naval).....		2	2	0.3
Engineers, civil.....		2	2	0.3
Agriculture.....	2		2	0.3
Musician.....		2	2	0.3
Engineers, geological.....		1	1	0.2
Historian.....	1		1	0.2
Coach - Athletics.....		1	1	0.2
Politician.....		1	1	0.2
Linguist.....	1		1	0.2
Philosopher.....	1		1	0.2
Totals.....	98	406	504	100.0

Characteristics and background factors of 504 superior science students.-- The second of the two answer sheets returned by the respondents was an I.B.M. answer sheet. This contained places for recording the answer choice for each question asked on the inquiry form. When the responses to each of the several choices of answers for each question had been recorded and their frequency discovered on an I.B.M. item-analysis machine and recorded as percentages for the 504 superior science students, they were recorded on a single I.B.M. answer sheet. The percentages of the 504 superior science students that selected any answer can be read directly on the answer sheet by using the answer numbers on the I.B.M. sheet to find the appropriate question that accompanies that

answer for the numbers were the same. Both these sheets were located in the appendix.

2. Contemporaries in General Education

Reasons for selection.-- A group of students was selected to serve as a comparison group. Comparisons were made to see if differences existed between the superior science students and their contemporaries in general education who were superior general ability students. These latter were used as a comparison group.

Characteristics of the comparison group.-- These students were as follows:

Education	:	40 freshmen, 38 sophomores, College of General Education, Boston University
Age	:	17.08 mean, 16 - 22 range
Sex	:	Girls are 14 per cent of the group
I.Q.	:	128 mean, 120 - 153 range
Family residence	:	98 per cent born in New England 90 per cent educated in New England

This group was used for comparative purposes because they represented the general rather than the specialized college student. In such factors as age, sex, and education they were quite comparable to the science group. Although the I.Q. of the comparison group may not be as high as the selected science group they are nonetheless a representative of a superior intellectual population as all I.Q.s were above

120. On factors such as motivation, honesty, willingness to cooperate they were quite comparable.

Occupational choices of 78 contemporaries in general education.-- The answer sheets were sorted and grouped according to the previously described procedure, in other words, according to their sex and first choice of a permanent occupation. All the responses in each lot were listed in order of frequency and percentages were calculated for each occupational title. The results are shown on Table 11 which follows:

Table 11. Occupational Choices--78 Contemporaries in General Education

Occupational Title of Chosen Occupation	No. Women	No. Men	Total Number	Choices in per cents
(1)	(2)	(3)	(4)	(5)
Undecided.....	3	16	19	24.3
Writer - Journalist.....		11	11	14.1
Teacher - College or H.S...		9	9	11.5
Business Man.....		6	6	7.6
Radio - Television - Entertainment.....	1	4	5	6.4
Medicine - Dentistry Practice.....		4	4	5.1
Lawyer.....	1	3	4	5.1
Civil Service.....	1	3	4	5.1
Psychologist.....	1	3	4	5.1
Engineer.....		3	3	3.8
Scientist.....		3	3	3.8
Social Worker.....	1	1	2	2.5
Medical Service.....	2		2	2.5
Theologist.....		1	1	1.2
Secretary.....	1		1	1.2
Total.....	11	67	78	100.0

Characteristics and background factors of 78 Contemporaries in General Education.-- The second of the two answer sheets for each respondent of the lot called 78 contemporaries in general education was an I.B.M. answer sheet. When the responses to each of the several choices of answers for each question had been recorded and their frequency discovered on an I.B.M. item-analysis machine for all of the 78 contemporaries in general education the frequencies were converted into percentages. The percentages of all the 78 contemporaries in general education that selected a given answer choice to each question were then recorded on a single I.B.M. answer sheet. The percentage of the 78 contemporaries in general education that selected any answer can be read directly on the answer sheet in the appendix by using the answer numbers on the I.B.M. answer sheet to identify the appropriate questions listed in the inquiry form that is found in the appendix.

3. Comparison of the Two Groups

Method of analysis.-- The answers to the questions in the inquiry form by the two groups were recorded in percentages. Differences in percentage responses were studied for statistical significance. From Palmer O. Johnson[1/]

1/ Palmer O. Johnson, Statistical Methods in Research, Prentice-Hall Inc., New York, 1949, p. 165.

a technique was adopted because it provided a sensitive measurement of the significant difference between two percentages, particularly when they deviated widely (as when one is in the tail and the other near the center of a distribution of variates). This situation was very common in this study. The percentages were transposed to degrees (of a circle) by the use of Fisher's tables [1] and thus the inverse sine transformation was accomplished. The difference between the degrees was determined by applying Johnson's method. [2] The difference was shown to be significant in terms of the probability of occurrence such as 5 per cent, 2 per cent, 1 per cent, and 0.1 per cent probability.

In all questions where a dichotomy of choice existed the Johnson [3] method of analysis was used. Thus, in Questions number 1 through 183 the answers were considered to be "yes" or otherwise ("no" and "I don't know" responses were grouped together). The "yes" responses were reported beside the item questions in Table 12 in percentages with their significance.

1/ Ronald A. Fisher and F. Yates, Statistical Tables for Biological, Agricultural and Medical Research, Hafner Publishing Company Inc., New York, 1953, p. 66, Table XII.

2/ Palmer O. Johnson, op. cit., p. 165.

3/ See Appendix C.

Responses were grouped to form a dichotomy of choice and the difference between these percentage responses was tested by the Johnson method for significance wherever it was possible. Thus in Questions numbered 239 through 300 the responses were grouped into "like" (A plus B response) or "dislike" (C plus D response) to form the dichotomy and the "like" responses were reported in percentages with their significance.

In Questions 184 through 238 there were some item questions that could be dichotomized if one selected a particular response and grouped all other responses to this question as the other choice of the dichotomy and thus reduced a multiple choice response to a dichotomy. The choice selected was tested for its significance and reported in Table 12 with its percentage. Questions number 185, 189, 195, 204, 207 through 211, 216 through 219, 227, and 232 through 238 were done in this manner. Some questions were not tested for significance for the percentage responses were too close in agreement. These were reported as "no" in Table 12.

There were about thirty questions in the group numbered 184 through 238 which could not be dichotomized and have been marked by a star *. These questions were analyzed by the Chi Square method.[1/] In these multiple choice items the choice

1/ See Appendix

(or choices) is indicated that contributed most to the value of the Chi Square. This choice by letter is shown in the data. This choice (or these choices) was selected by an inspection of the relative contribution of each Chi Square and is not based on a precise statistical test, for example: Question 184 - "About how often did you have pre-arranged dates with some members of the opposite sex?" choice A. "Two a week." The predominant contrast between the groups appeared to be in choice A "two a week." This suggests that the two groups are contrasted only when they date very frequently. From the percentages [1/] it is obvious that the contemporaries have more members of this type, hence the choice A was located in their block. Thus, we may deduce that the scientists do not "date as frequently" as their contemporaries in general education, hence nothing is recorded in the scientists' block.

Report of the data.-- The data were reported in the same manner and with the same numbers as were the questions in the inquiry form. The following three tables, numbers 12, 13, and 14 present data concerning the characteristics and backgrounds of the superior science students and their comparison group. Table 12 analyzes items which were answered by "yes" or "no" answers. Table 13 analyzes items which were answered by multiple choice selections. Table 14 analyzes items which were answered by "likes" that are related to various interests.

1/ See Appendix

Table 12. Questions 1 through 183 showing the "yes" responses for the science students and their contemporaries

Question and number	Response of Scientist per cent	Response of Contemps. per cent	Significance in per cent
(1)	(2)	(3)	(4)
Personality			
During your high school career did you:			
1. Usually prefer to work and study alone?.....	80	68	5
2. Usually prefer to share your play and pleasures with people?..	79	90	2
3. Usually concentrate on one or two well developed interests?....	51	44	No
4. Usually attempt more things than you can complete?.....	36	42	No
5. Like to assume responsibility?...	72	53	1
6. Use much of your energy helping other people?.....	48	45	No
7. Enjoy parties?.....	67	79	5
8. Find it difficult to keep a secret?.....	18	28	No
9. Ever find people calling you a "daydreamer"?.....	61	36	0.1
10. Ever find people calling you "nosey" because of your curiosity?.....	30	53	0.1
11. Make a determined effort to always be punctual?.....	71	58	5
12. Find that you were quite critical of yourself?.....	80	70	No
13. Prefer the usual to the new?.....	8	5	No
14. Ever try to solve social life problems by a science type procedure?.....	46	32	2
15. Thoroughly dislike having to work long and hard in order to be able to finish a job that you had assigned to yourself?.....	10	33	0.1

(continued on next page)

Table 12. (continued)

Question and number	Response of Scientist per cent	Response of Contemps. per cent	Significance in per cent
(1)	(2)	(3)	(4)
16. Enjoy trying to be original?....	93	86	No
17. Try to "cross your bridges before you came to them"?.....	58	51	No
18. Depend on your memory's being unusually reliable?.....	47	59	5
19. Usually seek causes for all effects?.....	75	55	0.1
20. Find that an unanswered question disturbed you?.....	90	79	2
21. Usually respect the opinion of established authorities?.....	63	62	No
22. Like to have the freedom to succeed or to fail by your own efforts with no one else responsible for your achievement?.	85	83	No
23. Prefer realistic to symbolic art?.....	60	75	1
24. Prefer classical to popular music?.....	60	44	1
25. Prefer solving problems that you made for yourself to those made for you by others?.....	45	46	No
26. Like to solve mental puzzles or riddles?.....	79	64	0.1
27. Often "stick your neck out"?....	52	54	No
28. Frequently write or tell imaginative tales?.....	33	37	No
29. Ever have occasions to regret losing your temper?.....	48	76	0.1
30. Frequently try to discount single facts by general principles?.....	30	36	No
31. Try to develop yourself into a "well-rounded person"?.....	77	79	No
32. Enjoy being a leader of group activities in science?.....	68	16	0.1

(continued on next page)

Table 12. (continued)

Question and number	Response of Scientist per cent	Response of Contemps. per cent	Significance in per cent
(1)	(2)	(3)	(4)
33. Enjoy informal social gatherings?.....	85	86	No
Your Family History			
34. Was your father's birthplace in America?.....	77	66	5
35. Was your mother's birthplace in America?.....	83	72	5
36. Was your family tongue English?.	92	85	No
37. Did some inheritance support the family?.....	3	4	No
38. Did both parents support the family?.....	28	22	No
39. Did relatives support the family?.....	1	1	No
40. Did your father "boss" the family?.....	24	47	0.1
41. Did your mother "boss" the family?.....	12	22	5
42. Did your father support the family?.....	92	92	No
43. Did your mother support the family?.....	24	23	No
44. Did your family collect classical music records?.....	31	20	5
45. Did your family strongly urge you to "be somebody important"?.	22	32	2
46. Was your parent an employer managing his own business?.....	27	23	No
47. Does your female parent or guardian belong to any civic clubs?.....	47	46	No
48. Did any of your family highly praise and respect science?.....	59	28	0.1
49. Did any of your family criticize and condemn science?.....	5	5	No

(continued on next page)

Table 12. (continued)

Question and number	Response of Scientist per cent	Response of Contemps. per cent	Significance in per cent
(1)	(2)	(3)	(4)
During your high school career did you:			
50. Have an after-school job?.....	36	69	0.1
51. Have a vacation-time job?.....	79	89	5
52. Have leisure time to study science?.....	86	59	0.1
53. Have public library facilities available?.....	95	96	No
54. Have a home workshop or laboratory?.....	55	23	0.1
55. Have a study room of your own?..	70	58	5
56. Have adequate workshop or laboratory facilties available?.	63	32	0.1
57. Keep domestic pets at home?.....	53	65	5
58. Keep wild animal pets at home?..	13	14	No
59. Admire and respect your father's achievements?.....	78	70	No
60. Admire and respect your mother's achievements?.....	77	64	2
Among your older relatives were there any:			
61. Scientists?.....	33	11	0.1
62. Musicians?.....	23	35	2
63. Artists?.....	21	19	No
64. Teachers?.....	58	36	0.1
65. Lawyers?.....	25	28	No
66. Theologians?.....	20	18	No
67. Writers?.....	18	12	No

(continued on next page)

Table 12. (continued)

Question and Number	Response of Scientist per cent	Response of Contemps. per cent	Significance in per cent
(1)	(2)	(3)	(4)
Associates			
Consider your associates and friends during high school. Did you:			
68. Personally know a scientist?....	53	25	0.1
69. Work with a scientist?.....	27	6	0.1
70. Have a scientist for your personal hero?.....	18	6	1
71. Try to behave like a scientist?.	41	15	0.1
72. Have any chums who wanted to be scientists?.....	79	63	1
73. Direct yourself like a "lone wolf" in science?.....	30	12	0.1
74. Have any family friends who were scientists?.....	31	14	0.1
75. Have any relatives living near you who were scientists?.....	13	9	No
76. Have friends who let you lead or organize group science activities with them?.....	42	4	0.1
77. Find that any older students would help, guide, and encourage you in your science activities?.	34	15	1
78. Find that any newspaper or magazine articles could strongly influence you toward starting a career in science?.....	35	33	No
Science Teacher			
Consider your most influential science teacher. Was he or she:			
79. A male?.....	78	81	No
80. Patient and understanding with his students?.....	85	77	No

(continued on next page)

Table 12. (continued)

Question and number	Response of Scientist per cent	Response of Contemps. per cent	Significance in per cent
(1)	(2)	(3)	(4)
81. Clear and expressive in his conversation?	89	81	No
82. Fun to be with most of the time?	82	55	0.1
83. Almost a second parent to you?	24	12	1
84. Trained to be a scientist before he became a teacher?	38	25	5
85. Using his greatest ability as a science teacher?	60	29	0.1
To the best of your ability to recall, did he:			
86. Give you help on confidential personal problems?	32	21	5
87. Work in business before he was a teacher?	13	10	No
88. Seem to enjoy his job of teaching?	89	79	5
89. Appear to have adequate training to teach science?	93	89	No
90. Have ambitions related to his job of being a science teacher?	44	29	1
91. Believe in hard work for himself; long hours?	61	40	0.1
92. Believe in hard work for his students?	62	62	No
93. Communicate with teachers from other schools?	61	36	0.1
94. Communicate with any scientists?	43	16	0.1
95. Belong to any professional organizations?	43	25	1
96. Appear to have enough time to teach well?	91	85	No
97. Act as sponsor to any science clubs?	73	54	1
98. Write any articles or books that were published?	20	12	No

(continued on next page)

Table 12. (continued)

Question and number	Response of Scientist per cent	Response of Contemps. per cent	Significance in per cent
(1)	(2)	(3)	(4)
99. Ever invent any scientific or science-teaching devices?.....	23	4	0.1
100. Assist students in any after-hours science activities?.....	91	79	1
101. Give anybody opportunities to organize and lead any group science activities?.....	71	48	0.1
102. Teach anything beside science?.	27	30	No
103. Coach athletics?.....	15	19	No
104. Have an after-school job?.....	22	9	1
105. Teach part time in a college?..	14	8	5
106. Make use of audio-visual aids?.	78	74	No
107. Ever discuss "The Great Scientists?".....	53	77	0.1
108. Have a hobby?.....	55	36	1
109. Have a pleasing personality?...	89	81	No
110. Talk too much?.....	8	8	No
111. Get angry often and lose his temper?.....	9	17	5
112. Have a good sense of humor?....	90	79	2
113. Quickly gain your admiration and respect?.....	85	69	1
Activities			
Consider the influence of your high school activities. Were you:			
114. A scout?.....	42	45	No
115. A member of any scientific societies?.....	67	8	0.1
116. A member of any clubs that were not science clubs?.....	91	78	1
117. An active member of any athletic teams?.....	40	56	1
118. An active member of a dramatic group?.....	29	25	No

(continued on next page)

Table 12. (continued)

Question and number	Response of Scientist per cent	Response of Contemps. per cent	Significance in per cent
(1)	(2)	(3)	(4)
119. An active member of a social group or formal club?	47	56	No
120. An active member of any voluntary military organization?	4	11	1
121. An elected officer in student government?	36	24	5
122. Ever compete in a science fair?	30	9	0.1
123. Ever compete in a science congress?	15	1	0.1
124. Ever compete for science prizes in contests?	73	5	0.1
125. Ever win any science prizes in contests?	65	3	0.1
126. Ever plan an experiment and then do it yourself?	86	26	0.1
127. Ever perform any high grade scientific research?	33	5	0.1
128. Ever improve any scientific method or device?	30	9	0.1
129. Ever invent anything scientific?	25	4	0.1
130. Ever publish a scientific or other article?	19	3	0.1
131. Like the study of mathematics?	91	54	0.1
132. Have the use of a well-equipped science laboratory?	60	46	5
133. Have a place to study science at home?	72	44	0.1
134. Ever act as a teaching assistant?	41	9	0.1
135. Ever give lecture demonstrations in school?	62	12	0.1
136. Ever go on any field trips?	63	31	0.1
137. Ever lead or organize any field trips?	19	1	0.1
138. Ever visit a science museum?	86	74	2

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Table 12. (continued)

Question and number	Response of Scientist per cent	Response of Contemps. per cent	Significance in per cent
(1)	(2)	(3)	(4)
139. Ever visit any scientific industry?.....	62	33	0.1
140. Ever help operate audio-visual aids?.....	48	25	0.1
141. Ever work on a school publication?.....	59	41	1
142. Have a regular job during vacations?.....	66	73	No
143. Ever have a part-time job in science?.....	18	6	1
144. Have almost enough time to study science at home?.....	71	54	1
145. Spend time regularly each week in after school science? studies?.....	50	12	0.1
146. Belong to "Science Clubs of America"?.....	37	1	0.1
147. Belong to any agricultural club?.....	4	1	No
148. Belong to a Junior Academy of Science?.....	21	1	0.1
149. Ever become a member of any honor society?.....	83	18	0.1
150. Ever hold office in a science club?.....	17	3	0.1
Attitudes and Opinions			
Among your attitudes and opinions while you were in high school, did you:			
151. Change your ideas of what you thought to be eternally true?..	54	58	No
152. Decide that in the event of a disaster that people should be saved in the order of their worth to science?.....	20	12	No

(continued on next page)

Table 12. (continued)

Question and number	Response of Scientist per cent	Response of Contemps. per cent	Significance in per cent
(1)	(2)	(3)	(4)
153. Think that people should be studied with nothing held to be too sacred to be studied by the men of science?.....	50	36	5
154. Conclude that a person is responsible to himself alone?....	14	29	1
155. Decide that a good scientist can succeed without help from anybody?.....	11	8	No
156. Decide that a scientist should work in science and ignore money?.....	28	18	No
157. Believe that a science student should first earn the necessary money and then study for a career in science?.....	10	8	No
158. Believe in a material cause for all events?.....	39	27	5
159. Ever accept any ideas unsupported by proof?.....	62	63	No
160. Believe in any superstition?...	7	23	0.1
161. Ever try to live by a plan?....	58	53	No
162. Let events of chance plan your life?.....	26	42	1
163. Ever make a decision based only on a hunch?.....	78	89	2
164. Always gather your own facts?..	32	15	0.1
165. Quickly change your opinion if you were proved wrong?.....	76	59	1
166. Silence others who had ideas contrary to your own?.....	5	4	No
167. Ever consciously separate your judgment from your likes?.....	78	49	0.1
168. Ever go away alone just to think?.....	86	86	No
169. Usually assume more work than you could handle?.....	30	38	No

(concluded on next page)

Table 12. (concluded)

Question and number	Response of Scientist per cent	Response of Contemps. per cent	Significance in per cent
(1)	(2)	(3)	(4)
170. Ever question the validity of published facts?.....	92	85	No
171. Ever accept a temporary solution to a hard problem?.....	71	73	No
172. Always respect civil law even though it might appear to you to be silly?.....	61	51	No
173. Ever question the soundness of religion?.....	65	73	No
174. Ever feel that you had no time for religious acts?.....	32	32	No
175. Like to work steadily on one job until it was completed?....	74	64	No
176. Ever get real help in science from anyone else?.....	72	36	0.1
177. Have a lively curiosity about the natural world?.....	92	66	0.1
178. Enjoy free competition if the rules were obeyed?.....	91	81	2
179. Usually persist tenaciously on a job to its completion?.....	68	40	0.1
180. Ever question the use to which science is put?.....	74	56	1
181. Ever advocate that science stop and let society gain?.....	6	11	No
182. Believe that a scientist was responsible for the misuse of discoveries?.....	17	12	No
183. Decide that scientists and science students were so scarce and so valuable to the nation that they should not be drafted for military service, but kept in their scientific work and study?.....	62	35	0.1

