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College Environments and the Development of Talent

Characteristics of colleges are related to the percentage of graduates who attain the Ph.D.

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The hazards of ranking colleges with respect to the quality of undergraduate instruction are well known. Recently a number of investigators have stressed the need for a method of controlling differences in student quality among institutions so that comparisons of institutions on the basis of the attainments of their graduates will not be affected by diversities in their talent supplies. In this article (*1*), measures of the relative success of colleges in stimulating their students to attain the Ph.D. have been adjusted to remove the effects of differences in the intellectual caliber of the student bodies. Two indices of Ph.D. productivity have been developed—one for the natural sciences and one for the arts, humanities, and social sciences—and these indices have been related to various college characteristics, including type of program and student body, geographical location, and student reports of faculty and administrative behavior.

The analysis tests and affirms the general hypothesis that the nature of contacts between undergraduate students and faculty partly determines whether or not the student will seek advanced training. Student observations of faculty behavior indicate that the teacher who stimulates students to enter graduate study is distinguished by certain attitudes and actions. Furthermore, faculties which inspire achievement in the natural sciences have traits that are different from those of faculties which stimulate achievement in the arts, humanities, and social sciences.

Since previous indices for assessing college productivity failed to take into account diversities in supplies of college talent, they cannot be regarded as accurate estimates of educational effectiveness. Several investigators (*2*) have pointed out that some institutions get a higher proportion of talented students than others, and so should be expected to have a higher proportion of their graduates attain Ph.D.'s. The Knapp and Goodrich (*3*) and the Knapp and Greenbaum (*4*) indices, as well as Traxler's (*5*) rankings of American colleges according to the percentage of their male graduates listed in *Who's Who in America,* suffer from this limitation.

The seriousness of the errors introduced by ignoring diversities in the intellectual ability of different student bodies seems to vary with the type of productivity assessed. As is shown below, the percentage of a college's freshman class who are finalists in the National Merit Scholarship competition is a good index of the college's supply of talent. Assuming that diversities in college talent supplies remain relatively the same over a period of years, we may use this index to estimate student quality for the periods during which the Ph.D.'s identified in recent studies (*3, 4*) were undergraduates. The Knapp-Goodrich index of science productivity correlates .38 with this talent supply index, a figure consistent with the .39 reported by these authors as the correlation coefficient between their index and American Council of Education Scholastic Aptitude Examination score averages for 50 colleges. On the other hand, the talent supply index correlates .71 and .64, respectively with the male and female indices of productivity devised by Knapp and Greenbaum. Variations in student quality appear to account for 40 or 50 percent of the variance in the Knapp-Greenbaum indices, which are composite measures of scholarly and scientific productivity, and for approximately 15 percent of the variance in the Knapp-Goodrich index of science productivity. In short, the errors which result from overlooking diversities in talent supply seem to be greater for scholarly than for scientific indices.

New Productivity Indices

The first two annual National Merit Scholarship Programs, which provide records of the college enrollments of over 9600 talented students throughout the nation, offer one means of attacking the problem of equating colleges with respect to talent supplies so that valid comparisons of their effectiveness can be made. For freshman men attending 39 colleges, the correlation between mean scores on the College Entrance Examination Board Scholastic Aptitude Test (SAT) and the percentage of the freshman class who were Merit finalists was .74; for freshman women attending 43 colleges, the correlation between mean SAT scores and this percentage index was .76 (*6*). These estimates of validity are probably conservative, since College Board schools for which SAT scores are available tend to attract su-

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perior students, and consequently the range of talent is narrower than that which would be found in a more representative sample of colleges.

In using the percentage of the freshman class who were Merit finalists as the talent supply index, I have assumed that the quality of the college's talent supply and the behavior of its faculty do not vary greatly over a 10- to 15-year period. Evidence bearing on the second assumption is not available, but there is some correlational evidence to support the first (*7*).

The index was used to estimate the supplies of student talent of 511 colleges during the period 1939–45. (Although only 4-year institutions attended by one or more Merit finalists during the first two years of the Merit Program are included, these 511 colleges enrolled about 70 percent of the total number who entered 4-year colleges or universities in 1956 and 1957.) The number of each college's graduates who, after receiving their bachelor's degrees, earned doctorates in the years 1950–56 inclusive was determined from data collected by the National Academy of Sciences–National Research Council (*8*). Since the median lapse between baccalaureate and science doctorate degrees is about 7 years, the number of graduates from each college was estimated for the period 1943–49 (*9*). The percentage of each college's graduates who went on to get the doctorate was then estimated by dividing the number of Ph.D.'s who did their undergraduate work at the college by the estimated number of graduates from that college during the selected time intervals.

