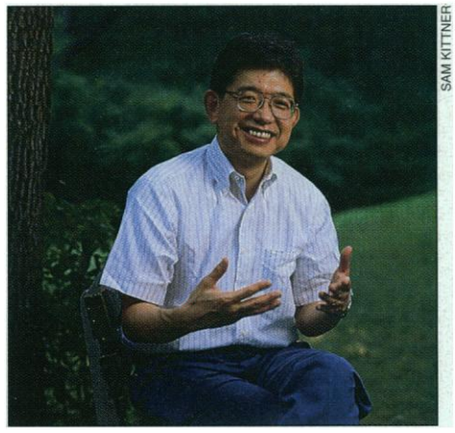
THE NEXT GENERATION

System's Rigidity Reduces Lure of Science As a Career



SAM KITTNER

Clear vision. Nagoya astronomer Yasuo Fukui spreads the word about science in summer symposia for the public.

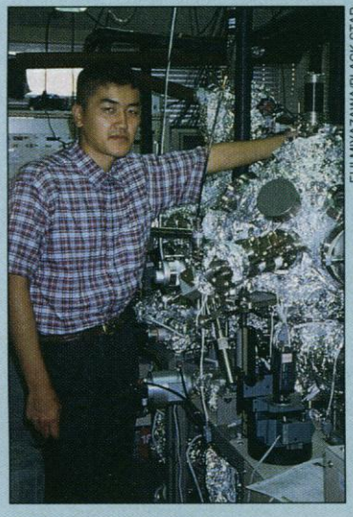
The obstacles facing a young student who contemplates an academic research career in Japan are truly daunting. First, there are stultifying, fact-packed high school classes, geared toward scoring high on the all-important college entrance exam. Once over that hurdle, there are several years of insipid college and graduate school curricula that often fail to provide a solid foundation in one's field. Then comes a long apprenticeship in a senior professor's lab, leading to a small measure of research independence by middle age. It's no wonder that Japanese research is often seen as lacking in innovation.

Indeed, as Japan embarks on an ambitious effort to increase spending on basic research, overhaul its universities, and double over the next decade the number of Ph.D.s awarded each year (see p. 52), some observers are arguing that those gains may not be sufficient to propel Japan to the front ranks of global science. The central challenge, they believe, will be to introduce real competition and tolerance of debate and nonconformity into a society that cherishes stability and hierarchy. "The [values of the] Japanese system work against progress in science," says one Japanese researcher who has opted for a career in the United States. But he doesn't rule out the possibility of returning to Japan some day. "In 20 years, things may be different," he says. "There are many talented people trying to change the system from the inside."

One sure sign of the need to shake up the system is evident at the point of entry: In a recent survey by the Ministry of Education, Science, Sports, and Culture (Monbusho), a majority of college students, including 66% of science majors, said they prefer courses that are "easy to understand," and 49% cited "usefulness." On the other hand, only 12% of science majors cited responses such as "schol-

Job Market Shapes Undergrad Studies

TSUKUBA, JAPAN—Shigeru Sugawara happily admits to a streak of individualism. In high school, his interest in physics was spurred by his classmates' dislike of the "gloomy" subject. Now he is a physics major at the University of Tsukuba, where he studies hard "because I figure it will help me stand out."



ELJI MIYAZAWA/BLACK STAR

Doctor, no. Shigeru Sugawara thinks job prospects are better with a master's degree than with a Ph.D.

This contrarian streak, however, is tempered by pragmatism. He set his sights on Tsukuba, for example, because living expenses are much lower than in Tokyo. With help from his parents, who live in nearby Chiba Prefecture, he pays $180 a month for a one-room, shared-kitchen-and-bath apartment that "goes for $500 a month in Tokyo," he says. And it's only a 5-minute bicycle ride from campus, meaning that he doesn't need to spend money on a car.

His one indulgence is tennis; he has joined the university tennis club and spends all of either Saturday or Sunday on the courts. "It might be a bit much," he confesses. Other leisure time is spent studying English or reading books, mostly science-related.

Like most fourth-year science and engineering students, the 22-year-old Sugawara has completed his regular courses and doesn't need to worry about a final exam or a minimum grade-point average. To graduate he needs only the additional credits he will earn writing a thesis. His topic is the structure and properties of gallium arsenide semiconductor materials using molecular beam epitaxy (MBE) techniques.