Table 13. Questions 184 through 238 showing the "choice" responses for the science students and their contemporaries

Question and number	Response of Scientist per cent	Response of Contemps. per cent	Significance in per cent
(1)	(2)	(3)	(4)
Personality			
184. *About how often did you have pre-arranged dates with some member of the opposite sex? A. Two a week B. One to two a week C. One a week D. One a month E. Less than one a month		A	0.1
185. In which of these games of chance did you participate? A. Bet on races B. Poker C. Dice D. Lottery E. Never gamble this way	E67	40	0.1
186. *How often did you willingly go to church? A. Twice a week or more B. Once a week C. Once a month D. Once or twice a year E. Almost never	A		1
187. *Physically, how tall were you compared to your classmates? A. Tallest of all B. Taller than most C. About average D. Shorter than most E. Shortest of all		C	0.1
188. *What kind of people did you most wish to be like? A. Statesmen B. Writers C. Artists D. Athletes E. Explorers and Inventors		D	1

(continued on next page)

* Analysis by chi square method, see appendix

Table. 13. (continued)

Question and number	Response of Scientist per cent	Response of Contemps. per cent	Significance in per cent
(1)	(2)	(3)	(4)
189. Who or what was most to blame for your failure to achieve more in science than you have? A. The schools B. My parents C. My friends and associates D. Lack of money E. Myself	E76	91	0.1
Family History			
190. *How much formal education did your father have? A. Post graduate degree B. College C. Junior college D. High school E. Less than high school	A		0.1
191. *How much formal education did your mother have? A. Post graduate degree B. College C. Junior college or two-year diploma D. High school E. Less than high school	A+B		0.1
192. About how large was the family income that supported you? A. Above $8000 B. $8000 - $6000 C. $5900 - $4000 D. $3900 - $2000 E. $1900 and less	No	No	No
193. *Was your principle residence a community with a population of A. a million plus? B. a million to 250,001? C. 250,000 - 50,001? D. 50,000 - 5001? E. 5000 or less?	A		0.1

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Table 13. (continued)

Question and number	Response of Scientist per cent	Response of Contemps. per cent	Significance in per cent
(1)	(2)	(3)	(4)
194. *What kind of work did your working parent do? A. Professional D. Tradesman B. Business man E. Laborer C. Farmer		B	0.1
195. During high school years how many times did you move and have to change schools? A. Four times D. Once B. Three times E. Not at all C. Twice	E88	74	1
196. How many sisters did you have? A. Four or more D. One B. Three E. None C. Two	E52	42	No
197. How many brothers did you have? A. Four or more D. One B. Three E. None C. Two	E48	33	2
198. What was your position in order of birth? A. First child B. Second child C. Third child D. Fourth child E. Fifth child or more	A64	40	0.1
199. What was the status of your parents? A. Both living B. Mother only living C. Father only living D. Neither parent living E. Their status is unknown	A91	89	No
200. What was the status of your parents' home? A. Happily married B. Separated or divorced C. Unhappily married D. Divorced and remarried E. Unknown	A86	83	No

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Table 13. (continued)

Question and number	Response of Scientist per cent	Response of Contemps. per cent	Significance in per cent
(1)	(2)	(3)	(4)
201. Where did you get your spending money? A. Earned it all B. Earnings, gifts and allowances C. Gifts and allowances D. Regular allowance E. Had practically none	No	No	No
202. Where did you get most of your science equipment? A. Gift B. Earned money and bought it C. Loaned to me D. Bought with gifts and earnings E. Made it myself	D32	21	5
203. How many books owned at home in your family? A. 0 - 10 D. 151 - 200 B. 11 - 100 E. Over 200 C. 101 - 150	No	No	No
204. What does your parent or guardian think of your career plans in science? A. Strongly for it B. They are more in favor than against it C. They are divided on it D. More opposed than for it E. They are strongly against it	A62	44	1
205. *How many magazines does your family buy each month? A. 6 - 10 D. 1 B. 3 - 5 E. 0 C. 2	A		5

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Table 13. (continued)

Question and number	Response of Scientist per cent	Response of Contemps. per cent	Significance in per cent
(1)	(2)	(3)	(4)
206. Were you allowed to use the family car? A. Restricted to family use B. Can use it C. Have my own car D. Do not drive E. No car in the family	No	No	No
Associates			
207. Which of the following people gave you the most encouragement and inspiration in your plan to become a scientist? A. Guidance counsellor B. Science teacher C. Parent D. Other relatives E. None of these	B41	21	0.1
208. Which of the following acquaintances was most encouraging and helpful in developing your plan to become a scientist? A. Employer B. Family doctor or dentist C. None of these D. Club leader E. Adult friend of the family	C74	77	No
209. Which of the following things gave you inspiration and encouragement about becoming a scientist? A. Television B. Radio C. Movies D. Books E. Science fiction	D84	54	0.1
210. Where did you spend the majority of your elementary schooling? A. University laboratory school B. Public school C. Parochial school D. Private school E. Tutor	B87	76	2

(continued on next page)

Table 13. (continued)

Question and number	Response of Scientist per cent	Response of Contemps. per cent	Significance in per cent
211. Where did you spend the majority of your high school years? A. University high school B. Public school C. Parochial school D. Private school E. Tutor	B87	78	5
Science Teacher			
212. In what age group does your science teacher belong? A. 20 - 25 years B. 26 - 35 years C. 36 - 45 years D. 46 - 55 years E. 56 years or more	No	No	No
213. *For how many years had he been teaching? A. 0 - 5 years B. 6 - 15 years C. 16 - 25 years D. 26 - 35 years E. Don't know		E	1
214. *What method of teaching did he use most in his classes? A. Lectures B. Textbook study C. Class laboratory exercise D. He demonstrated using equipment E. Individual study and experiments	A		0.1
215. *Which of the following teaching principles were most characteristic of his methods? A. Teach facts to disciplined groups B. Guided the studies of individuals who followed a prescribed plan C. Guided, stimulated, encouraged individual study along different lines D. Drove students by many means to work at their utmost capacity E. Gave students great freedom to learn or not as they were best able to do		A	1

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Table 13. (continued)

Question and number	Response of Scientist per cent	Response of Contemps. per cent	Significance in per cent
(1)	(2)	(3)	(4)
216. How much educational preparation did your science teacher have? A. Teachers college B. Bachelor of Science or Arts C. Doctor's degree D. Master's degree (science or education) E. Science and education degree (Both)	D50	28	0.1
217. Select the thing that he did most often with the students "after hours and away from school." A. Took field trips in nature and industry B. Visited with them at his home or their home C. Chaperoned their parties and gatherings D. Corresponded with them E. Lent a willing ear and helping hand to their problems	E59	56	No
Activities			
218. Were you ever expelled from high school for discipline reasons? A. Never B. Once C. Twice D. Three times E. More than three times	A99	87	0.1
219. Did you ever fail a course in high school? A. Four B. Three C. Two D. One E. None	E95	56	0.1
220. *In which of these studies did you earn the best grades? A. English B. Mathematics C. Language D. History and Social Studies E. Science		A	0.1

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Table 13. (continued)

Number and question	Response of Scientist per cent	Response of Contemps. per cent	Significance in per cent
(1)	(2)	(3)	(4)
221. *In which of these studies did you earn the poorest grades? A. English D. History and B. Mathematics Social Studies C. Language E. Science		B	0.1
222. *How much absence did you accumulate during your whole high school career? A. More than one month B. One month - two weeks C. Two - one week D. Less than one week E. Perfect attendance		A	5
223. How many non-fiction books did you borrow from the public library in an average high school year? A. 21 or more D. 4 - 1 B. 20 - 10 E. None C. 9 - 5	No	No	No
224. *During high school what percentage of the time were you on the honor roll? A. Never D. 75% B. 25% E. 100% C. 50%	E		0.1
225. *During your high school career what was your academic average in marks? A. 90 - 100 (A- to A+) B. 80 - 90 (B- to B+) C. 70 - 80 (C- to C+) D. We use a different system E. I cannot say accurately enough		C	0.1
226. *During your high school career to how many clubs, committees and societies did you belong? A. None D. 9 - 15 B. 1 - 3 E. 16 or C. 4 - 8 more		A	0.1

(continued on next page)

Table 13. (continued)

Question and number	Response of Scientist per cent	Response of Contemps. per cent	Significance in per cent
(1)	(2)	(3)	(4)
227. On how many athletic teams were you a regular member? A. Four D. One B. Three E. None C. Two	E62	38	0.1
Attitudes and Opinions			
228. *Did you ever think that a scientist should ignore one of these? A. Pay B. Promotions C. Work conditions D. Associates E. None of these		B	5
229. What was your answer to this question: Which one of these should a scientist ignore? A. Religion D. Finance B. Politics E. Civil Law C. War	No	No	No
230. Did you ever believe that a worthy student's financial needs should be met by a loan and repaid as follows: A. In cash to loaner B. In work C. No repayment D. To another student loan fund E. To another student	No	No	No
231. After listening to all the talk of space travel, atomic energy, hormones, communism, what did you think of things "just as they were."? A. They were "OK" as they were. B. Economics needed changing. C. Education needed changing. D. Laws and customs needed changing. E. Everything needed almost complete revision.	No	No	No

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[illegible]			
C. The exactness of science satisfied you. D. You like to "explore the unknown." E. None of these reasons	A35	17	0.1

(concluded on next page)

Table 13. (concluded)

Question and number	Response of Scientist per cent	Response of Contemps. per cent	Significance in per cent
(1)	(2)	(3)	(4)
236. Did you think that you would become a scientist because: A. You could extend the boundaries of human knowledge. B. It is easy to get good jobs in science. C. You could show results of a definite nature. D. You could grow and develop working on important problems. E. None of these reasons	A34	15	0.1
237. Did you think that you would become a scientist because: A. You could develop your specialty and become an authority. B. You could work without close supervision. C. You could have a strong voice in selecting your problems. D. You could anticipate steady, sure advancement. E. None of these reasons	E49	64	No
238. Did you think that you would become a scientist because: A. You "sort of drifted" into it. B. You followed somebody else's successful career. C. Someone else convinced you to become a scientist. D. The men you respected most were scientists. E. None of these reasons	E64	86	No

Table 14. Questions 239 through 300 showing "Like" responses for science students and their contemporaries.

Question and number	Response of Scientist per cent	Response of Contemps. per cent	Significance in per cent
(1)	(2)	(3)	(4)
Interests			
239. Watching sports.....	88	91	No
240. Playing sports.....	86	86	No
241. Reading about sports.....	52	64	5
242. Playing games outdoors.....	87	89	No
243. Social card games.....	63	63	No
244. Social gabfests or conventions.	66	66	No
245. Club meetings.....	79	66	2
246. Dancing.....	76	78	No
247. Political activity.....	58	63	No
248. Travel.....	96	98	No
249. Nature walks.....	86	73	1
250. Seashore walks.....	88	88	No
251. Mountain hikes.....	90	85	No
252. Long-distance hikes.....	80	69	5
253. Short walks.....	90	88	No
254. Driving for sightseeing or joy riding.....	89	92	No
255. Boating for sightseeing.....	90	89	No
256. Flying for sightseeing.....	83	86	No
257. Writing stories or articles....	65	69	No
258. Journalism.....	50	63	5
259. Reading science.....	86	65	0.1
260. Reading science-fiction.....	62	50	No
261. Reading regular fiction.....	77	84	No
262. Reading regular non-fiction....	91	85	No
263. Language study.....	60	60	No
264. Music: playing.....	69	76	No
265. Music: listening to classical.	89	86	No
266. Music: listening to jazz.....	64	71	No
267. Public speaking.....	55	58	No
268. Civic service (local committees).....	45	46	No

(continued on next page)

Table 14. (continued)

Question and number	Response of Scientist per cent	Response of Contemps. per cent	Significance in per cent
(1)	(2)	(3)	(4)
269. Theatre, Dramatics: Participating	52	52	No
270. Theatre: spectator	80	95	0.1
271. Television: watching it	66	78	1
272. Radio: listening to it	82	91	5
273. Radio: amateur ham operator	60	50	No
274. Radio: Hi-Fi and set building.	69	37	0.1
275. Movies: seeing them	90	92	No
276. Movies: making them	62	58	No
277. Painting	56	63	No
278. Sculpturing	45	45	No
279. Handiwork, crafts and carpentry	81	71	No
280. Photography: taking, developing and printing	87	67	0.1
281. Mechanics: repairing and tinkering	83	64	0.1
282. Inventing things	92	66	0.1
283. Science studies on projects	95	53	0.1
284. Winter sports outdoors	84	86	No
285. Model building, boats or airplanes	64	63	No
286. Aquatic (water) sports of all kinds	87	89	No
287. Study of courses for school	83	65	0.1
288. Household arts: cooking, sewing, decorating	38	26	5
289. Collecting stamps, matches, coins, etc	47	40	No
290. Gardening	52	44	No
291. Raising pets, fish, animals, birds	66	62	No
292. Zoo study	60	53	No
293. Museum study or work	67	60	No

(concluded on next page)

Table 14. (concluded)

Question and number	Responses of Scientist per cent	Responses of Contemps. per cent	Significance in per cent
(1)	(2)	(3)	(4)
294. Hunting or fishing.....	66	72	No
295. Scouting activities.....	59	55	No
296. Astronomy.....	86	65	0.1
297. Community service with children.....	47	53	No
298. Playing chess.....	71	55	1
299. Day dreaming.....	79	67	5
300. Passing the time of day by small talk.....	50	57	No

Numerical summary of the tabulated data.-- An appraisal of the data in the preceding tables revealed that there were many significant items: 31 items significant at the 5 per cent level, 13 significant at the 2 per cent level, 32 significant at the one per cent level, and 93 significant at the .01 per cent level. A total of 131 items were not significant. Although many items appear to discriminate statistically between the two groups, "superior science students" and "generalists," this discrimination is based upon group comparisons and it is recognized that frequently individuals within each group were not consistent with the group pattern. Lack of equation of the I.Q. factor may have contributed to some of these differences. Conclusions drawn from a more detailed analysis of the items and a synthesis of a portrait consisting of the characteristics of superior science students and some factors that were found in their backgrounds have been presented in the following chapter.

CHAPTER V

SUMMARY AND CONCLUSIONS

1. Conclusions Drawn from the Portrait

Characteristics of superior science students.-- The portrait appearing below describes those characteristics of the superior science students which are significantly different at the 1 per cent level from those characteristics of their contemporaries in general education. These portraits were developed by grouping significant items which might be related to such general categories as Personality, Attitudes and Opinions, Activities, Interests and the like. To clarify this procedure further, numbers appear after the first five items in the portrait under the general category Personality. These numbers identify the items in the portraits with their source as an item in the inquiry form. Further identification can be made by examining the comparison of portraits that follows in this chapter.

Personality.-- The superior science students have a strong curiosity about the cause of everything (19). Their thoughts often take the form of day-dreaming (9) or mental puzzle solving (26), although they do not believe that people are aware of this (10). Many have a strong sense of personal responsibility (5). They can control their own tempers and persist on a job to its completion. Many have

an appreciation of the values of complex things for they enjoy symbolic art and classical music. At their present age they spend more time in church than in pre-arranged dates with members of the opposite sex. Many indicate a lack of participation in games of chance or athletics. They also are disinterested in participation as spectators.

Attitudes and opinions.-- The superior science students recognized the importance of other people for they get science knowledge and help from them and feel a responsibility to others. They were confident that neither superstitions nor events of chance ruled their lives. They respected intelligence for almost all of them consciously tried to separate their judgment from their likes and would quickly change their opinion if proven wrong. Curiosity about everything in the natural world was a strong motive in their lives. It may be a form of this that drove them to finish whatever job they started. They did not share society's lack of reverence for science for they questioned the use to which science was put and the drafting of scientists for military use.

Interests.-- The interests of the superior science students are those of persons whose activities are solitary or nearly so. They like to read science and to study their courses of study for school. Nearly all liked to take nature walks and play chess. In their workshops nearly all liked to tinker with and repair mechanical things, do photography

and build radios and hi-fi sets. They were frequently trying to invent things. They did not enjoy being a spectator and watching people perform in the theater or on television as much as did their contemporaries in general education.

Activities.-- In their high school activities the superior science students were found to be scholarly, scientific and desirable additions to a classroom. They earned a high academic average, were on the honor roll all the time, never failed a course and became members of honor societies. They were a pleasure to have as students for they sometimes acted as teaching assistants, frequently gave lecture demonstrations, helped operate audio-visual aids, worked on school publications and were never expelled for discipline reasons. They were, as would be expected, above all, scientific in their activities. These included membership in scientific societies and some were members of Junior Academies of Science and Science Clubs of America. They did occasionally hold office in these organizations. Nearly all enjoyed mathematics and earned good marks in it. Nearly all did many science experiments, some of which were high grade research projects or inventions or an improvement in a scientific method or device. They entered their work very frequently in science contests and won awards. Some demonstrated their work in science fairs or in congresses or they published articles about them. Many took field trips, a few students even planned and led them.

Frequently these field trips were to scientific industry. They nearly always had a time and a place to study science in school after hours or at home. A few had a part time job in science. Most of their time was taken by science but they did join some non-science clubs or organizations but these were never athletic teams or voluntary military organizations.

Factors that were found in their background.-- The portrait appearing below describes those factors in the background of the superior science students that were significant at the 1 per cent level and differed from those of their contemporaries in general education.

Family history.-- The influence of the family on the superior science students was rather ideal. Among their older relatives were many teachers and some scientists. The fathers usually had a post-graduate degree and the mothers also were college graduates or beyond. Many of the students were the first born child in the family. The principal residence was in a large city of a million or more population. During high school years the family did not move or change residence. The families were apparently financially comfortable because the students did not have an after school job and they did have leisure time to study science. They had adequate laboratory or workshop facilities available and often these were at home. The fathers did not "boss" the family. The families highly respected and praised

science and were strongly in favor of the students' plans for a scientific career.

Associates.-- The superior science students had many stimulating influences among their associates. Many personally knew a scientist or had a family friend who was a scientist. A few had a scientist for their personal hero. Some worked with a scientist. Some tried to behave like a scientist. Almost all had chums who wanted to be scientists and sometimes these friends let themselves be led into group science activities. Some directed themselves as a "lone wolf" in science while others found some older student who would help, direct and guide their science activities. Some found their science teacher to be the greatest influence that they knew in helping and encouraging them in their plans to become a scientist. Nearly all agreed that books gave them encouragement and inspiration in becoming a scientist.

Science teacher.-- The science teacher was an important person in the lives of the superior science students. To a few he was almost a second parent. To nearly all he was fun to be with most of the time and he quickly gained their admiration and respect. Some teachers had a master's degree in science or education and had ambitions that were related to their career as a science teacher. Many students thought that the science teacher was using his greatest ability as a science teacher. They appeared to be quite professional in behavior for many communicated with other science teachers

and some communicated with scientists and belonged to professional organizations. Many had a hobby and a few invented scientific or teaching devices. A few had after school jobs. Many believed in hard work for themselves, that is, long hours; so they sponsored science clubs, gave students opportunities to lead group science activities and almost all assisted students in after school science activities. Whatever their teaching philosophy was they did not believe in teaching facts to disciplined groups, although some used lectures in their classrooms.

Decision to be a scientist.-- It was difficult to secure valid data on this topic, however there is evidence that the superior science students decided on a scientific career early in life, some when they were still in elementary school. They reported that this was because science was so interesting to them, they had a natural aptitude for it and that they thought they might extend the boundaries of human knowledge.

Comparison of the portraits.-- The following is an attempt by the writer to compare the portrait of the "gifted-student-scientist" that has been drawn from a study of the published research with a portrait of the superior science student that has been drawn from this study. Those items in the left column are items that were found in the review of published research. Those in the right column are items that were found in this study. The latter are significant

by 1 or 0.1 per cent in contrasting the scientists with their contemporaries. The items in both columns are placed in contrast with each other showing the contribution of this study to the body of knowledge on this topic.

