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A follow-up study of the careers of graduates in biology

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A FOLLOW-UP STUDY OF THE CAREERS OF GRADUATES IN BIOLOGY

Submitted by

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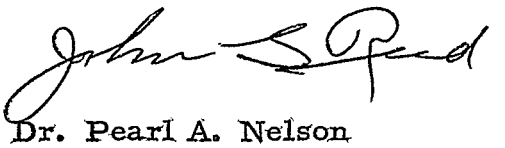

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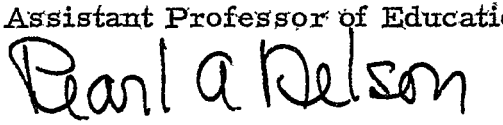

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

Much interest has been exhibited in the problem of America's scientific manpower. General Donald Putt stated the case in strong terms when he said, "Our economic growth and our national prosperity in the future lies (sic) squarely on the shoulders of our scientists and engineers." [1/] The National Committee for the Development of Scientists and Engineers, established by President Eisenhower in 1956, is studying various aspects of the problem such as the utilization of scientists, engineers and technicians, and a survey of facilities and faculties of engineering and technical schools. [2/] Recent developments, which have brought to light Russia's great advances, have intensified the realization that not only progress, but possibly survival, may be contingent upon solving the problem. [3/]

1/ Lt. Gen. Donald L. Putt, "Our Personnel Shortage", Vital Speeches, (July 15, 1955), 21:1371-3.

2/ Martha A. Shull, "The Critical Fields of Science and Engineering", National Education Association Journal, (April 1957), 46:268.

3/ Donald Quarles, "Cultivating our Science Talent--- Key to Long-Term Security", Scientific Monthly, (June 1955), 80:352-5.

This is a far cry from the situation in 1891 when John Campbell wrote, "The increased attention given biology.....has had the effect of almost overstocking the market with men thoroughly trained in the methods of teaching and research." [1/]

"We are not attracting enough able students into scientific careers", the analysts state, and they begin to cite all the factors which inhibit the high-school student from continuing work in science in college. High-school science teachers have borne a large share of the condemnation for not lighting the flame of interest, or fanning it into a possible career, though this censure is often softened by, "What could you expect on the salaries they are paid?" Announcement that the Science Talent Search awards, given by the Westinghouse Educational Foundation are to be tripled this coming year shows that steps are being taken to encourage promising research scientists. [2/] Another suggested solution to the problem is to increase the "broad base of our educated population from which scientists and leaders in other fields must come". [3/]

1/ John P. Campbell, Biological Teaching in the Colleges of the United States, Washington Government Printing Office, Washington, D. C., 1891, pp. 132-3.

2/ Science News Letter, (August 31, 1957), 72:133.

3/ Alan T. Waterman, "The Science of Producing Good Scientists", The New York Times Magazine, (July 31, 1955), p. 9+.

Towards such an end the National Merit Scholarship Corporation in 1956 granted 556 scholarships to high-school seniors, an average award of $628 a year for four years.[1/] The suggestion to give "national recognition to those who excel in the scientific and engineering fields"[2/], illustrates a different approach to the problem.

But what of those students, who either because of inspiring teachers and family, or in spite of its lack, have pursued their scientific interests and graduate from college with a bachelor's degree in some field of science? "Is the economic and social investment in professional training securing a maximum return?"[3/] Can our country count on these people as part of their scientific manpower supply? Since statistics of this nature are usually quoted in terms of numbers of college graduates, it seemed appropriate to study the careers of science graduates from various colleges. For the sake of convenience this study was limited to colleges in the Boston area. In particular the writer attempted to investigate the professional lives of graduates in biology 5, 10 and 15 years after graduation in order to determine whether those trained in biology are

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1/ John L. Holland and John M. Stalnaker, "An Honorary Scholastic Award", The Journal of Higher Education, (October 1957), 28:361-8.

2/ Arthur S. Fleming, "Nation's Interest in Scientists and Engineers", Scientific Monthly, (June 1956), 82:282-5.

3/ Helen Wood, "Occupational Mobility of Scientific and Technical Personnel", Occupations, (May 1950), 28:510-3.

active in their field at a later date. As an indication of the need of a future study, a sampling of chemistry graduates from these institutions was included.

The initial questions were:

1) What percentage of persons who had received their baccalaureate degree in biology are now doing work in their field 15 years later?

2) How soon after graduation was biology as a career abandoned?

3) What were some of the principle factors responsible for the defection?

4) What percentage of those women who had left for marital reasons might be expected to return to their field when their family grew up?

Such a study seemed significant from the standpoint of the prospective scientist and the country as a whole. Although there is no wish to deny the value of science in a liberal education[1/], the rigorous training in that field, which is part of the requirements for a bachelor's degree, seems inappropriate for a future clubwoman or businessman, at a time when there is such an acute shortage of trained personnel and facilities

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1/ George E. Nelson, The Introductory Biological Sciences in the Traditional Liberal Arts College, Teachers College, Columbia University Contributions to Education, No. 501, Teachers College, Columbia University, New York, 1931.

for training them. If a more realistic picture were painted of their possible futures in science, by those attempting to guide high-school and college students, we might be able to reduce such wasted training and more effectively use our teaching talent to augment the scientific forces of our country. This might include an apprentice system for talented high-school and college science students, such as the training program at Jackson Memorial Laboratory in Bar Harbor, Maine[1/], where each year many students are introduced to the techniques of cancer research. This would not only aid in the "development of student's scientific abilities, aptitudes, interests and social values", but would offset the "glamorized picture of research work"[2/] which frequently leads to disillusionment when routine laboratory matters are the daily task. And finally, elucidating the sources of dissatisfaction could be a first step in ameliorating the professional problems encountered by the budding scientists before they leave for greener pastures.

1/ Science News Letter, (September 15, 1956), 70:168.

2/ Philip Pollack, Careers and Opportunities in Science, E. P. Dutton and Company, New York, 1954, p. 45.

CHAPTER II

A REVIEW OF THE LITERATURE

Since the launching of the Russian satellites, the public has been aroused to a fact long known to those working in the field: --- there is a serious lack of trained scientists. Proposals for alleviating the shortage are made daily, but considering the years of training involved, we cannot expect an overnight increase in number of scientists or a complete shift in educational emphasis. The situation is compounded by the fact that the teachers, needed to train the next generation of scientists, are being lured by industry's more attractive salaries.[1/] Yet, as Knapp and Goodrich mentioned, ". . to assure the continued progress of science, it is obviously necessary to maintain a steady flow of competent young people into the profession".[2/] Associated with this is the need for more effective utilization of those who have been trained as scientists. It will be the aim of this study to determine, in the field of biology, the extent to which such training has been utilized.

1/ Anonymous; "I Am a Kidnaper of Sorts", Saturday Evening Post, (September 14, 1957), 230:42+.

2/ R. H. Knapp and H. B. Goodrich, Origins of American Scientists, The University of Chicago Press, Middletown, Conn., 1952, preface.

The exact status of science education in this country has been a matter of considerable disagreement. "Expanding opportunities in science and technology have not been attractive enough to reverse the decline in student interest"[1], stated Edward Palmquist at a colloquium whose topic was "The Growing Shortage of Scientists and Engineers". Yet the statistics do not bear out this "decline in student interest". In spite of the modern tendency towards "adjustment" and "do-it-yourself" education, there are more students than ever submitting themselves to the rigors of science courses. With the large increase in total high-school population during the past 50 years, this steady increase in the number of students enrolled in science and mathematics courses could still be viewed as a decrease in the percentage of high-school students in such courses. However, a 1957 United States Office of Education report[2] finally showed an increase in the percentage of high-school enrollment in science and mathematics, the first since 1910. In addition, though admitting wide regional variation, Van Cleve Morris states that there are now more schools offering these courses, and 94 per cent of our

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1/ Edward Palmquist, The Growing Shortage of Scientists, Proceeding of the Sixth Thomas Alva Edison Foundation Institute, New York University Press, 1956, pp. 41-42.

2/ Science, (September 13, 1957), 126:499.

high-school students attend schools where chemistry or physics is available.[1/]

Once corralled in the science class, the next problem in our "scientist production line" is maintaining the student's interest. That competent science teachers exist is verified by the position given them by many superior science students. The 1952 and 1953 winners of the Science Talent Search were analyzed by Robert MacCurdy in an attempt to "identify the future scientist and guide him towards a scientific career".[2/] A strong characteristic common to many of the 600 winners was a consideration of the science teacher as a "father figure".[3/] Ascher and Nichamin[4/] point out that much of the counseling for science careers falls on the shoulders of the science teacher, and will continue to do so until we have "...an improved guidance program"[5/] with counselors aware of the possibilities and limitations of science as a profession. The home

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1/ Van Cleve Morris, "Training of a Scientist", Scientific Monthly, (September 1957), 85:126-9.

