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The Contradictory Roles of Institutional Status in Retaining Underrepresented Minorities in Biomedical and Behavioral Science Majors

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In 2006, the U.S. Congress held numerous hearings about why the proportion of undergraduates taking studies in the hard sciences was declining. Those concerns were driven in part by interests in preserving the nation's economic competitiveness and position in technological leadership. Some legislators have called the American science pipeline "leakier than warped rubber tubing" (Epstein, 2006). Indeed, roughly half of those undergraduates who show an initial interest in majoring in the sciences switch out of these fields within their first two years of study, and very few non-science majors switch to science majors (Center for Institutional Data Exchange and Analysis, 2000). The rates of science major completion for underrepresented minority students (African American, Latino, and Native American) are even

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more dismal. Looking at degree attainment, only 24% of underrepresented students who begin college as a science major complete a bachelor's degree in science within six years of college entry, as compared to 40% of White students (Center for Institutional Data Exchange and Analysis, 2000).

Moreover, the Sullivan Commission (2004) reported that the gap in participation rates between underrepresented minority students (URMs) and their White and Asian peers widens at the graduate and professional school levels. Nelson (2004), for example, reported that between 1993 and 2002, African Americans accounted for only 2.6% of earned doctorates in biological sciences, whereas Latinos accounted for 3.6%. In 2002, only 122 African Americans and 178 Latinos received doctorates in biological sciences compared to 3,114 Whites and 580 Asians. When considering future generations of scientists and health care professionals, the Sullivan Commission declared underrepresented minorities to be "missing persons" in those fields. Retaining more URM undergraduate science majors would certainly help in reversing these trends.

The overarching purpose of our study is to examine factors that contribute to the chances of retaining underrepresented minority students in an undergraduate biomedical or behavioral science major. Of particular interest is the extent to which institutional status, as related to undergraduate selectivity, student perceptions, and other institutional characteristics, affects those chances of retention, given that this issue is relevant to current policy debates regarding access to quality higher education. Policies such as race-conscious admissions practices, for example, attempt to increase the proportion of URM students attending the most selective colleges and universities.

We employ two differing theoretical viewpoints about the impact of such policies on college students' chances of academic success to inform and frame this study. According to anticipatory socialization theory (Kamens, 1981), attending "higher status" institutions should improve one's chances of persisting. Conversely, the "mismatch hypothesis" (Sowell, 1993; Thernstrom, 1995) claims that URM students lower their odds of achieving their initial educational goals when they attend highly selective institutions where the White and Asian students are academically better prepared. By extension, applying race-conscious admissions in higher education mismatches URM students and dampens their academic or career aspirations. This study will empirically examine this running debate in the context of concerns raised about our nation's capacity to fulfill our science-related interests, especially as they relate to the growing presence of the racial/ethnic minority populations in U.S. society.

Background

According to the American Association for the Advancement of Science (2001), three of the most important variables contributing to undergraduate degree completion in the sciences are the intensity and quality of high school curriculum, test scores, and class rank or grade point average in high school. However, undergraduate students who major in science, math, and engineering (SME) majors are usually better prepared than students in other majors (Seymour, 1992). Even though students are particularly vulnerable to changing their initial educational course during the first year of college (Tinto, 1993; Upcraft & Gardner, 1989), SME majors are even more likely than their counterparts to switch majors, as noted earlier.

There is a voluminous body of research regarding undergraduate student persistence (see, for example, Astin, 1993; Braxton, 2000; Hurtado, in press; Nora, Barlow, & Crisp, 2005; Tinto, 1993). A few important points relevant to retaining URM students can be drawn from this literature. First, an individual student's educational success is more than the sum of his or her personal will, aspiration, and traditional academic indicators such as test scores and high school grades. Other factors, such as gender, race, and socioeconomic background, for example, also help shape one's opportunity for college success. Second, institutional structures and normative contexts are differentiated and can be potent socializing forces that affect life after college, such as the likelihood of pursuing graduate degrees (Bowen & Bok, 1998). Third, educational experiences in institutions are not uniform but are directly affected by a student's racial background and the structure of opportunity encountered in predominantly White institutions (PWIs) and minority-serving institutions (MSIs), which include historically Black colleges and universities (HBCUs) and Hispanic-serving institutions (HSIs).

Our focus is mainly on URM students, their science major choice, and the type of institution they attend. In a recent study, Bonous-Hammarth (2006) found that attending a selective institution is negatively associated with URM persistence as science majors. She argued that a lack of institutional diversity and a highly competitive environment work jointly to impede URM persistence, especially when there are fewer minority students present on campus. Indeed, Grandy (1998) found that URMs who received support from other minority students at their institution showed stronger levels of commitment to the science field both during and after college. Curiously, the chances of receiving support such as academic advice and mentorship from advanced students, according to Grandy, are highest at a university or research institution, which tend to be more selective and enjoy greater prestige than other types of institutions (Trent, Owens-Nicholson, Eatman, Burke, Daugherty, & Norman, 2003). It appears, then, that unlike other types of institutions, more selective ones have a unique capacity to both significantly derail and

support URM students' science major aspirations.

To better understand the potential contradictory roles of those institutions that enjoy greater status in preparing underrepresented students in the sciences, we employ two different frameworks. Each was particularly relevant for this study because each considers the dynamics between students and the normative context of an institution even though they offer seemingly opposing positions on the benefits of attending "high status" institutions for URM students.

Anticipatory Socialization Theory

Anticipatory socialization theory links the socializing and allocation function of schools, which can be extended to colleges and universities. According to Kamens (1981), educational institutions signal to students the social identities that they can occupy. Subsequently, students engage in "anticipatory socialization" to the roles for which a school is preparing them. Students' expectations of and preparation for future positions vary as a function of their school's status. Kamens argues that "higher status" institutions give their students higher levels of anticipation and socialization for higher status opportunities than "lower status" institutions. Thus, students who attend higher status institutions are more likely than their counterparts to develop the identities, attitudes, and skills that are considered appropriate for future status opportunities. Although much of the work that supports anticipatory socialization theory is based on research in the K–12 system, it can be easily adapted to higher education and the preparation of undergraduates. For instance, if becoming a research scientist or health-care professional is considered a status opportunity, then the same mechanisms of anticipatory socialization should, in theory, operate for biomedical and behavioral science majors.

It is widely accepted that the U.S. system of higher education serves a socializing function and is highly differentiated with respect to allocating future opportunities and status (Bowen & Bok, 1998; Brint & Karabel, 1989; Trent et al., 2003). For URM students in particular, several studies have documented the benefits of attending such institutions, although they do not explain the benefits as a function of anticipatory socialization. Bowen and Bok (1998), for example, found consistent positive associations between institutional selectivity and several outcomes for Black students, including degree completion, earnings, leadership, and college satisfaction. Alon and Tienda (2005) also found in their examination of three different datasets using several analytical methods that, for Black and Latino (as well as White and Asian) students, the likelihood of graduation increases as the selectivity of the institution attended rises. In his review of the literature, Kane (1998) argues that the net relationship between institutional selectivity and college retention rates is positive for all students, which may be a result of better

learning opportunities via better-prepared classmates or better instructors at more selective institutions. Beyond undergraduate retention, some studies have shown that graduating from "high quality" colleges, usually measured by the level of competitiveness for admissions, increases the probability of attending graduate school (Ethington & Smart, 1986; Smart 1986), particularly in doctoral programs and research universities (Eide, Brewer, & Ehrenberg, 1998; Lang, 1987; Zhang, 2005).

If attending a more selective or elite institution improves the likelihood of achieving one's educational goals, a major problem in addressing the intractable racial disparities that persist in the sciences is that URMs are much less likely than their White and Asian counterparts to attend "high status" institutions or those that open "status opportunities" for graduates (Trent et al., 2003). URMs who received an undergraduate degree in the sciences are more likely to have graduated from a minority-serving institution than from a "high status" one, especially for African American students. *Diverse* listed the top 15 institutions that, in 2004–2005, graduated the largest numbers of African Americans who majored in the biological and biomedical sciences ("Biological and Biomedical," 2006). Taken together, they graduated approximately 778 African American students, but only two (98 total graduates) of those top 15 institutions were not either a historically Black college or university.