Portrait from research of the "gifted-student-scientist" 1/	Portrait from this study of the superior science student 2/
Personality	
Enjoys leadership	5. Likes to assume responsibility 32. Likes to be a group leader in science
Curious	10. Not called "nosey" for his curiosity 19. Seeks causes for all effects
Puzzles	26. Liked to solve puzzles and riddles
Sophisticated	23. Prefers symbolic to realistic art 24. Prefers classical to popular music
Stable	15. Worked long and hard on self-assigned tasks 29. Never regretted having lost his temper
High intelligence	9. People call him a "day-dreamer"

1/ P. 65

2/ P. 113

Independent	184. Seldom has pre-arranged "dates"
Likes society	186. Goes to church twice a week
Vocal	
Physically healthy and active	187. Not average height
	185. Never gambles in games of chance 188. No desire to be like an athlete

Attitudes and opinions

	154. Decided a person is not responsible only for himself 160. Believed in no superstitions 162. Chance to play no part in his life 164. Gathers his own information 165. Changes his opinion if proved wrong 167. Consciously separates likes from judgment 176. Got real help in science from people 177. Curious about the natural world 178. Tenaciously persisted on a job 180. Questioned the use to which science is put 183. Thought scientists too valuable to be drafted for military service

Interests

Walking	249. Took nature walks
Reading	259. Read science
Music	24. Preferred classical music

Radio	274. Liked to build radio and Hi-Fi sets
Photography	280. Liked to do photography
Courses of study	287. Liked courses of study in school
Laboratory work	281. Liked mechanical tinkering 282. Liked inventing things 283. Liked science projects
Art	23. Preferred symbolic art
Mathematics	131. Liked mathematics
Crafts Magic Collecting Hunting Fishing	
	270. Disliked attending theatre 271. Disliked watching television 296. Liked astronomy 298. Liked to play chess

Activities

Joined societies	115. Joined scientific societies 116. Joined non-science clubs 148. Joined Junior Academy of Science
Worked at his hobbies	126. Planned and did experiments alone 127. Did scientific research 128. Improved scientific devices 129. Invented scientific things
Enjoyed his family	133. Had a place to study science at home
Is an avid reader	130. Published scientific articles 141. Worked on school publication 259. Liked to read science

	117. No interest in athletic teams 120. Joined no military organizations 122. Competed in science fairs 123. Competed in science congresses 124. Competed for science prizes 125. Won science prizes 134. Acted as a teaching assistant 135. Gave lecture demonstrations 136. Went on field trips 137. Led field trips 139. Visited scientific industry 140. Operated audio-visual aids 143. Had a part-time science job 144. Had time for home science study 145. Studied science "after school" 146. Belonged to "Science Clubs of America" 149. Became an Honor Society member 150. Held office in a science club 218. Never expelled from school 219. Never failed a course 220. Poorest course not mathematics 224. On Honor Roll all the time 225. Earned high marks in courses 226. Belonged to some clubs 227. Played on no athletic teams

Family History	
Family in high economic level	50. Had no after school job 52. Had leisure time for science 54. Had a home workshop or lab
Father a business executive or a professional man	190. Father has a post-graduate degree 194. Father not a business man

Family in a high cultural level	191. Mother a college graduate and has post-graduate training 61. Scientists among older relatives 64. Teachers among older relatives
	40. Father did not "boss" the family 48. Family praised science 56. Adequate laboratory facilities were available 193. Lived in a city of a million people 195. Did not change residence during high school 198. Was first born child - boy 204. Family strongly supported student's science plans
Associates	
	68. Personally knew a scientist 69. Worked with a scientist 70. Had a "hero" scientist 71. Tried to behave like a scientist 72. Had chums also in science 73. Directed self in science 74. Had friends who wanted to be scientists 76. Friends let themselves be led in science activities 77. Had older students as advisors in science 207. Science teacher was greatest person of influence in science 209. Books were greatest things of influence in science
Science teacher	
Had a love for his students	82. Fun to be with most of the time 83. Almost a second parent

Had a wide range of information	93. Communicated with other teachers 94. Communicated with scientists
Had a mastery of his subject matter	95. Belonged to professional organizations 99. Invented scientific devices 216. Had a master's degree in science or education
Gave students guidance and assistance	100. Assisted students in after hours science activities 97. Sponsored the science clubs
Gave students much freedom to find out for themselves	101. Gave students a chance to organize and lead their own science instruction
Inspired students by personal example	99. He invented scientific devices 113. Quickly gained the students' admiration and respect 108. Had a hobby 90. Had ambitions related to his job of teaching science
Used projects, seminars, and visual aids	140. Helped teacher by operating audio-visual aids 283. Liked science studies or projects
Had a high intelligence	
Had a sense of responsibility	91. Believed in hard work for himself and long hours
	85. Used his greatest ability as a science teacher 104. Had an after school job 214. Used lectures in teaching 215. Teaching philosophy was not to teach facts to disciplined groups

Decision to be a scientist	
	232. It came early, usually when student was in elementary school 234. He had a natural aptitude for science 235. It was interesting 236. He thought that he could extend the boundaries of human knowledge

Occupational choices	
Science	Physicist--research
Physician	Doctor--practice
	Chemist--research
Engineering	Engineer--chemical
Mathematician	Mathematician
	Chemist--general Physicist--general Biologist--research Doctor--research Engineer--electronic Undecided Engineer--electrical Engineer--aeronautical Engineer--mechanical Engineer--physics Teacher Astronomer Psychologist
Journalist	Writer--journalist
Professor	Science professor
	Medical service Engineer--unspecialized Biologist--general Engineer--automatic control Engineer--nuclear
Lawyer	Lawyer

	Theologist Engineer--architect Engineer--industrial Radio--TV--entertainment
Business management	Business

2. Implications for Further Study

There are implications for further study on this problem. They appear to be as follows:

The 504 superior science students can be subdivided into the following smaller groups and each studied in the same manner as the whole group of 504 superior science students in this study: Winners of the Science Talent Search, Potential Scientists, Potential Engineers, Women Science Students, Potential Members of the Professions.

There could be investigations to discover the causal factors behind certain characteristics or factors in the background. For example, certain students had an interest in science that began while they were in the elementary school. Why is this so, what grade were they in and what were their programs, schools, and teachers like in those years?

Further studies could be undertaken with smaller groups in which a better control was maintained over such factors as intelligence, mechanical ability and mathematical ability.

A new instrument for selecting superior science students could be developed using only those items of significance that are highly critical.

The methods employed in this study could be applied to the study of science teachers and other professional or scientific personnel.

3. Limitations of this Study

A major limitation of this study is the lack of comparability of the intelligence factors between the "scientists" and the "generalists" groups. Intelligence quotients of the members of the science group are probably 140 or more, whereas those of the general group are over 120 with a known mean of 128. Equating the intelligence factor might reduce the number of significant items markedly.

A second limitation may occur in recalling data which in many instances are not too recent. Since inconsistencies in recall may be comparable for both groups it may be assumed that this had slight effect on the critical analysis of the items.

APPENDIX A

ENCE CLUBS OF AMERICA · 1719 N STREET NW · WASHINGTON DC

SCA

DEDICATED TO THE DEVELOPMENT OF SCIENCE TALENT
ADMINISTERED BY SCIENCE SERVICE, the Institution for the Popularization of Science. WATSON DAVIS, DIRECTOR

Fall 1953

Here Are the Thirteenth Science Talent Search Materials You Requested:

There are two different booklets for use in connection with contestants: the Science Aptitude Examination and the Personal Data Blank. Complete directions for the use of these booklets are given below.

The sealed envelope containing the Science Aptitude Examination must NOT be opened until the time of the administering of the examination. IT MUST BE OPENED IN THE PRESENCE OF THE CONTESTANTS.

Get the contestants started on their reports at once if they have not already begun or completed this requirement.

As soon as possible, have the teachers and the principal fill out the Personal Data Blank. This blank must not be shown to the contestant after completion.

Administer the Science Aptitude Examination on or after Monday, December 7 and not later than Sunday, December 27, 1953. All three parts of each entry submitted in the Science Talent Search must reach the offices of Science Clubs of America, 1719 N Street N.W., Washington 6, D.C., not later than midnight, Sunday, December 27, 1953.

Enclosed is a suggested publicity announcement of your school's participation in this contest to send to your local newspapers.

DIRECTIONS

Each contestant in the Science Talent Search must submit evidence of his fitness for the further study of science in three ways:

1. By taking the Science Aptitude Examination.
2. By having faculty and the principal complete the Personal Data Blank.
3. By writing a report on the topic, "My Scientific Project."

The directions for doing each of these are given on pages 2 and 3. It is important that these directions be followed carefully, and that all materials in regard to each contestant have on them the name and address of the contestant and the name and address of his school.

Inadequately or incompletely filled out credentials make it impossible to evaluate a contestant's capabilities, and result in elimination of the contestant from the competition.

PERSONAL DATA BLANK

The Personal Data Blank is designed to furnish information about the student and h academic training. There are two parts to the blank. Both parts must be filled out careful by the principal and faculty. After this has been done, the completed blank must not be shown to the pupil.

Part I, Recommendation, should be filled out by those members of the school Facul who are in a position to judge the student's fitness for the further study of science. A talk with the student in advance is suggested if he is not already well-known to those filling in t blank. In evaluating these two pages, credit will be given only for specific and concrete ev dence of competence in the trait. Be specific. By making your recommendations full and complete you enable the judges to make fairer evaluations in both the national and the state Science Talent Searches.

Part II, Secondary School Record, will be completed by the school office. The estim ted rank in the high school class (based on the entire high school record) and also the numb of students in the senior class must be given. To report "in upper fourth" is not specific enough; in fact, it may penalize some potential winner.

By having all of the Personal Data Blank filled in before the student takes the Scien Aptitude Examination, it will be possible to mail the Science Aptitude Examination, the Per sonal Data Blank, and the Project Report to Science Clubs of America immediately after th examination.

THE REPORT: "MY SCIENTIFIC PROJECT"

Each contestant must write a report on the topic, "MY SCIENTIFIC PROJECT." T report must represent the thinking and composition of the student. It should be approxima 1,000 words in length, typed on white paper, double spaced and on only one side of the shee The name and address of the student should be put on the back of each sheet. The report should be creative, original and interpretative in character. It should tell what the student doing or plans to do in science in the way of experimentation or other research activity. Sketches or photographs may be submitted, but are not required. Drawings must be done neatly in India ink. All reports will become the property of Science Service and cannot be turned. Therefore, all students are requested to keep a carbon copy of the report for pers use.

THE SCIENCE APTITUDE EXAMINATION

The Science Aptitude Examination has been designed to measure the student's abilit to read, understand and think in terms of the concepts and techniques of science. It is not test of knowledge of science, but it does require many of the skills and abilities which seem be basic to the study of science at the college level. In giving the test in your school, follo the directions carefully, so that each student will have the opportunity of doing his best. A one period of three hours for the Science Aptitude Examination (one-half hour for the preli naries and two and one-half hours for the examination).

ADMINISTRATION OF THE SCIENCE APTITUDE EXAMINATION

Be sure that each student has at least two well-sharpened, soft pencils and an erase The test should be given in a well-lighted, quiet room. This room should be kept free from disturbances. As soon as the students are assembled, and before opening the sealed packa of tests, read the following aloud to the students:

"I am now about to open this sealed envelope containing the examination papers. Please note that I am doing this in your presence, since at the end of the examination you will be required to sign a statement that you saw me do this."

Then open the sealed package containing the Science Aptitude Examinations, and give each student one Science Aptitude Examination, face up. Then read the following directions, allowing time for the students to comply with them.

"On the blank where it says FULL LEGAL NAME, print your name in capital letters - your last name first, then your first name, and middle name. Print in CAPITAL letters." (If student has same names as father, Jr. should be indicated.)

"On the next line write the address of your home - street and number, the city and zone, and the state."

"On the third line, write the name of your school, then its address - the city and zone, and the state."

"Fill in your age, date of birth and sex."

"Now go ahead and answer the remaining questions on pages 1, 2, and at the top of page 3. Answer each one carefully as they are used by the judges and for publicity purposes. After you finish answering the questions, wait for instructions before beginning the test."

The questions on the first three pages should be answered in not more than 20 minutes. The teacher in charge may aid the contestants in answering these questions. As soon as all have answered the questions, proceed with the reading of the directions and the examination as follows:

"Now read the DIRECTIONS; read them carefully so you will know just what you are to do on this test."

As soon as the students have had time to read the Directions on page 3 and to answer the sample questions, see that each student has the right answer marked in the proper fashion. The answer to question 3 is 2; and to 4, the correct answer is 1.

When you are certain that the students understand the directions, say - "Turn to page and BEGIN . . ."

The entire test, Parts A, B and C, must be completed at one test session. Students shall be allowed two and one-half hours in which to take the test.

At the end of two hours interrupt the students and announce: "You have used two hours your time. You have one-half hour more in which to finish the examination."

At the end of two and one-half hours say: "Stop work. Now fill out the Certification r Student on page 16." Then all tests must be collected, and the Certification by Teacher gned. No examination will be considered unless these two certifications are signed.

After the tests have been collected be sure that:

1. The Certification by Teacher has been properly signed.
2. The Certification by Student has been properly signed.
3. The student's name and address, and the name and address of the high school, are correct and legible.

SHIPPING

Before shipping the Science Talent Search materials back to Science Clubs of Ameri check them as follows:

1. For each student there MUST be three evidences of fitness: a Science Aptitude Examination, a Personal Data Blank, and a Project Report.
2. The name and address of the student MUST appear on each of the three evidences of fitness.
3. The materials, after careful checking MUST be shipped by EXPRESS PREPAID or FIRST CLASS MAIL to Science Clubs of America, 1719 N Street N.W., Washington 6, D.C. All three parts of each entry submitted in the Science Talent Search must reach the offices of Science Clubs of America not later than midnight, Sunday, December 27, 1953.
4. Only complete entries will be considered for judging. Do NOT send incomplete entries. Arrivals after the deadline cannot be considered.

Send in entries early to avoid any delays by overcrowded Christmas mails. Entries cannot be acknowledged. If you wish to confirm arrival, register your entries and ask for a delivery receipt.

Individual scores on the Science Aptitude Examination are not reported. Please do n request them.

HOW WINNERS ARE ANNOUNCED

The 40 top winners will be notified by telegram.
Teachers and Principals of the 40 top winners will be notified by mail.
The 260 honorable mentions will be notified by mail.
Teachers and Principals of the 260 honorable mentions will be notified by mail.

A list of winners and honorable mentions in the Thirteenth Annual Science Talent Search will be available in February, 1954. Anyone may have a cope by sending a 3¢ long, self-addressed envelope to Science Clubs of America, 1719 N Street N.W., Washington 6, D.C. Include your envelope when you return your entries to SCA. This will assure you a copy as soon as the list is ready. An answer sheet for the examination will be included.

The 40 chosen to come to Washington will be announced in newspapers and in a late January or early February issue of the weekly magazine SCIENCE NEWS LETTER.

If your state is conducting a State Science Talent Search cooperatively with the National Search, all completed entries, submitted to the National Science Talent Search, will be considered in your state competition. Those planning to hold State Searches in 1953-54 are:

Alabama	Iowa	Minnesota	South Dakota
Arkansas	Kansas	Montana	Tennessee
Connecticut *	Louisiana	New Hampshire *	Texas
District of Columbia	Maine *	Pennsylvania	Vermont *
Georgia	Massachusetts *	Rhode Island *	Virginia
Illinois	Michigan	South Carolina	West Virginia
Indiana			Wisconsin

* All included in the New England Science Talent Search

SCIENCE APTITUDE EXAMINATION

THE THIRTEENTH ANNUAL

Science Talent Search

Conducted by Science Clubs of America, administered by Science Service, for the

WESTINGHOUSE SCIENCE SCHOLARSHIPS

ll Legal Name: _____, _____, _____
(INT IN PITAL LETTERS) last name first name middle name

ldress: _____, _____, _____
street and number city and zone state

me of School: _____ Address of School _____, _____
city and zone state

e at Last Birthday: _____ Date of Birth: _____, _____, _____ Sex: _____
month day year male or female

hat college or professional school do you expect to attend?

_____

_____
Name and address of college

ve the name and location of the college or professional school hich you would *prefer to attend* above all others.

_____

_____
Name and address of college

hat course of study do you plan to follow in college or ofessional school?

_____

_____

_____

_____

_____

hat occupation do you actually expect to follow?

First Choice _____

Second Choice _____

If you could do just as you please, what would you really like to be doing ten to fifteen years from now? Why?

_____

_____

_____

CHECK HERE the *extra-class activities* (outside the classroom) in which you have participated, and the *organizations* to which you have belonged:

Formerly	*Now*	
____	____	School Publication
____	____	Mathematics Club
____	____	Science Club
____	____	Glee Club
____	____	Athletics (specify) _____
____	____	_____
____	____	_____
____	____	Science Clubs of America
____	____	Junior Academy of Science
____	____	Boy Scouts
____	____	Boys Clubs of America
____	____	Future Farmers of America
____	____	Hi-Y
____	____	Tri-Y
____	____	Quill and Scroll
____	____	Girl Scouts
____	____	Campfire Girls
____	____	4-H Club
____	____	Girl Reserves
____	____	Other (specify) _____
____	____	_____
____	____	_____

LIST HERE *special recognitions*, prizes, honors, and scholarships (e.g., valedictorian, honors in state scholarship contests, National Honor Society, medals, cups, presidencies, managerships, athletic awards, etc.)

LIST HERE the *hobbies* in which you have engaged since entering secondary school (e.g., photography, aviation, cryptanalysis, etc.).

LIST HERE, and briefly describe, any *special scientific* or professional apparatus or other mechanical devices which you are competent to use.

Describe briefly any research or other special work which you now have in progress.

What are the main things you have learned about science during the past year?

What do you think have been your principal contributions to science during the past year?

What have you done during the summers while you have been in high school?

What foreign languages do you read readily?

What studies in high school have you liked *least*?

What studies in high school have you liked *most*?

What is your father's name and occupation? If deceased, che
here ☐, and state his occupation prior to death.

What college or professional schools (if any) did your fath
attend; and what degree or degrees (if any) did he obtai
If none, write "None."

What is your mother's name and occupation? If deceased, che
here ☐, and state her occupation prior to death.

What colleges or professional schools (if any) did your moth
attend; and what degree or degrees (if any) did she obtai
If none, write "None."

Have you had any scientists in your family? If none, wri
"None." If answer is "Yes," give their names, relation to yo
and contributions to science.

Height: _____ ft. _____ in. Weight _____ lbs.

Specify any physical defects, disease, or disability, particular
any and all defects which might in any way limit your worki
capacity. If none, write "None." If answer is "Yes," give detai

/hat one person has been most influential in the development of our scientific career?

_____
(Name) (Position)

_____
(Mailing address)

what way?

_____

_____

_____

If answer to any of the following four questions is "Yes," give details:

1. Have you ever come to the attention of a court? (Check one)
   Yes_____ No_____

2. Have you ever had a nervous breakdown? (Check one)
   Yes_____ No_____

3. Have you ever been examined or treated for a personality disturbance? (Check one) Yes_____ No_____

4. Are you considered nervous? (Check one) Yes____ No____

I certify that all the information given is correct. I also understand that the report I am submitting may be used in any way by ience Service.

ate _____ Signature of Student _____

DIRECTIONS: Your standing in the Science Talent Search ill be determined in part by what you do on this test. Read the rections carefully so you will know exactly what you are to do.

There are three parts to this test. The entire test **MUST** e completed during one test session. You will be allowed two d one-half hours for the entire test. Most students will be le to finish in less than this time.

Do not spend all your time on Parts A and B. If at the end two hours you have not completed Parts A and B, be sure go on to Part C.

Part A consists of 50 questions. For each question there are ur possible answers. To answer a question, put an X in the arentheses corresponding to the answer which you think is **ost nearly correct.**

In Part B, the questions following each paragraph are based the information given. Read the paragraph and then answer ch of the questions. For each question four possible answers e given. To answer a question, put an X in the parentheses rresponding to the answer which you think is **most nearly rrect.**

Do not spend too much time on any one question. You may turn to it later. In case you wish to change an answer, erase mpletely, and then mark the correct answer. In Parts A and any question with more than one answer X'ed will be counted rong. For each question there is **one best answer.**

Directions for Part C are given in Part C.

As soon as you have completed Part A, do not wait for any gnal, but go on immediately to Part B. Likewise when you have ished Part B go on immediately to Part C.

In order to make sure that you understand the directions, answer the questions below which refer to these directions. The correct answers are indicated for the first two questions. Then mark the correct answers for questions 3 and 4.

