

The Business of Academic Physics

A physics education is a solid foundation for a diverse range of careers, but physics students do not know it. It is time they found out, and physics alumnae and alumni can help.

John S. Rigden and James H. Stith

There are two products of academic physics: new knowledge and new physicists. If we academics were to consider academic physics in business terms, there are specific questions we might ask: Are the two product lines successful in the marketplace? Is the supply of the needed raw materials adequate to support the two product lines? Is there a sufficient customer demand for the products? Are the products marketed successfully? Is academic physics well managed? Although it might disturb some people to think of physics in these terms, in our experience, questions never asked are rarely considered and therefore can provide no insights.

The products

In considering the first product line, it is immediately apparent that great quantities of high-quality new knowledge are produced regularly. Much of it is quietly deposited in the vast storehouse of physical knowledge. In addition, with some regularity, stunning new developments occur that expand our scientific horizons. Such major advances have huge market value and attract wide media coverage: Consider the accelerating universe and dark energy; the last piece of the standard model—the top quark; Bose–Einstein condensates (BECs); bringing light to a dead stop. Such examples of new knowledge capture the attention and stimulate the interest of world citizens. Perhaps even more significant, much of the new knowledge, whether spectacular or incremental, will in time be applied in practical ways to benefit the peoples of the world.

One may assess the second product line, new physicists, in at least two ways. On one hand, the intellectual quality of new physicists is high, and their reception in the marketplace is favorable. New physicists pursue a wide range of careers and often do so with notable success. The vast majority are pleased that they focused their education on physics. They routinely cite their problem-solving skills and model-building abilities as strengths that set them apart from other professionals, and they typically credit their physics education for the development of those valuable attributes. Moreover, many managers in the workplace recognize physicists' abilities and appreciate their knowledge and skills. "We call our physicists our problem solvers," said one human resources director. "When we have a problem, we call our physicists," said another.

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On the other hand, if one considers the supply of and demand for new physicists, significant improvements can and must be made. Furthermore, the two product lines of academic physics are linked: A weakness in one weakens the other. The viability of academic physics as the source of new knowledge depends on the production of new physicists. But is the supply of

raw materials adequate to sustain the two product lines?

The raw materials

The raw materials for new knowledge are twofold: inspired ideas and the resources to implement them. Not all physicists are created equal. But there are many truly creative physicists with the gift of seeing hidden connections between the known and the unknown, and who have the courage to act on their insights. Through their creativity, these physicists open new fields and plant new ideas that enable other physicists to harvest new knowledge. Of course, financial resources are needed to transform new insights into new ideas that can then be moved forward, and physicists always believe they are underfunded. However, as a look back over the past 50 years amply demonstrates, the resources provided by the larger society have been perhaps generous, but certainly sufficient, to ensure a steady supply of exciting new knowledge.

Academic physics must compete with other academic units for both fiscal and human resources. Very often, those resources are based on accounting numbers such as the number of new physicists produced per faculty member, the student-to-faculty ratio, and the number of student credit hours offered. To compete successfully, the new physicist product line must have a steady and sufficient supply of raw material—apprentices, that is, incoming students who choose to study physics.

Here the picture is troubling. The production of new physicists is an inefficient process, and to compound the problem, fewer students are choosing to apprentice in physics. (For some details, see the three articles in *PHYSICS TODAY*, September 2003, beginning on page 38.) In addition, many academics can't even agree on who is and who is not a physicist. We think it is vital to consider *all* physics graduates—bachelors, masters, and doctors—to be bona fide physicists.

In the US, the American Institute of Physics tracks the number of bachelor's degrees granted in physics. Despite some modest gain in recent years, the data show that physics baccalaureates are still down 9% since 1991.^{1,2} This decline is exacerbated by the fact that, over the same period, the total number of bachelor's degrees granted in the US was up more than 17%. Quite generally, European countries also report declines in the number of students pursuing a degree in physics.

With the decline in student numbers, there is reason to worry about both product lines: new knowledge and new physicists. The viability of academic physics directly depends on sufficient student numbers. Traditionally, physics has always attracted relatively few apprentices. If, however, this already small number continues to decrease,

academic managers—deans and provosts—will be pressured to decrease the number of academic physicists, the producers of new knowledge. The linkage between the two product lines is now evident.