Mismatch Hypothesis

Still, it would seem, based on anticipatory socialization theory and the documented benefits of attending elite institutions, that one basic solution for addressing racial disparities in the sciences would be to enroll larger numbers of URM science majors in those "high status" institutions. Some would object to this strategy because URM students who attend highly selective institutions tend, on average, to have lower graduation rates and grades than their White and Asian peers with comparable academic preparation and socioeconomic backgrounds (Cole & Barber, 2003; Klitgaard, 1985). Many factors contribute to this "underperformance" among URM students. Certainly, racial inequities in educational opportunities, which are particularly pervasive in the areas of mathematics and science at the K–12 levels, contribute to URM students being less prepared academically on average to compete as science majors than their White and Asian peers (Cole & Barber, 2003; Massey, Charles, Lundy, & Fischer, 2003). Moreover, some studies have shown that URMs are more likely than their peers to perform poorly due, in part, to reasons unrelated to academic preparation but which hint at issues of campus climate and disengagement (Seymour & Hewitt, 1997; Steele & Aronson, 1998).

In any case, the well-documented underperformance of URM students has been used to challenge race-conscious efforts to increase URM admission to

high status institutions. Cole and Barber (2003) argue that "mismatching" URM students in terms of institutions and SAT scores has a harmful effect on the students' ability to reach their intended goals. They found, in their study of students who, in their first year, expressed a desire to become college professors, a much higher likelihood among Black and Latino students of advancing toward this initial intention when they attend somewhat less selective schools. They concluded that attending a more selective institution contributed to lower grades for these URM students, which in turn discouraged them from pursuing careers in academia. They claim that, if URM students want to improve their chances of persisting with their initial intentions toward careers that recruit from those who receive higher undergraduate grades, then they should avoid institutions where the White and Asian students are academically better prepared.

The mismatch hypothesis also raises doubts that attending high status institutions necessarily improves the chances that URM science students will achieve their intended science career goals, as suggested by anticipatory socialization theory. Thus, this study examines whether institutional status affects the chances of persisting in a science major, especially as it applies to URM science students. The main research question is: "To what extent does institutional status, as measured by undergraduate selectivity, student perceptions, and other institutional characteristics, contribute to undergraduate persistence at the end of the first college year in a biomedical and behavioral science major?" The findings address both the controversy surrounding the benefits of attending elite institutions and the preparation of future URM scientists and health care providers.

METHOD

Data Source and Sample

This study draws from data collected by the Higher Education Research Institute (HERI), as part of its 2004 Cooperative Institutional Research Program (CIRP) Freshman Survey and 2005 Your First College Year (YFCY) Survey. These two waves of data collection are part of a larger longitudinal study funded by the National Institutes of Health (NIH). For the purposes of this larger study, we also targeted and surveyed students from a group of institutions that do not regularly participate in HERI surveys. These institutions (n = 104) included minority-serving institutions (MSIs), campuses with National Institutes of Health-funded retention programs, and campuses with a reputation for graduating large numbers of baccalaureates in the sciences. (See Hurtado et al., 2006, for more detail.) In total, over 26,000 students from 203 four-year institutions participated in both surveys to constitute a longitudinal assessment over the first-year of college, with an

overall survey response rate of 22.5%.

We selected from the full sample two subgroups of students who, in the 2004 CIRP freshman survey indicated plans to major in biology, chemistry, health science, or psychology. These biomedical or behavioral science majors are of special interest to NIH because they have invested heavily in improving URM success in those areas. One group included URM students, which served as our baseline sample, and the other was a sample of matched White and Asian students who were randomly selected from institutions that corresponded with those in the baseline group. When reporting descriptive data, we applied standard statistical weights that adjust the sample to better approximate the original population (Babbie, 2001; Dey, 1997). The actual weighting procedure used for this study is drawn from another study (Hurtado et al., 2006) that uses a similar sample and accounts for the probability of responding to both the 2004 and 2005 surveys. This procedure also corrected for inaccurate standard errors caused by producing a larger weighted sample size, which adjusts the sample size to better reflect the original data. The final weighted sample for this study consisted of 2,964 students (1,692 URM science majors and 1,272 White or Asian science majors) enrolled in 159 institutions.

Dependent Variable

The dependent dichotomous variable in this study measures whether those students in our sample who planned to major in a biomedical or behavioral science field remained in the major after their first college year. These were the students who indicated on the YFCY that (a) they did not change their major during their first college year, and/or (b) they intended to pursue a biological or behavioral science major. All other students were identified as having departed from their initial science major interest after their first college year.

Independent Variables

The key independent measures related to our research question involve institutional status. As the literature reviewed earlier suggests, this concept is complex and can be operationalized in different ways. Perhaps the most common approach for assessing institutional status is to measure "exclusivity" or selectivity, which for this study was calculated by the average SAT composite score (math + verbal) of the entering freshman class in 2004 for each of the institutions in the sample. To improve the interpretation of practical significance, we divided that average class score by 10. Additionally, we also included a variety of other measures, with the goal of assessing the multiple ways of defining institutional status. (See Appendix A.)

One set of variables consists of students' perceptions of the institutions they attended, including whether the institution was considered his or her

first choice as well as the level of importance that the institution's reputation played in a student's decision to attend that particular institution. These perceptions are certainly influenced by external assessments of an institution's quality (i.e., popular national rankings), but they may contribute to those valuations as well. Moreover, their effects on science persistence may function independently of externally applied "status" measures, such as selectivity. For example, although a student may be attending her first-choice college, that college may have a relatively low level of selectivity, yet the student's high regard for the college by appointing it her "first choice" institution may have a positive effect on her retention because she regards it as a highly legitimate training ground for her intended career aspirations and will subsequently be more engaged in her field of study as suggested by anticipatory socialization theory.

Another set of variables is more descriptive and characterizes key status attributes of an institution. They include institutional control (public/private) and production of science bachelors (as determined by IPEDS 2001 data on the aggregate percentage of degrees awarded in the four science fields of interest). The latter attempts to capture an institution's potential for socializing students in the sciences, as discussed in anticipatory socialization theory. Arguably, a school that produces a larger proportion of science majors imparts resources, a peer environment, or perhaps an institutional emphasis that supports the pursuit of science. Lastly, we included institutional race because minority-serving institutions are often perceived as "lower-status," yet URMs may generally hold an opposite view that can yield different effects. African American students, for example, may have a much higher regard for historically Black colleges and universities (HBCUs) because they produce a larger proportion of African American science degree earners and also play a special role in higher education. To examine potential differences in how reputation is considered and subsequently affects students, we developed separate variables for enrollment at either a HBCU or a Hispanic-serving institution (HSI) because these two institutional types were developed under different historical circumstances and can potentially hold different meanings for students with respect to institutional status.

Other variables in our analyses included students' background characteristics, precollege experiences, and first-year college experiences, perceptions, and behaviors. (See Appendix A.) Student background characteristics consisted of a student's race/ethnicity, gender, and socioeconomic status (i.e., a combination of parental education and income), while precollege experience variables include a variety of high school behavior and self-perceptions about personal competencies, goals, and college expectations. Recent studies (Hurtado et al., 2006) have demonstrated that these background characteristics and precollege experiences are important points of reference

to consider when examining how college students aspire to science-based degrees and careers. Lastly, we included items from the YFCY such as major type, participation in various academic and social activities on campus, college GPA, and views about different aspects of campus life.

It is important to note that some of the variables described above include a combination of survey items. To combine items that measure a common construct, we conducted a series of factor analyses, using principal components factoring with varimax rotation. After verifying the reliability of these factors, we developed new scales for each factor, using a regression approach. (See Appendices A and B for more details about these variables.) In addition to the final list of variables, we also considered and tested other related variables during preliminary analyses but eventually omitted them in the interest of developing more parsimonious statistical models that minimized the inclusion of confounding variables. Most notable is the omission of students' SAT scores, which for aspiring biomedical and behavioral science majors was highly correlated with students' average high school GPA, the number of years they studied mathematics and biological science during high school, and institutional selectivity. Unlike those other variables, however, students' SAT scores did not make a meaningful contribution to predicting persistence, so we omitted them from Model 1 (discussed below). Other variables, omitted for reasons associated mainly with multicollinearity, included: a student's high school volunteerism, his or her aspiration to a science research career, the percentage of URMs enrolled at the institution, his or her interactions with faculty outside of class, and other academic engagement behaviors, such as hours per week spent studying or doing homework.