1. The time allowed for this test is
   ( ) 1. two hours
   (X) 2. two and one-half hours
   ( ) 3. three hours
   ( ) 4. three and one-half hours

2. How many students can expect to complete the test within two and one-half hours?
   (X) 1. most
   ( ) 2. half
   ( ) 3. a few
   ( ) 4. none

3. The right way to indicate your answer to a question in Parts A and B is to
   ( ) 1. mark out an answer
   ( ) 2. make an X in the appropriate parentheses
   ( ) 3. write the answer in the margin
   ( ) 4. mark out all the wrong answers

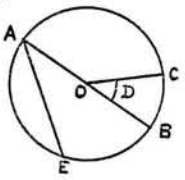
4. Among the answers for each question in Parts A and B you should find
   ( ) 1. one best answer
   ( ) 2. one right and three wrong answers
   ( ) 3. two answers which are correct
   ( ) 4. no completely correct answers

DO NOT TURN THIS PAGE UNTIL TOLD TO DO SO

PART A

DIRECTIONS: Four possible answers are given for each question. Put an X in the parentheses in front of the number corresponding to that answer which you think is **most nearly correct.**

1. Which of the following is *not* correct?



( ) 1. central angle: BAE
( ) 2. chord: AE
( ) 3. diameter: AOB
( ) 4. radius: OB

2. Why do cold-water pipes in a basement often "sweat" on a hot summer day?

( ) 1. More water is drawn through the pipes on warm days.
( ) 2. The air around the pipes expands and loses water vapor.
( ) 3. Water evaporates from the surrounding air.
( ) 4. Water vapor in the surrounding air condenses on the pipes.

3. The *newton*, a unit of measurement, measures the same sort of physical quantity as the

( ) 1. ampere
( ) 2. dyne
( ) 3. meter
( ) 4. second

4. Which of the following is *not* a use of the mineral quartz?

( ) 1. as parts in ultra-violet lamps
( ) 2. cutting diamonds
( ) 3. manufacturing glass
( ) 4. regulating radio-wave frequency

5. Which of these is *not* a classification of rocks?

( ) 1. fragmentary
( ) 2. igneous
( ) 3. metamorphic
( ) 4. sedimentary

6. When a lighted match is thrust into a bottle containing pure oxygen, the match

( ) 1. burns more slowly
( ) 2. burns more rapidly
( ) 3. explodes
( ) 4. ignites the oxygen

7. The *tympanic membrane* is located in the

( ) 1. ear
( ) 2. eye
( ) 3. larynx
( ) 4. nose

8. Which of the following is used to transfer power from a drive shaft to another operating at right angles to it?

( ) 1. bevel gears
( ) 2. helical gears
( ) 3. planetary gears
( ) 4. spur gears

9. Which of the following is *not* an antibiotic?

( ) 1. aureomycin
( ) 2. bacitracin
( ) 3. prothrombin
( ) 4. streptomycin

10. New drugs, the isoniazids, have been tried on 237 patie gravely ill with tuberculosis. The drugs cut the death r for this group to 10.5 per cent. The expected death rate this group without the isoniazids treatment was 75 per ce It is proper to conclude that

( ) 1. a sample as small as 237 is too limited to perm conclusions
( ) 2. the new treatment appears very good, and shou be given further trial
( ) 3. the new treatment is adequate for advanc cases
( ) 4. the new treatment should be prescribed for tuberculosis patients

11. Which of the following is *not* a chemical element?

( ) 1. borax
( ) 2. iridium
( ) 3. protactinium
( ) 4. xenon

12. The greatest nutritional problem in the U. S. A. is

( ) 1. arthritis
( ) 2. obesity
( ) 3. scurvy
( ) 4. underweight

13. Ultra-microscopic infectious agents are called

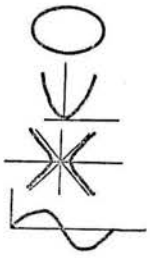
( ) 1. bacteria
( ) 2. germs
( ) 3. spores
( ) 4. viruses

14. Which of the following bones is *not* found in the arm?

( ) 1. femur
( ) 2. humerus
( ) 3. radius
( ) 4. ulna

15. Which of these figures is *not* an ellipse, a hyperbola, nor parabola?

( ) 1.
( ) 2.
( ) 3.
( ) 4.



16. Dwarf star L886-6 is only 2,500 miles in diameter, with estimated average density 5.5 x 10^7 times that of wat About how much would 1 cc of the material of this st weigh?

( ) 1. 5,500 tons
( ) 2. 55,000 kilograms
( ) 3. 550,000 grams
( ) 4. 550,000,000 grams

17. One of two or more normal human offspring, produced the same parents, is called a

( ) 1. birthmate
( ) 2. sibling
( ) 3. spawn
( ) 4. sport

"The experimental method cannot give new and fruitful ideas to men who have none; it can serve only to guide the ideas of men who have them, to direct their ideas and to develop them so as to get the best possible results." Which of the following statements can *least* well be implied on the basis of the quotation?

( ) 1. Creativeness is more a function of the individual than the method.
( ) 2. Experiment in and of itself is not creative.
( ) 3. Science offers nothing new, only rearrangement of the old.
( ) 4. Scientists who are creative can derive new ideas from their experiments.

A pail with a very small hole in the bottom will sometimes hold water without leaking. This is explained by the fact that

( ) 1. surface tension of the water prevents it from escaping
( ) 2. water is more viscous than air
( ) 3. water molecules are different in size from air molecules
( ) 4. water molecules move more slowly than air molecules

Mercury is used as a solvent in refining

( ) 1. aluminum
( ) 2. calcium
( ) 3. potassium
( ) 4. silver

The population of the world is increasing at the rate of about 60,000 per day. Which of the following problems does such a fact probably make most urgent?

( ) 1. clothing
( ) 2. food
( ) 3. sanitation
( ) 4. shelter

For which of the following products is the bulk of the sulfur mined used?

( ) 1. rubber
( ) 2. sulfa drugs
( ) 3. sulfuric acid
( ) 4. superphosphates

A hyperthyroid condition is likely to be associated with

( ) 1. increased metabolism
( ) 2. low blood pressure
( ) 3. low body temperature
( ) 4. retarded mental activity

The number of ounces in a kilogram is approximately

( ) 1. 25
( ) 2. 30
( ) 3. 35
( ) 4. 40

Which of the following is a colloidal dispersion?

( ) 1. mineral oil
( ) 2. protoplasm
( ) 3. water
( ) 4. whiskey

Which of the following is a property of sodium hydroxide?

( ) 1. deliquescence
( ) 2. effervescence
( ) 3. efflorescence
( ) 4. triboluminescence

27. .00025 mfd equals

( ) 1. 0.0025 mmf
( ) 2. 25 ohms
( ) 3. 250 mmf
( ) 4. 2.5 hy

28. An *anorectic* agent is used to

( ) 1. increase oxygen absorption
( ) 2. reduce the appetite
( ) 3. replace a placebo
( ) 4. slow down the growth of hair

29. *Parthenogenesis* refers to

( ) 1. a branch of science which deals with the origins of rocks
( ) 2. a division of insects characterized by gradual metamorphosis
( ) 3. the development of eggs without fertilization
( ) 4. the occurrence of individuals of two forms in the same species

30. Rare earths occur in all the following *except*

( ) 1. cecite
( ) 2. cinnabar
( ) 3. gadolinite
( ) 4. monazite

31. The structures in the human eye upon which the perception of color apparently is most dependent are the

( ) 1. cone cells in the region of the fovea centralis
( ) 2. peripheral cone cells
( ) 3. peripheral rod cells
( ) 4. rod cells in the region of the fovea centralis

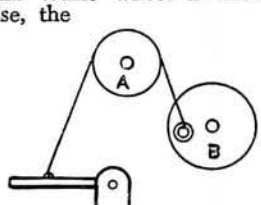
32. On the basis of the blood-donor program in the United States, it has been found that

( ) 1. indices of anemia currently used are unsatisfactory
( ) 2. men and women are about equally anemic
( ) 3. more men than women are anemic
( ) 4. more women than men are anemic

33. The rate at which the earth rotates has been found to vary in three distinct ways. Which of the following is *not* one of these three?

( ) 1. In the spring the earth rotates slower than in the autumn.
( ) 2. The earth is gradually slowing down, so that the length of the day increases about 0.01 seconds in a century.
( ) 3. The earth is sometimes ahead and sometimes behind its average orientation; and in the past 200 years the accumulated variation has been as great as 30 seconds.
( ) 4. There is a cyclic variation which coincides with leap year.

34. The axles of wheels A and B are in fixed positions as shown in the diagram. While wheel B makes a complete turn counterclockwise, the



( ) 1. arm moves down only
( ) 2. arm moves first down, then up
( ) 3. arm moves first up, then down
( ) 4. direction of the movement cannot be determined from the information given

35. What are the missing words in the following sentence? "Lenses in eyeglasses for near–sighted persons are _____ or _____."
( ) 1. concave - magnifying
( ) 2. concave - reducing
( ) 3. convex - magnifying
( ) 4. convex - reducing

36. The density of the central core of the earth is studied by means of
( ) 1. attraction for other planets
( ) 2. core borings
( ) 3. geomagnetic lines
( ) 4. observations of earthquake waves

37. Which of the following is most likely to be put in a desiccator?
( ) 1. chickens
( ) 2. fruit
( ) 3. gasoline
( ) 4. rocks

38. *Brucellosis* is
( ) 1. cell growth
( ) 2. deterioration of tissue
( ) 3. fermentation
( ) 4. undulant fever

39. —||— This is the symbol for
( ) 1. a battery
( ) 2. a condenser
( ) 3. a resistor
( ) 4. an aerial

40. The *integumentary system* refers to
( ) 1. connective tissue
( ) 2. overt behavior
( ) 3. pigmentation
( ) 4. the skin

41. About how frequently do we have two full moons in a calendar month?
( ) 1. once a year
( ) 2. once in three years and ten months
( ) 3. once in two years and eight months
( ) 4. twice a year

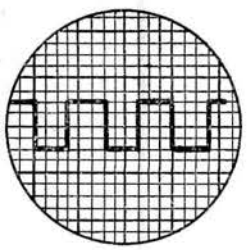
42. Which of the following is most likely to be used for exercise of certain muscles?
( ) 1. cryoscope
( ) 2. kaleidoscope
( ) 3. laryngoscope
( ) 4. stereoscope

43. Which of the following materials is used for control rods in uranium reactions?
( ) 1. antimony
( ) 2. boron steel
( ) 3. carbon steel
( ) 4. titanium

44. Intense streams of neutrons when applied to mice
( ) 1. produce equal reduction of male and fema fertility
( ) 2. produce no reduction in fertility
( ) 3. reduce female fertility more than male
( ) 4. reduce male fertility more than female

45. The study of the origin and chronological successions of th observable rocks of the lithosphere is called
( ) 1. mineralogy
( ) 2. paleogeography
( ) 3. paleontology
( ) 4. stratigraphy

46. This pattern is most likely to found in
( ) 1. a barograph
( ) 2. a cardiograph
( ) 3. a seismograph
( ) 4. an oscillograph



47. Which one of the following is supposed to have *lea* resembled man of today?
( ) 1. Cro-Magnon man
( ) 2. Neanderthal man
( ) 3. Piltdown man
( ) 4. Pithecanthropus erectus

48. *Diptera* refers to
( ) 1. a deficiency of pyriodoxine, causing symptor of Parkinsonism
( ) 2. a disease similar to diphtheria
( ) 3. a star constellation
( ) 4. flies, mosquitoes, and other two-winged insect

49. For approximately how many human characters is the pa tern of inheritance definitely known?
( ) 1. 10
( ) 2. 50
( ) 3. 100
( ) 4. 500

50. The best evidence to date indicates that the space betwe the stars is sparsely filled primarily with
( ) 1. helium
( ) 2. hydrogen
( ) 3. oxygen
( ) 4. tritium

GO ON TO PART B—DO NOT STOP

PART B

DIRECTIONS: Read each Section carefully. The questions following each Section are based on the information given. In other words, the answers to the questions are dependent in some way on the materials of the Section to which they belong. Four possible answers are given for each question. Put an "X" in the parentheses in front of the number corresponding to that answer which you think is **most nearly correct.**

SECTION A

All tumors are divided into two groups, the benign and the malignant. A benign tumor is comparatively harmless; it grows slowly, pushes aside surrounding tissues, and does not spread to other parts of the body. A benign tumor is dangerous to life only when growing in some vital organ, such as the brain.

A malignant tumor is a cancer. Unlike a benign tumor, a cancer can grow rapidly, destroy surrounding tissues, and often spread to distant parts of the body. A malignant tumor is dangerous to life wherever it may grow. Sometimes it is very difficult to say whether a tumor is benign or malignant. Only thorough examination and special tests will determine the true nature of some tumors. The failure to distinguish between benign and malignant tumors in the early stages of growth may result in tragedy.

QUESTIONS ON SECTION A

1. An early cancer is

   ( ) 1. always a benign tumor
   ( ) 2. always a malignant tumor
   ( ) 3. neither a benign nor a malignant tumor
   ( ) 4. sometimes a benign and sometimes a malignant tumor

2. An early cancer

   ( ) 1. always spreads rapidly
   ( ) 2. is easy to diagnose
   ( ) 3. is not curable
   ( ) 4. represents an emergency

3. A test for differentiating malignant and benign tumors is

   ( ) 1. being sought
   ( ) 2. described
   ( ) 3. needed only when growing on some vital organ
   ( ) 4. referred to only in general terms

SECTION B

The symbol $>$ means "greater than." The symbol $<$ means "less than." Given the following: $A<B$, $B<C$, $C=D$, $E<D$, $E>B$, and $F>D$.

QUESTIONS ON SECTION B

. Which statement is correct?

   ( ) 1. $A>C$
   ( ) 2. $A>E$
   ( ) 3. $E>F$
   ( ) 4. $F>C$

. Which statement is correct?

   ( ) 1. $A>D$
   ( ) 2. $C>F$
   ( ) 3. $E<A$
   ( ) 4. $F>A$

56. Which statement is correct?

   ( ) 1. $A+B=D$
   ( ) 2. $A+B>D$
   ( ) 3. $A+B<D$
   ( ) 4. The relationship of $(A+B)$ to D is not given.

57. For which statement is sufficient information given so that its correctness or incorrectness can be judged?

   ( ) 1. $AB=CE$
   ( ) 2. $(A+B)>(C+D)$
   ( ) 3. $(A+E)<2D$
   ( ) 4. $F>(D+A-E)$

SECTION C

The order and arrangement of the gears are shown in Fig. 1. The internal gear is fastened to a rigid cup which holds it stationary.

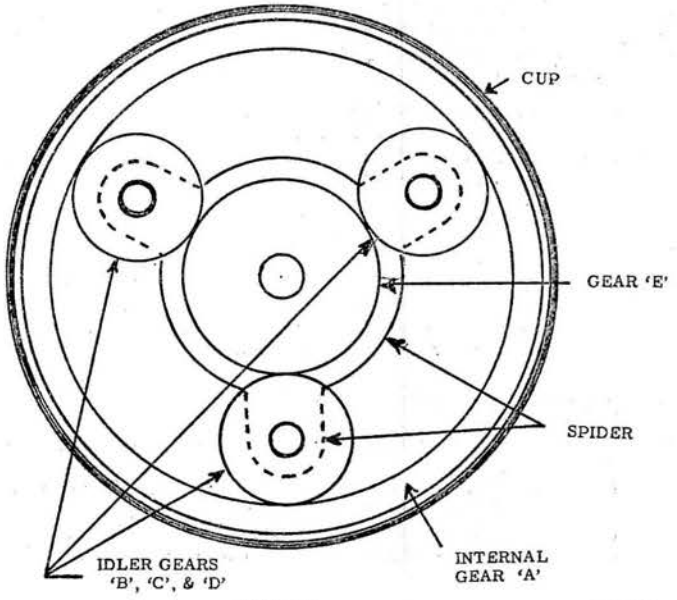


FIGURE I

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The idler gears B, C, and D are in mesh with the internal gear, and are mounted on shafts which are an integral part of the spider.

The spider is mounted on a shaft which allows for its rotation. Gear E is in mesh with the three idler gears and, although mounted on the same shaft as the spider, its motion and speed are independent.

The internal gear has 60 teeth. The idler gears have 15 teeth each. Gear E has 20 teeth.

QUESTIONS ON SECTION C

58. When gear E is rotated clockwise, the idler gears will rotate

   ( ) 1. clockwise, and the spider will rotate clockwise
   ( ) 2. counterclockwise, and the spider gear will rotate clockwise
   ( ) 3. counterclockwise, and the spider will turn counterclockwise
   ( ) 4. on the stationary spider

59. The mechanical advantage gained when gear E is rotated is

( ) 1. ⅛
( ) 2. 3
( ) 3. 4
( ) 4. 6

60. When gear E makes one turn on its shaft, the spider will be turned

( ) 1. ¼ of a rotation
( ) 2. ⅓ of a rotation
( ) 3. 1 rotation
( ) 4. 4 rotations

61. The idler gears increase the mechanical advantage of the system

( ) 1. ⅙ times
( ) 2. ¾ times
( ) 3. 4 times
( ) 4. none

SECTION D

In paleobotany, one of the most interesting orders of plants to study is the Ginkgoales. A member of the gymnosperms, the Ginkgoales are now survived by one species, *Ginkgo biloba*, the Maidenhair tree. Probably originating in the late Paleozoic, the Ginkgoales reached their zenith during the middle of the Mesozoic.

A fossil found in the Upper Devonian of Ireland that was referred to as *Ginkgo* has caused much confusion. Since that specimen is now known to be a fernlike plant, *Ginkgo* is actually not that ancient. *Ginkgo* fossils are found in great abundance in Europe.

Even though *Ginkgo biloba* is probably the oldest living seed plant, it is not certain whether it has been preserved by man, or whether it is a native to the regions in which it now grows, Eastern Asia. Recently explorers in China have reported *Ginkgo biloba* growing in a natural state. The other genera of the Ginkgoales were not so fortunate, only one, *Torellia,* surviving as late as the Tertiary before it became extinct.

QUESTIONS ON SECTION D

62. Which of the following statements may be inferred from the paragraph?

( ) 1. *Ginkgo biloba* is probably the oldest living plant.
( ) 2. *Ginkgo biloba* may be native to Eastern Asia.
( ) 3. *Ginkgo* originated in the middle of the Mesozoic.
( ) 4. The Ginkgoales became extinct in the early Tertiary.

63. Where did the Ginkgoales originate?

( ) 1. Eastern Asia
( ) 2. Europe
( ) 3. Ireland
( ) 4. The paragraphs do not indicate.

64. Which of the following words mentioned in the paragrap refers to the earliest times?

( ) 1. Mesozoic
( ) 2. Paleozoic
( ) 3. Tertiary
( ) 4. Upper Devonian

SECTION E

The purpose of this investigation was to determine the extent the resistance of DDT-resistant *Drosophila melanogaster* to oth contact poisons.

Fine crystals of DDT were scattered in the cage in gradually i creasing amounts as the flies became more resistant. At the en of a year, only about 5% were killed by a concentration of DD that killed about 95% of the control flies.

The flies to be tested were the descendants of flies taken fro the selection cages and from a control population. They we tested at an age of 4 days with 5 doses of the insecticide to tested. The dosage levels were equally spaced logarithmically, 1 flies of each sex and strain being tested at each dosage level. T insecticides were prepared as acetone solutions, and 0.5 ml of t solution was pipetted onto a rectangular filter paper 6x7 cm whi was fitted into a glass vial. After the solution had dried, 20 fli of the same sex were placed in the vial at 26°C. Humidity w kept constant at about 56%. At the end of 6 hrs., the flies were r moved and placed in food vials, and mortality counts we recorded 24 hrs. later.

Tests were made with 10 insecticides other than DDT. The were DDD, Lindane (benzene hexachloride), 118 ("Aldrin" toxophene, methoxychlor, parathion, sabadilla, pyrethrum, nic tine, and TEPP (tetraethylpyrophosphate).

The results of these tests are shown in Table 1.

