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What Does It Take to Be Successful?

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Physicists were asked the question, "What do you think are the most important qualities needed to be successful at the type of work you do?" The results demonstrate which qualities physicists value and how values vary among the qualities they identified. The results also show how physicists' beliefs about success vary by the rank of their department, age, productivity, and gender. More generally, the findings cast light on the moral order of physics by eliciting how members of an occupation construe the structure of success in their line of work.

Keywords: *achievement; higher education; stratification; scientists; academia*

What does it take to be successful? Answers to the question might be thought to vary from person to person; between men and women; among the young, old, and middle aged; and between those who have achieved "success" and those who are striving for it. In the case of one academic field—physics—the answers provided by practitioners do vary on some of these dimensions; on others, they do not. The results cast light on the moral order of physics by accounting of members' beliefs about how success is structured in their line of work. Because the question posed is generic—asked in reference to and applicable as much as to an array of jobs as to life in general—the answers provided, while coming from one specialized field in the occupational spectrum, may apply to a variety of types of work. The answers may interest not only physicists or other academics who wish to see how their own answers compare with others but also

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students and those embarking on their futures who seek to know what the veterans (and the new recruits) say about success.

Background

For how generic the question is to social life and to work specifically—"What does it take to be successful?"—it has withstood remarkably little scrutiny by researchers. It seems the question is always asked, perhaps especially by the young, and people everywhere allegedly have the answers. It is likely a question that weighs heavily on the minds of those seeking to make their way in a world of work, whether as aspiring physicians, attorneys, or CEOs. It may be no less often asked by those seeking to make their way in the world broadly, whether as Polish immigrants in Chicago or night students at Miami-Dade community college.

In her seminal research on Nobel laureates, Zuckerman (1977) arguably comes closest to ascertaining the characteristics underlying scientists' success. Yet the question above is not asked in her sample of scientists. Attention is focused instead on such factors as accumulative advantage, family background, educational training, and facilitative work environments that are seen to foster comparative accomplishment. Scientists' own accounting of accomplishment (or lack thereof) remains to be gleaned. In addition, Nobel laureates are but a small segment of the scientific community. In the absence of including other, less recognized scientists to study, it is unclear how characteristics of Nobel Prize winners—short of their prize—are similar or different from other scientists. Thus, the results of studying a spectrum of scientists has the potential to provide an inside look at how they variously construct and interpret what it takes to succeed.

Answers to the question "What does it take to be successful?" convey meaning about a group's moral order because the question is fundamentally normative: it asks how people "ought to be" to reap the rewards that a group confers on its members (cf. Merton 1973a). A moral order, in turn, more broadly consists of a social arrangement of desired and valued actions, beliefs, and orientations held among a group (such as physicists, clergy, or garbage collectors) that has been organized around a specific purpose or set of purposes (Durkheim [1915] 1965). In other words, it specifies how life "ought to be" in any given social arena where people have organized themselves together around a shared purpose. To understand individual beliefs about success, then, is to ascertain generalizable characteristics about "what makes a group tick," whether the group studied is relatively small (U.S. physicists) or large (U.S. citizens).

Research Design and Method

The research on which this work is based was completed in 1994 as part of a larger national study of scientific careers (Hermanowicz 1998). In this work, sixty physicists of all ages working at a range of U.S. universities were interviewed in person by the author about multiple aspects of their careers, including the scientists' aspirations, assessments of their achievements and failures, and beliefs about success in their field. A total of thirty-two questions were asked of the scientists on these topics, which composed the structured interview protocol. Follow-up and probe questions were asked as necessary in the interviews, which averaged ninety minutes in length. All of the interviews were conducted under the assurance of both individual and institutional anonymity. All of them were tape-recorded, transcribed, and coded for analysis. Most of the scientists contacted expressed an eagerness to participate: the response rate for the study was 70 percent.

The scientists were selected randomly within their departments. Departments were selected on the basis of their ranking in the assessment of graduate programs conducted by the National Research Council (NRC; Jones, Lindzey, and Coggeshall 1982).[1] Top-, middle-, and low-ranked departments were selected as part of the research design. This was done on the premise that differences in these departments establish different conditions—both structural and cultural—for careers. Thus, the selection of departments across a spectrum aimed to maximize variation in careers and to see how individual scientists view and experience them from various locations in the institution of science.

