

## Malthus And Graduate Students: Checks On Burgeoning Ranks Of Ph.D.'s

by Jesse H Ausubel

The proletariat of American research, the graduate students and the postdocs, cry and whisper. Internet traffic even suggests they organize. At Yale, some struck. Meanwhile, William Massy of Stanford University and Charles Goldman of RAND Corp. present a fresh analysis to explain the doctoral system (W.F. Massy, C.A. Goldman, *The Production and Utilization of Science and Engineering Doctorates in the United States*, Stanford Institute for Higher Education Research, 1995), and the National Academy of Sciences (NAS) complex releases two major assessments of American graduate education and research (*Reshaping the Graduate Education of Scientists and Engineers and Research-Doctorate Programs in the United States*, NAS, Washington, D.C., 1995). The bottom line is that alma mater is doctoring too many children.

Malthus's classic negative checks on population were famine, war, and ill health. Here I would like to provide a backdrop for considering more positive checks on the burgeoning number of Ph.D.'s, drawing in part on the facts and findings in the three 1995 studies. Five features dominate: expansion of degree-granting franchises; the forgotten origin of the expansion, a need for teachers; emergence of a research enterprise recruiting students to sustain itself; a star system for faculty, further tipping graduate schools toward research; and, finally, too many doctorates. My positive checks, like those of Malthus, will involve better understanding and purposeful action as well as moral restraint.

The number and size of universities granting doctorates have multiplied. Gaining status, the institutions awarding a Ph.D. in science and engineering (S&E) doubled from 1961 to 1991, reaching 299. Grantors of master's degrees in S&E slightly more than doubled in the same period, reaching 442, and provide a ready pool to multiply the population of schools granting Ph.D.'s still more.

No convincing logic defines the optimal set of doctoral programs for America. However, absolute numbers now impress in almost every field. In each major sub-field within biology, 100 to 200 schools now award Ph.D.'s. Circa 1990, 182 granted degrees in physics, 169 in mathematics, and 130 in civil engineering. Even in a sub-sub field such as biomedical engineering 86 granted Ph.D.'s, and in the sub-field of physics and biology called oceanography, 50 did so.

Enrollment multiplied as the franchises expanded. From 1967 to 1992, graduate students of all kinds increased about half, twice the growth of the United States population. They multiplied from slightly less than a half-million to just over

two-thirds million. The swelling number of schools increased the annual output of S&E Ph.D.'s from about 18,000 to 25,000 during the decade 1983-93.

If a franchise means spending \$30 million or more of federal money annually for basic research, about 100 institutions have franchises. In 1970 only about 30 universities had large research programs. (The 100 produce about 90 percent of Ph.D.'s.)

From 1960 to now, major league baseball added more franchises, too, from 16 to 28. The New York Yankees could not maintain their dynasty in that expanding field. The 1995 NAS ranking of doctoral programs in dozens of fields showed predictably that the average rank of most universities declined with the expanding number of competitors, worsening morale and lengthening the climb to the top of the standings. Questions also arise about the qualifications of a larger absolute number of students and faculty.

In the 1950s, war veterans swelled the ranks of students. Recovering from the thin years of the Depression, colleges needed teachers quickly. Fresh Ph.D.'s staffed the rapidly expanding state universities and enlarging older institutions, too. Subsequently, democratization of educational opportunity and the baby boom sustained the college boom.

Secondarily, the government paid for training technical personnel to compete with the perceived scientific prowess of the Soviets. With fresh memories of the victories of science in World War II and ample tax revenues, the government paid for research campaigns, even a war on cancer. These payments to spend more time on research encouraged professors to cut their hours of contact with students from, say, nine to three per week, tripling-in this example-the need for teachers (or teaching assistants).

Notwithstanding the college boom, the fraction of Ph.D.'s employed in academe declined from about 55 percent in 1973 to about 45 percent in 1991. The fraction whose primary work is teaching dropped from 36 percent in 1972 to 23 percent in 1991. Meanwhile, the fraction no longer performing research, the presumed goal of a Ph.D., or whose work was unclear, doubled to about one-third of those surveyed. When the investment in a degree totals \$250,000, one wonders for these lost researchers whether doctoral training was a wise choice, for them or the nation.

By the 1980s, the demand for full-fledged teachers slowed, a large cadre of principal investigators was in place, and the research enterprise needed skilled workers. The

market for Ph.D.'s no longer drove the production of Ph.D.'s but rather the need of the research enterprise for low-cost labor called graduate students and postdocs. The enterprise perfumes this reality by praising the effectiveness of joint education and research. Of course, no oppressive conspiracy existed. Rather, individual faculty and funders have acted rationally in their self-interest, heedless until recently of possibly harmful collective effects.

Objective understanding of doctoral production and use demystifies many current features of the system. These include the lengthening time to get a degree and the growing number of foreign students. Doctoral students and postdocs substitute for faculty in research. They also unburden faculty, more in the humanities and social sciences, in undergraduate teaching and evaluation. Expanding graduate enrollments and postdocs costs less than hiring new faculty. Moreover, faculty—especially young faculty—competing for promotion and eminence through research logically recruit yet more graduate students but lack an incentive to speed them to a degree.

Recruits to S&E face a dim future: six or seven years registered for a degree, eight or nine years from B.S. to Ph.D., then one or more postdocs, and thus no substantial income until past age 30. In the life sciences, for example, the Ph.D.'s age to a median of 33 years by the time they land their first permanent job.