Analyses

In order to maintain statistical power, we replaced missing values for all continuous variables using the Expectation Maximization (EM) algorithm. The EM algorithm represents a general method for obtaining maximum likelihood estimates when a small proportion of the data is missing (Dempster, Laird, & Rubin, 1977, cited in Allison, 2002; McLachlan & Krishnan, 1997). No single variable had more than 10% missing cases, and missing case substitutions were not conducted for variables such as gender and race. Also, students who did not answer items related to the dependent variable were omitted from the sample.

Because our dependent variable is a binary measure of a first-year student's persistence in a biomedical or behavioral science major, we employed logistic regression as our main analytical approach. In so doing, we developed five models to assess the probability of persistence, with Model 1 accounting

for students' background characteristics, Model 2 for student's perception of institutional status, Model 3 for institutional characteristics associated with status, Model 4 for institutional race and selectivity, and Model 5 for students' college experiences. We first applied this statistical approach on the aggregate "all student" sample, which let us test how a student's race contributed to his or her persistence and provided results helpful in understanding subsequent analyses. We then examined only the URM sample to identify characteristics that contributed uniquely to the students' chances of persisting in a biomedical or behavioral science major. For these analyses, we did not apply statistical weights because the number and types of variables included in the models sufficiently accounted for response bias.

RESULTS

The descriptive findings reported in Table 1 show that 82.3% of the students in our sample who intended to major in the biomedical or behavioral sciences upon entering college remained in those majors at the end of their first college year. That rate varied slightly across different race groups, with Latinos having the highest departure rate: approximately 21%. The differences were more striking according to the four majors. Psychology majors were more likely to switch majors than those in the non-behavioral sciences. Table 1 also reports slight differences in persistence rates by institutional type. Students who attended HBCUs had a higher rate (86.2%) of remaining in their initial biomedical or behavioral science major than students in other types of institutions. The differences reported here had implications for the multivariate analyses findings, as we discuss below.

Although higher retention rates are preferred in practice, the imbalance in achieving this outcome is not statistically ideal and an evenly divided distribution is more desirable. An imbalance in outcome can compromise the power of binary logistic regression. So given our situation, we evaluated all pairs of discrete variables to make sure that all cells have expected frequencies greater than 1 and that no more than 20% have frequencies less than 5, as recommended by Mertler and Vannatta (2005) to ensure that there would be an acceptable level of power before conducting further analyses.

All Students

The results for the first set of logistic regression analyses that included all students are reported in Table 2. Coefficients are exponentiated to reflect odds ratios. The model summaries reported in Table 2 show that each of the five models performed better than chance (50%) in predicting both persistence in the biomedical and behavioral science majors (in sample) and departure from those same majors (not in sample). Although the overall model fit was questionable as indicated by the large -2 Log Likelihood sta-

Table 1

Description of sample

	*Total**	*Number of Students Retained*	*% Retained*
Aggregate Sample	2,964	2,440	82.3
Race/Ethnicity			
American Indian/Alaska Native	124	107	86.3
Asian/Asian American	304	254	83.6
Black/African American	930	795	85.5
Latino	638	502	78.7
White/Caucasian	968	782	80.8
Science Major			
Biology, biochemistry, biomedical, preprofessional health	2,176	1,843	84.7
Behavioral science (psychology)	787	598	76.0
Institutional Type			
PWI	2,188	1,775	81.1
HBCU	565	487	86.2
HSI	210	178	84.8

*Note: Data is weighted. Some numbers may not add to total due to rounding.

tistic, the final model (Model 5) was statistically reliable in distinguishing between persisters and nonpersisters (χ^2–(39) = 212.148, $p < .000$), and the model prediction did not significantly differ from the observed (χ^2–(8) = 6.523, $p = .589$).

Curiously, Model 1 was slightly better at predicting persistence (62.8%) than the other models, while each successive model improves prediction of departure from major. The overall percent predicted for both persistence and departure improved from 61.4% in Model 1 when only student background characteristics were considered to 62.7% in Model 5 after all other variables were accounted for. The greatest gain in explained variance in the analyses was made in Model 5, after the inclusion of first-year college experiences. Given the strengths of Model 1 for predicting persistence and Model 5 for predicting both persistence and departure, we now focus our discussion on the results from these two models.

Although the first model included only student background characteristics, it was relatively proficient at predicting persistence in those science majors (62.8%). Of those variables included in Model 1, four entering stu-

TABLE 2A

PERSISTENCE IN BIOLOGICAL, BIOMEDICAL, OR BEHAVIOR SCIENCE MAJOR

ALL STUDENTS; N = 3,176 (unweighted)	Simple r		Model 1		Model 2		Model 3		Model 4		Model 5	
Background Characteristics												
(Male)	---		---		---		---		---		---	
Female	-0.01		1.00		0.98		0.98		0.95		0.94	
White/Caucasian	---		---		---		---		---		---	
American Indian/Alaska Native	0.02		1.41		1.41		1.37		1.39		1.50	
Asian/Asian American	0.02		1.30		1.26		1.22		1.28		1.26	
Black/African American	0.05	**	1.36	*	1.32	*	1.22		1.14		1.25	
Latino/a	-0.06	**	0.82		0.82		0.81		0.83		0.89	
Entering degree aspiration	0.12	**	1.42	***	1.39	***	1.39	***	1.41	***	1.35	***
Socioeconomic status	0.01		0.98		0.97		0.98		1.01		0.96	
Personal goal: Be Very Well Off Financially	0.03		1.02		1.01		1.00		0.98		0.99	
Personal goal: Make Theoretical Contrib to Science	0.07	**	1.06		1.06		1.06		1.05		1.03	
Personal goal: Work to Find Cure for Health Problem	0.10	**	1.16	*	1.15	*	1.14	*	1.14	*	1.08	
Average High School Grade	0.06	**	1.08		1.08		1.08	*	1.13	**	1.04	
High school research program participation	0.03		0.97		0.97		0.95		0.95		0.88	
Entering social self-concept	0.05	**	1.03		1.03		1.03		1.02		1.02	
Entering academic self-concept	0.09	**	1.10		1.10		1.09		1.10		1.06	
Yrs. study high school mathematics	0.06	**	1.20	*	1.20	*	1.21	*	1.24	*	1.19	
Yrs. study high school biological science	0.04	*	1.06		1.06		1.06		1.07		1.04	
Number of schools applied	0.01		0.99		0.98		0.98		1.00		1.00	
Perceptions of institution												
Choice of This Institution: 1st choice	-0.03				0.81		0.80	*	0.82		0.83	
Institutional reputation	0.08	**			1.07		1.06		1.11		1.10	
Institutional characteristics												
Institutional Control: Private	0.03						0.98		1.03		1.04	
Percent of bachelors awarded in science	0.06	**					2.01	*	1.48		1.56	
Institutional Race and Selectivity												
(Predominantly White Institution)	---								---		---	
Hispanic Serving Institution	0.00								1.08		1.02	
Historically Black College/University	0.07	**							1.02		0.91	
Selectivity index	-0.03								0.98	**	0.98	**
College experiences												
(Biological science major)	---										---	
Behavioral science major (psychology)	-0.11	**									0.73	*
Received tutoring	0.02										1.10	
Received negative feedback about academic work	-0.05	**									0.96	
Received advice about educational program from a professor	-0.01										0.77	*
Enrolled in learning community	0.03										1.24	
Taken a college adjustment seminar	0.02										0.97	
Participated in a health science research program	0.05	**									1.64	**
Joined a pre-professional or departmental club	0.14	**									2.28	***
Participated in an academic support program for URMs	0.01										0.90	
Sense of belonging	0.05	**									1.05	
View: Racial tension on this campus	-0.03										0.83	
View: Strong competition for high grades	0.04	*									1.12	
Current GPA	0.11	**									1.19	***
Academic success	0.07	**									1.05	
Job responsibilities interfered w/schoolwork	-0.03										0.87	

*** p < .001, ** p<.01, *p<.05

TABLE 2B

ALL-STUDENT MODEL SUMMARIES

	Model 1			Model 2			Model 3			Model 4			Model 5		
		df	Sig.		df	Sig.		df	Sig.		df	Sig.		df	Sig.
-2 log likelihood	2787.98			2783.49			2779.44			2766.91			2674.13		
Omnibus Test of Model Coefficents (Chi-square)	98.300	17	.000	102.790	19	.000	106.836	21	.000	119.367	24	.000	212.148	39	.000
Hosmer & Lemeshow Test (Chi-square)	3.317	8	.913	3.540	8	.896	3.755	8	.896	7.632	8	.470	6.52	8	.589
Cox & Snell R Square	0.030			0.032			0.033			0.037			0.064		
Percent predicted overall	61.4			61.7			61.2			61.6			62.7		
Percent predicted in sample	62.8			62.8			61.8			61.8			61.9		
Percent predicted not in sample	54.9			56.3			58.2			60.6			66.8		

dent characteristics proved to be statistically significant as shown in Table 2. One was relatively robust, retaining its statistical significance through each successive model. Conversely, the other three were no longer significant by the final model after accounting for all other variables.

