ing pendant to the polymer backbone. The pendant double bonds serve as cross-linkage sites in sulfur vulcanization but prevent unsaturation in the polymer backbone, where degrading agents cause chain cleavage and loss of desirable physical properties.

Technological evaluation of ethylene-propylene elastomers is being made to an increasing degree, and materials of this class will be produced in commercial quantities in 1963.

Summary

Elastomers are produced by the controlled cross-linking of linear, flexible chains of polymers of high molecular weight. The structures must be above the glass temperature, and they must be amorphous in the unstretched state. At moderate elongations, the elastic force is due almost entirely to a decrease in entropy. At higher elongations, partial crystallization may occur; if it does not, reinforcement with fillers of colloidal carbon black is required. The physical properties of an elastomer are modified greatly by interaction with the fillers and other components of the vulcanizate.

Synthetic elastomers have largely replaced natural rubber in the United States since World War II. Currently the major product of general usage is styrene-butadiene rubber, a copolymer manufactured by free-radical emulsion polymerization. It is vulcanized with sulfur and requires reinforcement. A number of other synthetic elastomers have been developed for improved performance at elevated temperatures and in the presence of oxygen, ozone, oils, chemicals, and so on. They represent a variety of structures, methods of synthesis, and methods of vulcanization.

The homopolymerization of isoprene in the all-*cis*- configuration has been achieved with the advent of stereospecific polymerization methods. This synthetic *cis*-1,4-polyisoprene appears to be fully equivalent to natural rubber. With the newer catalysts, *cis*-1,4-polybutadiene and the new ethylene-propylene copolymers have also been produced. It is anticipated that the commercial importance of these new synthetic elastomers will increase rapidly.

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Undergraduate Institutions and the Production of Scientists

The talented student's decision to become a scientist can be influenced by the type of college he attends.

Alexander W. Astin

The number of undergraduate students who abandon plans to pursue a career in science far exceeds the number who decide to enter science from other fields. Hence, the number of qualified individuals who are available to enter fields in which there is already a shortage of trained manpower tends to be reduced. The factors in the student's undergraduate college experience which affect his motivation to pursue a career in science therefore seem worthy of investigation (*1*).

Among the factors which may influence a student's decision to pursue a career in science at graduation are his personal characteristics at the time he enters college and the type of college he attends. But it is difficult to study the influence of the institution, since students are not distributed randomly among different types of colleges. Under these conditions, variations among institutions with respect to the career plans of their graduates may reflect differences in the kinds of student bodies initially recruited, differences in the effects of the institutions themselves, or some combination of these two factors.

The importance of using rigorous research designs in attempting to compare the effects of different types of colleges on student performance is clearly illustrated by the history of the "Ph.D. productivity" problem. In the earliest studies (*2*) it was found that undergraduate institutions differed markedly

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in the proportions of their graduates who eventually obtained Ph.D. degrees. Such differences were "explained" in terms of the college's characteristics: type of control, level of training of the faculty, geographical region, laboratory facilities, and so on. However, in subsequent studies (*3*) it was found that these differences in output of Ph.D.'s could be attributed at least partially to the characteristics of the entering students, rather than wholly to the effects of the institutions themselves. Two recent studies (*4*, *5*) have, in fact, shown that many of the institutions which were classified previously as "highly productive" turn out to be among the most "underproductive" when selected characteristics of their student inputs are controlled.

The study discussed in this article compares the effects of different types of colleges on the motivation of high-aptitude students to pursue careers as scientists. The technique used to control student input, which is described for each section, was an adaptation of the methods used in recent studies of Ph.D. productivity.

Subjects

The sample of 6254 Merit finalists and recipients of the letter of commendation from the National Merit Scholarship competition included 4235 boys and 2019 girls who entered college in the fall of 1957. Shortly after enrollment, each student completed a questionnaire on his intended course of study in college, his educational and vocational plans, his socioeconomic background, and miscellaneous related matters. Data from these questionnaires, together with scores on aptitude tests and class ranks in high school, which had been obtained 1 year earlier in connection with the Merit scholarship competition, were used as input (control) data. Twenty-one control variables were selected:

1) Career choice in 1957.
2) Major field of study in 1957.
3) Sex.
4) Highest degree sought in 1957 (three-point scale: bachelor's, master's, or doctor's).
5) Verbal aptitude (Scholarship Qualifying Test, or SQT).
6) Mathematical aptitude (SQT).
7) SQT selection score: Mathematical aptitude score plus twice the verbal aptitude score.
8) High school grades (percentile rank).
9) Degree of satisfaction with career choice (dichotomy: "very satisfied" versus all other degrees of satisfaction).
10) High school curriculum (dichotomy: academic versus all others).
11) "Drop-out" predictor, a scale developed in a previous study (*6*) to predict dropping out of college.
12) Number of semesters of mathematics taken in high school.
13) Number of scholarships applied for in 1957.
14) Number of scholarship offers received in 1957 (dichotomy: none versus one or more).
15) Distance from home to college.
16) Commuter versus resident in 1957.
17) Percentage of high school peers attending college in 1957.
18) Father's occupation (dichotomy: executive and professional versus all others).
19) Father's educational level.
20) Mother's educational level.
21) Number of books in the home.

During the late spring of 1961—approximately at the time of graduation—the students completed a second questionnaire in which they again reported their career plans. Students who indicated that they intended to do scientific research or to teach science at the college or university level were designated as pursuing a "career in science." This dichotomous criterion served as the dependent variable for the study.

College Variables

A subsample of 1548 students was selected for the analyses of the differential effects of college. Only students who attended one of the 82 colleges and universities which enrolled 15 or more students from the total sample of 6254 in the fall of 1957 were included in the subsample. To minimize the contribution of any single institution, not more than 25 students from any single college were chosen. If a college enrolled more than 25, the students for the subsample were selected at random.

Ten measures of institutional characteristics or "traits" were used to assess the college. Four were general characteristics (affluence, size, homogeneity, and masculinity), for which measures were taken from a recent factor analysis of 335 institutions (*7*), and six were "personal orientations" (realistic, intellectual, social, conventional, enterprising, and artistic), measured according to the Environmental Assessment Technique. Scores on these "personal orientations" are obtained by determining the percentage of baccalaureate degrees awarded by the institutions in each of six broad fields. Recent studies (*8*) have shown that these percentages yield valid information about the psychological climate at the institution.

The 82 institutions were also classified according to five a priori "type" characteristics: coeducational liberal arts colleges, men's colleges in the Northeast, women's colleges, public universities, and technological institutions. Each of these "type" characteristics was scored as a dichotomy.

Table 1. Trends in the distribution of career choices of high-aptitude students (N=4706) during the undergraduate years.

Career choice	Proportion of total sample 1957	1961	Percentage change
Scientist	0.220	0.182	−17.3
Engineer	.190	.091	−52.1
All other	.590	.727	+23.2

Trends in Career Choice

Data for the remaining 4706 students were used to study trends in career choices and to obtain weights for two of the input variables. Table 1 shows the distribution of students' career choices at the time they entered college in 1957 and at the time of their graduation in 1961. In absolute terms, the net change in the proportion of students intending to pursue careers as scientists is not large (a loss of about 4 percent), but in relative terms this trend represents a decline of approximately 17 percent. The decrease in potential engineers is much more pronounced, with less than half as many students planning to be engineers as seniors than as freshmen. It should be remembered that these students are among the top 4 percent of the national population in academic ability. To people interested in increasing the supply of qualified manpower in science and engineering, such trends are a source of concern.

Since it was expected that the students' initial choices of careers and major fields of study would have a considerable bearing on their final career plans, the 4706 students were separated into several groups on the basis of their choices, as freshman, of careers and major fields. Table 2 shows the proportions of students in each of these groups who were aspiring to a career in science 4 years later.

As might have been expected, students who initially planned careers as scientific researchers or as college teachers of science were the most likely to aspire to careers in science after 4 years. Yet, even among those who initially planned to be research scientists, there were marked differences, as a function of the major field initially chosen, in the proportions who later aspired to be scientists. For example, among the male students who initially planned to be research scientists, those who majored in natural sciences were about twice as likely to pursue a career in science after 4 years as those who majored in engineering.

It is clear from Table 2 that, for students who choose nonscientific careers as freshmen, the probability of aspiring to a career in science after 4 years is extremely low. In fact, among the students of our sample (both boys and girls) who, as freshmen, chose the career of artist, diplomat, journalist, lawyer, or military officer, none aspired to a career in science at the time they graduated.