The analysis yielded two adjusted productivity measures, one for the natural sciences and one for the arts, humanities, and social sciences. (Since the two measures will be frequently referred to, it is convenient to use "NS" and "AHSS" as code words for the two broad fields of endeavor.) The productivity indices are the discrepancies between a school's expected rate of Ph.D. productivity (NS or AHSS), as predicted from its enrollment of talented students, and its actual rate of productivity (*10*). Figures for a particular school indicate the relative success of that school in stimulating its undergraduates to get Ph.D.'s of a given type, the rating of success being independent of the quality of the student body.

Because of the extrapolations used, the measures are not sufficiently reliable to permit comparison of individual institutions. However, several lines of evidence indicate that the indices have substantial validity for groups of colleges. First, according to students' reports, there is a clear difference between productive and unproductive institutions in emphasis upon preparation for graduate study. Second, the measures appear to be sensitive to differences in institutional objectives. As might be expected, professional and technical schools rank highest in NS productivity, but are lowest in AHSS productivity. Similarly, 96 and 61 percent of the student informants attending institutions ranking "high" and "low," respectively, on the AHSS index endorse the statement: "The library is exceptionally well equipped with journals, periodicals, and books in the social sciences." Third, institutions located in the South tend to rank low on both measures, a finding which is consistent with previous research (*4*).

Table 1. Ph.D. productivity of undergraduate programs by type of institution. In this table, and those which follow, a numerically low index indicates high productivity. Numbers in parentheses are ranks based upon mean productivity indices.

Institutions*		Adjusted productivity index			
		Natural sciences		Arts, humanities, and social sciences	
Type	No.	Mean	S.D.	Mean	S.D.
Professional or technical schools	28	173 (1)	28.7	214 (7)	18.3
Men's colleges and universities	52	181 (2)	24.2	164 (3)	27.2
Women's colleges and universities	66	236 (7)	20.2	199 (6)	24.0
Coeducational institutions					
Private colleges	155	194 (4)	26.6	161 (1)	26.9
Public colleges	63	206 (6)	29.0	164 (2)	30.3
Private universities	64	197 (5)	19.2	170 (4)	24.8
Public universities	80	183 (3)	18.2	175 (5)	17.1
Total	508				
F-ratio		43.5		32.4	
Probability		$< .01$		$< .01$	

* The source used in classifying institutions was: U.S. Department of Health, Education, and Welfare, *Education Directory, 1956–57: Part 3, Higher Education* (U.S. Govt. Printing Office, Washington, D.C., 1956). "Universities" in this table include only those institutions which have three or more professional schools, as well as a liberal arts and general program. Professional and technical schools include only those listed as offering a professional or technical program, except Rice Institute and Massachusetts Institute of Technology, which were classified with the technical schools. Colleges with co-ordinate student bodies were classified as coeducational institutions. Three institutions (Peabody Conservatory of Music, Curtis Institute of Music, and Philadelphia Museum School of Art) were not classified.

Table 2. Ph.D. productivity of institutions classified by geographical position. The geographical classification described by Knapp and Goodrich (*2*) is used here. One institution (University of Puerto Rico) is not classified. Numbers in parentheses are ranks based upon mean productivity indices.

Geographical position	No. of institutions	Adjusted productivity index			
		Natural sciences		Arts, humanities, and social sciences	
		Mean	S.D.	Mean	S.D.
New England	32	191 (1)	28.5	171 (2)	25.5
Atlantic Seaboard	117	196 (4)	32.5	174 (3)	32.0
Middle West	185	195 (3)	27.3	167 (1)	28.6
Far West	65	191 (2)	31.6	175 (4)	29.8
South	111	210 (5)	27.2	182 (5)	27.4
Total	510				
F-ratio		6.36		5.18	
Probability		$< .01$		$< .01$	

Kind and Location of Institutions

Table 1 compares the extent to which different types of institutions stimulate their undergraduate students to seek the Ph.D. Differences between the mean productivity indices of different types of undergraduate programs are statistically

significant for both NS and AHSS measures.

Cultural values and norms which discourage women from seeking the Ph.D. may account for the relatively poor showing of women's colleges and universities. The specialized character of the curriculum and student goals at professional and technical schools is reflected in the fact that these schools rank highest in NS productivity and lowest—even below women's colleges and universities—in AHSS productivity. Men's colleges and universities, which have the advantage of a student clientele for whom graduate study is culturally approved, rank relatively high on both measures. In view of their coeducational student bodies, publicly supported universities are outstandingly productive of Ph.D.'s in the natural sciences.

