Universities Step Up to the Challenge

Spurred by a government promise to boost spending on basic research, universities must now demonstrate their ability to produce world-class scientists

TOKYO—When *Science* last looked at Japan's universities in a special issue 4 years ago, the picture wasn't pretty: Crowded labs, worn-out equipment, scarce and formulaic funding, few postdoctorates, no technicians. The list of problems was long and seemingly intractable (*Science*, 23 October 1992, p. 564). But change has come—and come relatively quickly. Japan has rediscovered the importance of its universities as a home for advanced research and training and as an engine of economic growth.

Dozens of the country's 98 national universities can point to new or newly refurbished buildings, and many more have projects planned. New equipment is arriving by the truckload; in 1993 alone the government bought 11 supercomputers for research. New competitive grant schemes, often generously funded, are popping up faster than researchers can write proposals. And the best is yet to come: a new 5-year plan that calls for doubling the government's 1992 science spending by 2000. Universities will not only be prime beneficiaries but will also be charged with producing the researchers who will put that money to good use. "The mood [on campus] has brightened," says Hiroo Imura, president of Kyoto University, one of Japan's oldest and most prestigious schools.

But the improvement "is hardly sufficient," Imura adds quickly. It will take years, if not decades, to bring facilities up to date. The new grant programs and postdoc schemes are only now getting started. And the money for that 5-year plan is still only a promise. Moreover, the reforms themselves have given rise to a new set of challenges. The rapid expansion of reviewed grants is creating competition that will require universities to take a hard look at their strengths and weaknesses. And the need to foster a new breed of researchers capable of breakthrough work has led universities to rethink graduate education.

These challenges will require a basic shift in the current flat landscape of higher education, say many educators. "Universities [in Japan] all look the same," says Hiroyuki Yoshikawa, president of the University of Tokyo, which sits at the pinnacle of higher education in Japan. Because individual universities lack a distinctive curriculum or research focus, they rely largely on prestige to attract students and faculty. The effect, Yoshikawa says, is that "everything flows toward the University of Tokyo." That trend is a big obstacle to developing the kinds of educational and research diversity that many believe Japan needs.

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>
> HIROYUKI YOSHIKAWA

EIJI MIYAZAWA/BLACK STAR

Thank the recession

The newfound appreciation of universities owes a debt to Japan's recession, the country's longest in the postwar era. For one thing, it halted industry's drive into basic research. "Even before the onset of the recession, we recognized that what industry could do in basic research was limited," says Toshimitsu Shinohara, manager of the science and technology group for Keidanren, the nation's largest business organization.

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EIJI MIYAZAWA/BLACK STAR

But it took time for political leaders to answer corporate pleas to beef up public spending on basic research. "Japan has been very good at applying the basic technology developed in other countries, but not at developing its own technology," says Shinya Ono, a Liberal Democratic Party member of Japan's Diet. Ono was among a group of legislators that pushed through a Science and Technology Basic Law last fall that led to a 5-year plan (*Science*, 28 June, p. 1868).

