tutes and universities, the bosses or professors are 'great' people. We do not discuss our research with them frankly or frequently," says a physicist who graduated from the Tokyo Institute of Technology.

Academic reformers such as Arima of the University Council advocate abolishing tenure for junior faculty, but others worry that such changes, while desirable, would not attack the underlying problem. The lack of lateral career movement, they point out, is because vertical links with mentors and subordinates are far more important than are horizontal links with peers. "For most scientists in Japan, the greatest success is to inherit your post from your professor," says Harvard's Nakanishi. "If a professor doesn't get one of his own students to inherit his professorship, he's considered a failure."

A professor's biggest responsibility is to find good jobs for his or her students through *kone* ("connections"), says Cornell's Smith. A young scientist who changes labs or fields breaks that bond, and "without *kone*, you have a real problem," says Smith. "You would be seen as a disloyal person who cannot be counted on."

Not that this doesn't happen from time to time. "If a young student is ambitious enough, they want to become better than what exists now," says Yasuo Fukui, a Nagoya University radio astronomer. "But if not, they pay more attention to human relations." At age 28, Fukui himself left the University of Tokyo, where he was expected to work on projects designed by others, to join Nagoya, which offered him the chance to develop novel experiments.

Although many researchers say this kind of career flexibility is essential for Japanese science to become truly competitive, others question whether a competitive system is inherently more desirable than the stability they now enjoy. "Our system has some good points," argues Koji Kaya, a chemistry professor at Keio University. "In order to understand the fundamental science, you have to focus on a special point," something that would be difficult in a publish-or-perish atmosphere. What's more, without greater career flexibility in the larger society, it would be difficult, and perhaps cruel, to impose a competitive system only on academic researchers.

Fortunately, there are signs that society is beginning to move in that direction. Indeed, the strain of competing globally is forcing more Japanese companies to adopt a more flexible system of hiring and promotion. Advocates of greater openness and competition in science are hoping that the trend spills over into higher education in time to foster greater independence in the next generation of scientists.