The more robust variable is students' report of their degree aspiration ($p < .001$). For each unit increase on degree aspiration (from bachelor's to master's to doctorate/professional degree), students were about 40% more likely to persist in a biomedical or behavioral science major. The three other variables that were significant in Model 1 but were no longer significant by the final model were: students' level of commitment to working to find a cure for a health problem, being Black, and number of years studying mathematics in high school. Students who reported a stronger commitment to finding a cure for a health problem were also more likely to persist in a biological or behavioral science major than students with lower commitment levels; this measure remains significant ($p < .05$) through the fourth model.

All racial/ethnic groups (with the exception of Latina/os) showed an enhanced likelihood of retention in their biological/behavioral science majors compared to their White student counterparts (referent group); only identifying as a Black student was statistically significant ($p < .01$) after controlling for the full set of background characteristics. Black students were about 36% more likely than their White counterparts to persist in these science majors. This relationship, however, was no longer statistically significant in Model 3, suggesting that institutional characteristics moderate this race effect. Also worth noting is that Latinos are the only group less likely to persist in the science majors relative to White students, although this relationship is not statistically significant. With regard to precollege academic preparation, each additional year of study in math improved the chances of persistence by slightly over 20% through the fourth model in the analysis.

Moving now to the remainder of the results in Model 5, we first turn to institutional characteristics. The results reported in Table 2 shows that the average combined SAT score of a student body (selectivity) is statistically significant ($p < .01$). For every 10-point increase in the average SAT score of an entering cohort of freshmen at a given institution, the likelihood of retention decreased by two percentage points. Therefore, all things being equal, a student has a 20% higher chance of departing from a biomedical or behavioral science major if he or she attends an institution where the average undergraduate combined SAT score is 1100 versus another with an average of 1000. This effect does not appear to be moderated by first-year college experiences.

In respect to first-year experiences, Table 2 reports five additional statistically significant variables, suggesting that early experiences can make a difference in retaining students in the sciences. Most impressive here is that students who reported joining a preprofessional or departmental club

during their first-year of college were close to 130% more likely than their peers to have persisted in their respective biological or behavioral science major (log odds ratio = 2.28, $p < .001$). Likewise, students who reported participating in a health science research program during their first college year were over 60% more likely (log odds ratio = 1.64, $p < .01$) than those who do not participate in such programs to persist in their science major. The combined findings suggest possible areas for programmatic intervention during the critical first year of college to positively affect student persistence in the science majors.

Three other college experience variables also had a significant effect on persistence. Students who were behavioral science (psychology) majors are around 30% less likely (log odds ratio = 0.73, $p < .05$) than biological science majors to remain in their initial major. Similarly, every half-grade increase in students' reported grade point average, from C- to C, or C to C+/B- for example, yielded a positive likelihood (approximately 20% increase) of retention in major ($p < .001$). Curiously, we also found that receiving advice about an educational program from a professor had a negative effect on students' persistence. Students who reported that they occasionally or frequently received such advice during their first year were more than 20% less likely than their peers to persist in their initial major. Possibly students sought advice from faculty because they were having academic difficulties or doubts about pursuing their major, but the fact that it was a single-item question restricts more accurate interpretations regarding the purpose or nature of this advice.

Underrepresented Minority Students

To address whether unique factors contribute to URM student persistence in a biomedical or behavioral science major, we conducted a set of logistic regression analyses similar to those above for only the URM students in the sample (African Americans, American Indians, and Latina/os). Again, we regressed five models of variables on student persistence in a biomedical or behavioral science major at the end of their first year of college. The results for this second set of analyses are reported in Table 3; coefficients are exponentiated to reflect odds ratios.

The model summaries reported at the foot of Table 3, show that each of the five models performed better than chance (50%) in predicting both persistence in the biomedical and behavioral science majors and departure from those same majors. Once all five models were included, the percentage predicted for persistence (64.7%) and departure (65.5%) were practically equal. Although the overall model fit was questionable as indicated by the large -2 Log Likelihood statistic, the final model (Model 5) was statistically reliable in distinguishing between persisters and non-persisters (χ^2-(37) = 141.727, $p < .000$), and the model prediction did not significantly differ

TABLE 3A

PERSISTENCE IN A BIOLOGICAL, BIOMEDICAL, OR BEHAVIORAL SCIENCE MAJOR

URM STUDENTS; N= 1,775 (unweighted)	Simple r	Model 1	Model 2	Model 3	Model 4	Model 5
Background Characteristics						
(Male)	---	---	---	---	---	---
Female	-0.02	0.96	0.93	0.93	0.86	0.87
(Black/African American)	---	---	---	---	---	---
American Indian/Alaska Native	0.02	1.03	1.08	1.13	1.20	1.22
Latino/a	-0.09 **	0.64 **	0.66 **	0.70 *	0.77	0.74
Entering degree aspiration	0.09 **	1.33 **	1.30 *	1.31 *	1.32 *	1.31 *
Socioeconomic status	0.04	1.04	1.03	1.04	1.07	1.00
Personal goal: Be Very Well Off Financially	0.04	1.08	1.06	1.06	1.02	1.05
Personal goal: Make Theoretical Contrib to Science	0.08 **	1.13	1.13	1.13	1.12	1.11
Personal goal: Work to Find Cure for Health Problem	0.09 **	1.14	1.11	1.11	1.10	1.05
Average High School Grade	0.04	1.04	1.04	1.05	1.12 *	1.03
High school research program participation	0.02	0.93	0.93	0.91	0.91	0.82
Entering social self-concept	0.05 *	0.99	0.99	0.99	0.99	1.00
Entering academic self-concept	0.09 **	1.11	1.11	1.11	1.12	1.08
Yrs. study high school math ematics	0.05	1.14	1.14	1.15	1.21	1.21
Yrs. study high school biological science	0.03	1.02	1.02	1.03	1.04	1.00
Number of schools applied	-0.02	0.96	0.94 *	0.94 *	0.97	0.97
Perceptions of institution						
Choice of This Institution: 1st choice	-0.04		0.66 **	0.66 **	0.69 *	0.69 *
Institutional reputation	0.08 **		1.14	1.12	1.21 *	1.23 *
Institutional characteristics						
Institutional Control: Private	0.04			0.97	1.10	1.12
Percent of bachelors awarded in science	0.07 **			1.83	1.45	1.76
Institutional race and selectivity						
(Predominantly White Institution)	---				---	---
Hispanic serving institution	-0.02				0.74	0.67
Historically Black College/University	0.08 **				0.68	0.59
Selectivity index	-0.08 **				0.97 ***	0.97 ***
College experiences						
(Biological science major)	---					---
Behavioral science major	-0.09 **					0.78
Received tutoring	0.01					1.14
Received negative feedback about academic work	-0.04					1.07
Received advice about educational program from a professor	-0.02					0.70 *
Enrolled in learning community	0.02					1.26
Taken a college adjustment seminar	0.03					0.96
Participated in a health science research program	0.03					1.52
Joined a pre-professional or departmental club	0.14 **					2.56 ***
Participated in an academic support program for URMs	0.00					0.91
Sense of belonging	.056*					1.04
View: Racial tension on this campus	-0.03					0.96
View: Strong competition for high grades	0.00					0.98
Current GPA	0.12 **					1.23 ***
Academic success	0.09 **					1.12
Job responsibilities interfered w/schoolwork	-0.03					0.95

*** p < .001, ** p<.01, *p<.05

TABLE 3B

URM STUDENT MODEL SUMMARIES

	Model 1			Model 2			Model 3			Model 4			Model 5		
		df	Sig.		df	Sig.		df	Sig.		df	Sig.		df	Sig.
-2 log likelihood	1556.50			1547.47			1545.28			1528.34			1465.92		
Omnibus Test of Model Coefficents (Chi-square)	51.139	15	.000	60.176	17	.000	62.366	19	.000	79.300	22	.000	141.727	37	.000
Hosmer & Lemeshow Test (Chi-square)	10.893	8	.208	13.652	8	.091	8.479	8	.388	6.993	8	.537	4.615	8	.798
Cox & Snell R Square	0.028			0.033			0.034			0.043			0.076		
Percent predicted overall	61.9			62.6			62.2			63.4			64.9		
Percent predicted in sample	63.6			63.7			62.9			63.9			64.7		
Percent predicted not in sample	53.4			57.4			59.1			60.8			65.5		

from the observed (χ^2-(8) = 4.615, p = .798). The summaries also show that, for the most part, each successive model improved both types of prediction. The overall percentage predicted improved from 61.9% in Model 1 when only student background characteristics were considered to 64.9% in Model 5 after all other variables were accounted for. Given that Model 5 was the strongest of the five models, we will focus our discussion on the results from this final model.