TABLE 1
MEDIAN LETHAL CONCENTRATIONS ($\mu g/cm^2$) FOR DDT-RESISTANT AND SUSCEPTIBLE DROSOPHILA

	Females			Males		
	Resistant (R)	Control (C)	Ratio (R/C)	Resistant (R)	Control (C)	Ratio (R/C)
DDT	2670	830	3.22	2460	550	4.47
Other chlorinated insecticides						
DDD	48.1	28.1	1.71	43.0	27.0	1.63
Lindane	0.141	0.0611	2.30	0.105	0.0447	2.34
118	0.0237	0.0199	1.19	0.0207	0.0148	1.40
Toxophene	2.98	1.85	1.61	1.66	1.09	1.53
Methoxychlor	23.9	15.9	1.50	21.7	14.2	1.52
Nonchlorinated insecticides						
Parathion	0.251	0.206	1.16	0.217	0.212	1.02
Sabadilla	1.11	1.18	0.94	1.12	1.10	1.02
Pyrethrum	122	127	.97	118	112.	1.06
Nicotine	18.5	20.1	.92	18.6	17.1	1.09
TEPP	10.0	10.1	0.99	9.74	9.70	0.99

UESTIONS ON SECTION E

. What is the missing number in the following sentence? "According to the table, and taking into account all *Drosophila*, about _____ times the DDT concentration was required for the resistant strain as for the susceptible strain."

( ) 1. 1.7
( ) 2. 3.2
( ) 3. 3.8
( ) 4. 4.5

. Which of the following statements is *true*? "For the five nonchlorinated insecticides, the difference in the response of the two strains was

( ) 1. enormous."
( ) 2. not significant."
( ) 3. zero."
( ) 4. the same as for the chlorinated insecticides."

. It appears that, when flies are selected for resistance to DDT, there is some carry-over of resistance to other

( ) 1. chlorinated and nonchlorinated compounds
( ) 2. chlorinated compounds
( ) 3. contact poisons
( ) 4. nonchlorinated compounds

. An R/C ratio greater than unity means that

( ) 1. a greater concentration of the poison was required for the resistant group than the control group
( ) 2. DDT is typical of chlorinated insecticides
( ) 3. female flies showed essentially the same resistance to poison as the male flies
( ) 4. more of the resistant group than the control group were killed

. A median lethal concentration of an insecticide will kill what proportion of the standard test insects?

( ) 1. 5%
( ) 2. 50%
( ) 3. 95%
( ) 4. 100%

CTION F

e binary system of numbers requires only two symbols, which : usually written as 0 and 1. Let us first compare it with a list of ıbling numbers:

Decimal notation	*Binary notation*
0	0
1	1
2	10
4	100
8	1,000
16	10,000
32	100,000

e inference is obvious at a glance. To multiply a number by just add a zero. Or, in a machine, shift the columns one step the left. Now, let us see how the other numbers fit in. We will e just the first few.

Decimal	*Binary*
3	11
5	101
6	110
7	111
9	1,001

QUESTIONS ON SECTION F

70. The product of 5 and 7, stated in binary notation, is

( ) 1. 10,111
( ) 2. 100,011
( ) 3. 1,101,011
( ) 4. 10,111,101

71. The binary number 1,111,111 is, in decimal notation,

( ) 1. 66
( ) 2. 93
( ) 3. 127
( ) 4. 249

72. Evaluate the binary $\sqrt[11]{1,000}$ in decimal terms:

( ) 1. 2
( ) 2. 3
( ) 3. 7.3
( ) 4. 9

73. In the binary system, $\log_{10}X=100$ therefore, $X=$

( ) 1. 1,000
( ) 2. 1,100
( ) 3. 10,000
( ) 4. 11,101

74. 1,011 plus 111 plus 10,001 equals

( ) 1. 11,011
( ) 2. 100,011
( ) 3. 110,101
( ) 4. 111,000

75. The product of the binary numbers 111 and 1,110 is, in binary notation,

( ) 1. 1,100,010
( ) 2. 1,110,111
( ) 3. 10,110,110
( ) 4. 11,100,110

SECTION G

The troposphere is the atmospheric layer between ground level and the tropopause. The troposphere varies in height, depending on the latitude, from about 7 km at high latitudes to 18 km at the equator.

The stratosphere is the atmospheric region lying between the tropopause and an upper boundary known as the stratopause. It is at the latter level that the temperature first begins to increase on ascending at a more rapid rate than is characteristic of the lower stratosphere. The level of the stratopause varies between 35 km and 50 km, according to the latitude and time of year.

The mesosphere is the region between the stratopause and the mesopause, the latter term designating the level between 80 km and 90 km at which the mean termperature minimum occurs.

The mesopause is a very important region of the atmosphere because of its place in atmospheric chemistry. Above the mesopause is the thermosphere, and finally above this area, where the escape of molecules from the atmosphere occurs, is the exosphere.

QUESTIONS ON SECTION G

76. Mt. Everest, approximately 29,000 feet high, has a latitude of about 28° north. Its summit is most likely to be in the

( ) 1. stratopause
( ) 2. stratosphere
( ) 3. tropopause
( ) 4. troposphere

77. Between the tropopause and the mesopause, the highest region is the

( ) 1. exosphere
( ) 2. mesosphere
( ) 3. stratopause
( ) 4. stratosphere

78. Ascending from the mesopause,

( ) 1. no conclusion regarding mean temperature can be drawn
( ) 2. the mean temperature falls
( ) 3. the mean temperature remains constant
( ) 4. the mean temperature rises

79. In which of the layers do changes in height and ionization have the greatest effect on radio transmission?

( ) 1. exosphere
( ) 2. mesosphere
( ) 3. no information on this topic is given
( ) 4. thermopause

SECTION H

The common gregariousness of Cliff Swallows at their nest sites is observed in their tendency to build adjoining nests in large colonies. Although the colony is ordinarily one large unit, when suitable sites (bridges, eaves or walls of buildings, or overhanging cliffs) are available, subcolonies and peripheral groups do form within a half mile of the main colony. In four colonies studied there was no antagonism observed either between the members of two sections of a colony or between the members of separate colonies, and casual intermingling was not uncommon.

Synchrony of the breeding cycle was observed to be greater within any one colony or group than could be expected from individual responses to seasonal and weather factors. In some cases this synchrony was attributable to the withdrawal of pairs or individuals which were unsuccessful in establishing territories and building or occupying surrounding areas where they would remass and establish new groups quite apart from the original colony. On the whole, however, synchrony was interpreted as a result of the effect social forces have on the individual with regard to its breeding schedule.

QUESTIONS ON SECTION H

80. The settling of peripheral groups might indicate that

( ) 1. central positions are unobtainable or untenable
( ) 2. central positions are preferable
( ) 3. peripheral positions are preferable
( ) 4. positions are chosen at random

81. Which of the following statements is the most tenable?

( ) 1. Cliff Swallow colonies are essentially "open," that is, not restricted to original members.
( ) 2. Cliff Swallows always nest in groups.
( ) 3. The group nesting of Cliff Swallows sets up social forces which, acting through sensory channels, influence the physiological mechanisms of flock members so as to produce parallel development of the reproductive processes.
( ) 4. The possible effect of social factors is greater than seasonal or weather changes on the breeding cycles of Cliff Swallows.

82. Which of the following statements could *not* be derived fr the paragraphs?

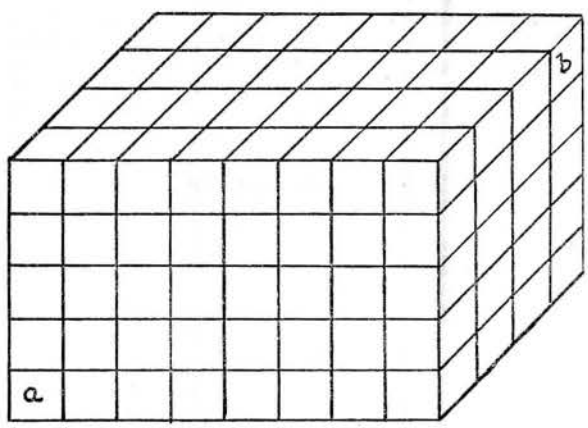
( ) 1. Cliff Swallows tend to nest in high vertical p tions.
( ) 2. Social forces seem to have an effect only on breeding cycle of Cliff Swallows.
( ) 3. Social forces seem to have an effect on the productive cycle of the Cliff Swallow.
( ) 4. The existence of unsuccessful pairs or individu in a colony might cause lack of synchrony.

83. Those Cliff Swallows which withdrew from the origi colony

( ) 1. had a different breeding season than those the original colony
( ) 2. were members of the last broods of the previ season
( ) 3. were socially antagonistic to the other Swallo
( ) 4. were unable to establish space in which to bu

SECTION I

A rectangular solid composed of 1-inch cubes is 8 inches l (x), 5 inches high (y), and 4 inches deep (z). The location any one inch cube may be described in terms of its coordin *system* (x, y, z). Thus cube a is (O, O, O) and cube b (7, 4, 3).



QUESTIONS ON SECTION I

84. How many cubes are there for which z=O, and for wh x + y is even?

( ) 1. 12
( ) 2. 16
( ) 3. 20
( ) 4. 24

85. What are the coordinates of cube b if the layer y = rotated 180°, layer z=2 is rotated 180°, and layer x= rotated 180°, in the order indicated?

( ) 1. (0, 0, 3)
( ) 2. (0, 4, 0)
( ) 3. (7, 0, 0)
( ) 4. (7, 0, 3)

6. If a line is drawn on the outer surface of the rectangular solid from cube a (center of face on which the letter appears) directly to cube b (center of the face on which the letter appears), which of the following cubes would *not* be touched by the line?

( ) 1. (3, 1, 0)
( ) 2. (6, 1, 0)
( ) 3. (7, 2, 0)
( ) 4. (7, 3, 2)

'. Which cube does *not* have a face which touches a face of cube (1, 2, 3)?

( ) 1. (0, 2, 2)
( ) 2. (0, 2, 3)
( ) 3. (1, 2, 2)
( ) 4. (2, 2, 3)

:. What is the side of the largest solid cube that could be constructed using the one inch cubes of the rectangular solid?

( ) 1. 4 inch
( ) 2. 5 inch
( ) 3. 6 inch
( ) 4. 7 inch

. What is the exterior surface area of the rectangular solid that could be constructed from the one inch cubes which would have the greatest exterior surface?

( ) 1. 328 square inches
( ) 2. 408 square inches
( ) 3. 484 square inches
( ) 4. 642 square inches

CTION J

order to give an idea of the moon's motion, a model can be nstructed. The orbit of the earth is a rail in the shape of an ipse whose plane is horizontal. The earth is a carriage on the l, and the sun a ball placed in the middle of the longest ameter. A straight bar is attached to the carriage by a ball d socket joint at the center of the bar. The bar forms the gest diameter of an elastic tube in the shape of an ellipse. e plane of the tube is inclined about 5° to the horizontal.

bead sliding within the tube represents the moon. The carriage s along the rail, making a complete circuit every 365¼ days. e plane of the elastic tube turns around slowly in the opposite rection. The tube oscillates not more than 5′ on either side of inclination of 5° to the horizontal. The bead moves in the ne direction as the carriage, completing a circuit once in the e every 27.5546 days.

JESTIONS ON SECTION J

The reason why only one face of the moon is seen is

( ) 1. actually contrary to the paragraphs
( ) 2. not made, but is implied in the first paragraph
( ) 3. not made, but is implied in the second paragraph
( ) 4. not stated in either paragraph

Lunar eclipses do not occur regularly every lunar month; and this is accounted for most nearly by

( ) 1. nothing mentioned in the paragraph
( ) 2. the circuit of the bead in the tube
( ) 3. the movement of the carriage along the rail
( ) 4. the oscillation of the elastic tube

92. If the model were built to a scale of 1:10,000,000, which of the following would be *true*?

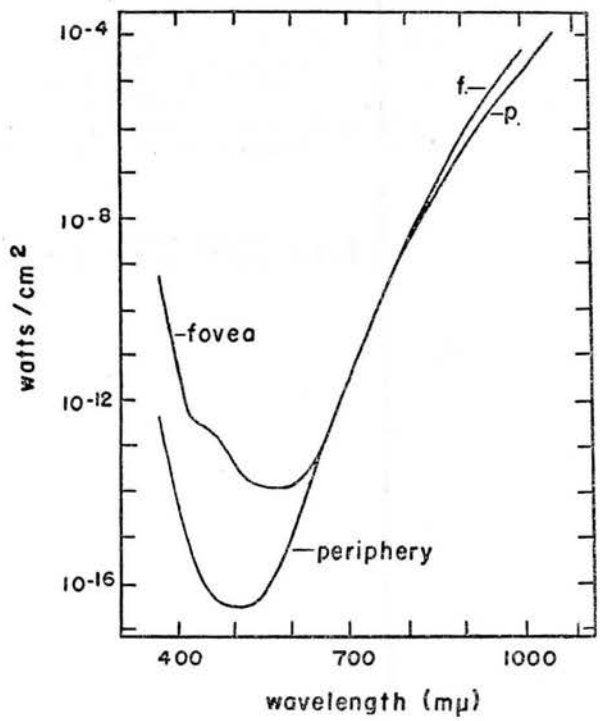
( ) 1. The diameters of the figure formed by the rail would be unequal.
( ) 2. The movement of the carriage would become less erratic.
( ) 3. The oscillation of the tube would be increased slightly.
( ) 4. The plane of the tube would reverse its motion.

93. The ratio of the longer to the shorter diameter of the earth's elliptical orbit is

( ) 1. 5:4
( ) 2. 8:5
( ) 3. 10:6
( ) 4. not given

SECTION K

The diagram shows the threshold of a human dark adapted eye. The ordinate (watts per square centimeter of radiant energy flux density) is the least amount of energy, measured at the cornea, that can be seen when it is focused on the fovea (the area where maximum visual acuity is obtained) or on the most senitive regions outside the fovea. The foveal curve represents cone vision, the peripheral curve the sensitivity of the rods. The abscissa is the wavelength of the stimulus light in millimicrons.



QUESTIONS ON SECTION K

94. Which of the following statements is most nearly *true*?

( ) 1. Because of the greater regularity of the curves one must assume that the measurements of peripheral vision were more precise than those of foveal vision.
( ) 2. Peripheral vision is no worse and frequently better for seeing under conditions of minimum illumination than is foveal vision.
( ) 3. Peripheral vision is superior to foveal vision for color discrimination.
( ) 4. We have better vision for blue than for red.

95. In the paragraph the term *threshold* refers to the

( ) 1. amount of stimulation necessary for an adequate response
( ) 2. least response that can be made for a given stimulation
( ) 3. minimum duration of stimulation required to obtain a response
( ) 4. smallest amount of stimulation necessary to obtain a response

96. At about what wavelength is there greatest sensitivity of cone vision?

( ) 1. 425mμ
( ) 2. 500mμ
( ) 3. 574mμ
( ) 4. 650mμ

97. About what is the maximum wavelength to which rod vision is sensitive?

( ) 1. 375mμ
( ) 2. 410mμ
( ) 3. 1,075mμ
( ) 4. The information is not given.

SECTION L

The penicillin method for the isolation of biochemically deficient mutants has been applied to the problem of the origin of streptomycin-dependent variants of Escherichia coli. If dependent cells arise spontaneously in an actively growing culture of normal bacteria, they should soon stop growing, since no streptomycin is present and since their requirement for this substance has been shown to be highly specific. If this cessation of growth occurs while the remainder of the population is still growing actively, penicillin may be expected to kill the normal cells and spa the streptomycin-dependent ones, as in the usual isolation biochemically deficient mutants by this method.

If, on the other hand, streptomycin-dependence represents adaptation to the antibiotic, no reason is known why the p cursors in the normal population before contact with streptomy would be uniquely insensitive to the bactericidal action penicillin.

QUESTIONS ON SECTION L

98. The statement that biochemically deficient mutants may separated from normal cells by the penicillin method is

( ) 1. contrary to the paragraphs
( ) 2. made in the paragraphs
( ) 3. neither made nor implied in the paragraphs
( ) 4. not made, but implied in the paragraphs

99. The statement that dependent cells arise spontaneously an actively growing culture of normal bacteria is

( ) 1. contrary to the paragraphs
( ) 2. made in the paragraphs
( ) 3. neither made nor implied in the paragraphs
( ) 4. not made, but implied in the paragraphs

100. The statement that, if biochemically deficient mutants re resent an adaptation to the chemical, then it is known t precursors in a normal strain would be insensitive to t bactericidal action of penicillin is

( ) 1. contrary to the paragraphs
( ) 2. made in the paragraphs
( ) 3. neither made nor implied in the paragraphs
( ) 4. not made, but implied in the paragraphs.

GO ON TO PART C—DO NOT STOP

PART C

. In Column I are diagrams of varieties of gears. In Column II are the names of these gears. Place the number of the gear from Column II in the parentheses before the diagram of that gear in Column I.

COLUMN I		COLUMN II
( ) 1.		1. Bevel gear
		2. Gear pump
( ) 2.		3. Spur gear
		4. Worm gear
( ) 3.		
( ) 4.		

2. Each item in Column I is a discovery or invention. In Column II are the names of some scientists. For each item in Column I, put the number in the parentheses representing the name of the discoverer or inventor listed in Column II.

COLUMN I	COLUMN II
( ) 1. Law of conservation of energy	1. Einstein
( ) 2. Laws of gravity	2. Galileo
( ) 3. Logarithms	3. Gay-Lussac
( ) 4. Oxygen	4. Harvey
( ) 5. Science of bacteriology	5. Helmholtz
( ) 6. Theory of relatively	6. Kepler
	7. Napier
	8. Newton
	9. Pascal
	10. Pasteur
	11. Priestly

3. Following are some types of rocks. Write after each one whether it is igneous, metamorphic, or sedimentary.

1. Basalt _____
2. Dolomite _____
3. Gneiss _____
4. Granite _____
5. Limestone _____
6. Marble _____
7. Pegmatite _____
8. Schist _____
9. Shale _____
10. Tuff _____

DIRECTIONS: Four possible answers are given for each of the questions 104, 105, and 106. Put an X in the parentheses in front of the number corresponding to that answer which you think is *most nearly correct.*

104. The man who discovered that blood circulates in a vascular system was
( ) 1. Darwin
( ) 2. Harvey
( ) 3. Mayo
( ) 4. Osler

105. In which year was the cyclotron invented?
( ) 1. 1921
( ) 2. 1931
( ) 3. 1941
( ) 4. 1951

106. The first accurate determination of the earth's circumference was made by
( ) 1. Eratosthenes
( ) 2. Galileo
( ) 3. Newton
( ) 4. Ptolemy

107. X is an element. Fill in the missing words in the following sentence. Given ${}_{z}X^{a}$, a is the atomic_____, and z is the atomic_____of the element.

108. If each of the substances listed in Column I were heated slowly at a pressure of one atmosphere from near absolute zero to 1,000°C, which of the things listed in Column II would happen to each *first*? Place the number corresponding to the thing (in Column II) in the parentheses next to each substance listed in Column I.

COLUMN I	COLUMN II
( ) 1. Argon	1. Boil
( ) 2. Calcium oxide	2. Decompose
( ) 3. Carbon dioxide	3. Melt
( ) 4. Iodine	4. Sublime
( ) 5. Limestone	5. None of the things listed above

109. For each category in Column I, select that formula in Column II with which it is most significantly associated. In each case put the number of your choice from Column II in the parentheses. (In Column II, d = distance, m = mass, and t = time.)

COLUMN I	COLUMN II
( ) 1. angular velocity	1. $1/t$
( ) 2. density	2. m/d^3
( ) 3. heat	3. m/dt^2
( ) 4. momentum	4. md/t
( ) 5. power	5. md/t^2
( ) 6. pressure	6. md^2/t^2
( ) 7. weight	7. md^2/t^3

TURN TO BACK PAGE
STUDENT AND
FACULTY MEMBER
MUST SIGN

CERTIFICATION BY STUDENT

In order that your paper will receive recognition you MUST sign this certificate which, for convenience, is broken into five stateme If any one of these statements is not true, please indicate which one by number and give a brief explanation. Space is provi for this immediately below.

I HEREBY CERTIFY THAT—

1. **I have not given help during this examination.**
2. **I have not received help during this examination.**
3. **I have had no prior information regarding the content of this examination.**
4. **I will give no information to others who intend to take this examination.**
5. **The seal on the package of tests was broken in my presence.**

..... ×.....
Date *Signature of Student*

If you cannot sign the above certificate, indicate by number the statement or statements which are not true, and sign below. example, if you were late and therefore cannot vouch for number 5, indicate that you were late and then sign.

Statement or statements not true .....**Reasons** .....

.....