–June Kinoshita

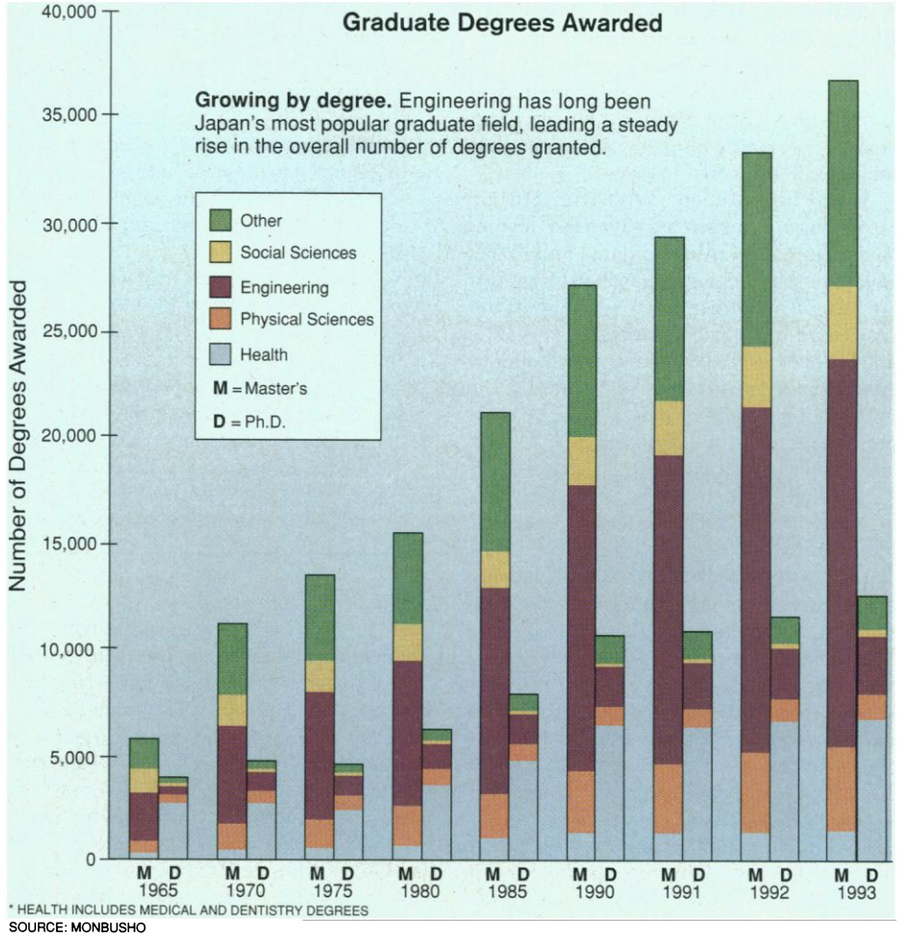
GRADUATE EDUCATION

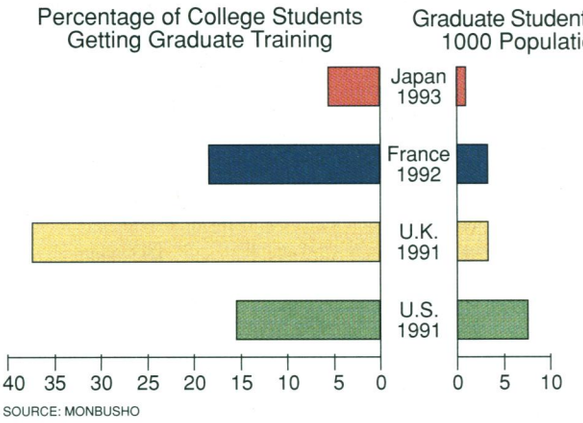
Corporate Concerns and Cost Clamp Down on Ph.D. Output

Six months after starting work on a master's degree in computer science at Nagoya University, Akira Naruse decided it would be the last degree he would pursue. "The feeling that there was any merit in going on [for a doctoral degree] disappeared," he says about his preference for developing new computer systems over expanding the boundaries of basic computer science. Then there were the financial considerations. "You're not making any money as a student at a Japanese university," he says. So this spring, after receiving his degree, Naruse joined Fujitsu Laboratories Ltd., the research subsidiary of the world's second-largest computer firm. He is working on future computer systems, a challenge he enjoys, and he's getting paid well to do it.

Naruse's choice illustrates two major obstacles facing Japanese universities as they try to expand dramatically the number of students obtaining advanced degrees, particularly doctorates. One is the view of the private sector that Ph.D.s are narrowly trained specialists with little inclination and inadequate preparation to tackle problems outside their niche. "The problem is that the expertise of Ph.D.s often differs from what a company needs," says Takuma Yamamoto, Fujitsu Ltd.'s chair. The second is the lack of financial rewards a student is likely to earn for the additional investment in time and training required for a research degree.

Industry's attitude is crucial in shaping the academic decisions of budding scientists simply because Japanese companies are the country's major R&D players. Even after declining for three consecutive years, corporate spending accounted for 78% of Japan's total research spending and some two-thirds of research employment. (By comparison, U.S. companies provide only 58% of the nation's R&D spending, although industrial scien-





Holding back. Graduate studies are much less popular in Japan than in several of its Western industrial counterparts.

tists and engineers perform the bulk of the country's R&D.)

That proportion seems unlikely to shift anytime soon. Akito Arima, former president of the University of Tokyo and a staunch supporter of expanding graduate schools, notes that a rapidly declining school-age population will make it difficult for the government to increase the number of university positions. And permanent places for Ph.D.s in government labs are not likely to expand much, either. For example, the Institute of Physical and Chemical Research (RIKEN), one of Japan's largest publicly supported research institutes, added just eight scientists to its permanent staff—all with Ph.D.s—although it gave contracts of 3 to 5 years to another hundred or so Ph.D.s. Providing positions for the new Ph.D.s, says Arima, now RIKEN's president, "will require the acceptance of Ph.D.s in industry, and this is not happening yet."

Take Hitachi Ltd., one of Japan's biggest corporate spenders on research. The company hired 107 graduating scientists and engineers this year for its research staff, but only 14 have doctorates. And those new hires are being paid roughly the same salaries as Hitachi employees of the same age who hold bachelor's and master's degrees, says Shojiro Asai, general manager of Hitachi's Advanced Research Laboratory. Even that policy, he says, is an improvement over the rules when he joined Hitachi in 1968 after earning a doctorate in applied physics at the University of Tokyo: Ph.D.s were paid less than colleagues the same age who had less education but more experience at Hitachi.