We conclude that the two product lines of academic physics are sound. However, one of the vital raw materials—students who choose physics as a course of study—is in dwindling supply. The declining number of physics students raises serious concerns.

Customers of the academic physics trade

What about the customer base for the products of academic physics? It is strong but, as we shall see, it can be made much stronger. The markets for new physical knowledge include physicists themselves, technology-based industries, and the general public.

For physicists, new knowledge is the basis for still further new knowledge, and physicists are adept at exploiting that supply chain. A simple glance at the references list in any research article makes the point. Or consider the creation of BECs, which has given rise to a cottage industry in which scores of physicists are busy uncovering ever more consequences of that singular advance.

Commercial industries are big customers of new knowledge: They immediately import and examine it for the potential applications that will eventually translate into sellable products. The process that converts basic knowledge to commercial products is successful and efficient. New basic knowledge often spawns practical applications, and the time between the discovery of new basic knowledge and the appearance of new products has decreased dramatically over the past century. As Tom Theis and Paul Horn of IBM wrote recently, “Time to market is everything” (PHYSICS TODAY, July 2003, page 44).

The general public is an important consumer of new knowledge, although it perhaps does not consume that knowledge as directly as the other two markets. The public’s fascination with both physics and physicists, however, helps maintain a cultural climate in which tax-supported funding agencies can exist. Put the name “Albert Einstein” or “Richard Feynman” or “Stephen Hawking” on the cover of a book and people buy the book. Those names are special, but it is the ideas of physics, not the names per se, that attract the public’s attention. Put the words “Black Hole” or “Quantum Uncertainty” or “Dark Matter” on the cover of a book and they too attract a reading public. Physics attracts attention.

Why is this? The subject of physics touches people in uncommon ways. Among all the sciences, only physics seeks to identify the fundamental Laws of Nature, the laws that define and constrain both the visionary and the practical. The apparent universality of deep physical laws and the power that derives from them elicit a sense of awe from many people, both physicists and nonphysicists.

Where do these basic laws come from? Here is where truly creative physicists come in: By sheer force of mind and a mastery of the tools of their trade, they divine the secrets of nature and, in the process, open its unseen workings for all to see. No wonder a mystique may arise around the names of those physicists who are the first to see nature from the inside. With both their interest and their resources, the general public supports the mission of physics. Thus, the customer base for new knowledge is huge. Those who dwell in the worlds of science, commerce, and society at large all consume physics knowledge in some form.

What about the customer base for new physicists? All industries and businesses that produce tangible products—from sausage to spacecraft—confront technical issues in the production process. The total number of such

enterprises is great, and includes large corporations in major industries, small start-up businesses, and much in between. Experience and observation show that physicists make vital contributions to these varied enterprises. Thus, virtually all product-oriented businesses are potential customers for new physicists. Governments are another customer. All governments call on physicists for their analytical ability and expertise related to technical issues of national interest, such as security and defense. In addition, physicists, with their penchants for problem analysis, model building, and disciplined thinking, have penetrated nearly all career sectors, from financial houses to news organizations, from marketing to teaching. Some small percentage even remain in the academic physics enterprise. Conclusion: The potential customer base for new physicists is huge.

Supply and demand

Although the business fundamentals of academic physics are strong, the academic physics enterprise is neither well managed nor well marketed. Consequently, the supply of new physicists is paltry even as the demand for new physicists could be significantly increased.