2/ Robert Douglas MacCurdy, "Characteristics of Superior Science Students and their own Sub-Groups", Science Education, (February 1956), 40:3-24.

3/ Robert Douglas MacCurdy, "Characteristics and Backgrounds of Superior Science Students", School Review, (February 1956), 64:67-71.

4/ Samuel Ascher and Philip Nichamin, "Public Partnership in Science Guidance", School Science and Mathematics, (February 1956), 56:151-3.

5/ Ibid.

and family also have been credited with inspiring children towards science, and again MacCurdy found that these Science Talent Search winners were marked by a "stable, cultured and educated family".[1/]

Other factors responsible for scientific interest are the Science Club Movement, organized in 1942, and now encompassing 12,000 clubs and 200,000 members[2/], and the Science Fair Movement, which as Pollack cited "... encourages original research projects in the pre-college students".[3/] An estimated 88 per cent of the 1956 National Science Fair participants will become scientists and engineers, according to one report.[4/] This figure is on the basis of a survey of the first five National Science Fair finalists, at which point most were in school studying science.[5/] But regardless of their final vocational choice, at least we've progressed past the high-school level and now have capable students studying science in college. There is further evidence that competent students have scientific interests in the fact that 50 per cent of the boys, (but alas, only 16 per cent of the girls), who were semi-finalists in the

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1/ Robert Douglas MacCurdy, "Characteristics and Backgrounds of Superior Science Students", op. cit.

2/ Philip Pollack, Careers and Opportunities in Science, E. P. Dutton and Company, Inc., New York, 1954, p. 10.

3/ Ibid., p. 11.

4/ "What Happens to Science Fair Participants?", Science, (June 22, 1956) 123:1111.

5/ Only 10 of the 131 college students were in non-science fields.

National Merit Scholarship competition of 1956, named science or engineering as career goals.[1]

On a more pessimistic side Finkel[2] discusses the untold numbers of high-school science students whose natural interest has been dampened along the way. A lack of information on the part of principals, heavy loads and poor training of many science teachers, and guidance counselors who are not interested in science, are some of the factors which act to discourage many would-be scientists. Many, such as Trytten,[3] stress the need for higher standards at the high-school level, with more meaningful and challenging courses to attract competent students, since, as Dollard points out, "...science, as a creative activity must compete for talent against all the other exciting and socially useful professions and vocations."[4]

The low estate of both the scientist and the teacher of science, which Morris[5] talks about, was attested to by a recent study by Margaret Mead

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1/ Science News Letter, (March 24, 1956), 69:184.

2/ Maurice Finkel, "A Science Career: How the High School Affects the Choice", The Bulletin of the National Association of Secondary-School Principals, (September 1957), 41:45-9.

3/ M. H. Trytten, "Soviet and U. S. Professional and Technical Manpower", Science, (July 5, 1957), 126:11-15.

4/ Charles Dollard, "Current Problems in Perspective", The Scientific Monthly, (June 1956), 82:277-81.

5/ Van Cleve Morris, op. cit.

and Rhoda Métraux.[1] Although "science" was considered favorably by the 35,000 students whose essays were analyzed, there was a strong negative response to science as a career for themselves or their future mates, or in other instances when they were involved personally. Philip Pollack's conclusion that the $3,000,000,000 spent every year on research in the United States, indicates that "... the attitude of society towards the man in the lab coat is today one of deference"[2] does not seem warranted, if the Mead and Métraux findings are indicative of our adult population as well as high-school students. The Edison Foundation is endeavoring to ".. enhance the admiration for scientists and inventors as heroes among our young people"[3], but there is still the strong impression of the scientist as one who works, as Dollard states, "..under wraps, on small segments of highly specialized problems defined by someone else".[4]

Dr. James Killian emphasized the loss in our scientific manpower resources between high-school and college graduation, when he said, "...of the ablest 50 per cent of high-school graduates, only about a third receive college degrees. He also cites the "... importance of

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1/ Margaret Mead and Rhoda Métraux, "Image of the Scientist among High School Students", Science, (August 30, 1957), 126:384-90.

2/ Philip Pollack, op. cit., p.27.

3/ The Growing Shortage of Scientists and Engineers, op. cit. p.1.

4/ Charles Dollard, op. cit.

motivating and using more of our exceptional talent and directing our attention to its conservation and cultivation".[1/] Statistics quoted by Armsby,[2/] which show a 50 per cent decrease in the number of bachelor's degrees in the sciences between 1949 and 1957, seem to bear this out, though how much this reflects a reduced college population due to a low birth rate during the depression is difficult to ascertain. The Wesleyan study[3/] to determine the effectiveness of several hundred colleges in the production of scientists,[4/] and the underlying factors that influence men to enter a career in science, had some startling results. Knapp and Goodrich found that the "production of scientists is inversely related to size and to vocationalism of curricular emphasis".[5/] Small liberal arts colleges with a strong intellectual orientation, such as Reed, Swarthmore and Oberlin, produced more scientists per total number of male graduates than vocational engineering institutions or larger universities.[6/]

1/ James R. Killian, Jr., "Augmenting our Scientific and Engineering Manpower Resources", School and Society, (June 22, 1957), 85:213-7.

2/ Henry Armsby, "The Manpower Situation in Engineering and Science", The Growing Shortage of Scientists and Engineers, op, cit., p. 6.

3/ R. H. Knapp and H. B. Goodrich, op.cit., pp. 3-5.

4/ "Scientist" is defined as a Ph.D. recipient or "starred scientist" from American Men of Science (1921 and 1944).

5/ Ibid., p. 291.

6/ With the exception of California Institute of Technology which ranked second.

The manifold reasons which convert an "interest in science" into a vocational decision have not been fully analyzed. That many drift into a vocation without first determining, as Ho suggests, "..what preparation is required, what the opportunities are, and what rate of progress may be expected"[1/], is evidenced by several studies of job dissatisfaction and vocational mobility. Based on past statistics, a prediction was made[2/] for the college graduate of the class of 1956, that 10 per cent would quit their first job within a year and one-third would quit within 5 years for such reasons as: (1) higher pay (2) geographical re-location (3) a chance for greater responsibility. This trend to vocational mobility creates, as Uhrbrock[3/] points out many problems for industrial and research concerns who expend a great deal of time, effort and money in training programs.

According to Wrenn's study[4/], 19 per cent of the Stanford graduates analyzed would not re-select their present vocation, though there was twice as much vocational dissatisfaction among those who did not follow

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1/ Ching-Ju Ho, Personnel Studies of Scientists in the United States, Bureau of Publications, vol. 298, Teachers College, Columbia University, New York, 1928, p.1.

2/ "What's Ahead for College Graduates", Changing Times, (June 1956), 10:6.

3/ Richard S. Uhrbrock, "The Role of the College Placement Officer, Personnel and Guidance Journal, (April 1956), 34:487-90.

4/ C. Gilbert Wrenn, "Vocational Satisfaction of Stanford Graduates", The Personnel Journal, (June 1934), 13:21-4.

out their college decisions. Koos made an earlier study[1] of graduates of Beloit College between 1917 and 1922 to determine the reasons behind the selection of a major field and the relationship of the major field to activities since graduation. Only 50 per cent of the men and about 79 per cent of the women were utilizing their major subjects in vocational pursuits, though less than 10 years had elapsed since graduation.

Dorothy Dyer's analysis[2] of the permanence of vocational interests of college men in relation to (1) the time the choice was made, (2) the chief origin of the choice and (3) ratings by Strong's Vocational Interest Blank, indicated that "...vocational choice made in the senior year of college held through at least 10 years of occupational history" for 72 per cent of the 89 cases studied. The effect of the depression period, however, is difficult to put into statistical terms. In addition, it was noted that vocational decisions, made early in life, have the greatest holding power.

A survey was made of the 24,000 college graduates employed by General Electric in 1957[3], to evaluate their higher education in order to determine the "...impact of various types of education upon the de-

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1/ Leonard Vincent Koos, The Junior College, University of Minnesota, Minneapolis, May 1924, pp. 281-6.

2/ Dorothy T. Dyer, "The Relation Between Vocational Interest of Men in College and their Subsequent Occupational Histories for 10 Years", Journal of Applied Psychology, (April 1939), 23:280-8.

3/ What they Think of their Higher Education, Educational Relations Service, General Electric, 1957.

velopment of managerial and professional skills"[1]. Only 54 per cent of the non-engineering group would choose the same course of study again.[2] [3]

That this dissatisfaction with undergraduate studies is not limited to liberal arts graduates, is seen in the survey made by Matthews and Schwartz of Yale College graduates, class of 1946, 10 years later[4]. Of the 53.3 per cent who had majored in engineering during this war period, only 24.3 per cent were still working in the field.

Dean Wilfred Lake of the College of Liberal Arts at Northeastern University in 1954 carried out several follow-up studies[5] on students who had graduated from that school in various departments. No statistical analysis was made of these unpublished studies, but evidence of changes in profession was noted.

1/ Ibid., p. 3.

2/ Ibid., p. 6.

