Japanese Academics Bemoan The Cost of Years of Neglect

After a taxi ride through the steel, glass, and concrete canyons of corporate Japan's headquarters in the Nihonbashi and Otemachi districts, the campus of Tokyo University comes as a shock. The university's main gate is a 10-foot-tall wooden structure, worm-eaten and missing bits of its decorative ironwork. Alongside, guarding the entrance, is a shabby brick gatehouse with a few weeds growing out of its roof. Peer through a window and inside there is a cracked washbasin, two half-dead cacti in pots, and a faded map of Tokyo—but no gatekeeper.

Beyond the gate the campus opens out. Summer grasses have overwhelmed the beds of flowers and shrubbery lining its main avenue. And behind are rows of dilapidated brick and cracked concrete buildings.

Welcome to Japan's most prestigious university. The initial impression of neglect is no illusion. Enter a laboratory and the complaints spill from scientists' lips: chief among them are the sad state of university buildings, the shortage of research grants, and the total absence of technicians. And it is not just the university buildings that seem to be in need of renovation. Many researchers say Japan needs to tackle an array of obstacles: A rigid and hierarchical appointments system, excessive bureaucracy, poor graduate training, lack of opportunities for the young and for women, and an unwillingness to reward individual excellence. All are blamed for Japan's comparatively poor performance in basic research, along with its relative isolation from the great world centers of research and Japanese science's short history.

Yet, in spite of the problems afflicting Japan's universities, there are many pockets of scientific excellence. As the data on pages 565 and 573 indicate, groups across the country—and not just in the elite universities—are turning out world-class research papers even though Japan's output of scientific papers and their citation rates lag far behind those of the United States and Europe. This suggests that if the universities, which perform most of the basic research in Japan, can be renovated and reformed, Japan could quickly take its place among the elite in basic research.

EIJI MIYAZAWA/BLACK STAR

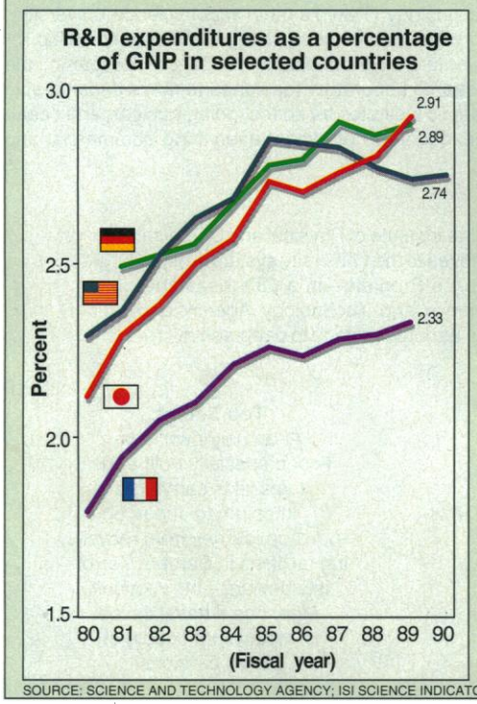
Battling president. Akito Arima offers tours of Tokyo University's decay.

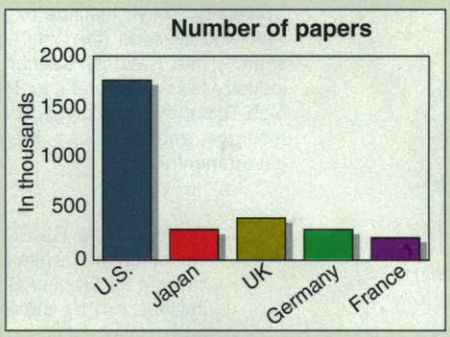
And just such a reformation might be in the wings—at least if the top university officials and government bureaucrats are to be believed. As the government recognizes more clearly the value of basic research—and the stubborn problems that the universities face—bigger budgets, organizational reform, and internationalization are in the air. Hopes run highest among the elite universities, where university presidents and government bureaucrats are celebrating the first big increases in funding for the universities in more than a decade. Additional hopes have been nurtured by high-level government statements promising cures for every ill in the university system. The coming decade could be a crucial one, as Japanese researchers wait to see whether these promises are kept—and whether the campus of Tokyo University becomes as impressive as the commercial district a mile to the south.

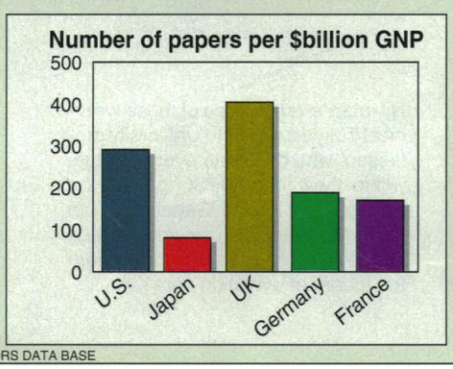
Climbing out of poverty?

