Sustainability of the Academic Enterprise in the United States

My interest in entrepreneurship in nanotechnology inspired my recent participation in the National Science Foundation (NSF) iCorp program.[1] What are the needs of potential customers, the amount of money they are willing to spend, and the costs of production at high-tech enterprises? However, I soon started thinking about how much ingenuity and entrepreneurship we need to apply in running the everyday operations of a university laboratory—the academic enterprises that give birth to new technologies. This subject of the academic enterprise itself and its costs—monetary and personal—appear to me more urgent.

The economics of an academic enterprise are pretty simple. A professor applies for grants to federal agencies, industry, and foundations. If those agencies like the professor and his research group's ideas and products, and trust in their ability to deliver, they give the group the money to implement them. The support goes to pay for the workforce (students, postdocs, staff, *etc.*), facilities, and raw materials.

Looking at the research process from this perspective gave me pause. It seems that the economic foundation of our research enterprise is in trouble. Its current business model based on this description is not sustainable with its current trajectory. The academic enterprise in the United States is threatened by the inability of our customers (*i.e.*, our funding agencies) to pay for our products. I do not want to give a macroeconomic assessment that can be found in official reports but rather to share some observations "from the trenches". A systematic review of these difficulties is also beyond my capabilities because, in fact, I have to complete my own NSF proposal as soon as possible!

The economic foundation of our research enterprise is in trouble.

First, the cost for the research workforce is constantly increasing, while the amount of money available to pay for it is persistently constant or decreasing. In fact, one typical single-investigator grant from the NSF or another federal agency cannot fund the research work of even a single Ph.D. student at my university when taking into account its full costs: stipend, tuition, benefits, and research expenses (facilities, chemicals, publications, *etc.*). Second, when I participate in NSF and National Institutes of Health (NIH) panels, of five to eight deserving proposals (from a total of 20 or 30) that propose exciting ideas, have PIs with top-notch past performance, and garner support of the panels, typically only one to three of them will eventually be funded, often with a much reduced budget. In the language of simple economics, the majority of professors and their students are not getting a return for the time they spent preparing their ideas and proposals. The resources used for the acquisition of preliminary results need to be covered from other sources, as well. Third, there are few opportunities to replace aging analytical and other routine instrumentation in established laboratories. Exceptions include NIH proposals with modular budgets, rare center grants with designated shared facilities, and equipment-focused programs with submissions from (even large) universities limited. Adding a routine $100,000 fluorescence spectrometer breaks the bank of any proposals to NSF, the Department of Defense, or industry; inclusion of instrumentation is often discouraged. Fourth, a dedicated and sympathetic program manager from one of these agencies responsible for basic research informed me that the budget for this agency was reduced by 27%. Under the program, managers have trouble fulfilling their obligations even to previously made grants. Fifth, the large instrumentation base in shared facilities essential for scientific discoveries in countries such as China, Singapore, and South Korea is often significantly better than in comparable universities in the United States. These are the countries that plan to be technological leaders and are making the investments necessary to realize these goals.

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I suspect that our readers can find more signs of trouble without encouragement. Some of the signs relate to intangible aspects of the academic enterprise. I would not underestimate them in assessing academia's sustainability because it is so strongly dependent on human factors. Although there is a good measure of prestige and freedom of direction associated with an academic position in the United States and ever increasing start-up funds provided by American colleges and universities to their young faculty, the attractiveness of academic jobs in the United States seems to be decreasing.[2] Many of our own group alumni choose to start their academic careers overseas, whereas they previously would have been more likely to stay in the United States. I was initially surprised, but then the logic became clear. The probability of getting a project funded is low, let us say 15%. Many would argue that it is lower, but let us consider the best case scenario for a young faculty with many exciting projects in mind that can electrify the review panels. By burning the midnight oil, one can write perhaps one fundable proposal per month (including revisions). This excruciating effort gives the principal investigator (PI) a reasonable chance to have funding for approximately one student. Repeating this cycle for a period of three years will give the PI three or so students and hopefully some summer salary. Will that be enough to get tenure? Will there be enough time left to write papers and to fight through their rejections? What is more important, a strong family or a strong career? These are painful questions that do not bode well for raising the hopes of talented young American and immigrant scientists. This situation does not sustain academic excellence in this country.

Another observation from the trenches is that the same doubts affect senior faculty. They are exemplified by the recent departures of several high-profile scientists to other countries. These scientists are dedicated, die-in-the-office, award-winning academicians who were nothing but successful in their academic enterprises. Since the second half of the 20th century, the United States has been the special destination for global academic talent, but there are strong indications that this trend is now being reversed. Our customers care about it as much as we do. We are in this situation together and are interested in the same outcome. Fixing the misguided strangulation of our domestic research enterprise will require both entrepreneurship and activism. Doing so will advance domestic *and* global science, technology, and medicine, as well as our economies.

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Disclosure: Views expressed in this editorial are those of the author and not necessarily the views of the ACS.

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