3/ In reference to the study to be described in this paper, it is interesting to note that biology and geology were the sciences most frequently mentioned as "lacking in business value" (p. 7), though they ranked high as courses which "contributed most to your use of leisure time". (p.8)

4/ Samuel W. Matthews and Richard D. Schwartz, "The Class of '46 Looks at Itself", The New York Times Magazine, (June 10, 1956), p. 14 - 15†

5/ Dean Wilfred Lake, Unpublished surveys of Northeastern University, Northeastern Graduates, Boston, 1954.

In another study discussed by Koos [1] of the occupational destination of college graduates, there was an attempt made to determine the shift in occupations by comparing classes 1 year after graduation and 10 years after graduation. The 60 per cent who were in educational fields a year after graduation included, not only those who were actually teachers, but a large group of graduate students. Ten years after graduation, education claimed only 25 per cent of the group. The largest shift over the years was to administration, business and the professions. Another striking fact was that, at the 10-year period, 60 per cent of the women were homemakers.

This orientation towards marriage of the female college student, was also noted in a survey by Christensen and Swihart [2] of 223 senior women at Purdue University in 1953, though one-third wanted to".. supplement homemaking with outside employment" between 21 and 25 years after graduation. A similar study of five freshman classes and four senior classes was conducted at Vassar College [3]. Bureau of Labor statistics show that only a small proportion of college girls want to prepare themselves for professional work. Many feel that they must

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1/ Leonard Vincent Koos, op. cit., pp. 287-94.

2/ Harold T. Christensen and Marilynn M. Swihart, "Postgraduation Role Preference of Senior Women in College", Marriage and Family Living, (February 1956), 18:52-7.

3/ "Is College Education Wasted on Women?", Ladies Home Journal, (May 1957), 74:78-9+

choose between marriage and serious work. Many marry immediately after graduation; others work at something below the ".. level of their ability" or attend graduate school to "mark time". All this while the need for trained people grows more acute every year. While preparation for a professional career is not the primary aim of liberal education, it is interesting to note that students with professional ambitions tend to weather their senior year best.

In 1956 the Department of Labor 1/ reported that 80 per cent of women college graduates were employed six months after graduation. However, ".. relatively few of the women secured training which could be utilized in shortage occupations other than teaching" 2/ with a mere 3 per cent biological science majors 3/. These statistics were based on a survey of 108 colleges and universities in all sections of the country ---- a stratified random sample of 81,000 representative women. Eighty per cent felt their jobs "contributed to vocational development", "were meeting economic needs" and admitted a relationship between undergraduate field of specialization and their first job. The latter was especially true for those trained in teaching and the sciences. Almost all commented favorably on their first jobs. About half of those questioned viewed their employment as temporary, and only 26 per cent admitted planning a career.

1/ Employment after College: Report on Women Graduates, Class of 1955., U. S. Department of Labor --- Women's Bureau, U. S. Government Printing Office, Washington, D.C. 1956.

2/ Ibid., p. 3.

3/ Ibid., p. 7.

The widespread occupational shifts noted in all the aforementioned studies is in sharp contrast to the study by Anne Roe of 64 eminent scientists[1]. Only one of these high-ranking men ever ".. seriously wanted to do anything else"[2]. From an analysis of the case histories of these men, Dr. Roe concluded that the discovery of the possibility of doing research on their own was usually the determining factor in their choice of a career. Scientific research to such men is a "calling"[3] --- the freedom for "constructive exercise of the mind upon the material world". Since, as Pollack states, science is not for the young man or woman who measures success "solely in terms of money"[4], the scientist, as Wendland points out, must find "enjoyment, satisfaction and real fun"[5] in his work, to make it a career.

However, proper qualifications are important, in addition to enthusiasm, and the need for graduate training and specialization is not always apparent to the person receiving his bachelor's degree. Then too, the length, cost and rigor of this additional training discourages many.

1/ Anne Roe, The Making of a Scientist, Dodd, Mead and Company, New York, 1952.

2/ Ibid., p. 81.

3/ "The Scientists", Fortune, (October 1948), pp. 107-12+.

4/ Philip Pollack, op. cit., p. 144.

5/ Roy Wendland, "Why Not Make Science Your Career?", School Science and Mathematics, (June 1955), 55:417-22.

Meyerhoff mentions that, "The one-degree scientist is often little more than a technician."[1/] Pollack states, "You cannot advance very far in certain fields of agriculture unless you have an M.S. or Ph.D. degree."[2/] For a medical research worker with the U. S. Public Health Service Pollack emphasizes that an "M.S. degree is advisable -- or, better still, a Ph.D. degree"[3/]. Often it is financially necessary for the recent college graduate to find a job. As King says, "It is difficult to estimate how many potentially able research scientists never attain positions commensurate with their talents for having postponed graduate education until it was out of reach"[4/]. Fellowships, such as those administered by the National Science Foundation[5/], are giving the opportunity for graduate education to many of tomorrow's scientists. In the past the Ph.D. degree was more of an "academic union card" needed only by those planning to teach or do research within the university. In 1928 when Ching-Ju Ho[6/] studied

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1/ Howard A. Meyerhoff, The Growing Shortage of Scientists and Engineers, op. cit., p. 27.

2/ Philip Pollack, op. cit., p. 139.

3/ Ibid., p. 169.

4/ Ronold King, "From Schoolroom to Research Laboratory --- A Problem in Education", American Association of University Professors Bulletin, (June 1957), 43:306-18.

5/ Harry C. Kelly, "The National Science Foundation's Program in Education in the Sciences", The Educational Record, (April 1957), 38:91-9.

6/ Ching-Ju Ho, op. cit., p. 22.

9,912 successful male scientists, more than half were teachers, and about 60 per cent had Ph.D. degrees, with considerable variation depending upon the branch of science analyzed.[1/] The National Science Foundation reported that in 1953-1954, there were 70,000 scientists employed by colleges and universities --- one-third in the "life sciences". Universities, as Pollack mentions, offer "freedom to carry on independent research to compensate for lower salaries"[2/], but this makes for a difficult decision when devotion to one's profession comes in conflict with more materialistic urges. Now, as that same author states, private industry also " .. prefers Ph. D. scientists in its laboratories, and pays them higher salaries"[3/]. Of the 50,000 scientists surveyed during 1954 and 1955 by the National Science Foundation, 40 per cent had Ph. D. degrees.[4/]

Since salary prospects are among the major incentives in career selection, it is of note that the median salary in 1956 of these scientists was $6,525.[5/] The Knapp and Goodrich study, referred to earlier, noted that scientists tend to come from the lower-middle class groups because "individuals ... rarely select occupations offering economic returns

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1/ Science, (September 6, 1957), 126:442.

2/ Philip Pollack, op. cit., p. 30.

3/ Ibid., p. 25.

4/ "Scientists' Pay", Scientific American, (February 1957), 196:56.

5/ Even lower salaries for teachers was noted.

inferior to those which they have been accustomed", and scientific careers are considered as having ".. limited economic prospects".[1] One of the problems associated with the scientists' salary has been called "salary telescoping".[2] This refers to the narrowing gap between scientists' pay and the salaries of craftsmen, resulting in a relative lowering of status for the former.

It is evident that salaries are only part of the motivational problem. As Roe says, "To work with a congenial group, to be needed and welcomed by that group are important aspects of the satisfactory job."[3] Closely associated are personal regard and social prestige. As she also points out, "Feelings of personal esteem are . . . closely linked to the amount of responsibility the job entails"[4], and responsibility involves recognition. For comparison we note the high rewards Russia gives her productive scientists --- high salaries, more freedom and greater prestige. Also there is military service exemption for physicists, mathematicians and engineers.[5] Though not advocating that education should be an instrument of the state, or asking for a one-sided emphasis on technical

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1/ R. H. Knapp and H. B. Goodrich, op. cit., p. 292.

2/ Anonymous, "I Am a Kidnaper of Sorts", op. cit.

3/ Anne Roe, The Psychology of Occupations, op. cit., p. 9.

4/ Ibid., p. 33.

5/ M. H. Trytten, op. cit.

education, this writer feels that the same motivational principles apply in our country.

Most scientific research projects depend on a mass of information, assembled after completion of laboratory procedures, discovered by the technical staff. It is the unusual supervisor who gives his technical assistants any more than a casual acknowledgment in his publications. Small wonder that laboratory administrators ponder over the rapid turnover in personnel. Sixty per cent of the female biological science majors become biological technicians, starting at an average salary of $3,038 a year, as compared with an average salary of $3,141 a year for all women graduates employed full time.[1/] Here is a potential source of scientists, if laboratory work could fire up their enthusiasm enough to convince them to return to graduate school or give their job more than a "9-5" interest. In 1946 Virginia Shapley wrote: "The dontinuance of women in scientific work is essential to replenish our depleted scientific resources."[2/] More recently Otto Kraushaar commented: "Since there is not enough manpower to go around, the nation will have to depend more and more on trained womanpower."[3/] Undoubtedly the problem of career

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1/ Employment after College, op. cit., pp. 12-15.