Six departments were included in the study. This number was reached to acquire a relatively equal number of scientists spread among the three "tiers." Two of the departments sampled ranked at or near the top of the NRC assessment, one of the departments ranked in the middle of the assessment, and the remaining three departments ranked at or near the bottom of the assessment. Roughly equal numbers of scientists were interviewed from each of the institutional tiers: twenty-three from top-ranking departments, eighteen from the middle-ranking department, and nineteen from bottom-ranking departments.

The total number of scientists interviewed facilitated the qualitative aims of the original study (Hermanowicz 1998), conducive to exploring the fine-grained details of scientists' careers on the topics cited above. The sample size has also made possible select quantitative and mixed-methods research, including that presented here. In this work, the sample is not used for statistical analysis. Rather, results from respondents are discussed for their suggestive patterns among scientists. While the sample is suitable for this purpose, it should be clear that only small numbers of respondents will pool into categories when the sample is variously divided as part of data analysis. Conclusions drawn from the work are therefore more illustrative than definitive.

Scientists were asked the question, "What do you think are the most important qualities needed to be successful at the type of work you do?" The purpose of the question was to solicit from scientists those personal characteristics that they believed were most central to career success in physics. A total of twenty-five adjectives were mentioned by the scientists. Twelve of these adjectives were mentioned by more than one scientist. They thus are used as the codes for analysis. Moreover, while some of the terms are related in meaning, they are sufficiently distinct from one another to justify their independent listing (as opposed to merging one or more of them into another of the adjectives mentioned). The remaining thirteen adjectives—cognates or synonyms that were mentioned by single scientists—were coded as they agreed with the adjectives comprising the dominant list.

Findings

While the list of characteristics necessary for success might be thought to vary from person to person and thus run inordinately long, the characteristics repeatedly identified by physicists number just twelve. The qualities named by physicists as necessary for success are listed in Table 1 along with their frequency of mention.

The quality most frequently cited as necessary for success was persistence, identified by thirty-one, or just more than half, of the scientists interviewed. The salience of persistence may be stated differently. Scientists were free to identify as many characteristics as they thought necessary for success in physics. Two scientists identified as many as five characteristics necessary for success, with five being the upper-most number of qualities offered by any of the scientists. Among the possible infinite number of characteristics to name, twenty-six scientists named only one, and of those identified, persistence was recognized by seventeen of the scientists as the single most important personal attribute necessary for success. (The second solely important attribute identified was smartness, named by seven scientists, a significant distance behind persistence.)

No other quality comes close to persistence in the frequency with which it was mentioned. Overall, smartness is the second-most frequently identified. But even in aggregate, it follows significantly behind, mentioned by a total of fifteen of the scientists.

Table 1
Qualities for Success by Frequency ($N = 60$ Scientists)

Quality	Mentions	% of Scientists	% of Responses
Persistent	31	51.6	24.8
Smart	15	25.0	12.0
Civil	14	23.3	11.2
Creative	12	20.0	9.6
Entrepreneurial	10	16.6	8.0
Aggressive	10	16.6	8.0
Tasteful	8	13.3	6.4
Confident	7	11.6	5.6
Adaptable	7	11.6	5.6
Ability to communicate	5	8.3	4.0
Service oriented	3	5.0	2.4
Lucky	3	5.0	2.4
Total qualities	12		
Total responses	125		100.0

Although persistence may be relevant to the multiple roles physicists perform, its referent was invariably to research. With only one exception (noted below), all of the adjectives cited by the scientists had a research referent, beyond that of physics as the general referent. Thus, when the scientists spoke of qualities necessary for success, research took center stage as the sole important component of the roles that made any difference between success and failure. Broadly, to talk of success was to talk about performance in research.