Of the students whose initial choices of career and major field are in some area other than science, those who major in English or history are particularly unlikely to pursue a career in science at graduation.

Some of the general trends shown in Table 1 can be accounted for in terms of the probabilities given in Table 2. For example, about one-third of the students who abandoned engineering as a career ended up pursuing a career in science. Thus, the net loss in the proportion of students pursuing careers in science was not great, even though about half of the students who initially chose careers in science changed to other careers. The data in Table 2 also make it clear that, while many students leave science to enter other fields, "recruitment" of scientists from other fields is very unlikely to occur at the undergraduate level. For example, 92 percent of the 854 students who ended up pursuing careers in science began their undergraduate careers either with plans to become scientists or with majors in science or engineering, whereas only about 2 percent of the 1631 students who entered college planning to pursue nonscientific careers and to major in fields other than science ended up pursuing careers in science.

Table 2. Probability of aspiring to a career in science at the time of graduation from college (1961) as a function of career and major field chosen as a freshman (1957).

Career choice in 1957	Major field choice in 1957	Males		Females	
		N	Probability of aspiring to science career in 1961	*N*	Probability of aspiring to science career in 1961
Scientific researcher	Chemistry	186	.61	101	.47
Scientific researcher	Physics	315	.58	31	.61
Scientific researcher	Biology	16	.56	20	.35
Scientific researcher	Mathematics	87	.46	49	.37
Scientific researcher	Engineering	52	.29		
Scientific researcher	Other fields	68	.43	37	.17
College professor	All sciences	55	.47	19	.42
College professor	History or philosophy	35	.00		
College professor	Other fields	62	.10	69	.03
Engineer	All sciences	39	.36		
Engineer	Engineering	783	.16		
Engineer	Other fields	42	.14	30	.23
School teacher	All sciences	30	.33	77	.23
School teacher	Other fields	48	.00	289	.02
Business executive	All sciences	26	.12		
Business executive	Other fields	99	.03	18	.00
Physician or dentist	All sciences	246	.07		
Physician or dentist	Other fields	33	.03	53	.15
Clergyman	All fields	90	.03		
Artist, diplomat, journalist, lawyer, or military officer	All fields	335	.00	108	.00
Undecided	All sciences	86	.27	63	.19
Undecided	English or history	51	.02	67	.03
Undecided	Undecided	196	.08	145	.08
Undecided	Other fields	36	.06	20	.10
Other choices	All sciences	34	.33	94	.10
Other choices	English or history	21	.00	31	.00
Other choices	Other fields	73	.10	241	.03

Controlling Student Input

For all students in the subsample of 1548 students, the careers and major fields initially chosen were assigned scores equal to the probabilities in the appropriate cells of Table 2. All students whose initially chosen careers and major fields were assigned probabilities of .00 on the basis of the data in Table 2 were excluded from the analyses of differential college effects, since these students' "criterion" scores can be considered to be completely predictable from input data. Exclusion of these students reduced the subsample from 1548 to 1332.

Multiple-regression techniques were used to control the 21 student-input variables prior to the analyses of differential college effects. Multiple point-biserial correlations between the dichotomous criterion (choice of science career versus choice of nonscience career at graduation) and the 21 input variables were computed by means of a stepwise technique for the selection of predictors. The student-input variables were added to the multiple correlation until further addition of variables failed to produce a reduction in the residual sum of squares which exceeded $p = .05$. These multiple-regression analyses were performed separately for the samples of 976 boys and 356 girls.

The results of the analyses of input variables are given in Table 3. Eight input variables entered into the multiple-regression equation for boys, and five variables entered into the equation for girls. As anticipated, the career and the major field initially chosen carried the largest weights in predicting final choices of science careers for students of both sexes. Other input variables which were common to the two analyses (that for boys and that for girls) were the highest degree sought as a freshman, the educational level of one parent (for boys, the father; for girls, the mother), and academic aptitude (for boys, the SQT selection score; for girls, the mathematical aptitude score). All of these input variables carried positive weights in both analyses.

In short, the entering freshman who is most likely to pursue a career in science after college is the one who initially chooses a career or major field in science or engineering; who initially hopes to attain an advanced degree; who has higher-than-average academic aptitude; and whose

Table 3. Results of analyses in which the input variables related to the student's decision to pursue a career in science are controlled.