The coefficients shown in the last column of Table 3 report the results for Model 5. Starting with URM students' background characteristics, their degree aspiration is significantly related to persistence in one of the four majors ($p < .05$). URM students who aspire to graduate work and degrees increased their chances of staying in the major by over 30% (log odds ratio = 1.31, $p < .05$). Also worth noting is the negative relationship between persistence and being Latino. Although the significance between these two variables diminished after controlling for institutional selectivity in Model 4, it reinforced earlier findings with the full sample. Compared to their Black/African American peers (referent group), Latino students were less likely to persist in these majors, perhaps in part because Latino students in the sample were more likely to attend PWIs (85.5%) than their Black/African American (41%) peers.

URM students' perception of their institution also had a significant effect on their chances of persisting. Students who attend what they considered to be their first-choice school were less likely to persist in a biomedical or behavioral science major. Conversely, students who viewed their school as having a good reputation (in terms of academics, rankings in national magazines, and ability to send graduates to top graduate and professional schools) were more likely to persist in the sciences through the first year of college. While these student perceptions both seemingly refer to positive attributes of an institution, they also appear to have contradictory effects—one dampening and the other facilitating persistence. These contradictory effects become statistically stronger once other institutional characteristics are added in following models, suggesting that their effects are moderated by other institutional characteristics.

Before discussing the contributions that other institutional characteristics make to persistence, which will require closer examination, we first turn to college experiences. Here, the findings are similar to those for the full sample. Again, joining a preprofessional or departmental club during the first year of college had an impressive impact on persistence (log odds ratio = 2.56, $p < .001$). Participation in one of these clubs improved URM students' likelihood of persisting by more than 150 percent. Additionally, a URM student's likelihood of persisting in the major increased by just over 20% with each incremental change in his or her current college GPA. Lastly, receiving "occasional" or "frequent" advice about an educational program

from a professor decreased a URM student's chances of staying in the major by 30% as compared to their peers who "rarely" or "never" sought such guidance.

We now turn to the findings about institutional characteristics. Although only one variable has a statistically significant effect on persistence, the results appear to be more complicated than just this single finding. Similar to the results for the full sample, the influence of the average combined SAT score of a student body (selectivity) was statistically significant ($p < .01$). For every 10-point increase in average SAT score in an entering cohort of freshmen for a given institution, the likelihood of retention decreased by three percentage points. Therefore, all things being equal, a URM student has a 30% higher chance of departing from a biomedical or behavioral science major if he or she attends an institution where the average undergraduate combined SAT score is 1100 versus one with an average of 1000. This effect does not appear to be moderated by first-year college experiences.

Although no other institutional characteristic contributed significantly to predicting URM persistence, we were particularly interested, given our research focus, in the negative relationship between minority-serving institutions (MSIs) and the dependent measure. The results reported in Table 3 under Model 5 show that both HSIs and HBCUs have a negative but statistically insignificant effect on retention. Recent reports ("Biological and Biomedical," 2006), in contrast, show that MSIs, particularly HBCUs, produce a disproportionally larger number of minority science graduates. Indeed, the simple correlation between persistence and matriculating at an HBCU is positive and statistically significant ($r = .08$, $p < .01$) for our sample, while there was no statistically meaningful relationship between persistence and attending an HSI.

Given that MSIs tend to be less selective than predominantly White institutions, we plotted that relationship by URM persistence rate. Figure 1 shows the plot of URM retention in the major by selectivity for PWIs, HSIs, and HBCUs. The figure shows that, as the level of selectivity increases for both PWIs and HSIs, the rate of persistence for URM students decreases at those institutions. In contrast, as the level of selectivity increases for HBCUs, the rate of persistence increases as well. Compared to PWIs and HSIs, it appears that higher average student body SAT scores have a very different effect on major persistence at HBCUs. Rather than increasing the risk of departure in the biomedical and behavioral sciences, attending an HBCU where students have higher average test scores may improve URM students' chances of persisting in those majors.

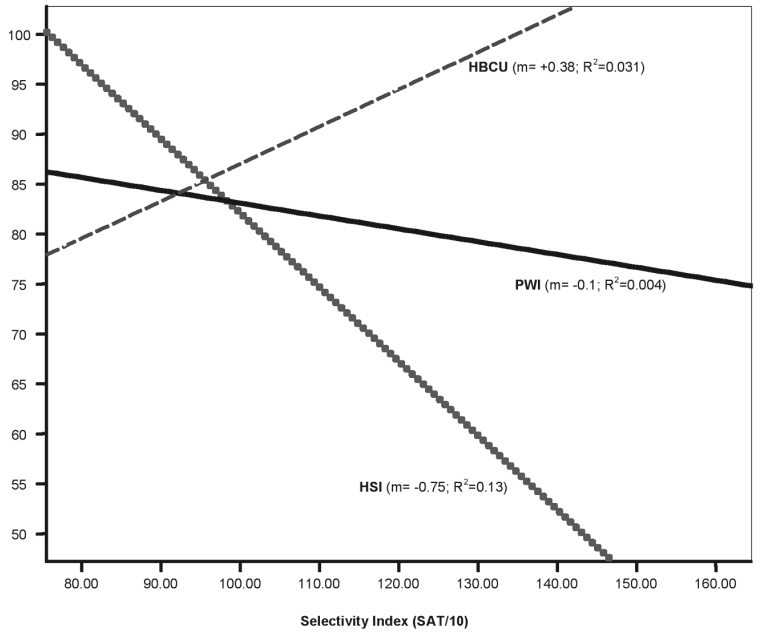

Figure 1. URM Retention Rate by Selectivity Index

LIMITATIONS AND FUTURE DIRECTIONS

A few limitations with this study should be acknowledged. First, our URM sample size was sufficient but limited our study in at least two ways. We could not conduct multi-level analyses that enable us to parse out institutional- and student-level effects on URM persistence. Additionally, we could not disaggregate our URM sample further by race/ethnicity, thereby limiting our understanding and comparisons among the unique experiences of African American, Latino, and American Indian students. For example, the higher rates of departure for Latino/a students could not be examined further, but this finding deserves more attention.

Second, our dependent variable has several limitations. It does not indicate exactly when during the first year a student departed from a biomedical or behavioral science major. Greater precision here could perhaps provide better information on the most critical period for institutional intervention. Beyond the first year, some reports (Center for Institutional Data Exchange and Analysis, 2000) show that approximately another 20% of students in those majors will likely depart by the end of the second year of studies. This study therefore captures only one important part of a longer educational process. Following up with these students is a necessary next step.

Lastly, we did not capture all possible notions or forms of institutional status. If data were available, it would be interesting to examine how the percentage of both faculty of color in the sciences and science graduates who go on to graduate school, as well as how financial support geared specifically for science students affect persistence in those majors. Inclusion of these and other variables might help clarify and further inform understanding about institutional status. It may also help to strengthen our statistical model. Although our models were adequate, the results also suggest that we did not account for all relevant factors.

Discussion

That the American science pipeline is "leakier than warped rubber tubing" has become serious enough to receive considerable attention from U.S. policymakers who have raised concerns about the future of our nation's economic competitiveness and position in technological leadership (Epstein, 2006). This study examined factors that contribute to the chances of persisting in a biomedical or behavioral science major through the first year of college. Of particular interest is the extent to which institutional status affects those chances for underrepresented minority students (URMs). On the one hand, anticipatory socialization theory (Kamens, 1981) claims that attending "higher status" institutions improves one's chances of persisting because those institutions possess unique resources and socializing forces. On the other hand, the "mismatch hypothesis" (Sowell, 1993; Thernstrom, 1995) maintains that URM students increase their risk of abandoning their initial educational goals when they attend more selective institutions in which White and Asian students are academically better prepared.