An array of laboratory studies in constructivist sociology of science has affirmed the importance of persistence to success in both theoretical and experimental research (e.g., Collins 1995; Knorr Cetina 1995; Krieger 1992; Latour 1987; Latour and Woolgar 1979; Pickering 1995; Traweek 1988). These studies, while not typically asking scientists directly about characteristics of success (or lack of success), have followed scientists and their efforts in the lab, usually in detailed ethnographic description. The result is an accounting of how, and under what environmentally constraining circumstances, certified scientific knowledge is produced. One deduces from this thick description of scientific practice that persistence stands as a chief moral condition of success in science (McGinn 1991; Ziman 1984).

Based on the interview data, persistence was typically raised as the most essential ingredient for success because it contained rejection and evidently the large doses of rejection that scientists encounter throughout their careers.

Rejection, and the persistence alleged necessary to overcome it, was most commonly voiced in relation to two core areas of the scientists' roles: the peer-review process of papers and grant proposals, and the actual process of experimental and theoretical work, conceived and executed well enough to yield significant results.

In broader ways, the significance of persistence points to the intense evaluative character of science and academe generally. Nearly every aspect of every role performed by scientists is evaluated with potentially consequential effects for scientists and their careers: in publication, in grants, in teaching, in mentoring, and in training new generations of scientists—all the staples of the scientific life come under scrutiny and judgment by peers and ultimately by individual scientists themselves, who have been socialized as members of a profession. Some of this evaluation is daily and omnipresent, as in performing before a class or seeking results in the lab; other evaluation is more formal and periodic, as in annual reviews or other performance measures used for salary and/or promotion recommendations. This omnipresence of rejection was typically conveyed as follows:

> Nobody has a career which is just uphill. Things don't work out; you get frustrated; nothing seems to be working. The experiments you are doing just aren't [working]; people aren't interested; you aren't getting interesting results; they are not going forward, etc., etc. There are dry periods. You think at those points that you've lost it. You begin to wonder if you are ever going to do anything good again. (Interview 1)

> I was quite disappointed by not getting a Sloan Foundation Fellowship. My disappointment was rather amplified by the fact that the Foundation then wrote to me and said "Will you apply again next year?"—which I did, and then they still didn't give me one. I was bruised by that. Every time I hear the Sloan Foundation I think, I don't like you. That upset me. There are probably other things like that, the occasional proposal that's turned down. But I content myself with the fact that most people have to put up with more rejection than I do. I don't handle rejection very well. (Interview 23)

Rejection seemingly all around, a scientist provided a typical account conveying the substance and significance of persistence:

> I think [the qualities for success] are the same in sociology as they are in physics. That is, a lot of drive. A sense that you want to accomplish something and a willingness to constantly work hard at it, because I think the most important thing for success is not just the creativity one has, although that's important. But probably more important than creativity is the consistency of effort, the consistent effort is what in the end makes a dramatic difference. I've seen too many people who are very creative, who do an occasional very good piece of work, be it in applied research or in technology or in fundamental physics, but then don't carry it through. . . . And when there is a setback, [they] take it too personally. There are always setbacks. (Interview 58)

Another scientist, echoing the predominant trend, put the salience of persistence succinctly:

> You must have the desire to do research. . . . And that means working very long hours; it means working on weekends, on holidays. . . . You cannot consider a forty- or even a fifty-hour week a job. . . . You need to have the necessary drive to work very long hours throughout the year . . . and the perseverance in the face of difficulties. You have to stick to things when things are going badly. (Interview 40)

Looking at the qualities ranking below persistence, each characteristic is relatively close to its adjacent adjective in frequency. *Smart* just tops the fourteen scientists who discussed civility, by which they meant a collegiality that helped to form a work environment conducive to productive research. Similar closeness in spacing is evident among characteristics descending the list.

One particular observation can be made about the substantive character of all of the qualities. Eight of the twelve adjectives are moral in character because of their stipulation for specific behavioral conduct. These adjectives, along with their definitional meanings as used by the scientists, include the following:

- *persistence*, the wherewithal to persevere in the face of adversity;
- *civility*, collegiality in the workplace and in general professional interaction;
- *entrepreneurship*, courage and audacity in selecting and pursuing problems;
- *aggression*, being competitive and demanding of oneself and others;
- *tastefulness*, cultivated discretion in selecting fundamental problems to research;
- *confidence*, a religious-like belief in the importance of one's own work;
- *adaptability*, knowing when to profitably change course in the midst of research; and
- *service orientation*, a dedication to helping others.