..... ×.....
Date *Signature of Student*

CERTIFICATION BY TEACHER

I have administered this examination in accordance with the rules and regulations, and I certify that the contestant has taken examination in accordance with the provisions. No student took more than two and one-half hours for Parts A, B, and C.

..... ×.....
Date *Signature of Faculty Member*

Examination compiled for Science Talent Search by
Harold A. Edgerton, Ph. D., Vice-President
Richardson, Bellows, Henry & Co., Inc., New York, N. Y.
and
Steuart Henderson Britt, Ph. D.,
Vice-President and Director of Research
Needham, Louis and Brorby, Inc., Chicago, Ill.

Science Service wishes to acknowledge with appreciation the following sources of adapted published materials used in this SCIENCE, Journal of American Association for the Advancement of Science. The Encyclopedia Americana. THE CONDOR, Journa the Cooper Ornithological Club, AMERICAN SCIENTIST, Journal of The Society of the Sigma Xi and The Scientific Research So of America. Arnold, An Introduction to Paleobotany, 1947, McGraw-Hill Book Co., Inc.

PERSONAL DATA BLANK

To be filled in by Teachers and Principal

THE THIRTEENTH ANNUAL

Science Talent Search

Conducted by Science Clubs of America, administered by Science Service, for the

WESTINGHOUSE SCIENCE SCHOLARSHIPS

Full Legal Name of Student:_____, _____ _____ Sex:_____
(PRINT IN CAPITAL LETTERS) last name first name middle name male or female

Address:_____, _____, _____
street and number city and zone state

Name of School:_____, Address of School:_____, _____
city and zone state

Before you fill in this blank, READ these directions CAREFULLY.

This BLANK should be filled in by the member or members of the school faculty in the best position to present evidence of the fitness of the student for the further study of science. Information regarding the several traits may be obtained from other teachers and students. In each instance, tell what the student has done or failed to do which demonstrates to you his standing in each trait. **Only specific and concrete evidence** regarding each trait can be used in the selection of scholarship winners.

General statements or evaluations are NOT accepted as evidence of the competence of a contestant. For example, such general statements as: "has good work habits"; "has a good scientific attitude"; "will go places"; "is a self starter"; "has been an excellent student"; "always makes his contributions"; "thoroughly responsible"; are given NO CREDIT. On the other hand, such statements as: "has built a Tesla coil"; "has designed and built a successful flying model airplane"; "suggested a new and workable way to test Faraday's laws of electrolysis"; "has made a collection of over 200 species of beetles"; will be accepted because they represent **specific evidence** showing that the student has promise as a scientist.

A score is given for each trait or "trait family" for traits 1 to 4, for which you give concrete and objective positive evidence. In other words, you must state specifically what has been done by the student to demonstrate competence in the trait. **If you give general statements or evaluations, they will be given a score of zero unless they are supported by specific examples.** The remaining categories will be evaluated separately.

For each trait group, a number of questions are asked in order that you may have a clearer understanding of the kinds of evidences to include under each heading. Each such specific question need not be answered, but be sure that **examples** of the student's qualities in each of the several trait groups are given.

If you need more space to give details you may attach extra sheets.

PART I (To be filled in by Faculty)

RECOMMENDATION

UNLESS YOU GIVE SPECIFIC EXAMPLES BELOW, YOU PENALIZE THE STUDENT.

(See Directions on Preceding Page)

1. **SCIENTIFIC ATTITUDE:** What has this student done to demonstrate his scientific attitude? Does he "jump to conclusions"? Does he discriminate between pertinent and non-pertinent evidence in solving a problem? Does he "try it and see"? **Unless you give specific examples you penalize the student.**

2. **CURIOSITY:** What has this student done when confronted with *new* devices? With *new* ideas? What new ideas and developments have particularly attracted his attention? How did he react to them? What apparatus or organism has he ever "taken apart" to see how it worked, or how it was made? **Unless you give specific examples you penalize the student.**

3. **INVENTIVENESS:** What *new* ideas has he himself had? What has he created or invented? Has he introduced *new* ideas and *new* ways of approaching problems? Has he ever designed an experiment by himself? What devices or apparatus has he constructed? **Unless you give specific examples you penalize the student.**

4. INITIATIVE: What has this student done to show his initiative? Has he let failure stop him? Is he able to adapt his ideas and materials to new situations? Does he always follow "the way it was done by others"? Does he attend to details, finish his work on time, stick to the task until it is finished, work steadily at an assigned job? **Unless you give specific examples you penalize the student.**

At the left of each statement or descriptive phrase, circle:

+ if the statement is a good description of the person.
? if the statement and its opposite are about equally true of the person.
− if the opposite of the statement is a good description of the person.
u unable to make a judgment.

One symbol is to be circled for each item.

5. + ? − u Has to be driven out of laboratory.

6. + ? − u Reluctant to accept help from others.

7. + ? − u Applies theories from other fields to explain observed phenomena.

8. + ? − u Gathers data before drawing conclusions.

9. + ? − u Keeps his ideas to himself.

10. + ? − u Tackles too many problems at one time.

11. + ? − u Does not work to the limit of ability.

12. + ? − u Continues to collect data after conclusiveness of results is evident.

13. + ? − u Questions validity of material in the literature.

14. + ? − u Will accept temporary solution to an urgent problem.

---

15. What do you consider this student's principal weakness? (Do **not** leave this space blank.)

16. OTHER: Add any information which will aid in evaluating this student's potentialities for leadership in science.

I certify that to the best of my knowledge, the information given in this Blank is complete and accurate.

Date..... Signature of Faculty Member **X**.....

PART II ***(To be filled in by the Principal)***

SECONDARY SCHOOL RECORD

Report all subjects taken, including courses failed. Record two marks whenever two semester marks a available. Include the marks of courses failed. For courses now being taken or to be taken before graduati and for which final marks are not yet available, draw a dash in column "Grade Earned."

Name of Study	Year Course Taken I, II, III, IV	Number of Weeks Pursued	Number of Periods Per Week	Grade Earned
English				
1st year				
2nd year				
3rd year				
4th year				
History				
Civil Government				
American				
World				
Ancient and Medieval				
Modern				
Community Civics				
Problems of Democracy				
Mathematics				
Algebra, through quads				
Algebra, beyond quads				
Geometry, Plane				
Geometry, Solid				
Trigonometry, Plane				
Science				
Physics				
Chemistry				
Physical Geography				
Botany				
Physiology				
Zoology				
Agriculture				
Biology				
General Science				

Name of Study	Year Course Taken I, II, III, IV	Number of Weeks Pursued	Number of Periods Per Week	Grade Earned
Foreign Language				
Latin—1st year				
2nd year				
3rd year				
4th year				
German—1st year				
2nd year				
3rd year				
4th year				
French—1st year				
2nd year				
3rd year				
4th year				
Spanish—1st year				
2nd year				
3rd year				
4th year				
Vocational Agriculture				
Man. Train.—Wood Shop				
Shopwork—Metal Shop				
Art				
Mechanical Drawing				
Domestic Science				
Music				
Bookkeeping				
Stenography				
Typewriting				
Commercial Arithmetic				
Commercial Law				
Commercial Geography				
Economics				
Sociology				
Other Subjects				
TOTAL UNITS EARNED				

Explanation of marking system used (e.g., A, excellent; B, superior, etc. or E, 93-100%).....

To Science Clubs of America, 1719 N Street, N.W., Washington 6, D.C.

This information MUST be given.

1. This student's estimated rank in scholarship in the senior class (based on entire high school record) ..... (Best student is **rank** 1, second best is **rank** 2, etc.)

2. Number of students in senior class..... Expected date of graduation..... 19

I Hereby Certify that the above is a correct copy of the secondary school record of

_____
(name of student)

The judges have the right to supplement the submitted information by inquiries made at their discretion. Where specified requested information is omitted or needs clarification, the certifying official agrees it may be requested by telegraph collect.

*Date*_____ *Signed* **X** _____
PRINCIPAL

APPENDIX B

SCIENCE SERVICE

THE INSTITUTION FOR THE POPULARIZATION OF SCIENCE organized 1921 as a non-profit corporation, with trustees nominated by the National Academy of Sciences, the National Research Council, the American Association for the Advancement of Science, the E. W. Scripps Estate and the Journalistic Profession. WATSON DAVIS, DIRECTOR.

1719 N Street, N. W. WASHINGTON 6, D. C.

Telephone NOrth 7-2255 Cable Address Scienservc

October 26, 1953

Dear STS Contestant:

This letter is being sent to the 300 students who were selected as winners or honorable mentions in the 1952 (Eleventh) Science Talent Search for the Westinghouse Science Scholarships and to the like group in the 1953 (Twelfth) Search.

As you no doubt know, the Science Talent Search is a long-time experiment to find out if it is possible to locate research scientists at the time they are seniors in high school.

Occasionally we ask our highly selected winners and honorable mentions to assist in a research study which may contribute to understanding young scientists and thus may enable us to do a more effective job of locating and assisting them.

This is such an occasion. We have allowed Mr. Robert C. MacCurdy, Science Teacher of the Senior High School, Watertown, Mass., to communicate with the above two groups via this mailing to gather data which he will use for his doctorate at Boston University. He will use another sample of "Non-STS" college students as his control in the study.

We trust that you, too, will consider this is a project worthy of cooperation and will send in your questionnaire promptly.

You have our appreciation in advance for your kindness in attending to this matter so that we may have the reaction of the greatest number of young scientists to Mr. MacCurdy's questions.

Sincerely yours,

WATSON DAVIS, Director
Science Service

WD:ah

CHARACTERISTICS OF SUPERIOR SCIENCE STUDENTS AND SOME FACTORS THAT HAVE LED TO THEIR DEVELOPMENT

by

Robert D. MacCurdy

The Science Education Center
School of Education
Boston University
332 Bay State Road
Boston, Massachusetts

This inquiry form is designed to uncover those characteristics and factors that were influential in developing superior students in science "WHILE THEY WERE IN HIGH SCHOOL." Please answer these questions as though you had just graduated from high school. Two words are frequently used throughout this paper; Webster defines them as follows:

science - "a branch of study concerned with observation and classification of facts with the establishment of verifiable natural laws, chiefly by induction and hypothesis as the biological, historical and mathematical sciences. Knowledge that relates to the physical world and its phenomena called natural sciences. A system based, or purporting to be based upon scientific principles, a method of arrangement functioning, reconciling practical or utilitarian ends. Accumulated and accepted knowledge which has been systematized and formulated with reference to the discovery of general truths or the operation of general laws: knowledge classified and made available in work, life. The search for truth, comprehension, profound, or philosophical knowledge."

scientist - "one learned in science, especially natural science."

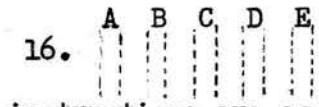
DIRECTIONS

There are nine different sets of questions to be answered in this inquiry form. Parts B through I.I. which follow form a series of eight different attributes of a science student. Please record your answers on the IBM form answer sheet. The answers will be machine tallied, hence please use the electrographic pencil which has been provided. Be sure to fill in the answer space completely and darkly. If you change answers, erase thoroughly or the machine will score incorrectly. There are two types of questions that are as follows:

Type One is of the "Yes," "Don't Know," "No" variety. For example, question No. 16 on the inquiry form reads as follows:

16. Did you enjoy trying to be original?

Look at answer No. 16 on the IBM answer sheet. It is like this:



The instructions are as follows:

If your answer is to be "Yes," fill in the space under the A.
If your answer is to be "Don't Know," fill in the space under the B.
If your answer is to be "No," fill in the space under the C.
Always omit the spaces under the D and E for the "Yes," "Don't Know," "No" questions.

Suppose your answer to this question was "No." Fill in the space of the C thus:

Type Two is of the multiple choice variety. For example, question No. 195 on the inquiry form reads as follows:

195. During high school how many times did you change schools?
A. Four times C. Twice E. Not at all
B. Three times D. Once

Look at answer No. 195 on the IBM answer sheet. It is like No. 16 above. The instructions are as follows:

Fill in the space under the letter which represents your choice of the best answer of the five that are offered. Consider all five A, B, C, D, E choices.

Suppose your answer to this question was "three" Fill in the space under the B thus:

B. The Characteristics of Your High School Personality

Type One: These are "Yes," "Don't Know," "No" questions. If your answer is "Yes," fill in under the A. If your answer is "Don't Know," fill in under the B. If it is "No," fill in under the C. Do not fill in any D or E choices for this group of questions.

During your high school career did you:

1. Usually prefer to work and study alone?
2. Usually prefer to share your play and pleasures with people?
3. Usually concentrate on one or two well developed interests?
4. Usually attempt more things than you can complete?
5. Like to assume responsibility?

6. Use much of your energy helping other people?
7. Enjoy parties?
8. Find it difficult to keep a secret?
9. Ever find people calling you a "daydreamer"?
10. Ever find people calling you "nosey" because of your curiosity?

11. Make a determined effort to always be punctual?
12. Find that you were quite critical of yourself?
13. Prefer the usual to the new?
14. Ever try to solve social life problems by a science type procedure?
15. Thoroughly dislike having to work long and hard in order to be able to finish a job that you had assigned to yourself?

16. Enjoy trying to be original?
17. Try to "cross your bridges before you came to them"?
18. Depend on your memory's being unusually reliable?
19. Usually seek causes for all effects?
20. Find that an unanswered question disturbed you?

21. Usually respect the opinion of established authorities?
22. Like to have the freedom to succeed or to fail by your own efforts with on one else responsible for your achievement?
23. Prefer realistic to symbolic art?
24. Prefer classical to popular music?
25. Prefer solving problems that you made for yourself to those made for you by others?

26. Like to solve mental puzzles or riddles?
27. Often "stick your neck out"?
28. Frequently write or tell imaginative tales?
29. Ever have occasions to regret losing your temper?
30. Frequently try to discount single facts by general principles?

31. Try to develop yourself into a "well-rounded person"?
32. Enjoy being a leader of group activities in science?
33. Enjoy informal social gatherings?

C. The Effect of Your Family History on Your High School Years

Type One: These are "Yes," "Don't Know," "No" questions. If your answer is "Yes," fill in under the A. If it is "Don't Know," fill in under the B. If it is "No," fill in under the C. Do not fill in any D or E choices for this group of questions.

34. Was your father's birthplace in America?
35. Was your mother's birthplace in America?
36. Was your family tongue English?
37. Did some inheritance support the family?
38. Did both parents support the family?

39. Did relatives support the family?
40. Did your father "boss" the family?
41. Did your mother "boss" the family?
42. Did your father support the family?
43. Did your mother support the family?

44. Did your family collect classical music records?
45. Did your family strongly urge you to "be somebody important"?
46. Was your parent an employer managing his own business?
47. Does your female parent or guardian belong to any civic clubs?
48. Did any of your family highly praise and respect science?

49. Did any of your family criticize and condemn science?

During your high school career did you:

50. Have an after-school job?
51. Have a vacation-time job?
52. Have leisure time to study science?
53. Have public library facilities available?
54. Have a home workshop or laboratory?

55. Have a study room of your own?
56. Have adequate workshop or laboratory facilities available?
57. Keep domestic pets at home?
58. Keep wild animal pets at home?
59. Admire and respect your father's achievements?

60. Admire and respect your mother's achievements?

Among your older relatives were there any:

61. Scientists?
62. Musicians?
63. Artists?
64. Teachers?
65. Lawyers?

66. Theologians?
67. Writers?

D. The Influence of Your Associates During High School

Type One: These are "Yes," "Don't Know," "No" questions. If your answer is "Yes," fill in under the A. If it is "Don't Know," fill in under the B. If it is "No," fill in under the C. Do not fill in any D or E choices for this group of questions.

Consider your associates and friends during high school. Did you:

68. Personally know a scientist?
69. Work with a scientist?
70. Have a scientist for your personal hero?
71. Try to behave like a scientist?
72. Have any chums who wanted to be scientists?

73. Direct yourself like a "lone wolf" in science?
74. Have any family friends who were scientists?
75. Have any relatives living near you who were scientists?
76. Have friends who let you lead or organize group science activities with them?
77. Find that any older students would help, guide, and encourage you in your science activities?

78. Find that any newspaper or magazine articles could strongly influence you toward starting a career in science?

E. The Influence of Your Most Inspirational Science Teacher

Type One: These are "Yes," "Don't Know," "No" questions. If your answer is "Yes," fill in under the A. If it is "Don't Know," fill in under the B. If it is "No," fill in under the C. Do not fill in any D or E choices for this group of questions.

Consider your most influential science teacher. Was he or she:

79. A male?
80. Patient and understanding with his students?
81. Clear and expressive in his conversation?
82. Fun to be with most of the time?
83. Almost a second parent to you?

84. Trained to be a scientist before he became a teacher?
85. Using his greatest ability as a science teacher?

To the best of your ability to recall, did he:

86. Give you help on confidential personal problems?
87. Work in business before he was a teacher?
88. Seem to enjoy his job of teaching?
89. Appear to have adequate training to teach science?
90. Have ambitions related to his job of being a science teacher?

91. Believe in hard work for himself; long hours?
92. Believe in hard work for his students?
93. Communicate with teachers from other schools?
94. Communicate with any scientists?
95. Belong to any professional organizations?

96. Appear to have enough time to teach well?
97. Act as sponsor to any science clubs?
98. Write any articles or books that were published?
99. Ever invent any scientific or science-teaching devices?
100. Assist students in any after-hours science activities?

101. Give anybody opportunities to organize and lead any group science activities?
102. Teach anything beside science?
103. Coach athletics?
104. Have an after-school job?
105. Teach part time in a college?

106. Make use of audio-visual aids?
107. Ever discuss "The Great Scientists"?
108. Have a hobby?
109. Have a pleasing personality?
110. Talk too much?

111. Get angry often and lose his temper?
112. Have a good sense of humor?
113. Quickly gain your admiration and respect?

F. The Influence of Your High School Activities

Type One: These are "Yes," "Don't Know," "No" questions. If your answer is "Yes," fill in under the A. If your answer is "Don't Know," fill in under the B. If it is "No," fill in under the C. Do not fill in any D or E choices for this group of questions.

Consider the influence of your high school activities. Were you:

114. A scout?
115. A member of any scientific societies?
116. A member of any clubs that were not science clubs?
117. An active member of any athletic teams?
118. An active member of a dramatic group?

119. An active member of a social group or formal club?
120. An active member of any voluntary military organization?
121. An elected officer in student government?

Among your many activities, did you:

122. Ever compete in a science fair?
123. Ever compete in a science congress?
124. Ever compete for science prizes in contests?
125. Ever win any science prizes in contests?
126. Ever plan an experiment and then do it yourself?

127. Ever perform any high grade scientific research?
128. Ever improve any scientific method or device?
129. Ever invent anything scientific?
130. Ever publish a scientific or other article?
131. Like the study of mathematics?

132. Have the use of a well-equipped science laboratory?
133. Have a place to study science at home?
134. Ever act as a teaching assistant?
135. Ever give lecture demonstrations in school?
136. Ever go on any field trips?

137. Ever lead or organize any field trips?
138. Ever visit a science museum?
139. Ever visit any scientific industry?
140. Ever help operate audio-visual aids?
141. Ever work on a school publication?

142. Have a regular job during vacations?
143. Ever have a part-time job in science?
144. Have almost enough time to study science at home?
145. Spend time regularly each week in after school science studies?
146. Belong to "Science Clubs of America"?

147. Belong to any agricultural club?
148. Belong to a Junior Academy of Science?
149. Ever become a member of any honor society?
150. Ever hold office in a science club?

G. Your Attitudes and Opinions While You Were in High School

Type One: These are "Yes," "Don't Know," "No" questions. If your answer is "Yes," fill in under the A. If your answer is "Don't Know," fill in under the B. If it is "No," fill in under the C. Do not fill in any D or E choices for this group of questions.

Among your attitudes and opinions while you were in high school, did you:

151. Change your ideas of what you thought to be eternally true?
152. Decide that in the event of a disaster that people should be saved in the order of their worth to science?
153. Think that people should be studied with nothing held to be too sacred to be studied by the men of science?
154. Conclude that a person is responsible to himself alone?
155. Decide that a good scientist can succeed without help from anybody?

156. Decide that a scientist should work in science and ignore money?
157. Believe that a science student should first earn the necessary money and then study for a career in science?
158. Believe in a material cause for all events?
159. Ever accept any ideas unsupported by proof?
160. Believe in any superstition?