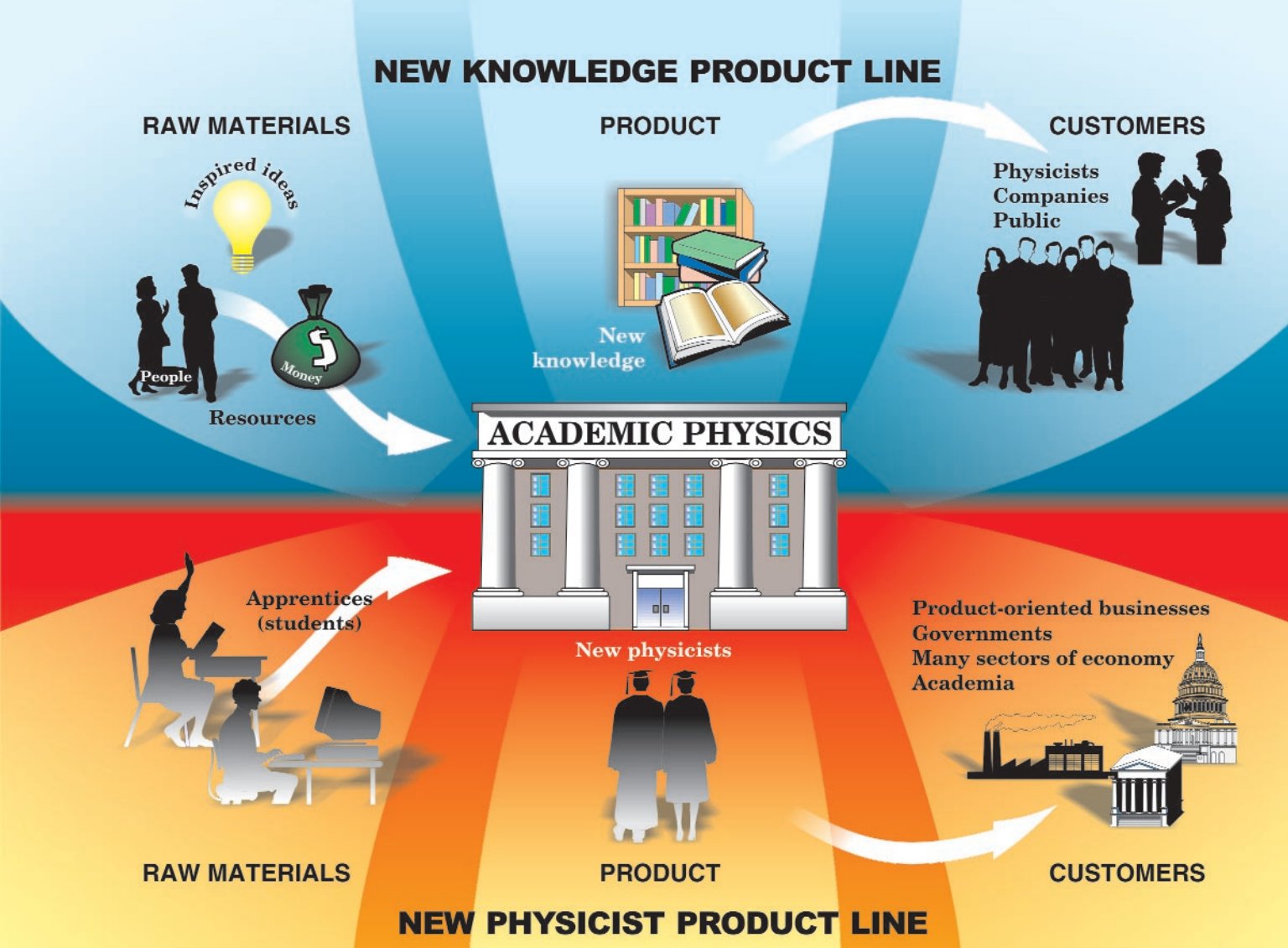
To increase the supply of new physicists, the business of academic physics must directly confront the decline in the number of apprentices. A direct confrontation is difficult, however, because there is no single cause or one explanation for fewer and fewer students’ electing physics as a course of study. Some physicists argue that student attitudes have changed and fewer students are willing to undertake the rigors required to pursue a physics degree. That argument nicely shifts the responsibility from academic physicists themselves to shortcomings in the raw materials—that is, deficiencies in students—but it is a false argument. How else to explain the success of certain thriving physics departments? (See the article “Why Many Undergraduate Physics Programs Are Good but Few Are Great,” by Robert Hilborn and Ruth Howes in PHYSICS TODAY, September 2003, page 38.)