The lab, headed by Shigehiko Yamamoto, recently acquired a 10-year-old piece of MBE equipment discarded by a national institute. But the device must first be refurbished, and Yamamoto, Sugawara, and a graduate student are doing the work themselves because there are no technicians. Replacing the worn-out vacuum pump, he says, was a case of "just following the directions in the manual."

Sugawara plans to remain at Tsukuba for a master's degree after passing an entrance exam for graduate school. He plans to continue his work with gallium arsenide before applying his scientific expertise to such worldly problems as dwindling energy supplies and rising pollution levels by working on a topic such as photovoltaic materials. He is also worried about science's "gloomy image" among younger students. To combat that image, Sugawara volunteers one Saturday morning a month helping youngsters build simple science experiments.

Sugawara's love of physics, serious attitude, and social concerns make him an ideal candidate for a Ph.D. in physics, according to Yamamoto. "I want him to go on," he says.

But Sugawara's practical side is arguing against it, and he questions whether the government can reach its goal of doubling the number of Ph.D.s awarded by 2000. "I don't think there is much of a market for Ph.D.s," he says with some resignation. With the uncertainty of employment, he says getting a Ph.D. "would be really hard on the spirit." Instead, Sugawara hopes the university will find him an appropriate spot in one of the area's government or corporate labs. Sometimes, even individuals have to go with the crowd.

–Dennis Normile

arly development," and only 8% picked "discussion." "Higher education is taken rather casually in Japan," says Robert Smith, a Cornell University cultural anthropologist specializing in Japan. "Japanese exchange students who come here are shocked by the workload."

Japan's grueling system of college entrance exams must shoulder some of the blame for that indifference, say critics, by smothering a student's desire to learn. It also doesn't help that job prospects are determined largely by the college one graduates from, not how well one does. "The idea is that if you're good enough to get into a prestigious university, that's enough to get a good job," observes Smith. What's more, students generally pick a university whose rank matches their academic performance in high school. "Self-selection is a big problem for us," says Fumio Murakami, a neurobiologist at Osaka University. "Students choose a faculty based on their high school grades. Then they arrive and say they don't know what they want to do. It's because they didn't choose based on their interests."

Proposals to adopt broader criteria for college admissions are being considered by the influential University Council, which advises Monbusho on academic reform. But the council's vice president, Akito Arima, who favors such changes, says he doesn't expect any major overhaul in the entrance exam

Women Fight Uphill Battle for Equity

Mariko Kato loves her husband, but 4 years ago she divorced him. It was strictly a divorce of convenience. Kato, a theoretical astrophysicist at Keio University, was fed up with the consequences of a Japanese law that requires married couples to take a single surname, generally the husband's. While legally she had changed her name, Kato was determined to use her maiden name professionally. But that meant every time Kato applied for a grant or a visa to travel to international meetings, she had to argue with uncaring bureaucrats that she and the scientist on the application were the same person. So in 1992, after 7 years of marriage, Kato divorced her husband, an astronomer at the University of Tokyo.

EIJI MIYAZAWA/BLACK STAR

Split loyalties. Keio's Kato resorted to divorce to retain her professional identity.

Kato's unusual domestic situation—she continues to live as a family with her former husband and their daughter—is part of a bigger problem facing female scientists in Japan. Although growing numbers are filling lab benches in Japanese universities and represent a vastly underutilized resource, women remain invisible to policymakers. Almost nothing, for example, is being done about such issues as workplace discrimination, sexual harassment, and the lack of adequate child care. Reports issued by the Science and Technology Agency and the Ministry of Education, Science, Sports, and Culture (Monbusho) promote the idea of women's participation in science but stop short of offering specific corrective measures. Indeed, a Monbusho publicist asked to locate anyone in the ministry who might be working on the issue paused before replying carefully, "That would be very difficult."

Why are women's issues not receiving more attention? One answer may be that conditions in academia, although difficult, are better than in the larger society. "Compared to working in a company, I think academics is more open to women," says Risa Kitagawa, a doctoral student in molecular biology at Nagoya University.