Three of the twelve adjectives are intellectual in character because of their stipulation for specific cognitive or technical capacity. These adjectives include

- *smart*, expert knowledge about the field;
- *creativity*, the imaginative application of skill and knowledge; and
- *ability to communicate*, skill in verbal and written exchange pertaining to research.

One of the twelve adjectives—*luck*—is neither moral nor intellectual but rather situational. It deviates from the other adjectives in not being a personal attribute but an attribute of allegedly random circumstances. Nevertheless, it was raised as significant by three of the scientists.

According to the scientists, being well schooled and well trained, and thus smart, creative, and able to communicate is important but less key than being behaviorally geared to operate in science—as persistent, civil, tasteful, and so on. In this respect, the group's belief system holds than an individual's moral attributes play a more prominent role in achieving success than one's technical capacity. This, of course, does not mean that technical capacity is irrelevant. Many of the scientists, such as one quoted above, believe smarts and creativity are important but, in the absence of other moral factors, have unrealizable results. In short, intellectual qualities must, according to the scientists, be acted on—indeed in numerous and sustained ways.

Also noteworthy is the nearly universal reference to the research roles of scientists. As with persistence, almost all of the adjectives point to this facet of scientists' careers, with service orientation the only exception. When used by the scientists, *service orientation* (although it could in principle refer to research and the community of science) referred to their diligence and commitment as teachers and in other professional obligations outside of their research roles (e.g., in committee assignments). Interestingly, when it was mentioned, *service orientation* always occurred in combination with other qualities, and it was never the first quality mentioned by any of the three scientists.

Other adjectives are noteworthy for their instructive ambiguities when compared to one another (Merton 1973b). For example, *civility* was the third-most frequently mentioned adjective, three places above *aggressiveness*, discussed by ten of the scientists. The two qualities are apparent contradictions. Indeed, they were never mentioned together by a single scientist, and in this sense, they represent contrasting characteristics. They are not necessarily incompatible with each other, however. One can imagine a dogged scientist who simultaneously observes norms of etiquette, cognizant of where civility lines are drawn and where they are crossed. As one scientist put it, "One of the beautiful things is that you compete with your friends in this business" (Interview 58). As the adjective was used, *aggressiveness*

typically entailed a form of persistence, underscoring the importance of that trait. It was also typically used in association with the practice of "promoting one's work." The scientist quoted below illustrates the point.

> I suppose unfortunately that one has to be ruthless as far as picking time to work on things. It takes long hours to get things done. Unfortunately, one has to be ruthless about publishing. The people whose names you know are well known because when a new idea comes out, they are quick about writing a paper on it. Even if it's half-baked. Even if they know that somebody else has really already done it. Just for the sake of getting something out and getting their name out, they will "chase the ambulance." The people who are very well known and at the top of the field, very few of them are actually nice people. (Interview 3)

Persistence and *adaptability* are also two adjectives that may in some senses appear contradictory. One connotes continuity, the other change. Four of the scientists who discussed *persistence* also mentioned *adaptability*. The logic of how the terms were used by the scientists, though, is straightforward: persist when on the right course and alter the course when you deem it unprofitable. One scientist put the combination of these, as well as other adjectives, in these terms:

> You have to be creative. You have to have good ideas and pursue them. You have to certainly be smart enough to get the ideas, tenacious enough to keep pushing, and confident enough to know that you're on the right track, and also to switch when you've made a mistake. (Interview 43)

Finally, an adjective triad—*creative*, *entrepreneurial*, and *tasteful*—presents an additional set of instructive ambiguities. Although the terms may sometimes be used in related ways, scientists employed them with sufficiently distinct meanings to justify their independent listing. In fact, only one scientist discussed creativity and tastefulness as essential qualities for success; none of the scientists discussed creativity and entrepreneurship, entrepreneurship and tastefulness, or all three adjectives together in their response to the question. *Creativity* was typically used by scientists to refer to "having good ideas and imagination," whereas *entrepreneurship* was used by scientists to refer to a personal resourcefulness, boldness, and adventurousness in going about research.