Given the incongruous frameworks that inform this study, we took a broad view of institutional status and measured it in multiple ways. Overall, logistic regression results for all students and for URMs were comparable, but there were both overlaps and differences in how the set of six institutional status variables affected each group's chances of persisting in a biomedical or behavioral science major. For both groups, a higher level of institutional selectivity resulted in a significant negative effect on persistence in a biomedical or behavioral science major. For the all-student sample, the likelihood of persisting in a science major decreased by 2% for every 10-point increase in the level of institutional selectivity. For the URM sample, the likelihood of persisting decreased by 3% for every 10-point increase in institutional selectivity. Thus, students who attend more selective institutions are at greater risk of not persisting in their science major. This effect appears to be somewhat stronger for URM students.

When comparing the findings between the full and URM samples, there are notable differences in how other status variables affected students'

chances of persisting in a biomedical or behavioral science major after one year. Although none of these status measures had a significant effect on the all-student sample, two of them made a difference in URM students' chances of persisting. First, URM students who attended their first-choice campus were less likely to persist. This finding seems to reaffirm the effect of institutional selectivity, namely that "first-choice" campuses are perhaps likely to be more exclusive or selective than second- or third- choice campuses. Consequently, a heightened sense of competition at first-choice institutions may trump the benefits that their status and prestige would otherwise offer URM students in terms of resources and opportunities.

Second, URM students who viewed their institution as having a good reputation with respect to academics, rankings in national magazines, and ability to send graduates to top graduate and professional schools, were more likely to persist in the sciences through the first year of college. Unlike the other status measures, this one is perhaps more closely linked with future career and graduate school placement, which may point to a longer-term perspective for a chosen field of study. Here, acceptance at what URM students perceive as a "high status" institution may be an important source of influence on their ambitions and self-concepts, perhaps triggering anticipatory socialization effects. According to Kamens (1981), attending a high status institution can serve as an important signal about the viability of career options, which in this case may improve URM students' positive self-concepts and aspirations relevant to a career in the sciences or health professions.

Unlike the results for all students, URM students' perceptions about an institution yielded significant effects independent of the level of institutional selectivity. Although these perceptual variables are correlated with selectivity, they do not appear to be as tightly bound with selectivity for URM students as they are for the full sample of students. Upon closer inspection, we found that the relationship (simple correlation) between perceptions of institutional reputation and selectivity were weaker for the URM sample than for the all-student sample. This finding suggests that, when it comes to institutional status, the linkage between academic reputation and institutional selectivity is weaker for URM students than for their White and Asian American peers. If institutional status also influences college choice, then this weaker relationship among status variables might also suggest that URM students are influenced by a more complex set of status factors than their peers when choosing a college. Indeed, URM students' choice of college tends to be more multifaceted, where considerations of family finances (as well as current and future financial stability) can complicate considerations of institutional status and selectivity in the decision-making process (Fries-Britt & Turner, 2002; Hurtado, Inkelas, & Rhee, 1997; St. John, Paulsen, & Carter, 2005).

The complex confluence among those factors is also evident at the institutional level. When we plotted URM science retention by institutional selectivity for PWIs, HSIs, and HBCUs, we found that, as the level of selectivity increased for HBCUs, the rate of persistence for URM students also increased at those institutions. In contrast, the rate of persistence decreased as the level of selectivity increased for both PWIs and HSIs. Given the unique mission of HBCUs to identify and nurture overlooked academic talent, it is not surprising that having a larger proportion of high-achieving students who are working toward a common goal operates differently at those institutions and tend to decrease rather than increase the risk of departure in the biomedical and behavioral sciences. In contrast, the HSI designation developed under different historical circumstances, and these campuses often have larger White and Asian populations than HBCUs and may be more similar to PWIs.

As expected, students' chances of persisting in the sciences are not determined solely by institutional status, and we identified several background characteristics and college experiences that also made a significant difference. The most notable among them for educational practice was joining a preprofessional or departmental club during the first year of college. Although participation in student organizations of any form enhances the level of involvement and engagement with the campus environment, which in turn enhances the process of adjustment and transition for students (Astin, 1993; Tinto, 1993), professional or departmental participation appears especially relevant for biomedical and behavioral science majors. In the findings for the full sample, students who joined such clubs improved their chances of persisting by 130 percent. For URM students, participation in one of these clubs improved the likelihood of persisting by over 150 percent. Joining these clubs may signal a stronger commitment or identification with a student's field of study or future careers. At best, these student groups may be important resources that serve to socialize and prepare students for future opportunities in the sciences by developing a firmer science identity. Such groups may also provide them with an opportunity to engage a peer group that shares similar academic and career interests, which in turn can help to reinforce their science identity. According to anticipatory socialization theory, mechanisms that socialize students for their anticipated roles, improve students' chances of reaching their academic goals (Kamens, 1981).

Lastly, with respect to the description of the American science pipeline as "warped rubber tubing," we found that first-year success in the sciences is largely a function of pre-college student characteristics, which predict over 60% of the chance of being retained. Although the focus of the science crisis has been mostly limited to discussions about poor academic preparation, we also found evidence that shaping students' aspirations and interests in substantive issues before they enter college is equally important. For example,

students who entered college anticipating that they would continue on to graduate school increased their chances of persisting in their science major. Also, students who reported a stronger commitment to finding a cure for health problems reduced their risk of departure, although this effect was weaker than students' degree aspirations at college entry. In short, the effects of students' precollege characteristics and predispositions suggest that better early science preparation includes not only learning science content but also developing higher degree aspirations and understanding the practical value of science for improving society.

Conclusion

Our findings show that institutional status matters but not in ways that can be explained solely by either the anticipatory socialization theory or the mismatch hypothesis. There does seem to be a mismatch occurring in science education at the college level. The problem, however, is not only an issue of poorly prepared URM students failing among high achievers, as suggested by the mismatch hypothesis. The problem is that all students, irrespective of their race, academic preparation, or motivation, are at greater risk of failing among high achievers at highly selective institutions where the undergraduate student body is mostly White and Asian. In other words, even highly capable and talented White and Asian students—who would otherwise continue in a biomedical or behavioral science major at less selective institutions—are leaving the sciences at higher rates at more selective institutions.

Ironically, the more selective colleges and universities tend to be viewed by students as possessing more "status qualities," which, according to anticipatory socialization theory, should facilitate degree completion. However, contrary to expectations of that theoretical orientation, our findings indicate that the more selective institutions may not be making the most of those qualities to socialize and advance students toward their anticipated educational goals. The underlying cause of this problem is not just an attribute of having high-achieving students. After all, selective HBCUs manage to balance the enrollment of high-achieving students with high rates of science completion. Instead, we suspect that the underlying issues have more to do with how highly selective institutions that enroll high achieving students tend to function.

That is, highly competitive environments tend to further sort out students in order to identify the very best ones, often providing limited resources to compensate for students' prior preparation. Therefore, by design, only a few can succeed with the assumption that admitted students received comparable educational preparation and are on equal footing to compete. Even when students are well matched and highly qualified, only some will

actually "make the cut" when institutions subscribe to a competitive educational model. In contrast, more selective HBCUs appear to approach the process differently and seem to focus less on further "weeding out" students. Once a rich talent pool has been identified, they seem to do a better job of socializing and cultivating that talent to improve students' chances of succeeding in the sciences.

Perhaps also related to differences in how institutions tend to advance the educational process is what Claude Steele (1997) call "stereotype-vulnerability or threat." He and his colleaques have consistently shown through a number of laboratory experiments that, under certain conditions, negative racial stereotypes can undermine the academic performance of highly talented Black students. According to his theory, Black students' reduced academic performance, for example, can be explained in part by anxiety associated with the fear that others' judgments or their own actions will confirm negative stereotypes about their group's intellectual capacity. With respect to explaining the differential effect of selectivity, it may be that African American students who attend more selective predominantly White and Asian institutions are at greater risk of stereotype threat than their counterparts who attend selective HBCUs. Given this possibility, examining differences in the risk of stereotype threat across different institutional types is an important line of research for explaining racial differences in academic achievement.