But that tolerance falls well short of equal status. According to 1992 Monbusho figures, only 6.7% of women on natural science faculties are full professors, compared with 29.6% of male faculty. The U.S. figure, in comparison, is 19%, although the percentage of U.S. men in the top rank—42%—is also higher than in Japan. The vast majority of women faculty, 70.3%, occupy the lowest rung as research associates, whereas only 35.5% of men do. Women scientists are virtually nonexistent in high administrative posts, as symposium speakers, or as major grant recipients.

However, even that low visibility is a step up from a generation ago. "At Kyushu University in the 1970s, advertisements for academic posts said clearly these were jobs for men only," recalls Mitiko Go, a theoretical biologist who once worked without pay at Kyushu and is now a full professor at Nagoya. Go suspects that most discrimination today takes a subtler form. "I myself can't say for certain that I've experienced discrimination—it's hard to see or prove," she says.

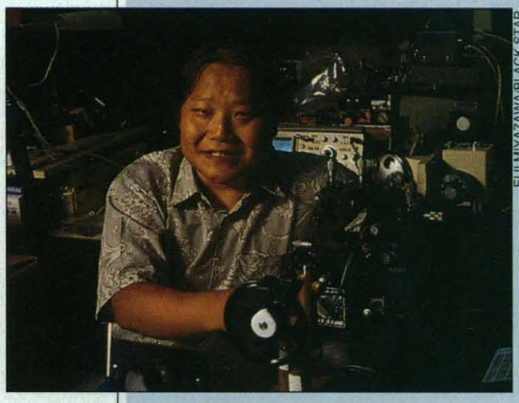
What is obvious to women researchers is the lack of social support for balancing the responsibilities of work and family. Although day care is widely available and inexpensive, persons who might provide child care after normal working hours—including baby sitters and nannies—are rare. That makes it hard for mothers to put in the extra time to finish a crucial experiment or a grant proposal. Such programs as on-site day care and facilities for nursing mothers, common on U.S. campuses, are unknown in Japan. Noriko Suzuki, a newly arrived postdoc at Johns Hopkins University, recalls her astonishment at finding a couch in the women's room for nursing infants. "We simply don't have this kind of support for women who are working and taking care of children," she says.

Even more important than institutional support, say women scientists, is family support. And those who receive it feel doubly blessed. Keiko Suzuki-Kamata, a volcanologist at Kobe University, credits her geologist husband, Hiroki Kamata, for urging her to apply for her present post even though he was working several hours away at the University of Tsukuba. He, in turn, credits a wider circle. "We could not have continued our jobs and raised a child without the help and encouragement of our friends, supervisors, and family," says Kamata, who has since found a job with the Geological Survey of Japan in nearby Osaka that allows them to live together again. "Of course, this does not reduce the responsibility of government or universities to do more for women," he adds.

For Mariko Kato, divorce has eased the red tape in applying for grants and visas. But one obstacle may not be so easy to remove. Her in-laws have not been told, Kato says, because "they wouldn't understand" why it is so important for her to preserve her professional identity. –J.K.

system. Indeed, although for the past 20 years the University of Tsukuba has used teacher recommendations and interviews as well as grades to admit some students, none of the country's other national universities has followed suit.

One factor that many educators see as just as big a problem as entrance exams is something that universities control—an uninspiring curriculum. At the top universities in particular, many science majors eager to plunge into research are dismayed to find themselves slogging through dull introductory science courses. "It was like high school again," recalls Akiko Kawamura, now a graduate student in physics at Nagoya University. "We come to college with the image of working in a lab," she adds, "so all the course work may cool our enthusiasm."



EIJI MIYAZAWA/BLACK STAR

Prudent passion. Kenji Kintaka hopes an optoelectronics Ph.D. will lead to a "fun" career at a national institute.

Indeed, Nagoya recently revamped its undergraduate curriculum to address such complaints. New introductory physics courses, for example, focus on frontier research topics such as elementary particles, condensed matter, and astrophysics. But professors there still worry that undergraduates are not prepared to work on advanced topics. "Young students have an interest in science, but it comes from TV and popular books," says Naoaki Horikawa, a particle physicist at Nagoya. "They give up [and do something else] when they see that science is hard work."