Taste was used to describe a more refined quality, alleged by many of the scientists who mentioned it to be, by its nature, scarcely found in the scientific community. It referred to the quality of the problems scientists select for research. As the term was used, research that had "good taste" appeared to exhibit two ancillary and interacting traits: fundamentalness (a property relating to serious core concerns of a field) and aesthetic beauty (a property relating to the original, creative approach to studying core phenomena). Taste was typically described by the account provided by the scientist quoted below:

> I think the world divides into two people: those whose tastes are above their reach, and those whose tastes are below their reach. People whose tastes are below their reach are generally happier people, and I'm not in that category. I can just sense what a really good problem is or a beautiful paper. I can just feel sometimes that some of those things are beyond what I can do. Some people don't sense that. You can tell when you read their papers. You just see crap. You can sense it. They are not even aware of it themselves. It's a taste in problems. As a theoretical physicist you have to have taste. You have to be able to look at problems and decide which are interesting problems and which aren't. You have to decide what you're going to learn and what you're not going to learn. You have to decide what you're going to concentrate on and what you're not going to concentrate on. Those are issues of taste. (Interview 1)

This account is instructive because it captures the essence of how the scientist, and others who discussed taste, understand its essential features. What may be most striking is that it is fundamentally scarce; indeed, many individuals may forever be incapable of developing it and, further still, unaware of what they are lacking. Yet while these aspects of the term may appear peculiar to taste, they in fact characterize many of the adjectives raised by the scientists. The majority of adjectives are, while readily identifiable by scientists, not as easily adoptable by the very people espousing them—a point to which I will return at the end of the article.

Variation by Tier, Age, Productivity, and Gender

Do responses to the question vary among scientists according to other criteria? To find out, responses were cross-tabulated with major variables available from the collected data, including departmental tier, scientists' ages, their publication productivity, and gender.

Responses to the question by scientists' departmental tier—high, middle, and low—are presented in Table 2. Several patterns are especially noteworthy. Regardless of tier, scientists identified persistence most frequently in describing ingredients necessary for success. While this particular pattern conveys intertier similarity, other patterns reveal intertier difference. The data show that a number of adjectives assume greater importance as one rises

Table 2
Qualities for Success by Departmental Tier

	Top Tier (n = 23)		Middle Tier (n = 18)		Low Tier (n = 19)	
Quality	n	%	n	%	n	%
Persistent	11	47.8	12	66.6	8	42.1
Smart	7	30.4	6	33.3	2	10.5
Civil	6	26.0	3	16.6	5	26.3
Creative	10	43.4	2	11.1	0	0.0
Entrepreneurial	5	21.7	3	16.6	2	10.5
Aggressive	7	30.4	2	11.1	1	5.2
Tasteful	3	13.0	4	22.2	1	5.2
Confident	5	21.0	0	0.0	2	10.5
Adaptable	2	8.7	2	11.1	3	15.8
Ability to communicate	1	4.3	3	16.6	1	5.2
Service oriented	0	0.0	1	5.5	2	10.5
Lucky	1	4.3	2	11.1	0	0.0

among the tiers. Top-tier scientists assigned comparatively greater value than did low-tier scientists to smartness, creativity, entrepreneurship, aggressiveness, and confidence. Top- and middle-tier scientists valued tastefulness more than did low-tier scientists. Scientists who placed a value on service orientation were clustered in the low tier, composed of institutions that emphasize teaching.

These patterns suggest that success at the top may be more driven by emphases on originality, possibly explaining the importance of creativity. Because originality is by definition difficult to achieve—one stands alone, or nearly alone, in the recognized accomplishment—other factors assume comparatively greater importance to help facilitate this marker of success: aggressiveness, entrepreneurship, confidence, taste, and the like. By contrast, success outside the top may be less dependent on originality than on sheer production of output. Thus, among low-tier scientists, persistence becomes singularly important. Alternatively, it could be that top-tier scientists are characterized by relative uniformity in persistence. To distinguish themselves, they emphasize other attributes. In low-tier departments, physicists might be able to stand out from their colleagues simply by persistence.