Although two measures of institutional status had negative effects on science persistence, we also found that one of them— students' perception of reputation—yielded a positive effect on URM students' chances of persisting, independent of the other status measures. This finding lends some support to the anticipatory socialization theory, namely that URM students' chances of persisting in the sciences are significantly improved at an institution that the student regards as having a good reputation in academics, rankings, and sending graduates to top graduate and professional schools. Those features of an institution may, as suggested by anticipatory socialization theory, improve the socialization and commitment of URM students toward their anticipated goals. It also appears that, when the concept of institutional status is decoupled from selectivity or exclusivity, some forms of status may actually improve the chances of persisting in a biomedical or behavioral science major.

From a policy and practice standpoint, our findings suggest that there are important countervailing forces to consider in a stratified higher education system. Although the nation's top research universities and most selective colleges have the resources, reputation, and normative advantages that position them well to train future scientists, most of them also appear to foster an educational context and process that can potentially increase students' risk of abandoning studies in the sciences. Such a context might include a highly

competitive peer environment where only a few are expected to succeed, a faculty who are more focused on research than teaching, and a limited number of role models, especially faculty of color. In any case, the context clearly matters; and in addressing the so-called science crisis, it is also important to rethink what constitutes an effective learning environment. One place that can both provide insight for improving context and also enrich the talent pool are those institutions that do a relatively better job retaining students in science majors but which tend to also be less exclusive or prestigious. Unfortunately, those same institutions are more likely to be perceived by the broader academic community as being less legitimate or reputable, which disadvantages their students who apply for graduate studies in the sciences and diminishes their potential role in developing future scientists.

If the broader policy objective is to prevent leakages in the science pipeline, then it seems that our research universities should take a much harder look at why those students who should otherwise complete a science major are not doing so on their campuses. Additionally, they can benefit greatly both from examining the practices of exemplary institutions that succeed in graduating science majors and from reconsidering a rigid stratified view of institutions that penalizes those graduate school applicants who received their degrees from institutions that are not widely held in high regard even though they provide exemplary undergraduate education.

References

Allison, P. D. (2002). *Missing data.* Thousand Oaks, CA: Sage Publications.

Alon, S., & Tienda, M. (2005, October). Assessing the "mismatch" hypothesis: Differences in college graduation rates by institutional selectivity. *Sociology of Education, 78*, 294–315.

American Association for the Advancement of Science (2001). *In pursuit of a diverse science, technology, engineering, and mathematics workforce: Recommended research priorities to enhance participation by underrepresented minorities.* Retrieved on October 2005 from http://ehrweb.aaas.org/mge/Reports/Report1/AGEP/AGEP_report.pdf.

Astin, A. W. (1993). *What matters in college: Four critical years revisited.* San Francisco: Jossey-Bass.

Babbie, E. (2001). *The practice of social research.* Belmont, CA: Wadsworth.

Biological and biomedical sciences: African-American baccalaureate. (2006). *Diverse, 23*(8), 54.

Bonous-Hammarth, M. (2006) Promoting student participation in science, technology, engineering and mathematics careers. In W. R. Allen, M. Bonous-Hammarth, & R. T. Teranishi, (Eds.), *Higher education in a global society: Achieving diversity, equity, and excellence* (pp. 269–282). Oxford: Elsevier.

Bowen, W. G., & Bok, D. (1998). *The shape of the river: Long-term consequences of considering race in college and university admissions.* Princeton, NJ: Princeton University Press.

Braxton, J. M. (2000). *Reworking the student departure puzzle.* Nashville, TN: Vanderbilt University Press.

Brint, S., & Karabel, J. (1989). *The diverted dream: Community colleges and the promise of educational opportunity in America, 1900–1985.* New York: Oxford University Press.

Center for Institutional Data Exchange and Analysis. (2000). *1999–2000 SMET retention report.* Norman: University of Oklahoma.

Cole, S., & Barber, E. (2003). *Increasing faculty diversity: The occupational choices of high-achieving minority students.* Cambridge, MA: Harvard University Press.

Mertler, C. A., & Vannatta, R. A. (2005). *Advanced and multivariate statistical methods* (3rd ed.). Glendale, CA: Pyrczak Publishing.

Dempster, A. P., Laird, N. M., & Rubin, D. B. (1977). Maximum likelihood from incomplete data via the EM algorithm. *Journal of the Royal Statistical Society 39*(1), 1–38.

Dey, E. L. (1997). Working with low survey response rates: The efficacy of weighting adjustments. *Research in Higher Education 38*(2), 215–227.

Eide, E., Brewer, D. J., & Ehrenberg, R. G. (1998). Does it pay to attend an elite private college? Evidence on the effects of undergraduate college quality on graduate school attendance. *Economics of Education Review, 17*(4), 371–376.

Epstein, D. (2006, July 26). So that's why they're leaving. *Inside Higher Education.* Retrieved July 2006 from http://www.insidehighered.com/news/2006/07/26/scipipeline.

Ethington, C., & Smart, J. (1986). Persistence to graduate education. *Research in Higher Education, 24*, 287–303.

Fries-Britt, S. F., & Turner, B. (2002). Uneven stories: Successful Black collegians at a Black and a White campus. *The Review of Higher Education, 25*(3), 315–330.

Grandy, J. (1998). Persistence in science of high-ability minority students. *The Journal of Higher Education, 69*(6), 589–620.

Hurtado, S. (in press). The sociology of the study of college impact. In P. Gumport (Ed.), *Sociology of higher education.*

Hurtado, S., Inkelas, K. K., & Rhee, B. S. (1997). Differences in college access and choice among racial/ethnic groups: Identifying continuing barriers. *Research in Higher Education, 38*(1), 43–75.

Hurtado, S., Cerna, O. S., Chang, J. C., Sàenz, V. B., Lopez, L. R., Mosqueda, C., Oseguera, L., Chang, M. J., & Korn, W. S. (2006). *Aspiring scientists: Characteristics of college freshmen interested in the biomedical and behavioral sciences.* Los Angeles: Higher Education Research Institute.

Hurtado, S., Han, J. C., Sáenz, V. B., Espinosa, L. L., Cabrera, N. L., & Cerna, O. S. (in press). Predicting transition and adjustment to college: Biomedical and behavioral science aspirants' and minority students' first year of college. *Research in Higher Education.*

Kamens, D. H. (1981). Organizational and institutional socialization in education. *Research in Sociology of Educational and Socialization, 2*, 111–126.

Kane, T. J. (1998). Misconceptions in the debate over affirmative action in college admissions. In G. Orfield & E. Miller (Eds.), *Chilling admissions: The affirma-*

tive action crisis and the search for alternatives (pp. 17–31). Cambridge, MA: Harvard Education Publishing Group.

Klitgaard, R. (1985). *Choosing elites.* New York: Basic Books.

Lang, D. (1987). Stratification and prestige hierarchies in graduate and professional education. *Sociological Inquiry, 57*, 12–31.

Massey, D. S., Charles, C. Z., Lundy, G. F., & Fischer, M. J. (2003). *The source of the river: The social origins of freshmen at America's selective colleges and universities.* Princeton, NJ: Princeton University Press.

McLachlan, G. J., & Krishnan, T. (1997). *The EM algorithm and extensions.* New York: Wiley.

Nelson, D. J. (2004) *Nelson diversity surveys.* Norman, OK: Diversity in Science Association. Retrieved in March 2006 from http://cheminfo.chem.ou.edu/~djn/diversity/top50.html.

Nora, A., Barlow, L., & Crisp, G. (2005). Student persistence and degree attainment beyond the first year in college. In A. Seidman (Ed.). *College student retention: Formula for success* (pp. 129–153). Westport, CT: Praeger Publications.

Seymour, E. (1992, February). The problem iceberg in science, mathematics, and engineering education: Student explanations for high attrition rates. *Journal of College Science Teaching, 21,* 230–238.

Seymour, E., & Hewitt, N. M. (1997). *Talking about leaving: Why undergraduates leave the sciences.* Boulder, CO: Westview Press.

Smart, J. (1986). College effects on occupational status attainment. *Research in Higher Education, 24*, 73–95.

Sowell, T. (1993). *Inside American education: The decline, the deception, the dogmas.* New York: Free Press.

Steele, C. M. (1997). A threat in the air: How stereotypes shape intellectual identity and performance. *American Psychologist*, *52*, 613–629.

St. John, E., Paulsen, M. B., & Carter, D. F. (2005). Diversity, college costs, and postsecondary opportunity: An examination of the financial nexus between college choice and persistence for African Americans and Whites. *The Journal of Higher Education, 76*(5), 545–569.