Even those students with the aptitude rarely choose to earn an advanced degree. According to Monbusho data, only 5.5% of Japanese college graduates enter graduate school, a figure much lower than in the United States (15.4%), Britain (37.2%), and France (19.3%). The ministry hopes to encourage more students to pursue Ph.D.s by doubling the number of slots at the most prestigious national universities. But it must cope with a paucity of financial aid for graduate students, who receive no pay for teaching or research, and a perceived job shortage.

Going against the flow. Although many of the current reforms are aimed at increasing the flow of students into the research pipeline, the solution is not that simple. Ironically, for many young scientists the problem—although it may not be perceived as one—is not that they will drop out but that they will stay put in their professor's lab. That lack of mobility deprives them of diverse experiences and opportunities to develop their own independent line of research. "They're giving up on the idea of exchanging ideas with other people," complains Nobuki Nakanishi, a neurobiologist at Harvard Medical School.

In Japan, the archetypal scientific career gets launched during the third year of college, when science and engineering majors choose a professor with whom to work during their final year. Those who go on to earn an advanced degree typically stay with the same professor. Those with a master's usually join a company, where they are likely to remain for the rest of their careers. And the best Ph.D.s are expected to remain with their professor and make a slow climb up the academic ladder. "I try to encourage students to go elsewhere," says one Osaka University professor. "But if I have a very good Ph.D. student, of course I want him to stay with me."

Some young Japanese scientists worry that the system forces students prematurely onto a research track. "When you're a third-year undergraduate, your knowledge is limited," says Kiyoshi Onuma, a physics graduate student at Nagoya University. "It's difficult to know what research is right for you." Others say the system keeps young scientists in a subordinate position. "In Japanese insti-

Simple Life Satisfies This Grad Student

OSAKA, JAPAN—The life of a Ph.D. student isn't easy. A dearth of government and industry fellowships forces most students to survive on parental handouts and meager earnings from moonlighting jobs while putting in long hours in the lab for no pay. That description fits Kenji Kintaka, 26, a third-year Ph.D. student at Osaka University, to a T.

Each weekday morning, Kintaka arrives in the lab by nine o'clock, gulps his breakfast—a cup of coffee—and sits down at a lab bench covered with lasers and lenses, where he investigates the properties of nonlinear optical materials. Most days he doesn't leave the lab until midnight, and he usually returns to work on weekends as well. Home is an aging, ground-floor flat only six tatami mats in area (about 3 by 4 meters) that costs $300 a month. "Most students now live in better apartments," he says. By eating his two meals a day in the school cafeteria he has been able to scrape by on what his parents send him, which is less than $1000 a month.

But Kintaka says his simple life suits him fine. "I'm a student, after all," he says with a shrug. Indeed, his behavior seems as much a matter of choice as of economic necessity. Although he recently received an $1800-a-month fellowship from the Japan Society for the Promotion of Science—finally relieving his parents of having to support him—"my lifestyle hasn't changed," he says. "I just save up the extra money."

Such prudence is a way of life for Kintaka. He applied to Osaka, for example, after calculating that his high-school test scores were good enough to get him into the country's third-ranked national university. In his fourth year, he did a similar calculation about his job prospects before seeking a laboratory position with Hiroshi Nishihara, an expert in optoelectronics: "This is a field that will become big, for sure." In typical Japanese fashion, Kintaka stayed in the lab to pursue his master's and doctoral degrees, forging an all-important link with a mentor who can help him find a job. "I think he is a typical student," says Nishihara. "He is very serious and devoted to his work."

But Nishihara says Kintaka has a lighter side, too. He enjoys tennis and "goes often to the drinking and Karaoke parties with his fellow students," says his mentor. As for Kintaka's long hours in the lab, Nishihara says, "it seems that research is almost his hobby."

Kintaka says he is not bothered by the fact that companies rarely hire engineers with doctorates. "I'm not very interested in an industry job," Kintaka says, "and I don't think I'm cut out for academics." His goal is a research post at a national institute, and he is not deterred by the stiff competition. "This looked like fun," he says about his decision to pursue a research career. Fortunately, a life of parsimony is a price he is happy to pay to indulge his passion for science. **–J.K.**

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-