Another explanation offered for the decline is that physics no longer enjoys the limelight it basked in for many years. Biology, with its great advances in the past two decades, has become a glamour science, and the life sciences are now on center stage and attracting students. This explanation is somewhat valid, but we do not pursue it here. We choose instead to emphasize an already well-known reason for the rejection of physics by students. Research shows that students are uncertain about whether job opportunities will be open to them if they pursue physics.³ A related reason students give for rejecting physics is that physics professors are unable to give knowledgeable and helpful career advice.

Perception is not reality

The job issue demands major attention. Many students pursue physics for the intellectual excitement it offers, but sooner or later all students are concerned about job prospects and career opportunities. With physics, students see uncertainty. Furthermore, students do not know the kinds of jobs available to physicists and are uncertain about the type of career they could pursue as a physicist. *This is a serious issue.*

Every degree in physics is special, whether a bachelor’s, master’s, or PhD. All academic degrees, regardless of the discipline, are worthy. However, certain degrees, for example in dentistry or mechanical engineering, point recipients toward a rather well-defined job market. By contrast, other degrees, say in literature or history, do not foreordain either a particular job or a defined career path. Graduates



Academic physics, when viewed as a business, uses raw materials (at left) to generate products (center) that are consumed by customers (right). The upper portion of the figure shows the new knowledge product line, which is generally robust. But the new physicist product line, shown in the lower part of the figure, is in trouble because of a shortage of raw materials and a lack of marketing initiatives on both the supply and demand sides.

with such degrees occupy a plethora of positions—important positions—throughout the world’s workplaces.

In that regard, physics is like literature and history. Physics is a broad-based body of basic cumulative knowledge and, like literature and history, does not point a physicist to any particular job. Unlike in literature and history, however, an education in physics has students develop quantitative, analytical, and technical skills that are widely applicable throughout the science- and technology-based employment arena. Many of the jobs available to physicists are in high-tech environments. Many others are not. Survey data confirm that physicists are found in a variety of workplaces—both technical and nontechnical—and experience shows that physicists do their jobs well in these environments.

Indeed, physicists pursue a diverse range of careers—in the computer sciences, telecommunications, solid-state and semiconductor industries, optics, photonics, aerospace, oil and gas, energy industries, and more. Many more. And physicists enjoy careers in engineering, chemistry, life sciences, and Earth sciences. Physicists also work in medicine, law-based organizations, news and media outlets, and financial and management consulting firms. Many physicists

are managers, company owners, and entrepreneurs. Physicists work in government. They work in the military. And, of course, physicists pursue careers at all levels of the educational system. Clearly, the careers of physicists are legion.

Unfortunately, students—the raw material required for new physicists—too often do not receive good career advice. They are unaware of the varied careers available, and many recognize only the one most visible to them: physics professor. This perception is, sadly, both misleading and restrictive. And at least in the US, it is wrong. Only about 1 of every 20 physics baccalaureates eventually becomes a physics professor.

But that ill-informed perception is not the worst of the problem. Physicists in the workplace are invisible. And it’s not only students who can’t see them; even their own managers often can’t. In the workplace, physicists are rarely identified as such. They are given other job titles: engineer, computer specialist, new product engineer, manager, software engineer. The list goes on. So we ask, Why would students choose physics as an academic course of study if they have no conception of what kinds of jobs are available and if they see little evidence that physicists actually have jobs? The invisibility may be responsible for

the often heard skepticism and advice students get from their parents and other elders: "If you go into physics, how will you earn a living? Go into engineering so you can get a job."

A serious need for serious marketing

The business of academic physics would be greatly strengthened if some marketing strategies were initiated. One of the product lines, new knowledge, is already marketed effectively: It is published in professional journals, where it is widely available to technically capable customers. If new knowledge has special significance, journalists are alerted, interviews are arranged with the knowledge producers, and stories get into newspapers and magazines and onto the airwaves and the Internet. Academic physicists themselves market their new knowledge in various ways. They give talks about their work. They contact student newspapers and other campus offices to make members of their local academic community aware of their accomplishments. They arrange to be interviewed by local radio stations. They write proposals highlighting their new knowledge. New knowledge is marketed in many ways and, by and large, it is done effectively.