Hitachi's salary schedule is indicative of how the private sector views Ph.D.s. "There is a feeling that those [in Ph.D. courses] are the leftovers," says Toshimitsu Shinohara, a manager in the science and technology group of Keidanren, Japan's most influential business organization. Consistent with that view is a widespread belief among business leaders that many students enrolled in graduate school during the recent recession simply to delay entering a weak job market.

But more fundamentally, corporations don't pay Ph.D.s. better because they don't see a doctorate as an indication of greater ability. "We have Ph.D.s who have proven very capable researchers," says Tatsuo Ishiguro, associate senior vice president for research at NEC Corp. "But Ph.D.s have not, overall, proven more capable than those with master's degrees."

Fujitsu's recent hiring practices illustrate that attitude. Of the 300 graduating scientists and engineers it hired this year for technical positions throughout the company, 240 had master's degrees and only 15 had doctorates. Before corporations hire Ph.D.s, they tend to look closely at whether their research interests fit with a current project. "With the high specialization of a Ph.D., [suitable] work is naturally restricted," says Rikuro Okazawa, general manager of human resources development at Fujitsu. NEC's Ishiguro adds that "it's not necessary for university and corporate interests to match exactly. But now there is little match at all."

Fujitsu's Yamamoto blames the mismatch on poor ties between universities and industry. He says Japan has "very few of the kinds of exchanges" that are common elsewhere—in which senior-level corporate researchers become professors and vice versa. Hitachi's Asai says that industry shares the blame, however, for not recognizing that the long deterioration of university facilities would undermine academic research. "Industry should have helped universities get refurbished earlier," he says.

Academia and industry are both trying to make up for lost time. Yamamoto says industry and academic leaders are meeting to discuss greater cooperation. In a report earlier this year, the Council for Science and Technology, an advisory body to the Science and Technology Agency, urged an easing of restrictions on what professors can do for private industry and stronger patent rights for campus discoveries. Eiichi Kajita, a professor at Kyoto University's Center for Integrative Research on Didactic Systems in Higher Education, says there is growing pressure for change stemming from a realization that graduate schools "have not really been fostering student creativity." And a new program by the Ministry of Education, Science, Sports, and Culture (Monbusho) has enabled 20 universities to set up venture business laboratories to promote research in emerging commercial fields.

There are also initiatives to ease the financial burdens on students. The largest student loan program, run by an arm of Monbusho, actually penalizes students who enter the private sector by requiring them to repay their loans. Those joining the public sector, which includes faculty at national universities, are exempt. And the stipends themselves—about $1070 a month for doctoral students—are not really adequate to cover both tuition and living expenses. Shigehiko Yamamoto, professor of physics at the University of Tsukuba, says the lack of financial assistance "is the biggest problem" in boosting graduate school enrollment.

Help may be on the way. A Monbusho advisory council is studying ways of making more financial aid available, including requiring public servants to repay all or part of the student loans. Monbusho and other government agencies are also expanding teaching and research assistantship schemes and outright grants and scholarships. And the Council for Science and Technology is weighing a plan to boost the pay of Ph.D.s at government labs and institutes in the hope of influencing the private sector.

There is anecdotal evidence that companies are beginning to lower the barrier to Ph.D.s. Fujitsu's Yamamoto, for example, says that increasingly tough international competition and Japan's skyrocketing personnel costs have forced industry to rethink its former "leisurely approach" to training personnel and to put more emphasis on finding students "whose university training can be directly useful to the company." They seem to be succeeding: This year's crop of 15 Ph.D.s at Fujitsu, notes Okazawa, is probably double the number hired 5 years ago.

Some academic scientists are optimistic that Ph.D.s will eventually catch on in the corporate world. "Thirty years ago, it wasn't clear that master's degree–holders would find jobs," says Shoji Usami, dean of the school of science and engineering at Waseda University. But others are worried that stronger demand for Ph.D.s may not evolve quickly enough to match the government's projected output. "We are increasing the number of Ph.D.s very quickly," says RIKEN's Arima. "But do we have enough positions for them? The answer is no," he says.

That answer is hardly news to students. "Very severe competition looms [for academic posts]," says Kyoto University neuroscience graduate student Atsushi Nishimune. Until that situation improves, Akira Naruse's decision to end his academic training at the master's level seems likely to remain the most popular option for graduate students interested in applied research.

–Dennis Normile

With additional reporting by June Kinoshita.