Variable entering	R_p*	Partial R_p* of variable entering with criterion	Probability associated with reduction in sum of squares due to variable entering
Males (N=*976*)			
Initial career choice and major field	.576	.576	<.001
Highest degree sought	.596	.192	<.001
Father's educational level	.603	.120	<.01
"Drop-out" predictor	.609	.103	<.05
SQT selection score	.612	.095	<.05
Number of books in the home	.616	−.084	<.05
Scholarship held	.619	−.083	<.05
Commuter (versus resident)	.621	−.078	<.05
Females (N=*356*)			
Initial career choice and major field	.516	.516	<.001
Mathematical aptitude	.552	.233	<.001
Highest degree sought	.566	.156	<.05
Percentage of peers attending college	.577	−.135	<.05
Mother's educational level	.589	.154	<.05

*Multiple point-biserial correlations corrected for coarse grouping.

like-sexed parent has a higher-than-average level of education.

Next, higher-order partial correlations (that is, correlations with the input variables held constant) were computed between the criterion and each of the 15 college characteristics (the ten continuous "trait" variables and the five dichotomous "type" variables). Table 4 shows the results of these analyses. Six of the college-characteristic variables appeared to have significant ($p < .05$) effects on the science-career choices of the male students, whereas only two college-characteristic variables appeared to have significant effects on the science-career choices of the female students.

The two college-characteristic variables that appear to have the most pronounced effects on the male student's choice of a science career are "type" characteristics: men's colleges in the Northeast (*9*), which seem to have a negative effect, and technological institutions (*10*), which seem to have a positive effect. A third "type" variable —coeducational liberal arts colleges (*11*)—also appeared to have a positive effect on the male student's choice of a career in science. "Trait" variables which had significant effects included the "enterprising" orientation (defined primarily by the degree of emphasis at the institution on business or law), the "artistic" orientation (defined primarily by the degree of emphasis on music, art, literature, and foreign languages), and the "homogeneity of the environment" (defined by the extent to which the institution is dominated by a single type of curriculum). When the college-characteristic variables were permitted to enter into the multiple-regression equation after the analysis of the control variables, the three "type" variables were selected; after this, no further environmental variable produced a significant reduction in the residual sum of squares.

Of the 15 college-characteristic variables, the "affluence" variable appeared to have the greatest effect on the female student's decision to pursue a career in science. This factorially derived variable, which reflects the institution's prestige and financial resources, the level of training of its faculty, and the quality of the student body, appeared to have a negative effect on the motivation of the female student to pursue a career in science. When the "affluence" variable was permitted to enter into the multiple-regression equation after the analysis of the control variables, no further college variables were selected.

Table 4. Effects of college characteristics on the student's decision to pursue a career in science.

College characteristic	Partial R_p* with criterion (after control of input variables)	p
Male students		
Northeastern men's colleges	−.134	<.001
Technological institutions	.113	<.01
"Enterprising" orientation	−.100	<.05
Homogeneity of the environment	.088	<.05
"Artistic" orientation	−.079	<.05
Coeducational liberal arts colleges	.079	<.05
Female students		
Affluence	−.181	<.01
Homogeneity of the environment	−.145	<.05

*Point-biserial correlations corrected for coarse grouping.

Discussion

Although several significant effects attributable to the characteristics of the college were identified in these analyses, the absolute magnitudes of these effects are small. Thus, the characteristics of the student of high aptitude as he enters college appear to be much more important than the characteristics of the college he attends in determining his final choice of career. It must be kept in mind, however, that our ability to predict the choice of a science career at graduation is still far from perfect; no doubt the individual student has many unique and important college experiences which we have not been able to assess. Nevertheless, with respect to gross effects, particular colleges and general college characteristics of the type considered in this study appear to contribute little to the talented student's decision to pursue a career in science.