However, that success is but one part of the story. The second product line languishes in darkness: Little if any effort is made to market new physicists. This is a serious oversight. Strategic marketing has a huge potential for en-

particular work environments. They identified how their education played into their day-to-day work and they identified skills that students would need to succeed in the workplace. For example, almost every alum urged students to hone their writing and speaking skills. Most pointed out that physicists often work alone in a university, but in the workplace they must learn to work with others from very different backgrounds (for example, engineers, accountants, managers, and marketing people). They often gave good advice about how to look for a job and sometimes offered to help students find a job. In some cases, they invited job applications.

Without exception, the alumnae and alumni were enthusiastic ambassadors for physics. They were proud of their physics education, which they credited for their successful careers. All identified themselves as physicists, although their job titles identified them as something else. Some of them had landed their jobs in curious ways; some had jobs with fascinating challenges; some had started new companies, sold their companies, and made lots of money. All enjoyed their lives as physicists. The visitors revealed a new world to the students, who described the experience as "eye-opening."

The alums were also honest ambassadors. Many of the nonacademic physicists reported that, because they wanted to take their bachelor's, master's, or doctor's degree and work in industry or in some other nonacademic environ-

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ment, their physics professors had made them feel like second-class citizens—even failures. In stark contrast, several of the visitors further revealed that the engineers with whom they worked—including those with bachelor's degrees only—were treated as professionals and respected by their former engineering professors. The alums indicated, either implicitly or explicitly, that their former physics professors did not regard them as legitimate physicists.

hancing both the supply side of apprentices and the demand side for new physicists. Consider first the supply side. A well-designed marketing program will demonstrate to students the strong base that a physics education, with its accompanying toolkit and disciplined way of thinking, provides for employment. Even more, it will reveal the great range of careers that physicists actually pursue. As soon as new physicists are produced, they become alumnae or alumni. A powerful marketing strategy can be organized around those alums, a many-faceted strategy with numerous benefits for the business of academic physics.

Alums: The untapped resource

The core of any marketing strategy for new physicists is to bring alumnae and alumni into direct contact with students and faculty. Such contact will expose students to a delightfully successful array of physics professionals pursuing a myriad of careers. A panel of several alums speaking to an introductory physics class could allay student concerns about job possibilities. In addition, exposure to physicists pursuing nonacademic careers could arm faculty with concrete information and specific insights that may strengthen their ability to advise students about career options.

For the past two years, one of us (Rigden) conducted a one-credit upper-division course in the physics department at the University of Maryland, College Park. Each week, an alum or a nonacademic physicist came to the physics department to talk with those in the class, including many—even some postdocs—who showed up for no credit. Throughout the semester there were physicists with BS, MS, and PhD degrees. All of them, regardless of degree, were identified as physicists. All of them, without exception, were delighted to have been asked and were delighted to talk to the students. The guest physicists opened up and discussed their professional lives in their

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Find and exploit the resource

Academic physics can exploit the untapped resource of its alumnae and alumni in many ways. A challenging prerequisite for any activity, however, is finding the former students—not just the PhDs, but all of them. Developing and maintaining an accurate database of graduates will pay enormous dividends. Engineering departments routinely keep track of former students. One strategy for locating alums is to send a letter of interest to their parents around the end-of-year holidays, when parents and children are typically in contact. Inform the parents of the department's interest in making or reestablishing contact with their children. One way or another, acquire and assemble the alums' postal addresses, e-mail addresses, jobs, and brief career profiles.

And don't neglect the nascent alums. Faculty members must demonstrate to their current students that they, the faculty, see their students as potential colleagues, are interested in the careers they choose to pursue, respect those career choices, and want to stay in touch. Impress on students the need to maintain contact and update their addresses. The World Wide Web is an ideal vehicle for such continued contact.