Table 2 shows that geographical location is significantly related to productivity, and that institutions located in the South rank lowest on both the NS and AHSS measures. The differences between the mean indices of the four remaining regions are not statistically significant for either measure. Although Knapp and Greenbaum (*4*) did not adjust their indices for differences in talent supplies, their results, like mine, place institutions located in the South at the bottom in productivity. These results are not in accord with the geographical differences reported by Knapp and Goodrich, who found, after making adjustments for student quality, that in a small sample of 50 colleges the Middle and Far West ranked highest, the South was intermediate, and the Middle Atlantic and New England regions ranked lowest in science productivity. The small number of colleges makes it difficult to draw any conclusions from the latter analysis.

Protestant institutions tend to stimulate a greater proportion of their graduates to seek the Ph.D. than Catholic institutions do (Table 3). Since the possession of a religious affiliation by a college is negatively related to NS productivity and unrelated to AHSS productivity (Table 4), the standing of Catholic schools can probably be attributed to factors indigenous to the Catholic college or its student body, rather than to any positive motivating influence on the part of Protestant colleges. These differences in Ph.D. productivity might be due to teaching practices, parental values, or to the initial goals and career motivations of the students.

Table 4 shows that possession of a coeducational student body is the college characteristic most closely related to productivity. To be sure, the unproductivity of women's colleges and universities tends to depress the average for all noncoeducational institutions and so to make schools with coeducational student bodies look much more productive. However, in spite of their advantage in having an all-male clientele, men's colleges and universities are not significantly more productive in the arts, humanities, and social sciences than coeducational institutions. Thus, the high standing of coeducational schools suggests that a mixed student body may be favorable to the development of motivation to seek advanced degrees in these fields.

The only other college characteristic related to both measures of productivity is the number of volumes in the institution's library. It is not surprising that schools with larger libraries tend to be more productive, since it is likely that superior faculties and resources will be found at such institutions.

The remaining correlations in Table 4 suggest that natural science Ph.D.'s tend to come from a different set of baccalaureate institutions than do Ph.D.'s in the arts, humanities and social sciences. NS productivity is associated with large freshman enrollments, graduate programs offering the Ph.D., public support, and absence of religious affiliation. These characteristics are typical of the state university, which, as we have already noted, tends to be outstandingly effective in stimulating achievement in the natural sciences.

It is more difficult to characterize institutions which are productive of Ph.D.'s in the arts, humanities and social sciences. They tend to be located in small cities, and—contrary to expectation—to have relatively large numbers of students per faculty number. Student-faculty ratios are notoriously difficult to interpret. One would expect that the ratios for colleges would be smaller than those for universities. However, this is not the case for coeducational institutions in the present sample. No doubt, part of the difficulty arises from the practice of including the faculties of graduate and

Table 3. Ph.D. productivity of institutions with different types of religious affiliation.

Type of affiliation	No. of institutions	Adjusted productivity index			
		Natural sciences		Arts, humanities, and social sciences	
		Mean	S.D.	Mean	S.D.
Catholic	81	209	32.9	189	26.5
Protestant	157	198	29.0	163	28.5
Difference		11		26	
Probability		$< .02$		$< .01$	

Table 4. Ph.D. productivity and college characteristics.

Characteristic*	No. of institutions	Correlation with adjusted productivity index	
		Natural sciences	Arts, humanities, and social sciences
Type of student body (coed.)	511	.21†	.26†
Number of volumes in library	488	.29†	.11†
Size of 1956 freshman class	511	.22†	−.04
Size of city	510	−.06	−.18†
Student/faculty ratio	498	.05	.12†
Level of training offered (Ph.D.)	511	.13†	−.04
Religious affiliation	511	−.12†	.04
Type of control (public)	511	.11†	−.03
Cost	511	−.04	.05

* The number of institutions varies because of incomplete data in the sources used for classification. Characteristics in parentheses indicate qualities weighted positively in computing point-biserial correlations. Signs of residuals have been reflected so that positive correlations indicate the characteristics associated with greater productivity. † $P < .01$.

professional schools in the denominators of such ratios. A clearer picture of the environments favorable to AHSS achievement is revealed by an analysis of faculty behavior associated with productivity.