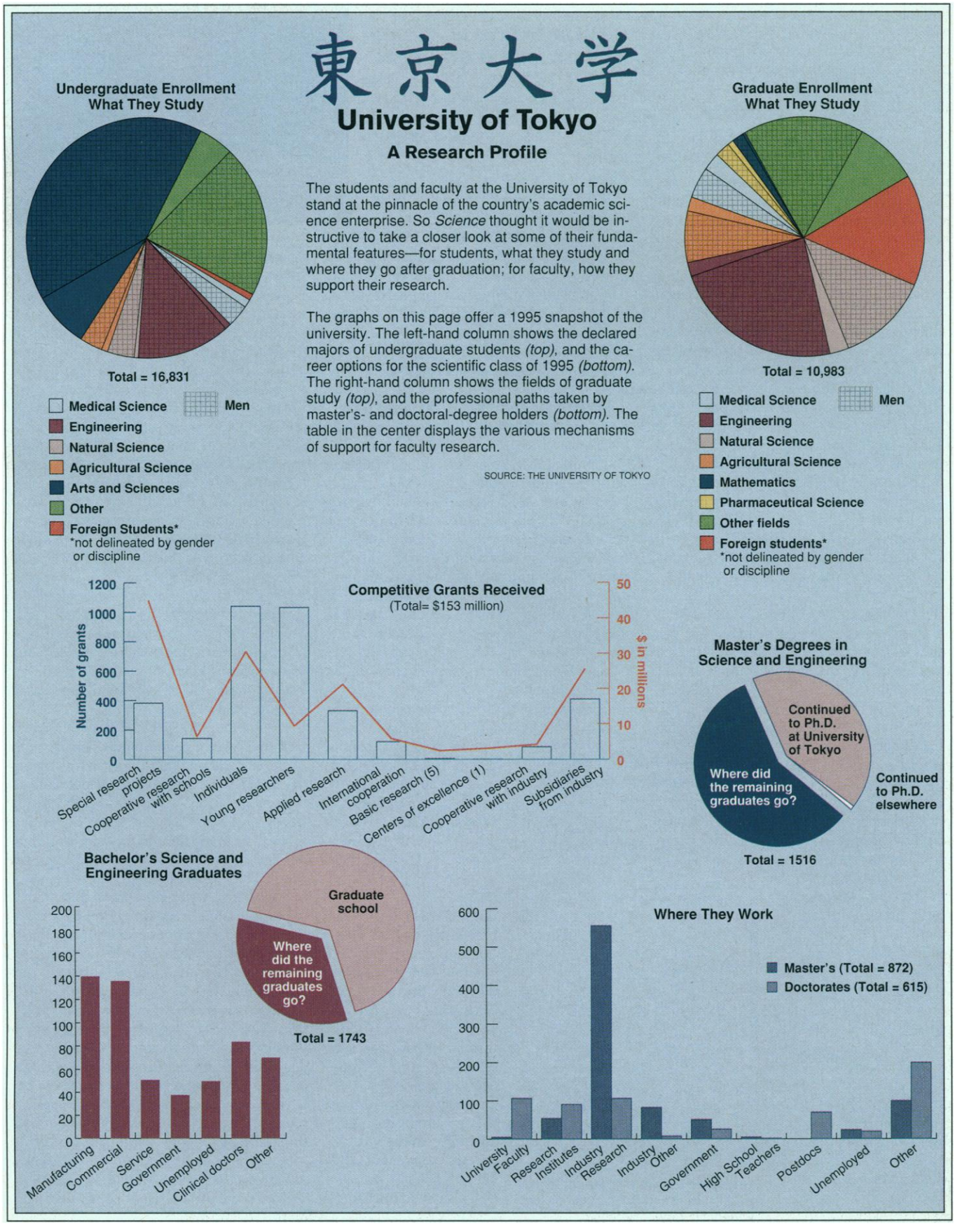
A series of emergency spending packages, aimed at jump-starting the slumping economy, provided more immediate benefits. Over the 5 years of the recession, the Ministry of Education, Science, Sports, and Culture (Monbusho) won money for such new facilities as a physics building for the University of Tokyo and a high-speed data and voice communications network for Osaka University.

The government also responded to long-standing academic requests with new funding schemes tailored for diverse research requirements. A Monbusho Centers of Excellence program, for example, allowed Kenji Sobue, a professor at Osaka University Medical School, to gather nine medical school researchers into what he calls an "internationally competitive" research team. Previous funding mechanisms precluded forming such a large and interdisciplinary group.

Lowering the fences between Japan's turf-conscious ministries has also been a boon to scientists. University of Tokyo molecular biologist Ken-Ichi Arai won a generous, 5-year grant from an arm of the Science and Technology Agency (STA), which previously couldn't fund university research, to study DNA replication. This "very good step" toward interministry cooperation, says Arai, also allows him to stay on campus to do the STA-funded research in his university lab and create precious slots for technicians.