Once an accurate database is in hand, there are several ways to implement a marketing program. Here are a few ideas:

► Bring alumnae, alumni, or nonacademic physicists to campus on a regular basis to talk with students in a for-

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mal credit course, an informal noncredit course, a seminar-type course, or a brown-bag colloquium series. Remember to provide opportunities for visiting physicists to talk with students informally so that the visitors can listen to student concerns and questions. Promote these events. But do it regularly, not sporadically. The occasional appearance of a nonacademic physicist on campus will not have the desired effect. Undergraduate students should see 5 or 6 such visitors *every* academic year.

- Create a departmental alum advisory committee and have committee members meet with faculty and students at least once a year. Physics alums would be willing, even eager, to serve on such an advisory group. The group can help faculty determine how the department offerings can better anticipate and meet needs in the workplace and how faculty can better advise students on career needs.

- Arrange for an alum or some members of the advisory committee to talk to students in the introductory physics classes. Some of those students are in the process of deciding on a major. A successful alumna or alumnus could turn a student's decision in the direction of physics. Alums can also talk to students in intermediate and advanced classes, particularly when an alum's work and the current class topic overlap.

- Provide opportunities, expedited when possible with the help of alums, for students to spend summers or a semester working in industry. Industries highly value internships, which provide enthusiastic help for little cost. And such experience makes students more attractive candidates for future employment. Often, an internship leads to a job offer.

- Visit key high schools with a team of faculty members plus an alum. Talk to students in the physics class about careers in physics.

- Encourage students to form their own departmental organizations, like a physics club or a chapter of the Society of Physics Students. If such an organization exists, encourage its members to work with faculty and alums as the students develop their programs or activities.

A major benefit of having alums help market new physicists is that such an effort costs little, if anything. Many businesses and industries welcome the opportunity for their employees to talk with students and faculty, and the companies often pay any related expenses. In the College Park program, not one alum asked for any expense money.

Needed: Increased visibility

An irony that must be recognized on the demand side for new physicists is that, although some managers and human resources personnel in industry and business are aware of physicists in their midst, most are not. A physicist is hired but then given a job title of, say, "engineer." It is soon forgotten that under that title lives a physicist. Such employees' talents and skills are recognized, but their identity is not. So, when positions need to be filled, industries routinely

send recruiters to engineering departments but rarely to physics departments.

Again, alums can be an asset. Alums invited back to their campus become acquainted with both students and faculty and thus help establish lines of communication. As graduation nears, students can contact alums and seek advice and help in the job hunt. When positions open at an alum's place of employment, he or she can suggest that recruiters visit the physics department and interview specific candidates. Alumnae and alumni can be encouraged to raise the visibility of physicists in the workplace by getting their titles changed to identify them as physicists. (One participant in the College Park program had her title changed from engineer to engineering physicist.)

A management makeover

In addition to adopting marketing initiatives, academic physics needs to modify its management style. Physics faculty tend to regard as physicists only those who hold a PhD in the field and are doing basic research. That narrow, self-perpetuating view is extremely counterproductive and leaves the vast majority of new physicists, at all degree levels, disenfranchised. The bulk of one of the two great product lines is tossed aside. Small wonder that the business of physics is having trouble. Physics graduates are generally proud of their physics degree, but they resent being treated by their professors as throwaways because they work in a nonacademic environment. All physics degree holders—bachelors, masters, and doctors—are physicists and should be treated as such.

The negative attitude exhibited by physics professors toward baccalaureates in physics has influenced attitudes in at least one industry that we know of. According to an honest, but in our view misguided, representative from a large industrial firm in New York, "We hire PhDs in physics and baccalaureates in engineering. Bright students in physics go on to get a PhD; dumb ones take their bachelor's and look for a job. By contrast, bright students in engineering take their bachelor's and look for a job; dumb engineering students go on for a PhD." Such an attitude echoes, and may have been fostered by, the attitudes prevalent in most physics departments, yet it is at odds with the notable success of physics baccalaureates. Physics management, in the form of department chairs and faculty, must recognize its own potential to pollute the workforce atmosphere and resolve to change its modus operandi.