161. Ever try to live by a plan?
162. Let events of chance plan your life?
163. Ever make a decision based only on a hunch?
164. Always gather your own facts?
165. Quickly change your opinion if you were proved wrong?

166. Silence others who had ideas contrary to your own?
167. Ever consciously separate your judgment from your likes?
168. Ever go away alone just to think?
169. Usually assume more work than you could handle?
170. Ever question the validity of published facts?

171. Ever accept a temporary solution to a hard problem?
172. Always respect civil law even though it might appear to you to be silly?
173. Ever question the soundness of religion?
174. Ever feel that you had no time for religious acts?
175. Like to work steadily on one job until it was completed?

176. Ever get real help in science from anyone else?
177. Have a lively curiosity about the natural world?
178. Enjoy free competition if the rules were obeyed?
179. Usually persist tenaciously on a job to its completion?
180. Ever question the use to which science is put?

181. Ever advocate that science stop and let society gain?
182. Believe that a scientist was responsible for the misuse of discoveries?
183. Decide that scientists and science students were so scarce and so valuable to the nation that they should not be drafted for military service, but kept in their scientific work and study?

B.B. Characteristics of Your High School Personality

Type Two: Multiple choice. Select one of the five answers.

184. About how often did you have pre-arranged dates with some member of the opposite sex?
A. Two a week
B. One to two a week
C. One a week
D. One a month
E. Less than one a month

185. In which of these games of chance did you participate?
A. Bet on races
B. Poker
C. Dice
D. Lottery
E. Never gamble this way

186. How often did you willingly go to church?
A. Twice a week or more
B. Once a week
C. Once a month
D. Once or twice a year
E. Almost never

187. Physically, how tall were you compared to your classmates?
A. Tallest of all
B. Taller than most
C. About average
D. Shorter than most
E. Shortest of all

188. What kind of people did you most wish to be like?
A. Statesmen
B. Writers
C. Artists
D. Athletes
E. Explorers and Inventors

189. Who or what was most to blame for your failure to achieve more in science than you have?
A. The schools
B. My parents
C. My friends and associates
D. Lack of money
E. Myself

C.C. The Effect of Your Family History on Your High School Years

Type Two: Multiple choice. Select one of the five answers.

190. How much formal education did your father have?
A. Post graduate degree
B. College
C. Junior college
D. High school
E. Less than high school

191. How much formal education did your mother have?
A. Post graduate degree
B. College
C. Junior college or two-year diploma
D. High school
E. Less than high school

192. About how large was the family income that supported you?
A. Above $8000
B. $8000 - $6000
C. $5900 - $4000
D. $3900 - $2000
E. $1900 and less

193. Was your principle residence a community with a population of
A. A million plus?
B. A million to 250,001?
C. 250,000 - 50,001?
D. 50,000 - 5001?
E. 5000 or less?

194. What kind of work did your working parent do?
A. Professional
B. Business man
C. Farmer
D. Tradesman
E. Laborer

195. During high school years how many times did you move and have to change schools?
A. Four times
B. Three times
C. Twice
D. Once
E. Not at all

196. How many sisters did you have?
A. Four or more
B. Three
C. Two
D. One
E. None

197. How many brothers did you have?
A. Four or more
B. Three
C. Two
D. One
E. None

198. What was your position in order of birth?
A. First child
B. Second child
C. Third child
D. Fourth child
E. Fifth child or more

199. What was the status of your parents?
A. Both living
B. Mother only living
C. Father only living
D. Neither parent living
E. Their status is unknown

200. What was the status of your parents' home?
A. Happily married
B. Separated or divorced
C. Unhappily married
D. Divorced and remarried
E. Unknown

201. Where did you get your spending money?
A. Earned it all
B. Earnings, gifts and allowances
C. Gifts and allowance
D. Regular allowance
E. Had practically done

202. Where did you get most of your science equipment?
A. Gift
B. Earned money and bought it
C. Loaned to me
D. Bought with gifts and earnings
E. Made it myself

203. How many books owned at home in your family?
A. 0 - 10
B. 11 - 100
C. 101 - 150
D. 151 - 200
E. Over 200

204. What does your parent or guardian think of your career plans in science?
A. Strongly for it
B. They are more in favor than against it.
C. They are divided on it.
D. More opposed than for it
E. They are strongly against it.

205. How many magazines does your family buy each month?
A. 6 - 10
B. 3 - 5
C. 2
D. 1
E. 0

206. Were you allowed to use the family car?
A. Restricted to family use
B. Can use it
C. Have my own car
D. Do not drive
E. No car in the family

D.D. The Influence of Your Associates During High School

Type Two: Multiple choice: Select one of the five answers.

207. Which of the following people gave you the most encouragement and inspiration in your plan to become a scientist?
A. Guidance counsellor
B. Science teacher
C. Parent
D. Other relatives
E. None of these

208. Which of the following acquaintances was most encouraging and helpful in developing your plan to become a scientist?
A. Employer
B. Family doctor or dentist
C. None of these
D. Club leader
E. Adult friend of the family

209. Which of the following things gave you inspiration and encouragement about becoming a scientist?
A. Television
B. Radio
C. Movies
D. Books
E. Science fiction

210. Where did you spend the majority of your elementary schooling?
A. University laboratory school
B. Public school
C. Parochial school
D. Private school
E. Tutor

211. Where did you spend the majority of your high school years?
A. University high school
B. Public school
C. Parochial school
D. Private school
E. Tutor

E.E. The Influence of Your Most Inspirational Science Teacher

Type Two: Multiple choice. Select one of the five answers.

212. In what age group does your science teacher belong?
A. 20 - 25 years
B. 26 - 35 years
C. 36 - 45 years
D. 46 - 55 years
E. 56 years or more

213. For how many years had he been teaching?
A. 0 - 5 years
B. 6 - 15 years
C. 16 - 25 years
D. 26 - 35 years
E. Don't know

214. What method of teaching did he use most in his classes?
A. Lectures
B. Textbook study
C. Class laboratory exercise
D. He demonstrated using equipment
E. Individual study and experiments

215. Which of the following teaching philosophies were most characteristic of his methods?
A. Teach facts to disciplined groups
B. Guided the studies of individuals who followed a prescribed plan
C. Guided, stimulated, encouraged individual study along different lines
D. Drove students by many means to work at their utmost capacity
E. Gave students great freedom to learn or not as they were best able to do

216. How much educational preparation did your science teacher have?

A. Teachers College
B. Bachelor of Science or Arts
C. Doctor's degree
D. Master's degree (science or education)
E. Science and education degree (Both)

217. Select the thing that he did most often with the students "after hours and away from school."

A. Took field trips in nature and industry
B. Visited with them at his home or their home
C. Chaperoned their parties and gatherings
D. Corresponded with them
E. Lent a willing ear and helping hand to their problems

F.F. The Influence of Your High School Activities

Type Two: Multiple choice. Select one of the five answers.

218. Were your ever expelled from high school for discipline reasons?

A. Never
B. Once
C. Twice
D. Three times
E. More than three times

219. Did your ever fail a course in high school?

A. Four
B. Three
C. Two
D. One
E. None

220. In which of these studies did you earn the best grades?

A. English
B. Mathematics
C. Language
D. History and Social Studies
E. Science

221. In which of these studies did you earn the poorest grades?

A. English
B. Mathematics
C. Language
D. History and Social Studies
E. Science

222. How much absence did you accumulate during your whole high school career?

A. More than one month
B. One month - two weeks
C. Two - one week
D. Less than one week
E. Perfect attendance

223. How many non-fiction books did you borrow from the public library in an average high school year?

A. 21 or more
B. 20 - 10
C. 9 - 5
D. 4 - 1
E. None

224. During high school what percentage of the time were you on the honor roll?

A. Never
B. 25%
C. 50%
D. 75%
E. 100%

225. During your high school career what was your academic average in marks?

A. 90 - 100 (A- to A+)
B. 80 - 90 (B- to B+)
C. 70 - 80 (C- to C+)
D. We use a different system.
E. I cannot say accurately enough.

226. During your high school career to how many clubs, committees and societies did you belong?

A. None
B. 1 - 3
C. 4 - 8
D. 9 - 15
E. 16 or more

227. On how many athletic teams were you a regular member?

A. Four
B. Three
C. Two
D. One
E. None

G.G. Your Attitudes and Opinions While You Were in High School

Type Two: Multiple choice. Select one of the five answers.

228. Did you ever think that a scientist should ignore one of these?

A. Pay
B. Promotions
C. Work conditions
D. Associates
E. None of these

229. What was your answer to this question: Which one of these should a scientist ignore?

A. Religion
B. Politics
C. War
D. Finance
E. Civil Law

230. Did you ever believe that a worthy student's financial needs should be met by a loan and repaid as follows:

A. In cash to loaner
B. In work
C. No repayment
D. To another student loan fund
E. To another student

231. After listening to all the talk of space travel, atomic energy, hormones, communism, what did you think of things "just as they were"?

A. They were "OK" as they were.
B. Economics needed changing.
C. Education needed changing.
D. Laws and customs needed changes.
E. Everything needed almost complete revision.

H.H. Your Decision To Be a Scientist

Type Two: Multiple choice: Select one of the five answers.

232. When was it that you decided to become a scientist?
A. Elementary school
B. Junior high school
C. Senior high school
D. Vacation time
E. I haven't made the decision yet.

233. Did you think that you would become a scientist because:
A. Science was glamorous.
B. We need more scientists.
C. Scientist may get rich.
D. The "brave search for truth" intrigued you.
E. None of these reasons

234. Did you think that you would become a scientist because:
A. You could serve humanity best there.
B. Associating with scientist promised satisfaction.
C. Science provided a worthy challenge to you.
D. You had a natural aptitude for it.
E. None of these reasons

235. Did you think that you would become a scientist because:
A. It was so interesting.
B. You could continue your education through experience.
C. The exactness of science satisfied you.
D. You like to "explore the unknown".
E. None of these reasons

236. Did you think that you would become a scientist because:
A. You could extend the boundaries of human knowledge.
B. It is easy to get good jobs in science.
C. You could show results of a definite nature.
D. You could grow and develop working on important problems.
E. None of these reasons

237. Did you think that you would become a scientist because:
A. You could develop your specialty and become an authority.
B. You could work without close supervision.
C. You could have a strong voice in selecting your problems.
D. You could anticipate steady, sure advancement.
E. None of these reasons

238. Did you think that you would become a scientist because:
A. You "sort of drifted" into it.
B. You followed somebody else's successful career.
C. Someone else convinced you to become a scientist.
D. The men you respected most were scientists.
E. None of these reasons

I.I. An Inventory of Your High School Interests

Type Two: Multiple choice questions MODIFIED. This is a special kind of choice. For all the following interest activities, select one of the responses that is included on this short list of responses. OMIT CHOICE E from all responses.

A. I like this very much indeed.
B. I have a moderate and mild interest in this.
C. I have a moderate and mild dislike in this.
D. I dislike this intensely.
E. OMIT THIS CHOICE from your possible responses.

239. Watching sports
240. Playing sports
241. Reading about sports
242. Playing games outdoors
243. Social card games

244. Social gabfests or conventions of an organized type
245. Club meetings
246. Dancing
247. Political activity
248. Travel

249. Nature walks
250. Seashore walks
251. Mountain hikes
252. Long distance hikes
253. Short walks

254. Driving for sightseeing or joy riding
255. Boating for sight seeing
256. Flying for sight seeing
257. Writing stories or articles
258. Journalism

259. Reading science
260. Reading science-fiction
261. Reading regular fiction
262. Reading regular non-fiction
263. Language study

264. Music: playing
265. Music: listening to classical
266. Music: listening to jazz
267. Public speaking
268. Civic service (local committees)

269. Theatre, Dramatics: participating
270. Theatre: spectator

271. Television: watching it
272. Radio: listening to it
273. Radio: amateur ham operator

274. Radio: Hi-Fi and set building
275. Movies: seeing them
276. Movies: making them
277. Painting
278. Sculpturing

279. Handiwork, crafts and carpentry
280. Photography: taking, developing and printing pictures
281. Mechanics: repairing and tinkering
282. Inventing things
283. Science studies on projects

284. Winter sports outdoors
285. Model building, boats or airplanes
286. Aquatic (water) sports of all kinds
287. Study of courses for school
288. Household arts: cooking, sewing, decorating

289. Collecting stamps, matches, coins, etc.
290. Gardening
291. Raising pets, fish, animals, birds
292. Zoo study
293. Museum study or work

294. Hunting or fishing
295. Scouting activities
296. Astronomy
297. Community service with children
298. Playing chess

299. Day dreaming
300. Passing the time of day by small talk.

Thank you for all of your time and effort. The results will be published and the combined answers will be made available to you. Please place the

Inquiry booklet of questions
Biographical Facts - page A
IBM answer sheet
Pencil

into the return envelope and mail it very soon.

Sincerely yours,

Robert D. MacCurdy

Robert D. MacCurdy
The Science Education Center
School of Education, Boston University
332 Bay State Road
Boston, Massachusetts

Biographical Facts About You

Write in the answers on this page. It will be tallied separately by hand. Leave it in here when you complete it.

1. What is your full name? _____
last first middle

2. On what date did you graduate? _____
day month year

3. What was your age at graduation from high school?
years: _____ months: _____

4. What high school did you attend?
name: _____
location: _____

5. Where were you born?
city: _____ state:

6. What is your home address?
street and number: _____
city: _____ state: _____

7. What is your college address?
street and number: _____
city: _____ state: _____

8. What class are you in at college now? Circle one.
Freshman Sophomore Junior Senior

9. What were you in the Westinghouse Science Talent Search? Check one.
( ) Washington Trip Winner
( ) Honorable Mention Winner
( ) Not a contestant

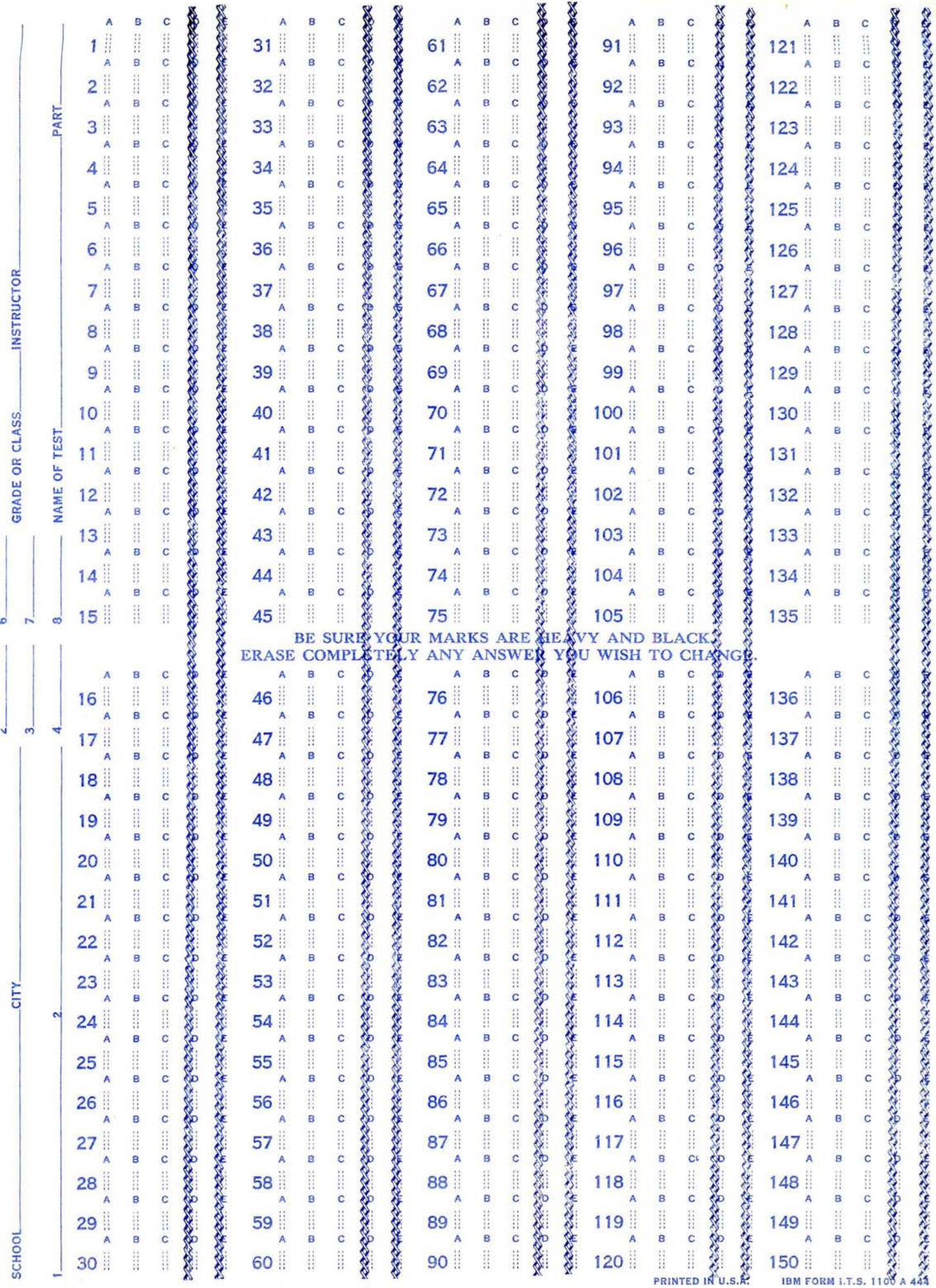
10. What is your present field of study concentration in college?

11. What is your choice of permanent occupation?
1st choice: _____
2d choice: _____
3d choice: _____

12. What kinds of vacation work have you done?
1. _____
2. _____
3. _____
4. _____

SCHOOL _____ CITY _____ 1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____ 7 _____ 8 _____ GRADE OR CLASS _____ INSTRUCTOR _____

NAME OF TEST _____ PART _____



BE SURE YOUR MARKS ARE HEAVY AND BLACK.
ERASE COMPLETELY ANY ANSWER YOU WISH TO CHANGE.