Curriculum reform

The flip side of this increased support, says Kyoto's Imura, "is higher expectations" for


東京大学
University of Tokyo
A Research Profile
The students and faculty at the University of Tokyo stand at the pinnacle of the country's academic science enterprise. So Science thought it would be instructive to take a closer look at some of their fundamental features—for students, what they study and where they go after graduation; for faculty, how they support their research.
The graphs on this page offer a 1995 snapshot of the university. The left-hand column shows the declared majors of undergraduate students (top), and the career options for the scientific class of 1995 (bottom). The right-hand column shows the fields of graduate study (top), and the professional paths taken by master's- and doctoral-degree holders (bottom). The table in the center displays the various mechanisms of support for faculty research.
SOURCE: THE UNIVERSITY OF TOKYO
Undergraduate Enrollment
What They Study
Total = 16,831
Men
Medical Science
Engineering
Natural Science
Agricultural Science
Arts and Sciences
Other
Foreign Students*
*not delineated by gender or discipline
Graduate Enrollment
What They Study
Total = 10,983
Men
Medical Science
Engineering
Natural Science
Agricultural Science
Mathematics
Pharmaceutical Science
Other fields
Foreign students*
*not delineated by gender or discipline
Competitive Grants Received
(Total= $153 million)
Number of grants
$ in millions
Special research projects
Cooperative research with schools
Individuals
Young researchers
Applied research
International cooperation
Basic research (5)
Centers of excellence (1)
Cooperative research with industry
Subsidiaries from industry
Master's Degrees in
Science and Engineering
Continued to Ph.D. at University of Tokyo
Where did the remaining graduates go?
Continued to Ph.D. elsewhere
Total = 1516
Bachelor's Science and
Engineering Graduates
Graduate school
Where did the remaining graduates go?
Total = 1743
Manufacturing
Commercial
Service
Government
Unemployed
Clinical doctors
Other
Where They Work
Master's (Total = 872)
Doctorates (Total = 615)
University Faculty
Research Institutes
Industry Research
Industry Other
Government
High School Teachers
Postdocs
Unemployed
Other

both the quantity and quality of graduates with advanced degrees. A plan adopted by Monbusho in 1991 calls for doubling 1990 graduate school enrollment by 2000, and those graduates are being counted on to provide a shot in the arm to the country's R&D efforts.

The first step in bringing about these changes was administrative. Monbusho encouraged universities to give graduate schools their own budgets, facilities, and faculties. "Previously, graduate schools were simply appendages on top of undergraduate departments," says Naoki Murata, head of Monbusho's Office for University Reform.

A bigger challenge is the graduate school curriculum. "There is no 'education' [of graduate students]," says physicist Akito Arima, former president of the University of Tokyo and a tireless campaigner for university reforms. When he attended graduate school in the late 1950s, Arima says, students studied on their own and, when ready, presented a thesis. "If it was OK, the student was given a Ph.D.," says Arima, now president of the Institute of Physical and Chemical Research.

That description is still apt. The emphasis in graduate school is on laboratory training, says Eiichi Kajita, a professor at Kyoto University's Center for Integrative Research on Didactic Systems in Higher Education, and the topic is often picked by the professor. "This approach does not really foster the creativity of the student," Kajita says.

Atsushi Nishimune, a neuroscience doctoral student at Kyoto University, says that there are no interdisciplinary courses available to fill in the gaps in his knowledge. "You have to learn on your own," he says. Tanya Sienko, an American physicist and policy researcher at Japan's National Institute of Science and Technology Policy who has completed a comparative study of U.S. and Japanese graduate programs, found that most Japanese master's program courses did not involve homework or tests and required only very short, end-of-term papers. What is more, Japanese students take all their electives within a narrowly defined department and typically work under the same professor from the last year of undergraduate school through to a Ph.D.

Monbusho's Murata says that this approach is a holdover from an era when a professor groomed his (virtually all were male) Ph.D. student to succeed him. "It was like an apprenticeship," he says. But many public and private officials question whether that model suits the goal of training large numbers of scientists for governmental and corporate labs. Shojiro Asai, general manager of Hitachi Ltd.'s Advanced Research Laboratory, says that compared to American-educated Ph.D.s, "Ph.D.s that come out of graduate schools in Japan don't necessarily have the same vision of what they will be doing in an industrial laboratory, and they don't have the same ability to pursue their own research."