To ascertain whether responses varied by scientists' ages, individuals were grouped according to when they earned their PhDs, thus establishing what we may call their "professional age" as marked and measured from

Table 3
Qualities for Success by Cohort

	I: PhD pre-1970 (n = 22)		II: PhD 1970-80 (n = 16)		III: PhD post-1980 (n = 22)	
Quality	n	%	n	%	n	%
Persistent	15	68.2	8	50.0	8	36.4
Smart	7	31.8	4	25.0	4	18.2
Civil	3	13.6	2	12.5	9	41.0
Creative	3	13.6	4	25.0	5	22.7
Entrepreneurial	5	22.7	2	12.5	3	13.3
Aggressive	3	13.3	3	18.7	4	18.2
Tasteful	4	18.2	2	12.5	2	9.1
Confident	3	13.3	2	12.5	2	9.1
Adaptable	4	18.2	2	12.5	1	4.5
Ability to communicate	2	9.1	0	0.0	3	13.3
Service oriented	2	9.1	0	0.0	1	4.5
Lucky	1	4.5	0	0.0	2	9.1

the point of receiving their highest terminal degree. Scientists were placed into one of three professional age cohorts. Cohort I consists of those scientists who received their PhD prior to 1970, cohort II consists of those scientists who received their PhD between 1970 and 1980, and cohort III consists of those scientists who received their PhD after 1980.

The results are displayed in Table 3. Overall, the dispersion of responses appears more even among the adjectives when looking at variation by age than when looking at variation by tier discussed above. Yet several patterns are notable.

What seems most interesting is that scientists learn, over time, to recognize the importance of some attributes over others as essential for success. Persistence is foremost among these qualities. While it is a quality highly valued among scientists of all ages, it is particularly recognized by the most senior scientists. This may be so because they have experienced, and perhaps withstood, comparatively more rejection, thus realizing the importance of perseverance in a highly evaluative line of work. While more junior scientists cite the importance of persistence, they are just as likely to cite the importance of civility and do so much more than their senior counterparts. The data suggest that for the comparatively young, one needs to behave to be successful. More senior scientists, while by no means dismissing civility, have less "hanging over them" and thus may be less likely

to value it as highly. Deference is paid to them by the young—at least in the scientists' stated values.

To see how responses varied by publication productivity, scientists were sorted into thirds by their number of published articles. Generally, the results are correlated with those found by tier and age since the most productive scientists tend to be both located in higher ranked departments and older, having had more time to establish their scholarly records. Nevertheless, it is worthwhile to present the results because productivity may be taken as the closest, albeit imperfect, measure of objective success—more so than tier or age. Productivity measures the volume, although of course not necessarily the qualitative significance, of contributions to science. The measure therefore conveys what the comparatively successful (and, by turn, the comparatively less successful) say about what it takes to succeed. The results are presented in Table 4.

The most successful scientists claim that success itself comes predominantly through persistence (though less productive scientists agree). The most successful scientists diverge from their less productive counterparts by assigning greater value to smartness, creativity, entrepreneurship, taste, and confidence. While the less productive most frequently cite persistence, they are more apt to cite civility, again likely for reasons discussed above: the less productive are younger, and the younger scientists are more likely to feel the importance of deference to senior scientists.

In terms of gender, only four of the scientists interviewed were female, reflecting the disparate gender ratios in physics generally (Sonnert and Holton 1995). All four women discussed persistence as essential for success, the only adjective of the twelve to be cited by all of the women. Two of the women cited creativity, generally valued by senior scientists and those in top-ranking departments. (Both women held positions in top-tier departments; one belonged to the most senior cohort, receiving her PhD prior to 1970; the other belonged to the most junior cohort, receiving her PhD after 1980.) One woman cited aggressiveness and another the ability to communicate as necessary for success. Thus, the women discussed a total of four attributes, all of them in agreement that persistence was most prominent among the qualities. In this regard, despite their small number, women parallel men in drawing attention to the reigning significance of perseverance.