Faculty Behavior and Productivity

To identify faculty behavior which motivates students to seek the Ph.D., student reports of faculties at 36 institutions varying in productivity were compared. The 36 colleges and universities were all institutions with relatively large enrollments of winners or near-winners in the National Merit Scholarship competition. Some 916 Merit finalists—all sophomores at the time of the study—were used as informants. The number of student observers per college averaged 25 and ranged from 12 to 47. Since the distributions of productivity measures for the 36 institutions had much smaller variances than the productivity distributions for the total group of 511 colleges and universities, the observed correlations are probably underestimated.

Each student observer completed an inventory consisting of 300 true-false items (*11*). Only those items which can be interpreted as measures of faculty behavior will be discussed here.

Items which seem to describe the same trait and which exhibit the same pattern of correlations with the two productivity measures have been grouped together. The hypothesized traits represented by each cluster, together with typical items, are listed in Tables 5 and 6. In Table 5 the 12 institutions which ranked highest in NS productivity among the 36 selected for study are compared with the 12 institutions ranking lowest. A similar analysis of faculty behaviors related to AHSS productivity is presented in Table 6.

Table 5. Faculty behavior and Ph.D. productivity in the natural sciences.

Hypothesized trait*	Items most descriptive of cluster	Percentage of observers† giving keyed response		Percentage difference
		Twelve most productive institutions	Twelve least productive institutions	
Informality and warmth of student-faculty contacts (+)	In talking with students, faculty members often refer to their colleagues by their first names. (F)	66	78	−12
	Faculty advisers and counselors are pretty practical and efficient in the way they dispatch their business. (T)	64	71	− 7
Emphasis upon high academic standards (+)	Personality, pull, and bluff get students through many courses. (F)	84	66	18
	The professors really push the students' capacities to the limit. (T)	60	45	15
Emphasis upon high standards of faculty selection and productivity (+)	Course offerings in the natural sciences are outstanding. (T)	87	75	12
	The school is outstanding for the emphasis and support it gives to pure scholarship and basic research. (T)	84	77	7
Closeness of supervision (−)	In many classes students have an assigned seat. (T)	35	62	−27
	Student organizations are closely supervised to guard against mistakes. (T)	18	30	−12
Directiveness of teaching methods (−)	It is hard to prepare for examinations because students seldom know what will be expected of them. (F)	60	88	−28
	It is easy to take clear notes in most courses. (T)	75	84	− 9

* Plus and minus signs indicate whether the trait is positively or negatively related to productivity.
† There were 334 observers at the most productive institutions and 328 observers at the least productive institutions.

The faculties of schools high in natural science productivity are described as follows. First, their contacts with students are characterized by informality and warmth: open displays of emotion are not likely to embarrass them; in talking with students they frequently refer to colleagues by their first names; they are not as likely to be described as practical and efficient in dealing with students; students do not feel obliged to address them as *professor* or *doctor*. Second, they emphasize high academic standards: according to student reports their standards are exacting; they see through the pretenses and bluffs of students; they push students to the limits of their capacities; and they give examinations which are genuine measures of the student's achievement and understanding. Third, they have high standards for evaluating faculty productivity and selecting new faculty members: the faculty values pure scholarship and basic research, and the course offerings and faculty in the natural sciences are outstanding. Fourth, the faculty does not play the role of Big Brother: students need not sit in assigned seats and attendance is not taken; student organizations are not closely supervised to guard against mistakes; faculty members are tolerant and understanding in dealing with violations of rules. Finally, they tend to be more nondirective in teaching methods: students find it relatively hard to predict examination questions and to take clear notes in class; instructors less frequently outline explicit goals and purposes for courses; students are not required to submit outlines before writing term papers and reports.

Motivation to seek the Ph.D. in arts, humanities, and social sciences appears to be influenced by a different set of faculty traits. There are to be sure, some items which are correlated with both measures of productivity—particularly those which relate to emphasis upon preparing for graduate study and freedom from close supervision—but the differences are more striking than the similarities (*12*). The following traits seem to characterize faculties outstandingly successful in encouraging undergraduate

students to get the Ph.D. in the arts, humanities and social sciences: (i) excellent social science faculty and resources, (ii) a high degree of energy and controversy in instruction, (iii) broad intellectual emphasis, (iv) frequent contacts with students outside the classroom, (v) a flexible, or somewhat unstructured, curriculum, (vi) emphasis upon independent study and the development of a critical attitude, (vii) excellent offerings in the arts and drama, and (viii) relatively infrequent appraisals of student performance.