2/ Philip Pollack, op. cit., pp. 186-7.

3/ Otto F. Kraushaar, "Science and the Education of Women", Association of American Colleges Bulletin, (March 1957), 43:89-94.

and/or marriage will have to be worked out first, but it will never be solved until it is faced.

On the more positive side, Pollack[1] mentions that a career in science offers good employment security, because of the overwhelming demand for scientists and teachers of science. Also, for those who achieve prominence, Ho[2] points out that it can be expected before one is 50 years old. Finally we return to the point discussed earlier --- the personal satisfaction derived from exploring the unknown. Roe found that "scientific research is a very satisfying manner of life for all who have pursued it wholeheartedly."[3] It seems as if the crux of the matter is that occupations must fill the basic psychological needs of the individual.[4] The relative importance of these needs should be weighed carefully, in relationship to the opportunities and requirements of the various vocations, before embarking on a career in science or any other field.

The present study was undertaken in an effort to determine: (1) the amount of occupational mobility for a group of college graduates trained in biology, (2) whether scientific work is viewed as a lifetime profession early in their career, and (3) the reasons why many, disregarding years of scientific education and training, change vocation.

1/ Philip Pollack, op. cit., p. 34.

2/ Ching-Ju Ho, op. cit., p.29.

3/ Anne Roe, The Making of a Scientist, op. cit., p. 82.

4/ Anne Roe, The Psychology of Occupations, op. cit., pp. 23-39.

CHAPTER III

PLAN OF PROCEDURE

In 1950, Helen Wood [1/] wrote, "The ideal study, which would follow the work histories of a representative group of college graduates with training in specified subjects and discover the fields into which they moved and the factors underlying their occupational shifts, has not yet been undertaken." The search of the literature, described in the preceding chapter, revealed few attempts to analyze the subject of vocational utilization of academic training in such a manner. With this goal in mind, the writer began this study of the occupational histories of graduates in biology.

1. The Years Studied

First, it was necessary to determine the period of years since graduation which were to be analyzed. Five, ten, and fifteen years seemed reasonable spans, during which graduate training is completed, marital positions defined and vocational plans clarified. It seemed as though a survey of a group 15 years after graduation would give complete information as to how many graduates in biology were actually productive scientists.

1/ Helen Wood, "Occupational Mobility of Scientific and Technical Personnel", Occupations, (May 1950), 28:510-3.

Except for shifts to more administrative positions, not always a matter of choice, a considerable amount of occupational stability was assumed after 15 years, in order to delimit this study. (See recommendations for further study.) But if we wished to pin-point the sources of dissatisfaction which had caused any change in vocation, it seemed necessary to include the 5 and 10 year periods, when such reasons would be more easily recalled. To inquire too soon after graduation as to vocational plans is not very meaningful. For many, early job experience has profound effect on their professional lives, either resulting in a desire to return to school for graduate training, or a complete shift in fields. In the case of women, their careers are often contingent on marital factors not always obvious a year or two after graduation.

The decision to study biology graduates from 1942, 1947, and 1952 presented an initial bias in the sample. 1942 was a war year, and males, who were fortunate enough to be allowed to continue their studies, were guided into scientific fields, both by the demand for scientists and since the alternative was more front-line activity. For such students there was not always the opportunity to continue in graduate school and, the G.I. Bill not withstanding, this presented problems when they returned from the service. The class of 1947 was also a war class. A large percentage of this class were returning veterans who were completing undergraduate work. In their case the restrictions of age and money were

more pressing than a selective service board in determining whether they would continue in graduate school.

2. Securing the Sample

The matter of determining the sample was settled more on the basis of convenience than on statistical grounds. It was realized from the outset that the limited size of this study was a statistical drawback, and it was hoped that the final generalizations would still be valid. In any case, reasons for leaving scientific work, the need for graduate training and the possible dissatisfaction with undergraduate studies would come to light. There was the additional bias factor inherent in all questionnaire studies, when anything less than a 100 per cent return is achieved ----- those who have been particularly successful or extremely dissatisfied are more apt to respond.

The colleges, whose alumni were studied, are all in the Boston area. Some schools were contacted in person, and others were able to handle the paper work involved by themselves and sent the writer the final list of names and addresses. An initial telephone call was made to each school to determine whether school policy allowed outsiders to secure the necessary information to contact their alumni. Another problem was whether the names of graduates in biology during the desired years could be obtained without combing through the individual records. The following is a list of colleges whose alumni are included in the sample, together with the means

by which the names were collected.

1) Massachusetts Institute of Technology

The desired list of names was copied from the 1947 and 1952 graduation programs on file in Hayden Library. Degree recipients are listed according to field of concentration. At the Registrar's Office the names from the 1942 commencement program were obtained. However, 1942 was before the M.I.T. Biology Department was reorganized, and biology covered fields such as: Biology and Public Health, Public Health Engineering, Biophysics, and Food Technology and Industrial Biology. After the complete list of names was compiled, the Alumni Office kindly looked through their files and mailed the most recent addresses.

2) Radcliffe College

The list of names was obtained from the Registrar's Office copy of commencement programs, where field of concentration had been indicated. The catalogs in the Alumni Office provided proper mailing names and addresses. Included in the sample of biology graduates were those from the smaller department of biochemistry.

3) Harvard College

Graduation programs are on file in the Archives Room of Widener Library. Only recipients of honor degrees had any

indication of their field of concentration. The only possible way to find the names of non-honors graduates would be to check the individual records of about 5,000 students for the three desired years, a task of enormous magnitude. For this reason graduates of Harvard College were not included in the general sample, but are discussed as a separate group. As in the case of Radcliffe College, both biology and biochemistry were considered. Most recent addresses were obtained at the Alumni Office.

4) Boston University

At the Recorder's Office of the College of Liberal Arts, names of graduates in biology were obtained from cards which indicated the field of concentration. At the Alumni Office the correct mailing names and addresses were secured.

5) Northeastern University

Records of graduates, which had been used by the Placement Office and therefore showed the field of concentration, are now on file in the Alumni Office. Here, too, are the files of mailing addresses. Included in the sample of biology graduates were a small group of Pre-med majors.

6) Simmons College

A secretary at the School of Science, handled the whole matter and sent the writer the final list of names and addresses for graduates in biology.

7) Brandeis University

In this relatively young university, the first year in which there were graduates of interest to this study was 1952. In that year there were seven biology graduates. A letter from the Registrar outlined their vocational history. These alumni will be discussed separately but not included in the sample.

8) Wellesley College

In response to a telephone call and subsequent request by mail for the necessary information, a complete list of names and addresses of graduates in zoology and botany was sent from the Office of the Recorder. This is the only school where a random group was sent the questionnaire. This was due to insufficient forms and the last minute inclusion of this college.

The following chart outlines according to the three years studied, the number of alumni from each college to whom questionnaires were sent.

Table 1. Distribution of Questionnaires Sent to Biology Graduates

School	Year of Graduation			Totals
	1942	1947	1952	
(1)	(2)	(3)	(4)	(5)
Mass. Inst. of Tech. .	15	2	6	23
Radcliffe	5	16	12	33
Boston U.	16	20	47	83
Northeastern U. . .	2	16	21	39
Simmons	8	5	8	21
Wellesley.	13	17	11	41
Total	59	76	105	240
Harvard 1/	2	2	15	19

3. Preparing the Questionnaire

Having secured the total list of over 250 names and addresses, the next step was to prepare a suitable questionnaire. Appendix A is a sample of the final two-page questionnaire which was xeroxed and mailed,

1/ Harvard graduates were not included in the group analyzed, but are discussed separately.

together with a stamped, self-addressed envelope and covering letter, to the entire group.

Items 1 (Name), 2 (Address) and 3 (Date) were included as a convenience to the writer. The possibility of sending duplicate mailings to those who did not return the initial questionnaire was considered, in which case a means of checking off those who filled out the forms was needed. The fact that all information would be kept confidential was noted in the covering letter. (See Appendix B). Of all those who did respond to the questionnaire, only two voiced objection to including their identity.

Items 4 (College attended), 5 (Undergraduate field of concentration), 6 (Degree received and date) and 7 (Graduate school: Number of years, degree received and date) ask for educational history, both undergraduate and graduate.

The critical questions was asked in Item 8 (Does your present position involve work of a scientific nature?). This was the question that would divide the respondents into a) those who were still utilizing their undergraduate scientific education and b) those who had left scientific work.

From the "scientist" the writer wished to find out whether scientific work was viewed as a permanent profession and therefore Item 9 (Do you expect it to be a lifetime profession?). This was especially important for the more recent graduates, where more occupational mobility was expected.

From the "non-scientists" an attempt was made to discover the reasons for their vocational change, and Item 10 was included. (Did you change

fields for ..... ?)