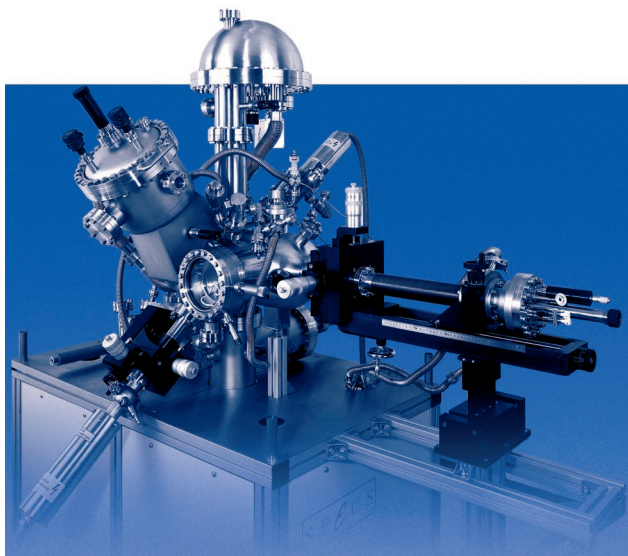
Most academic physicists begin and end their careers in an academic setting. Thus, they have no direct knowledge about the careers that the great majority of new physicists pursue. Management needs to address this ignorance.

The new knowledge product line of academic physics is robust with adequate raw materials, abundant customers, and an effective marketing program. New knowledge has great currency in the technological business world and resonates with the general public, which is fas-

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Tapping the Resource

During the current 2003–04 academic year, a number of US physics departments are offering a program similar to the one conducted at the University of Maryland, College Park. The participating departments include the University of Arkansas at Little Rock; Central Michigan University; University of Delaware; George Mason University; Georgia Institute of Technology; Georgia State University; Indiana University; Johns Hopkins University; University of Louisville; Loyola University of Chicago; University of Massachusetts, Boston; Miami University of Ohio; University of Missouri–Kansas City; Morgan State University; North Carolina State University; Purdue University; Rensselaer Polytechnic Institute; San Francisco State University; Washington University in St. Louis, Missouri; Xavier University in Cincinnati, Ohio; and Xavier University in New Orleans, Louisiana. The experiences of these 21 institutions, both the good and the bad, will be assembled by the American Institute of Physics staff, and the results will be disseminated to all physics departments.

There are other, but not nearly enough, efforts to make advantageous use of alumnae and alumni. For example, at Haverford College, seniors use an alum database to conduct telephone interviews with physics alums of their choice. They then share the results of the interview in an oral presentation to a senior seminar class. The results are also preserved in writing for the benefit of other students. We welcome information about other similar programs, which can be sent to jstith@aip.org

inated by the bizarre ideas of physics. The new physicist product line is a generally contented group of alumnae and alumni who make important contributions to their employers and society. But the new physicist product line of academic physics is hurting because of a shortage of raw materials and a lack of appropriate marketing efforts.

The management of academic physics needs review. Managers—administrators, department chairs, and faculty members—all need to acknowledge and accept the cogent reality that the large majority of new physicists want to contribute in new ways. New physicists are not interested in being academic physicists, not interested in being like their physics professors. And management needs to accept the validity of that stance. They also must recognize that the working world has many homes for physicists, and many physics graduates have found those homes to be happy ones. To stem the decline in the number of new physicists being produced, the managers need to initiate marketing strategies using a valuable untapped resource: their alumnae and alumni. A beginning has been made (see the box on this page), but it is only a beginning.

References

1. P. J. Mulvey, S. Nicholson, *Enrollments and Degrees Report*, AIP pub. no. R-151.39 (August 2003). The report is available online at <http://www.aip.org/statistics/trends/undtrends.htm>.
2. In recent years, the issue of the declining number of physics majors has drawn wide attention within the physics community. See in particular R. C. Hilborn, R. H. Howes, K. S. Krane, eds., *Strategic Programs for Innovations in Undergraduate Physics: Project Report*, American Association of Physics Teachers, College Park, Md. (2003) and R. Ehrlich, *Amer. J. Phys.* **66**, 79 (1998).
3. E. Seymour, N. M. Hewitt, *Talking About Leaving: Why Undergraduates Leave the Sciences*, Westview Press, Boulder, Colo. (1997).