Discussion

The identification of faculty behavior conducive to the development of intellectual talent is especially important since it may suggest methods for improving higher education. The results reported in this paper indicate that the teacher plays an important role in motivating talented undergraduates to seek advanced degrees. Equally important, the characteristics of undergraduate instruction which encourage the potential natural scientist seem to differ from those which stimulate the student in the arts, humanities, and social sciences. With improved techniques for assessing the overt behavior of college faculties, it should be possible to clarify the different roles the effective teacher must play.

This study needs to be supplemented in a number of respects. First, the practice of using different observers to report on different colleges may affect the results. It is possible that the college's students represent a biased sample and that systematic errors of observation are operating. If so, descriptions of faculty behaviors may be distorted by the peculiarities of student informants. Ultimately, it may be necessary to send a team of observers to each institution. An alternative would be to use faculty observers to report on teaching methods at different institutions. A comparison of the reports of faculty members with those of students should reveal whether observational biases are operating.

Second, the foregoing analysis rests upon the assumptions that student bodies have been adequately equated with respect to ability and initial motivation to enter graduate study, and that talent supplies and environments of colleges remain relatively the same over a period of years. Obviously, students at women's colleges have not been adequately equated with those at male or coeducational institutions with respect to motivation to enter graduate study; the low standing of women's colleges is therefore to be expected. Longitudinal studies which follow talented students (matched for aptitude and initial motivation) through undergraduate and graduate years would provide more rigorous tests

Table 6. Faculty behavior and Ph.D. productivity in the arts, humanities, and social sciences.

Hypothesized trait*	Items most descriptive of cluster	Percentage of observers† giving keyed response		Percentage difference
		Twelve most productive institutions	Twelve least productive institutions	
Excellence of social science faculty and resources (+)	Course offerings in the social sciences are outstanding. (T)	79	29	50
	The library is exceptionally well equipped with journals, periodicals, and books in the social sciences. (T)	96	61	35
Energy and controversy of instruction (+)	Professors often try to provoke arguments in class, the livelier the better. (T)	53	34	19
	Faculty members put a lot of energy and enthusiasm into their teaching. (T)	87	72	15
Broad intellectual emphasis (+)	Many courses stress the speculative or abstract rather than the concrete and tangible. (F)	12	44	−32
	There is a lot of emphasis on preparing for graduate work (T)	81	52	29
Frequency of student-faculty contacts outside the classroom (+)	Students almost never see the professors except in class. (F)	71	52	19
	Faculty members are impatient with students who interrupt their work. (T)	14	23	− 9
Flexibility of curriculum (+)	If a student fails a course he can usually substitute another one for it rather than take it over. (F)	30	88	−58
	Students are expected to work out the details of their own program in their own way. (F)	28	48	−20
Emphasis upon independent study (+)	Most courses require a lot of library work. (T)	65	15	50
	In class discussions, papers, and exams the main emphasis is on breadth of understanding, perspective and critical judgment. (T)	95	80	15
Excellence of college offerings in art and drama (+)	The school offers many opportunities for students to understand and criticize important works in art, music, and drama. (T)	90	43	47
Frequency of appraisals of student performance (−)	Frequent tests are given in most courses. (T)	26	64	−38

* Plus and minus signs indicate whether the trait is positively or negatively related to productivity.
† There were 334 observers at the most productive institutions and 268 observers at the least productive institutions.

of the generality of these findings. Such studies are now being initiated with finalists in the National Merit Scholarship Program.

Summary

A method for comparing the effectiveness of undergraduate colleges in stimulating their students to seek the Ph.D. is described. The procedure yields separate measures of productivity in the natural sciences and in the arts, humanities, and social sciences, adjusted to control differences in college talent supplies. The results suggest that the productivity measures have substantial validity, and argue for the importance of faculty behaviors in stimulating or inhibiting intellectual achievement.

References and Notes

1. This research was partially supported by the National Science Foundation and the Old Dominion Foundation. I am also indebted to John L. Holland and Laura Kent for their editorial assistance, and to Lindsey Harmon for making available unpublished data on doctorate production in American universities.