Item 11 (If you are not at present employed do you plan .... ?) was directed to the homemaker and student in order to obtain an indication whether those, not presently employed, were part of our future manpower supply, both in general and for science in particular.

Item 12 (Though not intending to return to work if circumstances forced it, would it be to scientific work?) was a hypothetical question to test vocational satisfaction in the group that did not plan to return to work.

Another hypothetical question was asked in Item 13 (If you had your undergraduate work to do over, what would be your field of concentration?), to determine satisfaction with undergraduate studies. This would be related to vocational satisfaction but might also indicate lacks in college work as viewed by the graduate.

Item 14 (Have you felt the need for a graduate degree?) was asked to validate the statement, frequently found in the literature, that graduate training is a necessity for success in scientific work.

Item 15 (Job Experience) was included to indicate the degree of occupational mobility in the sample.

Items 16 (Age), 17 (Marital status), 18 (Number of children) and 19 (Income) of a personal nature were to give statistics about the nature of the sample, since no attempt had been made to consider these a representative group of graduates in biology.

4. Preliminary Study

A preliminary questionnaire, which included the 19 items just discussed, was sent to 12 names chosen at random from the list. Enclosed was a letter indicating the purpose of the study, and a request for comments about the form itself. Five returns were received, all properly filled out, but no recommendations were made for modifying the questionnaire. Therefore the questionnaire was duplicated in its original form and mailed to the entire group.

5. Subsidiary Study

At the time when the names of graduates in biology were obtained from the various colleges, a few graduates in chemistry were included. These 22 chemistry majors, who also received questionnaires, were from the following schools: M. I. T., 4; Northeastern, 4; Radcliffe, 6; Harvard, 2; Boston University, 6; Wellesley, 1. It was hoped that the responses to these few questionnaires might provide a measure as to the value of further study in this field.

CHAPTER IV

RESULTS

The following table indicates the response to the questionnaire from the 240 biology graduates contacted.

Table 2. Response to the Questionnaire

School	Year of Graduation			Response	
	1942	1947	1952	Number	Percent
(1)	(2)	(3)	(4)	(5)	(6)
Mass. Inst. of Tech. .	7	2	2	11	48
Radcliffe	2	6	7	15	45
Boston U.	7	5	28	40	48
Northeastern U. . . .	1	4	8	13	33
Simmons	4	2	4	10	48
Wellesley.	7	11	7	25	61
Total	28	30	56	114	48
Harvard [1/]	1	1	9	11	58

1. Graduate School Attendance

One of the questions was whether a graduate degree is a necessary qualification for success in scientific work. Information was gathered

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1/ to be treated separately due to bias previously discussed.

both from Item 7, which objectively recorded those who had attended graduate schools, the number of years of graduate education and the degree received, and from the subjective Item 14, which asked whether the individual had felt a need for a graduate degree. The following table outlines the educational histories of the respondents after receiving their bachelors' degrees.

Table 3. Graduate School Histories of the Respondents

Graduate School Attendance	Biologists		Harv.[2]	Chemists[4]
	Total	in science		
(1)	(2)	(3)	(4)	(5)
Number of cases	63	54	11	8
Percent of total	55	47	100	67
Number of years: 1 or less	20	16	0	0
2	12	8	1	3
3	7	6	1	2
4 or more	24	24[1]	9[3]	3[5]

1/ 14 M.D., 6 Ph.D., 3 D.D.S., 1 several masters'

2/ all in science

3/ 6 M.D., 3 Ph.D.

4/ all in science

5/ 2 M.D., 3 Ph.D.

Of the 114 total respondents, exclusive of alumni of Harvard College[1/], 55 per cent attended graduate school. Several of these had changed fields by that point in their careers, but 47 per cent of the respondents attended graduate school in scientific fields. About half of these left graduate school with a doctorate degree. Since the total sample included many women, who married either during college, or directly after graduation, or considered their postgraduation employment a temporary affair, the base of 114 respondents is not a sufficient one to judge the importance of graduate education to those active in scientific fields. This question will be reconsidered in analyzing the present occupational status of the respondents.

1/ A general summary of results of Harvard graduates will be presented at the conclusion of the general results of the survey.

The results of the subjective evaluation of Item 14 are presented in the following table.

Table 4. Respondents' Estimation of Need for Graduate Education

Attitude Towards a Graduate Degree	Biologists					Chemists			
	"Non-scientists" without a graduate degree I	"Non-scientists" with a graduate degree II	"Scientists" without a graduate degree III	"Scientists" with a graduate degree IV	All 11 are "Scientists" with a graduate degree Harv.	"Non-scientists" without a graduate degree I	"Non-scientists" with a graduate degree II	"Scientists" without a graduate degree III	"Scientists" with a graduate degree IV
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Felt a need . .	17	7	11	22	3	0	0	0	4
Felt no need. .	24	1	5	1	0	1	1	3	1
Unanswered . .	6	1	0	19	8	0	1	0	1

Responses indicated an ambiguity in this question which should have read: Do you feel a graduate degree is necessary for success in science? Many "non-scientists" without a graduate degree (1) undoubtedly "felt no need" for such a degree because they have changed fields or do not intend to return to work. It may also be concluded that the large number of unanswered responses among "scientists" with a graduate degree (IV) is due to the assumption that having the graduate degree indicated that they had "felt the need".

Among the "scientists" in this group there is a preponderance (85 per cent of those who answered the question) of those who "felt the need" for a graduate degree. The six who answered in the negative were: 1) a teacher who, because of "poor cooperation in getting loaded classes, not enough time, not enough equipment .... also increased interest in audio-visual field" does not expect science teaching to be a lifetime profession; 2) a housewife whose present scientific work is an "outside interest"; 3) one who in Item 9 claimed that his present scientific position (drug salesman) would be a lifetime profession because he "liked it", and in the resumé of jobs indicated that he was entering the dry cleaning business for himself; 4) one who went to a company sponsored "design training school", which was a "40-week course in mechanical engineering covering 2-1/2 years of important M.E. courses", and is now a design engineer; 5) one who answered "never a need for a degree; a compulsion for scientific knowledge"; 6) a woman who expected marriage to terminate her scientific career.

2. "Scientists and Non-scientists"

The prime question, on which it was hoped this study would shed some light, was whether those trained in biology were active in that field several years after graduation. The following is a tabulation of the replies to Item 8 on the questionnaire, which asked whether their present work was of a scientific nature, in relationship to graduate school attendance.

Table 5. Proportion of "Scientists" and "Non-scientists" in the Sample as Related to Graduate Work in Science

Occupational Category	Biologists		1/ Harv.	Chemists	
	With grad. work in science	Without grad. work in science		With grad. work in science	Without grad. work in science
(1)	(2)	(3)	(4)	(5)	(6)
"Scientists" 2/ 3/	43	15	11	6	3
	1942-12	1942-3	1942-1	1942-1	1942-0
	1947-10	1947-5	1947-1	1947-2	1947-1
	1952-21	1952-7	1952-9	1952-3	1952-2
"Non-scientists" 4/ 5/	11	45	0	2	1
	1942-3	1942-10		1942-0	1942-1
	1947-2	1947-13		1947-1	1947-0
	1952-6	1952-22		1952-1	1952-0

Of the total respondents, 51 per cent are still in scientific work, and of these 75 per cent have spent some time in graduate school pursuing scientific studies. Of the "non-scientists" in the group, a large percentage are housewives, and this facet will be considered later. It is interesting to note that almost 20 per cent of the total group had completed graduate work in science before leaving the ranks of "scientists".

1/ All with graduate work in science

2/ Biologists: 38 Male; 19 Female

3/ Chemists: 8 Male; 1 Female

4/ Biologists: 8 Male; 48 Female

5/ Chemists: 0 Male; 3 Female

3. The "Scientists"

To determine whether those presently engaged in scientific work consider this a lifetime profession, was the object of Item 9. The following table analyzes the responses of the 58 "scientists".

Table 6. The "Scientist" Views his Profession

Response	Biologists No.	Biologists Reasons for...	Harv. No.	Chemists No.	Chemists Reasons for...
(1)	(2)	(3)	(4)	(5)	(6)
		Staying			Staying
Science as a lifetime profession . .	47	Personal enjoyment - 22 Financial reward - 3 Train. and exper. - 6 Challenge and inter. - 10	11	7	Interest - 1 Training - 2 Financial - 1 Enjoyment - 2 Security - 1
		Leaving			Leaving
Science as a temporary occupation . .	8 1/	Lack of opport. - 1 Lack of challenge - 1 Marital reasons - 4 Other interest - 2 Poor working cond. - 1	0	2	Marital - 1 Other inter. - 1
Unanswered . .	1		0	0	
Uncertain . . .	2		0	0	

1/ Three with graduate work in science; four without graduate work in science

It can be seen that 81 per cent of the "scientists" in the group consider science to be a lifetime profession. Of the small group contemplating an occupational shift, the largest number was from the class of 1952. Personal enjoyment ranked as the number one attraction of a scientific career, with the challenge and interest of the work an important second factor.