The results of the college-effects analyses for the male students are consistent with the findings of several other studies. In particular, the findings regarding the men's colleges in the Northeast are consistent with results of three previous studies, two of them made with samples unrelated to the samples of this study. In the first of these three studies (*4*) it was found that the men's colleges in the Northeast tend to produce fewer graduates who go on to get the Ph.D. degree than would be expected on the basis of the intelligence levels, major fields of study, and sex of their entering students. Similarly, in another study (*5*), made with some of the students of the study reported here, attendance at these colleges was found to have a negative effect on the students' plans to obtain the Ph.D. The third study (*12*), of finalists from the subsequent (1958) Merit Scholarship Program, showed that students who attended men's colleges in the Northeast got lower scores on the Mathematical Aptitude Test of the Graduate Record Examination than would have been predicted from their freshman aptitude-test scores, their initial career plans, and their fields of study.

The findings of the present study regarding technological institutions and coeducational liberal arts colleges also tend to be consistent with the results of these earlier studies, with some exceptions. For example, in one earlier study (*12*), attendance at a technological institution was found to enhance the student's mathematical aptitude, but attendance at a coeducational liberal arts college failed to have this effect. Conversely, attendance at a coeducational liberal arts college tended to increase the student's motivation to obtain the Ph.D., but this was not true of attendance at a technological institution (*5*). In the study of Ph.D. "productivity" (*4*), both the technological institutions and the coeducational liberal arts colleges tended to produce more Ph.D.'s than had been expected, though these trends were not statistically significant.

At this time, interpretation of these findings is difficult and at best speculative. For example, the men's colleges of the Northeast are characterized by prestige, affluence, and a high "enterprising" orientation; this combination may result in an environment which discourages the student from pursuing the highly specialized and technical training required in most scientific fields. Some of the findings in a recent study (*13*) suggest that attendance at these colleges tends to encourage the pursuit of careers in the "enterprising" category.

The results for the female students suggest that the effects of colleges on the student's motivation to pursue a career in science are not the same for women as for men. It is difficult to say why the affluence of a college should discourage women of high aptitude from pursuing scientific careers. (Ordinarily one would expect to find that attendance at an institution with highly trained faculty, students of high aptitude, and financial resources would tend to encourage the pursuit of scientific or scholarly careers.) In any case, since this finding has no parallel in previous research, it seems desirable to determine whether it can be replicated in independent samples.

Summary

The effects of different college characteristics on the student's motivation to pursue a career in science were examined in a 4-year longitudinal study of high-aptitude students attending 82 undergraduate institutions. The male student's motivation to pursue a career in science appeared to be positively influenced by attendance at a technological institution or a coeducational liberal arts college and to be negatively influenced by attendance at one of the men's colleges in the Northeast. The female student's motivation to pursue a career in science appeared to be negatively affected by the affluence of the institution attended. The student's decision to pursue a career in science at graduation from college appeared to be much more dependent on his characteristics as an entering freshman than on the characteristics of the college he attended.

References and Notes

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9. In this category are Amherst, Dartmouth, Harvard, Princeton, Wesleyan, Williams, and Yale.
10. In this category are California, Case, Georgia, Illinois, and Massachusetts institutes of technology and Auburn, Rensselaer, and Rice.
11. In this category are Antioch, Carleton, Grinnell, Oberlin, Pomona, Reed, and Swarthmore.
12. R. C. Nichols, unpublished manuscript.
13. A. W. Astin, unpublished manuscript.

News and Comment

Science and Government: A Survey of Some of the Major Elements in Growing, Troubled Relationship

If an observer gets away from the forest floor and gains enough altitude for a broad look at what science and government are doing to each other in this country, a number of large and interesting contours stand out.

First of all, with the exception of military defense and closely associated areas, scientific research turns out to be more heavily dependent on federal money than probably any other nationwide activity. Science and government have been in partnerships of various sorts since the early days of the Republic, but, as far as the division of financing goes, the postwar years have seen the federal government become the overwhelmingly dominant partner. The shift in the relationship is perhaps best illuminated by recalling the letter Einstein wrote to Roosevelt, in 1939, to alert him to the explosive potential of the atom. The letter, written at a time when the federal government was contributing less than $75 million a year to the sciences, suggested that funds for atomic research might be obtained from "private persons who are willing to make contributions for this cause, and perhaps also by obtaining the cooperation of industrial laboratories which have the necessary equipment."

There was no suggestion that the government finance the work, for the simple reason that the federal government had not yet become the principal source of support for the sciences. Figures for the period are not complete, but it appears that research-and-development expenditures by private industrial firms were in excess of the government's spending. Today, of course, the situation is markedly changed, and even if military research and development