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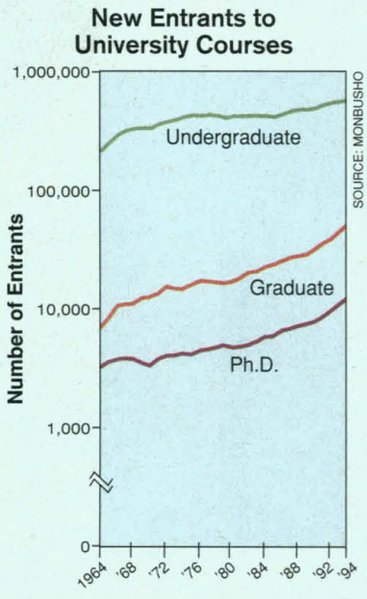
ELJI MIYAZAWA/BLACK STAR

Complaints like these have stimulated some isolated reform efforts. In 1992 and 1993, for example, Monbusho established two graduate schools, the Advanced Institute of Science and Technology in Hokuriku, Ishikawa Prefecture, and a sister Advanced Institute in Nara, just east of Osaka, with a new approach to graduate education (*Science*, 25 March 1994, p. 1680). Students are required to take a broader range of courses and undergo more rigorous testing. They also pursue two separate research themes under different professors.

Although both schools have had more applicants than slots, the demand may be due as much to new equipment, spacious labs, and on-campus dormitories as to their novel approach to graduate education. The two schools have yet to graduate their first crops of Ph.D.s, and none of the established universities has embraced the model. Kyoto's Kajita says that discussions of reforming curricula are only just beginning, and his 2-year-old center was formed in part to foster that discussion at Kyoto. Monbusho hopes each university will address the problem individually. "We think it is important that each university develop its own characteristic curriculum," Murata says.



Advanced training. A generation of rising student enrollment has boosted numbers in graduate school.

An era of competition

It is not just in graduate education that the universities are moving cautiously into a new era. They are also coming to terms with the unfamiliar concept of competing for students. A dwindling supply of students—the number of 18-year-olds peaked in the early 1990s and will drop 40% to 1.2 million by 2010—means that "universities are going to have to learn how to recruit freshmen," says Shinichi Yamamoto, director of the University of Tsukuba's Research Center for University Studies.

The competition will extend to research resources and grants as merit review becomes increasingly common. This is a remarkable change from past practice, Yamamoto says, where all faculty received the same basic level of research support, based on research category and professorial rank. Over the past 5 years, Yamamoto says competitive grants from Monbusho have increased 220% and grants from industry rose 236%, while the general fund used to support all researchers grew by only 149%.

Yamamoto says that there is tacit recognition that even if government spending continues to increase, the additional funds won't be enough to head off "some selective allocation of resources." The end result, he believes, will be a concentration of research money and graduate students at a small number of universities. The rest, he says, will need to focus on teaching.

Monbusho's Murata agrees that the increasing amount of competitive support will naturally lead to some specialization. But he emphasizes that Monbusho has no intention of pigeonholing universities. "It is up to each university to choose its own course," he says.

Setting a course, however, may be difficult. "University presidents have little real power," says Kyoto's Imura. He says presidents historically were representatives of the faculty, without authority over their colleagues. Although this has changed, vestiges remain: Presidents are elected by their faculties and typically have short terms of office, including 4 years at the University of Tokyo and 6 years at Kyoto.

More importantly, authority over such matters as curricula and entrance and gradu-

ation requirements is vested in departmental committees. Introducing sweeping changes, Imura says, requires "a great deal of leadership" to build a consensus.

Even consensus is not enough, however, in negotiating with government bureaucrats. "Universities have very little discretion," says Tokyo's Yoshikawa. Budget allocations, the construction and use of new facilities, and many personnel decisions must all be negotiated with Monbusho; even tuitions and professors' salaries are fixed on a nationwide basis. For example, any attempt to develop a unique strength by hiring talent in one area and pruning faculty in another requires Monbusho approval, says Yoshikawa.

But even Monbusho doesn't have a free hand. Employment policy for all national employees, which includes national university professors, is determined by Japan's Management and Coordination Agency. And given the push to shrink public-sector payrolls to reduce the deficit, Murata says, "you'd likely soon get approval for the cuts but not the increases." Adds Imura, "I think universities should be given more freedom. But even Monbusho doesn't have the freedom it needs."