4. The "Non-scientists"

Responses to Item 10, which attempted to investigate the reasons why almost half of the respondents were no longer utilizing their undergraduate training is collated in the following table. These 56 respondents (48 Female; 8 Male) in many instances cited more than one factor as responsible for their vocational change.

Table 7. Reasons "Non-scientists" Left their Original Field

Reason for Change of Field (1)	Biol.- Times cited (2)	Chem.- Times cited (3)
1. Financial	8	0
2. Marital	38	3
3. Prestige	1	0
4. Dissatisfaction with scientific work . . .	6	0
5. Development of other interest.	6	0
6. Need for part-time work	1	0
7. Lack of opportunity. . .	1	0

Except for the large group of women in the sample who left scientific work for marital reasons, the lack of financial opportunity was responsible for the greatest number of defections. It is of note that this factor is not cited among the reasons given by those presently engaged in scientific work who expect to change vocations. (See Table 6). It would seem that the scientists' salary problem becomes apparent early in his career, and claims its victims within 5 years of graduation. There is undoubtedly a relationship between the several factors enumerated. Thus a dissatisfaction with scientific work, coupled with its limited financial possibilities, might make one seek to develop other interests.

The 34 women who are now housewives answered Item 11 and the results are tabulated below. Since answers (a) and (b) may overlap, some gave multiple responses.

Table 8. Housewives' Future Work Plans

Work Plans for the Future	Biologists-No.	Chemists-No.
(1)	(2)	(3)
1. Plan to return to work	13	0
2. Plan to return to scientific work	10	0
3. Are attending school	2	0
4. Do not plan to return to work . .	20	1
5. Uncertain	6	2

Excluding the 8 questionable responses, 38 per cent of the housewives in the group plan to return to work, and almost that number would return to a scientific job. Only one answered emphatically that she was planning to return to work but not to science.

Of the 26 who had answered negatively or with reservation to Item 11, the following responses were obtained from Item 12, which hypothesized a return to work.

Table 9. Housewives' Plans if Forced to Return to Work

Vocational Plans	Biologists		Chemists	
	Number	Percent	Number	Percent
(1)	(2)	(3)	(4)	(5)
Would return to science . . .	17	68	3	100
Would not return to science .	6	4	0	0
Uncertain	3	12	0	0

The reason for her negative attitude towards a possible future job in science was clarified by one of the respondents.

> "I would return to work only if the necessity of providing for my family were present. Since the object in this case would be to make as much money as possible for the work involved, I should turn to more remunerative fields. Except in special cases, an A.B. in science is not sufficient to earn a 'living'.
>
> If my return to work came far in the future, I could expect that my education and training would be much less valuable than at the present....and it would require less time and schooling to become employable in another area."

This response was from a woman who had worked in university laboratories for 5 years while her husband was in medical school and who would have attended graduate school had not marital plans altered matters.

5. Undergraduate Field of Concentration

In response to Item 13, the following table indicates preferred fields of concentration of this group.

Table 10. Choice of Undergraduate Field of Concentration in Retrospect

Field of Concentration	Biologists		Harvard	Chemists
	Female	Male		
(1)	(2)	(3)	(4)	(5)
Biology	49	20	5	0
Chemistry	3	3	2	8
Physics	0	2	1	1
Engineering	0	7	0	0
Pre-Med	0	1	0	0
Geology	0	1	0	0
Psychology	1	1	0	0
Sociology	1	0	0	0
Social Science	6	4	1	0
Humanities	3	0	1	0
Education	1	0	0	0
Business Admin.	0	2	0	0
Liberal Arts	0	2	0	0
Unanswered	3	3	1	2 [1/]
Totals	67	46	11	12

1/ #1 "bricklaying"

A hypothetical change in undergraduate field of concentration of several doctors in the group does not necessarily mean dissatisfaction with their profession, but rather a desire to broaden the base of educational experience before specializing in medical school. Many of the women who indicated satisfaction with their undergraduate major, would have liked to include more humanities courses, while their male counterparts would have preferred more mathematics and physical science courses in their curricula, and would have avoided general liberal arts courses. With 74 per cent of the men and 78 per cent of the women who answered this question expressing an intent to remain in some scientific department, it would seem that there was a generalized satisfaction with their undergraduate education.

6. Job Experience

Have the 49 per cent of "non-scientists" in this sample made any contribution to our scientific manpower resources, before changing fields? The following table indicates the number of "non-scientists" who worked in science at some point in their careers.

Table 11. Job Experience of "Non-scientists"

Job Experience	Biologists		Chemists
	Male	Female	Female
(1)	(2)	(3)	(4)
Worked in science	4 1/	34	2
Never worked in science	4 2/	14 3/	? 4/

An interesting comment was made by one of the housewives in the sample, who never had a job, and who therefore might be accused of wasting a scientific education.

1/ all four are from the class of 1952

2/ three are from the class of 1952; one from the class of 1942 who was in the Air Force for 5 years

3/ seven never held any job due to early marriage

4/ one unanswered

"As a general comment, I do not feel that my scientific training was a waste, in spite of the fact that I have not used it professionally. As a housewife I find certain scientific methods useful, and surely I am extremely grateful that I can explain some of today's events to my children. If for nothing else, my training is invaluable in making science interesting to them."

7. The Nature of the Sample

Sex

Table 12. Sex Ratio of the Groups

Sex	Biologists	Harvard	Chemists
(1)	(2)	(3)	(4)
Male	46	11	8
Female . . .	67	0	4
Unspecified . .	1	0	0

Age

Table 13. Distribution of Ages of the Respondents

Age	Biologists		Harvard	Chemists	
	Male	Female		Male	Female
(1)	(2)	(3)	(4)	(5)	(6)
25-26 ...	1	10	5	1	2
27-28 ...	15	15	4	2	0
29-30 ...	6	4	0	0	0
31-32 ...	3	17	1	1	1
33-34 ...	3	5	0	0	0
35-36 ...	8	5	0	2	0
37-38 ...	10	9	0	1	1
39-40 ...	0	1	1	0	0
41-42 ...	0	0	0	1	0
Mean Age	32	31	28	33	30

For the women in the sample, the ages correspond relatively to their classes (i.e. the younger are from the more recent graduation years), but for the men this relationship does not hold[1/], due in the main to military service interruptions.

1/ one of the oldest was from the class of 1952

Marital Status

Table 14. Marital Status of the Respondents

Marital Status	Biologists			Chemists	
	Male	Female	Harvard	Male	Female
(1)	(2)	(3)	(4)	(5)	(6)
Married	34	48	8	6	3
Single	12	17	3	2	1
Divorced. . . .	0	1	0	0	0
Widowed	0	1	0	0	0

Number of Children 1/

Table 15. Number of Children in Respondents' Families

Number of Children	Biologists			Chemists	
	Male	Female	Harvard	Male	Female
(1)	(2)	(3)	(4)	(5)	(6)
0.	7	7	2	1	0
1	9	10	4	0	0
2	10	17	1	1	0
3	3	9	1	3	3
4	4	7	0	1	0
5	1	0	0	0	0

1/ of those respondents married, widowed or divorced

In viewing the preponderance of smaller families, it should be kept in mind that almost half of the sample is from the class of 1952.

Income

(a) "Scientists"

Table 16a. Income of "Scientists"--Biologist Sample

Annual Income	Biologists											
	M.D.; D.D.S. 1/			Ph.D. 2/			M.S. 3/			B.S. 4/		
	1942	1947	1952	1942	1947	1952	1942	1947	1952	1942	1947	1952
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Less than $4,000	0	2	3	0	0	0	0	1	4	0	1	4
$4000-5999	0	0	0	1	0	1	0	1	4	0	4	3
$6000-7999	0	0	3	1	0	3	0	3	1	1	0	1
$8000-9999	0	0	0	0	0	0	2	0	0	0	0	0
$10,000-$14,999	3	1	0	1	1	0	0	0	0	0	0	0
$15,000-$19,999	0	0	0	0	0	0	0	0	0	0	0	0
Over $20,000	4	0	0	0	0	0	0	0	0	0	0	0

1/ 11 Male; 4 Female

2/ 7 Male; 1 unspecified

3/ 10 Male; 5 Female

4/ 7 Male; 8 Female

Table 16b. Income of "Scientists"--Harvard and Chemistry Samples

Annual Income	Harvard					Chemists							
	M.D.		Ph.D.		M.A.	M.D.			Ph.D.		M.S	B.S.	
	1947	1952	1942	1952	1952	1942	1947	1952	1947	1952	1947	1947	1952
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Less than $4,000	0	2	0	1	0	0	0	1	0	0	0	0	0
$4000-5999	0	0	0	1	0	0	0	0	0	0	0	0	0
$6000-7999	0	3	0	1	0	0	0	0	0	0	0	1	2
$8000-9999	0	0	1	0	1	1	0	0	0	2	1	0	0
$10,000-$14,999	1	0	0	0	0	0	0	0	1	0	0	0	0
$15,000-$19,999	0	0	0	0	0	0	0	0	0	0	0	0	0
Over $20,000	0	0	0	0	0	0	0	0	0	0	0	0	0

It is evident that salary possibilities increase with both experience and graduate degrees held. Medicine, though involving a longer apprentice period, has a higher financial potential. Though some M.D. members of both the classes of 1952 and 1947 are still earning less than $4,000 a year, none from the class of 1942 earn less than $10,000 a year, and more than half earn over $20,000 annually.[1/] Compare this with the group of Ph.D.'s.