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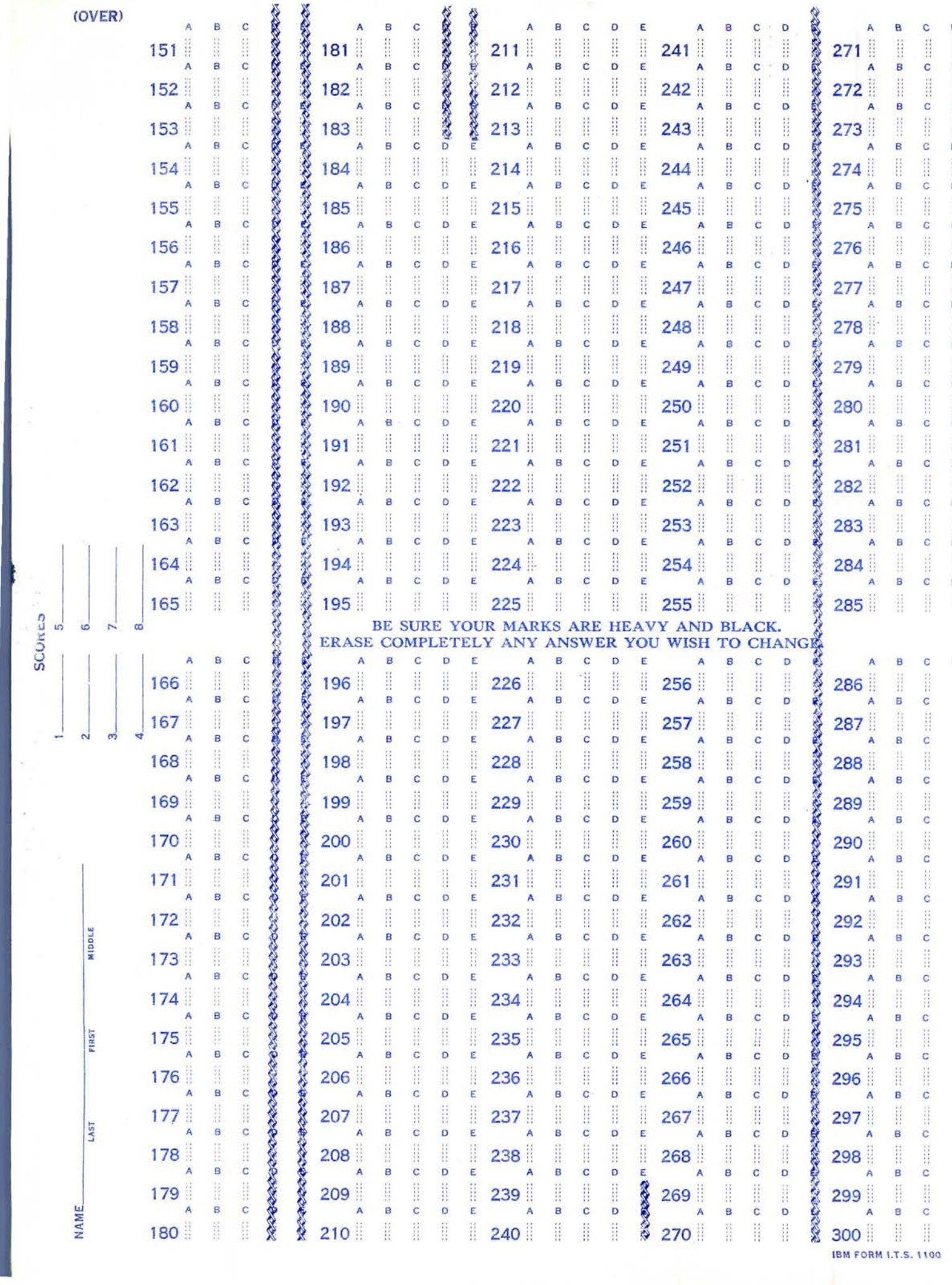

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ERASE COMPLETELY ANY ANSWER YOU WISH TO CHANGE

SCORES

1 _____ 5 _____

2 _____ 6 _____

3 _____ 7 _____

4 _____ 8 _____

NAME _____ LAST _____ FIRST _____ MIDDLE

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SCHOOL – High – CITY U.S.A. GRADE OR CLASS Fr. and So. INSTRUCTOR NAME OF TEST Ch. of S.S.S. PART

Winners and Hon. Mem. Winners

Percent Selecting These Answers

504 Superior Science Students

Item	A	B	C
1	80	4	14
2	79	5	16
3	51	4	45
4	36	10	54
5	72	14	12
6	48	23	29
7	67	11	22
8	18	8	72
9	30	8	61
10	17	10	72
11	71	4	25
12	80	10	10
13	8	16	76
14	46	24	33
15	10	10	80
16	93	5	2
17	58	17	25
18	47	10	43
19	75	15	10
20	90	5	5
21	63	16	21
22	85	10	5
23	60	18	22
24	60	15	25
25	45	33	21
26	79	7	14
27	52	17	31
28	33	4	65
29	48	6	43
30	30	39	31
31	77	8	14
32	68	13	18
33	85	7	7
34	77	1	22
35	83	0	17
36	92	0	7
37	3	2	95
38	28	1	71
39	1	1	98
40	24	12	63
41	12	12	75
42	92	0	8
43	24	1	75
44	31	1	68
45	22	8	70
46	27	1	72
47	47	2	51
48	59	10	30
49	5	5	90
50	36	0	64
51	79	0	19
52	86	1	12
53	95	0	4
54	55	1	43
55	70	0	30
56	63	4	33
57	53	0	43
58	13	1	86
59	78	7	15
60	77	12	11
61	33	5	62
62	23	5	72
63	21	5	74
64	56	4	40
65	25	6	69
66	20	5	72
67	18	6	76
68	53	1	46
69	27	2	71
70	18	6	76
71	41	18	41
72	79	3	18
73	30	18	51
74	31	2	67
75	13	1	86
76	42	4	54
77	34	8	58
78	35	16	49
79	78	1	21
80	85	3	12
81	89	4	6
82	82	9	9
83	24	9	67
84	38	31	30
85	60	25	15
86	32	6	62
87	13	40	45
88	89	5	6
89	93	2	5
90	44	42	13
91	61	30	8
92	62	14	24
93	61	34	5
94	43	48	8
95	53	37	7
96	91	3	6
97	78	6	21
98	20	50	30
99	23	53	22
100	91	4	5
101	71	15	13
102	27	8	64
103	15	5	80
104	22	21	58
105	24	17	47
106	78	4	18
107	53	10	36
108	55	41	3
109	89	3	7
110	8	6	86
111	9	4	87
112	90	4	6
113	85	6	9
114	42	0	58
115	67	1	32
116	91	0	9
117	40	1	58
118	29	1	70
119	47	1	52
120	4	1	95
121	36	1	62
122	30	1	68
123	15	3	82
124	73	1	25
125	65	1	34
126	86	3	11
127	33	11	55
128	30	9	61
129	25	7	67
130	19	2	78
131	91	2	7
132	60	2	38
133	72	1	37
134	41	2	56
135	62	1	36
136	63	1	35
137	19	1	79
138	86	1	13
139	62	2	35
140	48	1	50
141	59	0	4
142	66	1	32
143	18	1	81
144	71	7	21
145	50	3	46
146	37	2	60
147	4	0	95
148	21	2	76
149	83	1	16
150	47	0	52

BE SURE YOUR MARKS ARE HEAVY AND BLACK.
ERASE COMPLETELY ANY ANSWER YOU WISH TO CHANGE.

(OVER)

	A	B	C
151	54	12	33
152	20	12	68
153	50	13	37
154	14	6	80
155	11	8	80
156	28	13	58
157	10	13	77
158	39	10	50
159	62	11	26
160	7	7	86
161	58	8	34
162	26	17	57
163	78	9	13
164	32	6	62
165	76	8	15
166	5	5	90
167	78	13	8
168	86	4	9
169	30	10	60
170	92	3	5
171	71	13	16
172	61	7	31
173	65	4	31
174	32	6	62
175	74	6	20
176	72	4	24
177	92	3	4
178	91	4	5
179	68	10	22
180	74	7	19

	A	B	C
181	6	8	86
182	17	9	74
183	62	10	27

	A	B	C	D	E
184	8	15	16	19	42
185	1	27	2	3	67
186	16	32	13	13	25
187	4	39	42	14	1
188	9	8	5	5	71
189	11	1	1	10	76
190	25	26	7	19	23
191	8	29	14	31	18
192	22	20	35	20	1
193	29	7	20	31	13
194	42	32	3	10	12
195	0	2	3	7	88
196	2	3	9	34	52
197	2	2	14	34	48
198	64	25	7	2	22
199	91	7	2	0	0
200	86	3	6	2	22
201	13	58	9	16	32
202	13	11	24	32	18
203	2	18	16	12	52
204	62	28	5	2	12
205	45	38	10	4	32
206	4	48	8	26	14
207	3	41	23	4	29
208	2	3	74	3	16
209	0	2	1	84	8
210	1	87	8	2	00

	A	B	C	D	E
211	2	87	8	3	0
212	2	16	39	31	9
213	11	25	35	10	28
214	36	13	13	24	12
215	13	12	32	10	38
216	3	22	10	50	10
217	18	4	11	2	59
218	99	0	0	0	1
219	2	0	1	2	95
220	7	38	6	3	46
221	24	8	28	33	3
222	23	28	23	18	5
223	27	24	22	20	6
224	1	3	3	14	77
225	84	10	1	3	3
226	1	16	47	25	10
227	3	4	8	23	62
228	14	5	1	1	78
229	15	41	11	15	22
230	37	11	14	26	6
231	15	6	28	23	23
232	32	22	26	0	20
233	4	3	1	27	63
234	18	6	21	40	12
235	35	6	16	35	8
236	34	5	10	23	26
237	15	19	10	3	49
238	22	1	1	10	61
239	38	50	9	1	8
240	47	39	9	5	5

	A	B	C	D
241	9	43	32	15
242	43	44	9	2
243	21	43	22	12
244	24	42	25	7
245	28	51	16	4
246	38	38	14	9
247	21	37	29	13
248	74	22	3	0
249	50	36	10	3
250	55	35	8	1
251	63	27	6	2
252	47	33	15	4
253	52	38	4	1
254	59	30	7	3
255	53	37	6	1
256	45	38	7	2
257	29	36	25	7
258	17	33	25	18
259	68	18	2	1
260	32	30	29	6
261	44	33	19	2
262	52	39	6	1
263	33	27	22	16
264	39	30	18	6
265	68	21	8	2
266	33	31	18	16
267	27	28	33	12
268	13	32	39	14
269	25	27	30	17
270	47	33	18	1

	A	B	C	D
271	23	43	25	8
272	30	52	17	1
273	19	41	29	6
274	33	36	22	4
275	44	46	8	1
276	26	36	21	7
277	23	33	30	12
278	15	30	36	13
279	36	45	12	5
280	36	51	10	2
281	50	33	10	5
282	59	33	4	2
283	65	30	4	1
284	42	42	11	4
285	24	40	24	8
286	53	34	9	4
287	36	47	12	3
288	12	26	38	21
289	15	32	35	16
290	17	35	32	13
291	28	38	22	10
292	20	40	25	11
293	25	42	21	8
294	35	31	20	13
295	21	38	27	10
296	39	47	10	1
297	17	31	31	15
298	36	35	16	9
299	30	49	14	5
300	14	38	30	20

BE SURE YOUR MARKS ARE HEAVY AND BLACK.
ERASE COMPLETELY ANY ANSWER YOU WISH TO CHANGE.

NAME: LAST FIRST MIDDLE

Percent that Selected These Answers

IBM FORM I.T.S. 1100 A 444-2

SCHOOL (College of General Education, Boston University) CITY

GRADE OR CLASS Fr. & So. INSTRUCTOR

NAME OF TEST S.S.S. PART

Percent that Selected these Answers

78 Contemporaries in General Education

Item	A	B	C	Item	A	B	C	Item	A	B	C	Item	A	B	C	Item	A	B	C
1	68	4	28	31	79	11	9	61	11	4	85	91	40	54	6	121	24	1	73
2	90	5	5	32	18	22	62	62	35	3	62	92	62	25	13	122	9	1	85
3	44	7	49	33	86	6	8	63	19	3	78	93	36	64	0	123	1	3	91
4	42	10	47	34	66	1	33	64	36	2	60	94	16	70	4	124	5	1	90
5	53	11	28	35	72	1	27	65	28	4	67	95	25	69	5	125	3	1	92
6	45	23	32	36	85	3	11	66	18	3	79	96	85	10	5	126	26	1	70
7	79	6	14	37	4	4	91	67	12	8	78	97	54	32	11	127	5	4	89
8	28	17	55	38	22	0	78	68	25	3	72	98	12	66	21	128	9	3	85
9	53	11	36	39	1	1	96	69	6	3	90	99	4	77	19	129	4	1	92
10	27	9	64	40	47	15	37	70	6	6	87	100	79	14	5	130	3	1	89
11	58	9	33	41	22	19	57	71	15	9	74	101	48	37	15	131	54	5	32
12	70	8	22	42	92	0	8	72	63	5	32	102	30	20	50	132	46	53	49
13	5	19	70	43	23	1	76	73	12	12	74	103	19	11	68	133	44	3	51
14	32	28	38	44	20	3	77	74	14	9	77	104	9	55	33	134	9	1	88
15	33	14	53	45	32	12	55	75	9	1	90	105	8	53	38	135	12	1	86
16	86	10	4	46	23	1	76	76	4	4	92	106	74	8	18	136	31	0	69
17	51	18	31	47	46	3	51	77	15	10	72	107	77	14	9	137	1	3	95
18	59	10	29	48	28	29	43	78	33	10	55	108	36	61	3	138	74	0	26
19	55	17	28	49	5	8	87	79	81	4	14	109	81	8	11	139	33	5	59
20	79	8	12	50	69	0	29	80	77	11	9	110	8	18	74	140	28	4	67
21	62	19	19	51	89	0	11	81	81	12	5	111	17	9	74	141	41	1	58
22	83	12	3	52	59	10	29	82	55	22	23	112	79	11	10	142	73	2	25
23	75	14	11	53	96	0	4	83	12	9	78	113	69	12	17	143	6	1	92
24	44	15	40	54	23	4	73	84	25	58	15	114	45	1	54	144	54	14	29
25	46	26	28	55	58	4	38	85	29	49	14	115	8	1	90	145	12	3	82
26	64	12	23	56	32	4	64	86	21	9	67	116	78	1	21	146	1	1	97
27	54	18	27	57	65	0	35	87	10	60	27	117	56	1	41	147	1	1	95
28	37	12	50	58	14	4	82	88	79	14	6	118	25	1	73	148	1	1	97
29	76	3	22	59	70	15	15	89	89	10	0	119	56	1	41	149	18	1	81
30	36	41	23	60	64	19	17	90	27	63	9	120	11	1	87	150	3	3	94

BE SURE YOUR MARKS ARE HEAVY AND BLACK.
ERASE COMPLETELY ANY ANSWER YOU WISH TO CHANGE.

NAME _____ LAST FIRST MIDDLE

Percent that Selected these Answers

	A	B	C	D	E
151	58	23	19		
152	12	20	68		
153	36	29	35		
154	29	11	59		
155	8	22	68		
156	18	28	53		
157	8	41	50		
158	27	21	51		
159	62	12	23		
160	23	11	66		
161	53	6	41		
162	42	21	37		
163	89	5	6		
164	15	12	72		
165	59	14	27		
166	4	9	86		
167	49	28	23		
168	86	4	10		
169	38	9	53		
170	85	3	12		
171	73	10	12		
172	51	6	42		
173	73	1	26		
174	32	9	58		
175	64	15	21		
176	36	5	58		
177	66	3	27		
178	81	14	5		
179	40	17	40		
180	56	11	33		

	A	B	C	D	E
181	11	10	78		
182	12	19	68		
183	35	16	49		
184	26	15	10	14	35
185	6	49	3	4	40
186	4	51	9	22	14
187	3	29	53	14	1
188	14	25	9	18	31
189	4	1	1	0	91
190	5	14	8	41	37
191	4	6	12	46	31
192	17	11	38	32	1
193	11	15	25	41	6
194	14	45	1	28	11
195	4	1	7	14	71
196	2	10	18	28	42
197	6	3	12	45	33
198	40	35	12	6	7
199	89	8	3	0	0
200	83	5	6	3	1
201	18	68	5	6	3
202	23	9	21	21	9
203	5	25	12	12	44
204	44	29	18	4	5
205	25	53	12	6	4
206	3	45	12	22	18
207	1	21	5	1	56
208	1	3	77	0	5
209	3	1	1	54	8
210	0	76	18	3	1

	A	B	C	D	E
211	0	78	8	11	0
212	1	23	32	32	5
213	12	18	18	3	41
214	11	28	23	23	12
215	29	11	17	10	23
216	3	27	6	28	11
217	11	3	8	1	56
218	87	4	4	4	1
219	4	5	10	23	56
220	37	12	9	26	14
221	12	35	29	11	10
222	41	23	23	10	3
223	21	17	23	26	12
224	49	31	3	8	9
225	8	28	40	3	21
226	21	37	28	11	1
227	3	5	18	35	38
228	8	14	1	1	71
229	14	55	3	19	3
230	36	14	9	25	12
231	18	8	33	14	25
232	3	4	3	0	81
233	0	3	5	9	73
234	5	5	15	6	59
235	17	3	4	21	46
236	15	5	1	10	58
237	10	8	4	4	64
238	8	0	0	6	86
239	56	35	5	0	

	A	B	C	D	E
241	20	44	20	15	
242	53	36	10	1	
243	28	40	21	1	
244	26	40	26	8	
245	15	51	23	10	
246	46	32	18	4	
247	25	38	26	11	
248	86	12	0	1	
249	42	31	17	10	
250	51	37	9	1	
251	49	36	9	6	
252	33	36	22	9	
253	45	48	4	3	
254	54	38	4	4	
255	52	37	8	3	
256	54	32	9	3	
257	37	32	25	6	
258	26	37	29	8	
259	29	36	22	14	
260	17	33	29	19	
261	47	37	6	4	
262	40	46	12	2	
263	14	46	23	21	
264	45	31	17	8	
265	62	24	8	6	
266	42	29	14	10	
267	22	36	29	11	
268	14	32	41	10	
269	26	26	24	24	
270	69	28	3	1	

	A	B	C	D	E
271	32	46	17	4	
272	37	54	9	0	
273	17	33	35	12	
274	8	29	37	25	
275	52	40	8	0	
276	24	34	36	6	
277	23	40	29	8	
278	23	32	32	23	
279	26	45	18	11	
280	25	42	25	8	
281	22	42	22	12	
282	15	51	22	11	
283	11	42	21	25	
284	58	28	10	4	
285	25	38	26	11	
286	58	31	8	3	
287	19	46	26	9	
288	9	17	29	45	
289	9	31	32	28	
290	11	23	29	26	
291	26	36	26	12	
292	17	36	31	16	
293	22	38	22	18	
294	45	27	14	11	
295	25	30	28	17	
296	25	40	20	15	
297	18	35	32	14	
298	22	33	23	21	
299	29	38	18	8	
300	17	40	32	11	

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APPENDIX C

STATISTICAL PROCEDURES USED IN THIS STUDY

Significance of the difference between two percentages [1]

d = difference P_1 and P_2 = 1st and 2nd percentages
N_1 and N_2 = 1st and 2nd number of cases
S = significance t = t value σ d = sigma d

$$S = tx \cdot \sigma d \qquad \sigma d = \sqrt{\frac{821}{N_1} + \frac{821}{N_2}}$$

Since in this study:

$N_1 = 504$
$N_2 = 78$

therefore:

$$\sigma d = \sqrt{\frac{821}{504} + \frac{821}{78}} \quad \text{or} \quad \sigma d = 3.485$$

Table of Ordinary Values of t Normal Scale

t_x	• σd (3.485) = (t σd)	= Probability in per cent
$t_5 = 1.960$	• " = 6.832	= 5
$t_2 = 2.326$	• " = 8.108	= 2
$t_1 = 2.576$	• " = 8.979	= 1
$t_{0.\bar{1}} = 3.291$	• " = 11.471	= 0.1

From Table of Angular Transformation for Converting Percentages to Degrees [2]

99 = 84.3°	80 = 63.4°
50 = 45.0°	68 = 55.6°
37 = 37.5°	44 = 41.6°
1 = 5.7°	18 = 25.1°

1/ Palmer O. Johnson, Statistical Methods in Research, Prentice-Hall Inc., New York, 1949, p. 165

2/ Ronald A. Fisher and F. Yates, Statistical Tables for Biological, Agricultural and Medical Research, Hafner Publishing Co. Inc., New York, 1953, p. 66, Table XII

Example: From Table 12, Question 1. "Usually prefer to work and study alone?"

Scientists answering "yes" = 80 per cent
Contemporaries answering "yes" = 68 per cent

From Fisher's Tables:

$$80 = 63.4^{\circ}$$
$$68 = 55.6^{\circ}$$
$$\text{Difference} = 7.8^{\circ}$$

Since 7.8° located in the ($t \sigma_d$) scale is more than 6.832 but less than 8.108 the difference 7.8° has the probability value of 6.832 or 5 percent but not 8.108 or 2 per cent. Thus the answer is: Significance (S) of Scientists answering "yes" at 80 per cent is 5 per cent.

Analysis of data for significance by Chi Square

$$\text{Formula } X^2 = \frac{1}{Na\ Nb} \sum \frac{(\ aiNb - biNa\ )^2}{ai + bi}$$

Example: Question 184 in the Inquiry Form:

	A	B	C	D	E	Σ
Frequency Scientists	a_1 40	a_2 77	a_3 80	a_4 94	a_5 209	N_a 500
Frequency Contemporaries	b_1 20	b_2 12	b_3 8	b_4 11	b_5 27	N_b 78
Σ	a_1+b_1 60	a_2+b_2 89	a_3+b_3 88	a_4+b_4 105	a_5+b_5 236	

A = 788,906.6
B = .4
C = 57,018.2
D = 31,964.0
E = 33,267.8

Σ = 911,157.0

$N_aN_b = 500 \times 78 = 39,000$

$$\frac{911,157.0}{39,000} = X^2$$

$X^2 = 23.36$

On a Table of Distribution of X^2 Probability for four degrees of freedom (N = 5) 0.1 per cent value is surpassed, hence significance of this X^2 is 0.1 per cent or one thousandth.

APPENDIX D

APPENDIX

ADVISORS FOR THIS STUDY

The following people contributed much personal technical or professional assistance in developing the methods of the study, selecting the items for the questions, testing the questions for clarity and usefulness, preparation of the inquiry form, and the analysis of the returns. The writer acknowledges his deep debt to these helpful people.

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