Conclusion and Discussion

Five general conclusions may be made in light of the foregoing research. First, the adjectives themselves are a finding, both in terms of what they are

Table 4
Qualities for Success by Publication Productivity

	Top Third (n = 21)		Middle Third (n = 19)		Bottom Third (n = 20)	
Quality	n	%	n	%	n	%
Persistent	12	57.1	10	52.6	9	45.0
Smart	9	42.9	4	21.1	2	10.0
Civil	3	14.3	5	26.3	6	30.0
Creative	7	33.3	1	5.2	4	20.0
Entrepreneurial	6	28.6	2	10.5	2	10.0
Aggressive	5	23.8	1	5.2	4	20.0
Tasteful	5	23.8	3	15.8	0	0.0
Confident	5	23.8	0	0.0	2	10.0
Adaptable	3	14.3	3	15.8	1	5.0
Ability to communicate	1	4.8	1	5.2	3	15.0
Service oriented	0	0.0	0	0.0	3	15.0
Lucky	0	0.0	1	5.2	2	10.0

Note: The top third corresponds to 100 to 324 published articles, the middle third corresponds to 26 to 89 published articles, and the bottom third corresponds to 0 to 25 published articles. Data come from the vitae provided by the scientists. Journal articles are used because they are the standard publication medium for measuring research productivity in physics. The number excludes books; textbooks; book chapters; edited volumes; conference proceedings; invited and contributed papers; book reviews; encyclopedia, world book, and yearbook entries; and articles listed on the individual's vitae as "submitted," "in press," "accepted for publication," "in preparation," and so on. If the same journal article was published multiple times, it is counted once.

substantively and in their number—they are decidedly finite and nonrandom. Diverse members of a group cite only select adjectives to explain success.

Second, with just one infrequently mentioned exception, the adjectives had only one major referent: research. Other facets of scientists' roles were not construed as imperative components of their success. It is unclear, however, how qualities for success would vary, if at all, if the major referent were teaching, administering, consulting, or some other role performed by scientists. Emphasis on research may be understood as a perception of the stratification criteria in force in academic careers.

Third, one of these characteristics stands head and shoulders above the rest in its frequency of discussion: persistence. The significance of persistence is partly tautological. Persistence is so central because it buys the time necessary to realize that persistence itself eventually pays off, albeit perhaps not in originally wanted ways.

Fourth, moral—rather than intellectual—characteristics are cited more frequently overall as necessary for success. Ultimately, behavioral attributes are thought to weigh more heavily than cognitive ones in achievement.

Fifth, variation in the importance of certain characteristics is found by departmental rank, scientists' age, and productivity. The higher the departmental rank, the more likely that scientists will value creativity, smartness, aggressiveness, entrepreneurship, and taste. Older scientists are more apt to value persistence, smartness, and taste; younger ones are more apt to value persistence and civility. The most productive scientists value persistence, creativity, smartness, entrepreneurship, and taste; less productive scientists (a major function of age) especially value persistence and civility.

Taken as a whole, these conclusions lead to a further observation: most qualities deemed necessary for success by scientists are largely unteachable through formal means of instruction. A popular myth holds that scientific success—and academic success in general—comes by way of genius (Albert 1992; Ludwig 1995; Simonton 1994). The great are born, not made. And if one accepts that they are made, then it is because they are smart, having undergone years of extensive training to help breed their success. Intellectual ability undoubtedly plays a critical role in achievement. Scientists, however, point to another attribute—persistence—as more crucial.

What is more, persistence joins a host of other identified traits, the majority of which specify behavioral, rather than cognitive, mastery. Like taste, these other moral-behavioral elements are readily identified by scientists but are less easily adopted. Most attributes are not part of formal instruction, acquired instead informally over years of experience and observation, if they are acquired at all.

This leads to an additional point, namely, that while scientists may readily identify characteristics necessary for success, they may not of course uniformly enact them in their roles. If their beliefs are that particular qualities do in fact facilitate success, disparities in enacted behaviors can partly explain inequalities in science, such as in publication productivity. Put differently, the moral order that scientists outline through the discussion of these attributes prescribes how they ought to act in their institutional roles, but people operating in any order—whether of science or society largely—inevitably deviate from the normative codes.

Moreover, because most ingredients identified for success are not taught formally, scientists (and likely all people) will vary both in their acquisition of those ingredients and in their ability to realize which ones are more important than others. A group's agreement about the importance of certain traits appears to come with time. In the case of physicists, this is observable by the decidedly finite trait set the group identifies and by the character of particular traits, such as persistence, assigned considerably more importance by senior scientists than by junior ones, who nevertheless have been engaged in science long enough to realize the significance they in fact accord it.