Indeed, the red tape is about the only thing that hasn't gotten better for universities in the past 4 years. But a more favorable environment for reform, an influx of resources, and a slew of new policies have given university officials a more powerful tool to slice through that still-formidable bureaucracy.

–Dennis Normile

REGIONAL UNIVERSITIES

Schools Scramble for Niche To Keep Up With Competition

Faculty members at each one of Japan's 98 national universities get the same salaries, lab space, and base funding for research. At least they are supposed to, according to government policy. But some are more equal than others. The influence and prestige of the country's two oldest national universities, the University of Tokyo and Kyoto University, have allowed them to claim a disproportionate share of competitive government grants and big projects, and their faculty members enjoy the scientific perks that go along with such success.

That disparity began to diminish over the past decade, as talented researchers at less prestigious universities tapped into the large increases in funding for competitive grants. But the new push to expand graduate training and upgrade academic research to help underpin a stronger economy promises to have more ambiguous consequences for the academic research community.

To find out how the government's new policies are likely to change the topography of higher education in Japan, *Science* interviewed scores of administrators, faculty members, and students at national and private universities, including several with strong international reputations in one or more fields of science and engineering. Their answers suggest that the result could lead to greater parity among Tokyo, Kyoto, and the most active, large universities at the same time that it widens the gap between the top-tier and the less privileged universities.

A handful hope to carve out distinctive research and training niches to attract top students and faculty in a competition previously unknown on Japanese campuses. But others fear that their limited resources may be stretched even thinner as they are asked to do more. "The abilities of professors in smaller universities are by no means inferior," says Yahachi Saito, a physical chemist at Mie University in Tsu, 75 kilometers east of Osaka. "But the level of science in Japan will be lowered," he predicts, if the needs of such faculty members are not addressed.

What worries Saito and others is that the policy of equality espoused by the Ministry of Education, Science, Sports, and Culture (Monbusho) is a facade that hides its determination to strengthen a handful of the largest, most research-oriented universities. The rest would be relegated to producing a new breed of Ph.D.s for nonacademic careers. While all universities are encouraged to expand their Ph.D. programs, Naoki Murata, head of the ministry's university reform office, confirms that "the [ministry] research budget is distributed mainly to graduate schools and research centers that are very active." Each university, he adds, "must choose its direction."

EIJI MIYAZAWA/BLACK STAR

Real reform. Nagoya's Yamauchi hopes reorganization will give his graduate schools an edge.

However, observers say the playing field is not level. "If a university has a strong president, maybe it can pull itself up," says William Cummings, an authority on Japanese higher education at the State University of New York, Buffalo. "But the system is certainly weighted against them."

What galls many professors at second-tier national universities is that Monbusho has such tight control over the internal operations of individual universities that it can influence the outcome of the race. "If we can compete freely with other universities, that would be fine," says Katsumi Isono, a biologist at Kobe University. "But that requires financial and other types of autonomy that we don't have right now. If the city or provincial government wants to invest in our university so we could offer higher salaries or better facilities, they can't do it," he notes, because of rules governing faculty allocations.

Private universities, their financial situation already precarious, face an even worse situation. Although they are exempt from Monbusho's rules on salaries and hiring, they receive a smaller slice of competitive government grants. The drop in student-age population is cutting into their revenues from tuition—their main source of income—and a prolonged economic slump is hurting industry donations. The concept of overhead is still new: Waseda University, for example, only last year began adding 10% to industry grants and contract research to cover administrative costs. And private universities have not pursued royalties and licenses as a source of revenue.

Second-tier universities can't blame all their difficulties on external factors, however. One of their big problems stems from an overriding principle of academic life called *ji shu*, or self-government. Under that policy, for example, deans and presidents are elected by the faculty for limited terms and have little power to push through needed reforms. "It's even worse than it sounds," says a professor at the University of Tokyo. "None of the checks and balances at U.S. universities are in effect here."

Repackaging science. While most universities are scrambling to beef up their graduate programs, only a few seem to be attacking the task with gusto and originality. These tend to be large, competitive institutions with a critical mass of reform-minded faculty members and innovative leadership.