American undergraduates with exceptional talent likely spy the opportunity costs posed by the long apprenticeship. Far superior incomes in other careers leave science attracting only those young Americans who hear a profound calling. In fact, the number of American male Ph.D.'s has shrunk for a quarter-century. Women and foreign students account for the growth. In many schools and fields, roughly half of graduate students and postdocs are foreign.

Foreign youth still know graduate training in America will propel them upward. Preferring to remain in the U.S., they may accept slow progression to the degree and a succession of low-paying postdocs. The practically infinite availability of young foreign talent could maintain the system as it exists, although politics, prosperity, and currencies cause fluctuations. Japan, Taiwan, Korea, and China send the most students. China, India, Malaysia, and Indonesia send particularly high fractions for engineering and science.

Senior faculty have evolved a strategy of horizontally mobile stars, akin to "free agency" in baseball. The stars auction themselves to the highest bidder, driving up the cost of their services. Ratcheting up the top-most compensation packages, they restrict the dollars for expansion of the middle class of permanent faculty. The recent end to mandatory retirement at age 70 works in the same direction. At the same time the middle class is restricted, the enterprise tilts from teaching toward the research that brightens the stars.

The stars' ambitions and tastes require not more undergraduates but more workers. Thus, institutions offer or accommodate more graduate students and postdocs as part of their bid for a star, and also hire more cheap adjunct teaching faculty to moderate the wage bill. The number and years of the postdocs expanded most dramatically in biology, where the fraction of postdocs so employed one to four years after an American Ph.D. first climbed rapidly during the 1970s and now hovers around 40 percent. As almost all fields boarded the bandwagon, the number of S&E postdocs tripled from about 8,000 in 1975 to 24,000 in 1992. The stars are well served.

At the bottom line, one finds the "natural production rate" of Ph.D.'s in the American system based on the population of professors in doctorate programs and the total fertility rate of each professor. Physicist David Goodstein of the California Institute of Technology puts that fertility rate at about 15 Ph.D.'s per professorial career in fields he knows, while I guess the rate necessary for breeding professors to replace the national population of S&E Ph.D.'s is about five per career. The present outcome exceeds the steady-state intake of faculty into U.S. schools more than the demand from American industry and government and from abroad can absorb. Students stretch out their school years, partly because job prospects are poor, and partly because funders and peers of the discipline favor money for students or recruits. The life of the postdoc provides a further way to stretch the years, but even their numbers may be near saturation.

Persuasive recent findings by Massy and Goldman, funded by the New York-based Alfred P. Sloan Foundation, hint Ph.D.'s in engineering, math, and some sciences are currently overproduced fully 25 percent.

An expansion of universities or research could temporarily absorb the excess doctorates, but within a few years, sponsoring more university research would worsen Ph.D. job prospects in S&E. Immediate gains from faculty expansion would give way to more oversupply as expanded doctoral programs produce yet more graduates.

Universities must reconsider production of Ph.D.'s and the invisible hands of franchise expansion, recruiting to sustain the enterprise, and stars that propel it. We should seek positive checks on population rather than suffer the academic equivalents of famine, war, and ill health.

The prescription must produce research without producing the disillusioned. During a period when money from research remains steady or falls, some universities might well revisit an antiquated system of staffing that makes durable commitments to technicians and shelters faculty who do not hold the high expectations of fresh Ph.D.'s and postdocs. Universities could reward students who finish fast, and penalize faculty whose students loiter.

Valorizing the master's degree in sciences would reduce exploitation. In engineering, the master's is respected and

lucrative, while in scientific fields it is a stigmatized consolation. Consider students who look forward to careers in business or secondary schools, which might be where the elusive third of the Ph.D.'s went. For them, instead of a protracted and disillusioning Ph.D., an intensive two years of science courses after a B.S. program might meet their needs while benefiting the nation and reflecting glory instead of disenchantment on the university.

Another positive prescription is reducing the cost of research without a youthful army of exploited inductees minimizing labor cost. The late Yale historian of science Derek de Solla Price resignedly conjectured that scientific results grow at the discouraging price of the cube root of the expense (Little Science, Big Science ... and Beyond, Columbia University Press, 1986). Cannot science find routes to increase its productivity, as other service industries now aggressively do? Surely, for example, scientists in America should spend more time doing research and less time proposing and reviewing.

Affection for alma mater and recognition of the invisible hands driving her causes several of us to try seriously to create "SimU." Opportunities come from understanding the university as a system, in particular how the actors make their decisions. In more and more useful ways, simulation games raise questions about how agents behave and how the parts of a system interact. Such tools now simulate oil refineries and factories, the oceans and the atmosphere.

Maxis Software Inc. of Orinda, Calif., has created educational and commercially successful games, engagingly called SimEarth and SimCity. Seeking a learning tool for the many people and organizations concerned with the problems and solutions discussed here, experts in universities and simulations are beginning to create a virtual alma mater of Malthusian forces, invisible hands, and stakeholders. It may help universities manage better. The proletariat who cry and whisper on the Internet deserve at least this much.

Ausubei Jesse H. Ausubel is director of the Program for the Human Environment at Rockefeller University and a program officer for the Alfred P. Sloan Foundation in New York, where he leads the foundation's program on "The University as a System and the System of Universities."