1/ granted a biased sample due to small numbers of respondents in each category and the tendency of the more successful person to respond to such a questionnaire

No member of any class earnsless than $4,000 a year but neither do they earn more than $15,000 annually.

In an effort to determine whether a dual salary standard exists for men and women, salaries of "scientists" with only a bachelors' degree were also analyzed according to sex. The following is a tabulation of the results.

Table 16c. Income of "Scientists" with No Graduate Degree ----- According to Sex

Annual Income	Biologists							
	Male				Female			
	1942	1947	1952	Total	1942	1947	1952	Total
(I)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Less than $4,000 . . .	0	0	0	0	0	1	4	5
$4000-5999. .	0	2	3	5	0	2	0	2
$6000-7999. .	1	0	1	2	0	0	0	0

Although the numbers involved were small, the figures indicate a salary discrepancy mainly in the class of 1952. For those women who remained in the field at least 10 years after graduation, the salary scale seems on a par with that of the men of similar experience.

For the "scientists" with a Masters' degree, the salary scale seems relatively equal for both sexes. The following table analyzes the income of "scientists" holding either an M.S., and M.A., or an M.Ed. degree.

Table 16d. Income of "Scientists" with Masters' Degree ----- According to Sex

Annual Income	Biologists							
	Male				Female			
	1942	1947	1952	Total	1942	1947	1952	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Less than $4,000 . . .	0	0	2	2	0	1	2	3
$4000-5999. .	0	2	2	4	0	0	2	2
$6000-7999. .	0	2	1	3	0	1	0	1
$8000-9999. .	2	0	0	2	0	0	0	0

(b) "Non-scientists" --- exclusive of housewives

This data was analyzed according to sex because it was hypothesized that the male "non-scientists" in the sample would be holding better paying jobs, since a good many had left science for financial reasons. This supposition was borne out by the following table of results.

Table 17. Income of "Non-scientists" --- Exclusive of Housewives

Annual Income	Biologists							
	Male				Female			
	1942	1947	1952	Total	1942	1947	1952	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Less than $4,000. . .	0	0	0	0	1	0	2	3
$4000-5999 .	0	0	1	1	0	1	3	4
$6000-7999 .	0	0	5	5	0	1	0	1
$8000-9999 .	0	0	0	0	0	0	1	1
$10,000-$14,999 . .	0	0	1	1	0	0	0	0
$15,000-$19,999 . .	0	0	0	0	0	0	0	0
Over $20,000	1	0	0	1	0	0	0	0

(c) Housewives

It had been noted earlier that 37 per cent of the housewives in the group plan to return to work when their children are older. To determine whether there was a relationship between their husband's income (when specified in the questionnaire) and future work plans, the data was tabulated as follows:

Table 18. Family Income of Housewives and their Future Work Plans

Annual Income	Number of cases	Plan to return to work (Husband's occupation)
(1)	(2)	(3)
Less than $4,000 . . .	3	3 No (students, 2 specifically in medicine)
$4000-5999. .	3	1 No; 1 ? (M.D. in rsch.); 1 Yes, but not to science
$6000-7999. .	2	1 Yes; 1 ?, but if so to science
$8000-9999. .	2	1 No; 1 Yes
$10,000-$14,999. . .	8	4 No; 2 No, but if so to science; 1 ?, but if so to science; 1 Yes
$15,000-$19,999. . .	0	0
Over $20,000.	1	1 No, but if so to science

The only definite expression of a desire to return to work among housewives whose husbands earn more than $10,000 a year, was a woman who commented, "... perhaps only on a volunteer basis, and then later part time if I am needed." With such limited data it is impossible to ascertain whether those in lower income groups wish to return to work for financial reasons or because of other motivations.

With only four housewives indicating their last paid position, or maximum yearly salary when employed, no relationship could be drawn between this factor and their future work plans.

Table 19. Income of Housewives when Employed

Annual Income	Number of Cases
(1)	(2)
Less than $4000. . .	2
$4000-5999.	2

One of these respondents was presently employed part time. The other three either intend to return to science, or would go back to that field if forced to return to work. 1/

1/ 1 Yes, 1 ?, 1 No concerning intent to return to work

8. Harvard Graduates in Biology

As has been mentioned in the preceding chapter, Harvard graduates are being treated separately because of an initial bias in contacting only honors graduates. Itemized data have been tabulated alongside of the general sample, and this section will merely summarize the results and compare them with the other group of respondents.

Graduate school attendance.-- It will be noted that all 11 respondents spent at least 2 years in graduate school. In fact, ten received either Ph.D. (4) or M.D. (6) degrees, the eleventh receiving an M.A. degree. It seems likely that more successful completion (with honors) of undergraduate work, affected their ability to obtain admission to a graduate school. The same motivations which resulted in a desire to continue in graduate studies probably made for higher achievement levels in their undergraduate programs. Only three respondents answered that they had "felt the need" for a graduate degree, but the eight unanswered responses were most likely due to a misinterpretation of the question.[1/]

"Scientists".--All eleven of these alumni are "scientists", and they all indicated that they expect this to be a lifetime profession. Of those who gave the reasons for their choice, six mentioned personal enjoyment, and one cited the fact of his extensive training and experience in the field.

1/ see page 37 of this study concerning unanswered "IV's" in the general sample

Undergraduate field of concentration.-- Eight graduates would remain science majors, one did not answer, and two would change fields. However, this latter change does not indicate dissatisfaction with their profession. The one who would major in the humanities stated that he would still go to medical school and since the one who would major in social science mentions that he is "happy with it" (i.e. medicine), it may be presumed that he would do the same.

Nature of the sample.-- As already stated, this sample was biased intellectually. Since these are all male graduates, it is also difficult to compare them with the general biologist sample. There is also a greater number of younger alumni, nine of the eleven respondents coming from the class of 1952. The marital status, however, is well equated with the general sample, (as well as with the chemistry group), with about a three to one preponderance of married graduates. The younger nature of this group, together with the greater financial responsibilities of four years of graduate school, is reflected in the smaller family size of these Harvard alumni at the present. With such a small group no significant comparison of incomes can be made, though the range of incomes is comparable to the general sample.

9. The Chemistry Sample

The responses to the questionnaire, from the chemistry graduates, is indicated in the following table.

Table 20. Responses from the Chemistry Sample

School	Years of Graduation			Responses	
	1942	1947	1952	Number	Percent
(1)	(2)	(3)	(4)	(5)	(6)
Mass. Inst. of Tech. . .	0	1	1	2	50
Radcliffe	1	0	1	2	33
Boston U.	0	1	2	3	50
Northeastern U. . . .	1	1	1	3	75
Harvard	0	0	1	1	50
Wellesley	0	1	0	1	100
Total	2	4	6	12	52

As with the Harvard graduates, the data for the group of chemistry majors have been tabulated alongside the general sample.

Graduate school attendance.-- Eight of the twelve respondents had attended graduate school, all in science. This two-thirds proportion is a good deal higher than for the biologists sample, but a reversed sex ratio probably accounts for this pattern. Graduate school produced three Masters' degrees, three Ph.D.'s and two M.D.'s. Only four of the

"scientists" with a graduate degree admitted feeling a need for such a degree. A misinterpretation of the item seems likely in the case of the "scientist" with a graduate degree who "felt no need". The fact that the three "scientists" without a graduate degree "felt no need" for graduate education seems worthy of future study. The number are certainly too small to draw any conclusion, but it seems possible that the educational requirements for successful careers in chemistry and biology may vary.

"Scientists".-- The limited sample also becomes a problem in interpreting the percentage which is still engaged in scientific work. The fact that there are three times as many "scientists" as "non-scientists", as opposed to equal proportions among the biologists, may be indicative of professional opportunities, or it may simply reflect the sex ratio. Seven of the nine "scientists" expect their work to be a lifetime profession for reasons similar to those given by the biologists. The two who are contemplating a change are doing so because of 1) a forthcoming marriage and 2) increased interest in scientific management.

"Non-scientists".-- The "non-scientists" in this group are three housewives who left science for marital reasons. Two of these are undecided about future work plans, and the third does not intend to return to work, but all three would return to science if they were forced to resume work. Once again, we cannot interpret this favorable response to science as

significant with only three responses involved, but it does seem worthy of further study, both to indicate job satisfaction and our manpower situation.