Sullivan Commission (2004). *Missing persons: Minorities in the health professions.* Retrieved on March 2006 from http://www.sullivancommission.org/.

Tinto, V. (1993). *Leaving college: Rethinking the causes and cures of student attrition* (2nd ed.). Chicago: University of Chicago Press.

Thernstrom, S. (1995, Winter). The Black-White student mismatch problem in university admissions. *The Journal of Blacks in Higher Education, 6*, 62–65.

Trent, W., Owens-Nicholson, D., Eatman, T. K., Burke, M., Daugherty, J., & Norman, K. (2003). Justice, equality of educational opportunity, and affirmative action in higher education. In M. J. Chang, D. Witt, J. Jones, & K. Hakuta (Eds.), *Compelling interests: Examining the evidence on racial dynamics in colleges and universities* (pp. 22–48). Stanford, CA: Stanford University Press.

Upcraft, M. L., & Gardner, J. N. (1989). *The freshman year experience: Helping students survive and succeed in college.* San Francisco: Jossey-Bass.

Zhang, L. (2005). Advance to graduate education: The effect of college quality and undergraduate majors. *The Review of Higher Education, 28*(3), 313–338.

APPENDIX A: DESCRIPTION OF VARIABLES AND FACTORS

Variables	*Scale*
Dependent Variable	
Retention in biological, biomedical or behavioral science major:	
Indicate probable field of study (CIRP): biology (general), biochemistry or biophysics, microbiology or bacteriology, zoology, medicine, dentistry, veterinary medicine, pharmacy, psychology	1=marked, 0=not marked
Since entering this college have you (YFCY):	1=marked, 0=not marked
Decided to pursue a different major	
Intended to major in a health, biomedical, or behavioral science	
Independent Variables	
Background characteristics and pre-college experiences	
Gender: Female	1=no, 2=yes
Ethnic Background: White/Caucasian, American Indian/Alaska Native, Asian/Asian American, Black/African American, Latino	1=no, 2=yes
What is the highest academic degree you intend to obtain?	1=bachelor's degree or less, 2=master's, 3=doctorate/ professional degree
Socioeconomic status	A composite measure of three variables that assess family income, father's education, and mother's education.
Indicate the importance to you personally of the following:	
Being very well off financially	1=not important, 4=essential
Making a theoretical contribution to science	
Working to find a cure to a health problem	
High school grade point average	1=D; 8=A or A+
Have you participated in a summer research or health science research program?	1=no, 2=yes
Entering social self-concept	A composite measure of three variables that assess students' self-rated leadership ability, social self-confidence and intellectual self-confidence. The three variables are measured separately on a five-point scale: 1=lowest 10% to 5=highest 10%.

Entering academic self-concept	A composite measure of four variables that assess students' self-rated academic ability, mathematics ability, intellectual self-confidence and writing ability. The four variables are measured separately on a five-point scale: 1=lowest 10% to 5=highest 10%.
Years of math in high school	1=none; 7=five or more
Years of science in high school	1=none; 7=five or more
To how many college other than this one did you apply for admission?	1=none, 9=11 or more
Perception of institution	
Is this college your first choice?	1=no, 2=yes
Institutional reputation	A composite measure of three variables that assess the importance of an institution's academic reputation, ability to send graduates to top graduate / professional schools, national rankings in magazines. The three variables are measured separately on a three-point scale: 1=not important, 3=very important
Institutional characteristics	
Institutional control	1=public, 2=private
Percent bachelor's awarded in science	Range 0 to 1.00
Institutional race and selectivity	
Hispanic-serving institution	1=no, 2=yes
Historically Black college or university	1=no, 2=yes
Selectivity Index: Average combined SAT score of entering 2004 cohort divided by 10	Range 40 to 160
College experiences	
Behavioral science major	1=no, 2=yes
Since entering college, indicate how often you:	
Received tutoring	1=not at all to rarely
Received negative feedback about your academic work	2=occasionally or frequently
Received advice and guidance about your educational program from a professor	
Since entering this college have you:	

Appendix A, cont.

Variables	*Scale*
Enrolled in a formal program where a group of students takes 2 or more courses together (e.g., learning community)	1=not marked, 2=marked
Taken a college course/seminar specifically designed to help first-year students adjust to college	
Participated in a health science research program sponsored by this college	
Joined a pre-professional or departmental club	
Participated in an academic enrichment/support program for racial/ethnic minority students	
Sense of belonging	A composite measure of three variables that assess students' agreement with the statements: I see myself as a part of the campus community, I feel that I am a member of this college, and I feel I have a sense of belonging to this college. The three variables are measured separately on a four-point scale: 1=strongly disagree to 4=strongly agree.
Indicate the extent to which you agree or disagree with the following statements:	
There is a lot of racial tension on this campus	1=disagree, 2=agree
There is strong competition among most of the students for high grades	
Current grade average	1=no grades, 7=A
Success at managing the academic environment	A composite measure of five variables that assess students' success at understanding what your professors expect of you academically, developing effective study skills, adjusting to the academic demands of college, managing your time effectively and getting to know faculty. The five variables are measured separately on a three-point scale: 1=unsuccessful to 3=completely successful
Since entering this college, how often have you felt:	
That your job responsibilities interfered with your schoolwork	1=not at all to rarely, 2=occasionally or frequently

Components & Alpha Reliability†	*Factor Loadings*
Socioeconomic status (α =0.71)	
Parental income	0.57
Father's education	0.75
Mother's education	0.70
Academic self-concept (α=0.60)	
Academic ability	0.70
Mathematics ability	0.40
Self-rated intellectual self-confidence	0.50
Self-rated writing ability	0.32
Social self-concept (α=0.72)	
Leadership ability	0.69
Self-rated social self-confidence	0.59
Self-rated intellectual self-confidence	0.66
Institutional Reputation (α=0.66)	
How important was each reason in your decision to come here?	617
This college has a very good academic reputation	.660
This college's graduates gain admission to top graduate/professional schools	.532
Rankings in national magazines	
Sense of belonging (α=0.84)	
Level of agreement with the following statements:	
I see myself as part of the campus community.	693
I feel I am a member of this college	.795
I feel I have a sense of belonging to this college	.784

Appendix A, cont.

Components & Alpha Reliability†	*Factor Loadings*
Success at managing academic environment (α=0.78)	
Since entering this college, how successful have you felt at:	
Understanding what your professors expect of you academically	.673
Developing effective study skills	.815
Adjusting to the academic demands of college	.814
Managing your time effectively	.771
Getting to know faculty	.558

†Factors were equally reliable for disaggregated samples by race.

APPENDIX B: DESCRIPTIVE STATISTICS OF VARIABLES

Variable	*Mean*	*St. Dev.*
Retention in major	0.83	0.37
Gender: Female	1.77	0.42
American Indian/Alaska Native	1.04	0.20
Asian/Asian American	1.11	0.31
Black/African American	1.31	0.46
Latino	1.21	0.41
Degree aspirations	2.69	0.59
Socioeconomic status factor	0.00	1.00
Personal goal: Be very well off financially	3.17	0.83
Personal goal: Make theoretical contribution to science	2.26	0.94
Personal goal: Work to find a cure for health problem	2.70	1.00
Average high school grade	6.72	1.31
High school research program participation	1.15	0.36
Entering social self-concept factor	0.00	1.00
Entering academic self-concept factor	0.00	1.00
Years study high school math	5.93	0.55
Years study high school biology	3.79	1.03
Number of schools applied	4.67	2.39
Choice of this institution: 1st choice	1.65	0.48
Institutional reputation factor	0.00	1.00
Institutional control: Private	1.54	0.50
Percent of bachelor's awarded in science	0.26	0.17
Hispanic serving institution	1.06	0.24
Historically Black college/university	1.20	0.40
Selectivity index	111.94	12.72
Behavioral science major	1.24	0.42
Received tutoring	1.35	0.48
Received negative feedback about academic work	1.24	0.43
Received advice about educational program from a professor	1.40	0.49
Enrolled in learning community	1.09	0.29
Took a college adjustment seminar	1.50	0.50
Participated in a health science research program	1.12	0.32
Joined a pre-professional/departmental club	1.24	0.43
Participated in an academic support program for URMs	1.16	0.37
Sense of belonging factor	0.00	1.00
View: Racial tension on this campus	1.12	0.32
View: Strong competition for high grades	1.64	0.48
Current GPA	5.13	1.32
Academic success factor	0.00	1.00
Job responsibilities interfered with school	1.24	0.43