2. J. L. Holland, "Undergraduate origins of American scientists," *Science* 126, 433 (1957); D. B. Stuit, G. C. Helmstadter, N. Fredericksen, *Survey of College Evaluation Methods and Needs* (Educational Testing Service, Princeton, N.J., 1956), p. 192; P. A. Heist, "The diversified student population of American higher education" (paper presented at the meeting of the American Psychological Association, Washington, D.C., 1 Sept. 1958).
3. R. H. Knapp and H. B. Goodrich, *Origins of American Scientists* (Univ. of Chicago Press, Chicago, 1952). These authors report an analysis for a small sample of 50 colleges in which productivity rates are adjusted for diversities in student quality. Geographic differences and cost of attendance were the only variables which appeared to be significantly related to the adjusted indices (p. 342). However, the major analysis ignores differences in supplies of college talent.
4. R. H. Knapp and J. J. Greenbaum, *The Younger American Scholar: His Collegiate Origins* (Univ. of Chicago Press, Chicago, 1953).
5. A. E. Traxler, "An appraisal of American colleges on the basis of men graduates listed in *Who's Who in America*" (paper presented at the meeting of the AAAS, Indianapolis, 29 Dec. 1957).
6. The college's first-time, opening enrollment was used as an index of the freshman class: M. C. Johnson and A. J. Fenton, *Opening Enrollment in Higher Educational Institutions, Fall, 1956* and *Fall, 1957,* U.S. Department of Health, Education, and Welfare, Circulars 496 and 518 (Washington, D.C., 1957–58).
7. The product moment correlation between the 1956 and 1957 talent supply indices of 511 colleges is .92. Further, the correlation between mean ACE scores of entering freshmen at 19 Minnesota institutions of higher learning, over the 7-year period 1947–1954, was .80 (data from W. R. Layton, University of Minnesota, personal communication).
8. *The Baccalaureate Origins of Science Doctorates Awarded in the United States, 1936–1950,* Office of Scientific Personnel, National Academy of Sciences–National Research Council, Publ. No. 382 (Washington, D.C., 1955); *Baccalaureate Origins of Doctorates in the Arts, Humanities, and Social Sciences Awarded in the United States, 1936–1950,* Office of Scientific Personnel, National Academy of Sciences–National Research Council, Publ. No. 460 (Washington, D.C., 1956); *Doctorate Production in United States Universities, 1936–1956,* Office of Scientific Personnel, National Academy of Sciences–National Research Council, Publ. No. 585 (Washington, D.C., 1958). The classification of disciplines described in the last-mentioned publication was used in the present study to obtain separate indices, for productivity in the natural sciences and in the arts, humanities, and social sciences; thus anthropology, geography, and psychology are included within the social sciences.
9. *Earned Degrees Conferred by Higher Educational Institutions, 1947–48,* Office of Education, Circ. No. 247 (Washington, D.C., 1949); *Earned Degrees Conferred by Higher Educational Institutions, 1948–49,* Office of Education, Circ. No. 262 (Washington, D.C., 1950).
10. The regression analyses were actually performed on logarithmic transformations of the percentages, since both the rates of producing Ph.D.'s (in the natural sciences and in the arts, humanities, and social sciences) and the rates of enrolling Merit finalists were highly skewed.
11. C. R. Pace and G. C. Stern, *College Characteristics Index, Form 457* (The authors, Syracuse, N.Y., 1957).
12. This is not surprising since the correlations between the two productivity measures are only .09 for the 36 selected institutions and .35 for the entire group of 511 colleges and universities.

Deposition of Strontium-90 through October 1958

The global deposition of strontium-90 is discussed in relation to the absorption of the isotope by man.

Merril Eisenbud

This article is intended to update previous reports (*1, 2*) in which the present and future global deposition of strontium-90 were discussed in relation to the contamination of foods and deposition of this isotope in the skeleton of man.

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Methods of Measurement

The accumulation of fallout in various parts of the world continues to be documented by the methods described earlier. The oldest method is that of the network of gummed films, which was initiated in 1952 and which permits daily observations of the rate and accumulation of fallout at a great many locations in the United States and abroad. In addition, beginning in 1955, soil samples have been collected annually from a number of locations and have been analyzed radiochemically for strontium-90 (*3*). A third method is the collection of deposited or precipitated dust in pots. Such sampling was begun by the United States in early 1954, and the program now includes 41 stations in the United States and elsewhere (*4*).

Although it is the most difficult of the three methods, radiochemical analysis of soil is the best indicator of the possible human hazard in that it is a direct measure of the strontium-90 potentially available for introduction into biological processes. However, for some purposes it is desirable to know not only how much strontium-90 has accumulated in the soil at any given time but what the fallout rate is over a given period of time. The use of pots or gummed film is convenient for determining both.

A serious limitation to the use of gummed films is the fact that the amount of strontium-90 is not determined directly but is computed from a measurement of total beta activity. This computation requires access to classified