Undergraduate field of concentration.-- The sample as a whole seemed satisfied with their undergraduate field of concentration, with nine of the twelve wishing to repeat scientific curricula. There were two unanswered responses, and one jokester who, thinking of his present salary in comparison with certain laborers, mentioned "bricklaying".

Job experience.-- Two of the "non-scientists" had worked in science at some point in their careers. The third did not answer this item, but marital status (married), education (M.A. in 1954), age (26) and number of children (3), indicate that she probably never worked.

The nature of the sample.-- These data are also tabulated alongside of their biology counterparts. It will be seen that the male chemists are twice as numerous as the female chemists, whereas the female biology graduates exceed the male biologists by about 40 per cent. The range of ages is comparable, as is the marital status and number of children. The range of incomes for the group is also comparable to the biologists of corresponding age and educational level. The fact that all three chemists with only bachelors' degrees, including two from the class of 1952, earn at least $6000 a year, while only about 15 per cent of

the equivalent biologists earn that much, possibly indicates a higher salary schedule for the chemistry graduate, although the sample is too small for final conclusions. The two housewives who indicated their husbands' income had no plans to return to work, but would return to science if forced to resume work.

10. Biology Graduates from Brandeis University

The following is from a letter from Brandeis University's Registrar, Charles Duhig, in response to the writer's request for the names and addresses of Brandeis' biology graduates.

"In Brandeis University Class of 1952, its first class, seven students concentrated in Biology. Of the seven, four entered Dental School. They have all graduated from Dental School and are all practicing dentistry, one with the U. S. Expedition to Antarctica. Two went to Medical School, have since graduated, have done their internship and now hold Assistant Residenceships in Medicine. The seventh is doing research work in the field of Biology in Texas. All of the above are males."

This group was not included in the general sample because they were not reached personally with the questionnaire. However, it is of note that, at the time of the correspondence with their university, all seven were active in scientific fields.

CHAPTER V

SUMMARY, CONCLUSIONS AND SUGGESTIONS FOR FUTURE STUDY

1. Summary

1. Of the total respondents, 51 per cent are still in scientific work.
2. Of those "scientists" who answered the question, 85 per cent admitted having "felt the need" for a graduate degree.
3. Of all the respondents, 47 per cent had attended graduate school in scientific fields.
4. Science was considered a lifetime profession by 81 per cent of the "scientists", with personal enjoyment the main attraction of a scientific career.
5. Marital reasons accounted for most changes of fields, though limited financial opportunities disturbed many.
6. Only 38 per cent of the housewives plan to return to work, almost all of these to scientific jobs.
7. A generalized satisfaction with undergraduate education was indicated by a willingness to repeat a similar curriculum by about three-fourths of the entire group.

2. Conclusions

It is difficult to evaluate the importance of their biological training to those who responded to this questionnaire. It was noted that only 51 per cent are still in scientific work, so from the standpoint of our manpower supply we must educate two biologists for every scientist we hope to have actively participating in that profession. To expect professional endeavors from each graduate would be illogical, and only by comparing biology with other fields of study could any failings in the undergraduate field be determined. Cursory examination of the literature produced no evidence of an analysis of other undergraduate studies in relation to vocation. Viewing the situation from the individual point of view, the general satisfaction with their undergraduate field of concentration indicates the value of scientific studies for other than vocational training, and its place in the liberal education of today's scientifically-oriented society.

The importance of graduate education for success in a scientific career was pointed out by the respondents, both by their stated opinion and their educational histories. If we consider financial status as a criterion of success, we also note the strong correlation between advanced degrees and income. Just as the pre-medical student is made fully aware of the years of education and internship ahead of him, a more realistic

vocational picture should be presented to the would-be scientist. Possibly this would result in fewer science undergraduate majors, but it also seems likely that those entering the profession would remain in the field.

With personal enjoyment the chief attraction of a scientific career, one wonders whether the typical undergraduate program of lectures and well-defined laboratory exercises are the proper impetus needed to increase an interest in such a vocation. As was observed in the study of Knapp and Goodrich[1/], schools with liberal educational philosophies were noted for their higher production of scientists. It seems a pity that the pleasures of an individual research project are generally limited to senior honors candidates.

Further support for their satisfaction with biological studies was given by the housewife element of this sample. Though only 38 per cent plan to return to work, almost that per cent expect it to be to a scientific job. In these cases financial considerations appear secondary. In contrast, being "forced to return to work" implies more monetary pressures, and of those who would work only under such circumstances, only 68 per cent would return to science.

The results of this study indicate the values of biological studies at the college level and the pleasures and satisfactions to be derived from a career in science. The limitations are likewise apparent to those who judge success in terms of financial returns. For others the lack of

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1/ Knapp and Goodrich, op. cit.

an advanced degree will probably make the climb in terms of position, prestige and responsibility more difficult. But the opportunities and potentialities are great and if fully explained might attract greater numbers of competent students to careers in science.

3. Suggestions for Future Study

1) The small sampling of graduates in chemistry indicated several differences in comparison with graduates in biology. Some of these disparities may be due to a reversed sex ratio, which only further sampling could ascertain. Although a much higher percentage of these chemistry graduates had attended graduate school, the fact that all three "scientists" without a graduate degree felt no need for such education (in comparison to less than one-third of the comparable group of biologists) may indicate different educational requirements for successful careers in those two sciences. If this is true a study of other scientific fields in this respect could be most helpful for prospective science students.

2) An analysis of the Harvard graduates in biology, all of whom had received degrees with honors, indicated that the entire group had attended graduate school and were now embarked on their lifetime careers in science. After determining the educational requirements for success in science, it would be useful to know more about the relationship between undergraduate grades and admissability to graduate school. What percentage of graduates in biology do not attend graduate school because

of a lack of desire to do so, and how many are denied admission for reasons which include both intellectual and financial abilities?

3) A similar study which would contact science graduates who have been out of college for 20 or 25 years might determine whether housewives return to jobs in keeping with their undergraduate education, if there is a big shift from technical to administrative positions during this period, and give a general indication of occupational stability after the 15 year period surveyed in this study.

4) One of the respondents suggested an investigation of hobbies, particularly of professional men. These avocational activities might indicate some of the values of scientific education for other than vocational training.

APPENDICES

APPENDIX A
QUESTIONNAIRE

1) NAME

2) ADDRESS

3) DATE

4) COLLEGE ATTENDED

5) UNDERGRADUATE FIELD OF CONCENTRATION

6) DEGREE RECEIVED AND DATE

7) GRADUATE SCHOOL: NUMBER OF YEARS
DEGREE RECEIVED AND DATE

8) DOES YOUR PRESENT POSITION INVOLVE WORK OF A SCIENTIFIC NATURE?

9) IF SO, DO YOU EXPECT IT TO BE A LIFETIME PROFESSION?
WHY?

10) IF NOT, DID YOU CHANGE FIELDS FOR
   (a) FINANCIAL IMPROVEMENT?
   (b) MARITAL REASONS?
   (c) INCREASED PRESTIGE?
   (d) DISSATISFACTION WITH SCIENTIFIC WORK?
   (e) OTHER? (if so, please elaborate)

11) IF YOU ARE NOT AT PRESENT EMPLOYED
   (a) DO YOU PLAN TO GO BACK TO WORK IN THE FUTURE?
   (b) DO YOU PLAN TO GO BACK TO SCIENTIFIC WORK?
   (c) ARE YOU GOING TO SCHOOL?
   (d) HAVE YOU RETIRED?
   (e) OTHER?(if so, please specify)

12) THOUGH NOT INTENDING TO RETURN TO WORK, IF CIRCUMSTANCES FORCED IT, WOULD IT BE TO SCIENTIFIC WORK?

13) IF YOU HAD YOUR UNDERGRADUATE WORK TO DO OVER, WHAT WOULD BE YOUR FIELD OF CONCENTRATION?

14) HAVE YOU FELT THE NEED FOR A GRADUATE DEGREE?

15) JOB EXPERIENCE: (starting from first job after graduation)

A

B

C

D

E

PERSONAL

16) AGE

17) MARITAL STATUS

18) NUMBER OF CHILDREN

19) INCOME: LESS THAN $4000
$4000-$5999
$6000-$7999
$8000-$9999
$10,000-$14,999
$15,000-$19,999
OVER $20,000

APPENDIX B

BOSTON UNIVERSITY
SCHOOL OF EDUCATION
332 BAY STATE ROAD
BOSTON 15, MASSACHUSETTS

Much emphasis has been placed recently on increasing our facilities for training our country's future scientists and encouraging the would-be scientist. This study is being undertaken in an attempt to discover whether the student, prepared in science in college, is using his training in his post-graduation vocation.

All information on the questionnaire will be kept confidential and your anonymity in the group analyzed will be preserved.

Zelda K. Sokal

Zelda K. Sokal

The research activities accompanying this paper are being done under my direction.

It is believed that they are scholarly and useful.

Your cooperation is enlisted and will be appreciated.

Cordially,

John G. Read

John G. Read
Professor of Education

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