Nevertheless, senior membership in a group does not alone breed behavior for success. Socialized members, even senior ones, continue to vary in their opportunities for exposure to those who can informally show them "what it takes." This is evidenced in varying types of university environments, which press academics in different degrees toward achievement based on the moral composition of people working in them (Glaser 1964; Hermanowicz 1998; Pelz and Andrews 1966; Zuckerman 1977). Senior scientists in low-tier departments are less productive than senior scientists in top-tier departments, not only because resources and infrastructure are more scant but also because the moral mandate to achieve is less intense (Cole and Cole 1973; Hermanowicz 1998). A comparative absence of high achievers in a department makes high achievement less enforceable by a group.

The results of this work have implications for graduate training as well as on-the-job socialization once scientists enter their positions. They suggest that scientists are most apt to profit in their roles when they operate in environments—departments and their faculties—that stress the informally learned, crucial lessons of career development and not exclusively the technical knowledge that forms the basis of scientific competence. The importance of such environments highlights the possible effects that mentoring can exert on people at various stages of a career. Mentoring itself has been seen to occur in many styles (Sonnert and Holton 1995; Zuckerman 1977). The necessary common denominator evinced by this work is transmission of "success rules."

The adjectives offered, mostly moral, point to the existence of numerous informally learned rules that, when followed, foster achievement (but by no means guarantee it). Why would scientists collectively assert that persistence plays such a prominent role in careers? Time allows them to learn what to do and what to change—"how to be"—largely through interaction with those who have more experience by having earlier endured similar circumstances. Such rules likely run a gamut about how one "ought to be," stipulating behavior about writing papers and grants and revising and resubmitting them, elements in problem selection, follow-through in one's work, and the belief (noted by several scientists) that in graduate school—as in many professorships—there are no vacations.

The knowledge that rejection is commonplace in science, even for those accorded high recognition, alone empowers persistence as an adoptable character trait—if that knowledge is transmitted. Such is gleaned from Gans

and Shepherd's work (1994; also Shepherd 1995), who in studying the world's leading economists, observe how frequently their articles—which went on to become classics—were routinely rejected in the early rounds. "In the big leagues," they note, "even the best hitters regularly strike out" (Gans and Shepherd 1994, 166). Evidently, persistence allowed them to hit their home runs.

The scientists studied here were never asked the question, but many of them might wish they had known previously what they know now—or at least interpret—about success in their field. The results provide a formal way to convey informally understood substance, accumulated over years of experience, about the basis of success.

Note

1. The sample of schools in this study is drawn from the ranking of departments in the 1982 NRC assessment. The rankings of the specific schools sampled closely correspond to those compiled in the more recent National Research Council ranking (Goldberger, Maher, and Flattau 1995). Because fieldwork for this study was completed in 1994, rankings from the earlier study were used for sampling.

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Precaution as an Approach to Technology Development

The Case of Transgenic Crops

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The commercialization of transgenic crops has engendered significant resistance from environmental groups and defensive responses from industry. A part of this struggle entails the politicization of science as groups gather evidence from the scholarly literature to defend a supportive or opposing position to transgenic crop commercialization. The authors argue that novel technology development and associated scientific uncertainty have led to two competing approaches to risk management: precaution and ex post trial and error. In this paper we use the controversies over currently commercialized transgenic crops to analyze the debate over these competing approaches. We also suggest a hybrid approach that incorporates a precautionary selection process, but also relies on ex post trial and error after commercialization. This approach is labeled *precaution through experience* since the development of a technology's characteristics would ideally take into account previous experience with similar technologies, or rather technologies with similar applications. The authors argue that substantial public participation and dialogue is needed to identify socially desirable crop traits to guide research and development. Policy tools are also recommended that provide incentives to private-sector firms to engineer the identified traits into crops.

Keywords: *Precautionary Principle; transgenic crops; environmental risks; regulatory science; scientific controversies*

All the scientific demonstrations in the world would have no influence if a people had no faith in science. Even today, if it should happen that science

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