For an optimistic view of how things may soon change for the better, and how they got the way they are, there is no better person to ask than physicist Akito Arima, president of Tokyo University since 1989 and probably the most outspoken campaigner for university reform Japan has had in decades (see

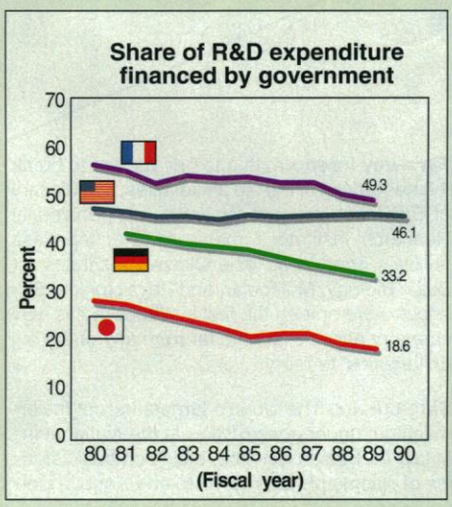
Big Spender, but Little Basic Clout







Japan spends a bigger percentage of its GNP on R&D than the United States or any European nation *(far left)* but its total output of academic papers published in 1981-1990 is small *(left, upper)*, especially if compared with GNP *(left, lower)*, probably because funding comes mostly from industry, not government *(below)*.



SOURCE: SCIENCE AND TECHNOLOGY AGENCY; ISI SCIENCE INDICATORS DATA BASE

perspective by Arima). First, Arima dispels any misconceptions a visitor may have: "Foreign friends expect that the Japanese government is rich," he says, looking a visitor in the eye, "but they are not right. The government is not rich at all, even though industry is thriving. That's why these past 10 years the universities have suffered a financial crisis. Every year we had 10% less than the year before."

Essentially, the universities have been forced to help pay for Japan's economic miracle. As Arima explains it, the government has had to slash its budget every year to pay off the mountain of debt accrued over the years to finance industrial growth (relative to GNP, the government deficit is larger than that of the United States). The budget for university facilities is now at the level it was 17 years ago—thus the vanished gatekeepers and gardeners.

At the same time, continues Arima, what little additional government money has been available for research has been concentrated in new and independent centers of excellence like the Institute of Space and Astronautical Science, the National Laboratory for High-Energy Physics, and the Okazaki Institutes for Basic Biology, Molecular, and Physiological Sciences. And to add insult to injury, while the impoverished universities still contain by far the major concentration of Japan's basic researchers, the big corporations, overflowing with money, have begun to perform basic research for themselves, often in glittering institutes overflowing with new equipment (see page 570).

But that could soon all be history. "I'm very happy these days," Arima says. "Government, industry, and politicians have finally recognized the importance of the universities." The first tangible evidence of that change came in this year's university budget, which included an extra $800 million, spread over 5 years, to help university renovation—a development for which Arima gets much of the credit.

"Thanks to Arima, finally the Japanese government has realized the situation," says Michio Oishi, a professor at the University of Tokyo's Institute of Applied Microbiology who spent 15 years in the United States at Princeton and the New York Public Health Research Institute. Oishi will show you his own dark and cramped laboratory—if you are up to the skillful footwork needed to squeeze around equipment and people. "The lab was built in the 1940s when Japan was very poor," explains Oishi.

Arima's campaign tactic was to turn the state of labs like Oishi's to his advantage. He began offering top politicians and the media tours of the worst of Tokyo University—leaking roofs, crumbling walls, and cramped, dark laboratories were the chief attractions. "I have taken around so many politicians, financiers, and news reporters," Arima explains. "Two ministers of [MESC], and other influential politicians have come, including even communist party representatives."

The result was a flood of news articles on the poor state of Japan's universities and a massive wave of public and political sympathy for the universities. "It's not occurred in 50 years," says Arima. "There's never been enthusiasm about higher education before."

Strong words, but Arima is not alone among those at the top of Japan's great universities in believing that major renewal may be on the way. "Within 5 years the system will be changed," says Saburo Nagakura, a renowned Tokyo University chemist who now heads the Graduate University for Ad-

BASIC SCIENCE IN JAPAN
The most productive and most cited institutes, 1981-1991

BIOLOGICAL SCIENCES	Av. cites per paper	Total papers
> 3000 publications		
MIT	23.29	6078
Osaka University	10.02	8045
Kyoto University	9.96	9343
Tokyo University	9.87	10359
Hokkaido University	8.86	4184
Kyushu University	8.17	6382
Nagoya University	7.91	4585
1000 to 3000 publications		
Caltech	24.49	2327
Kobe University	13.80	1808
National Cancer Center	12.25	2211
Jichi Medical School	9.97	1121
Tokyo Institute of Technology	9.39	1374
RIKEN	9.10	1126
300 to 1000 publications		
National Institute for Basic Biology	20.74	612
Japanese Foundation for Cancer Research	20.08	468
National Institute for Physiological Sciences	16.74	366
Miyazaki Medical College	12.77	705
National Institute of Genetics	11.83	599
Shizuoka College of Pharmacy	11.18	562

PHYSICAL SCIENCES	Av. cites per paper	Total papers
> 3000 publications		
Harvard University	15.71	7049
Tokyo University	8.22	10,982
Kyoto University	7.05	8853
Osaka University	6.54	7549
Tokyo Institute of Technology	6.49	6037
Nagoya University	6.29	4851
Tohoku University	6.27	6797
1000 to 3000 publications		
Institute for Advanced Study (Princeton)	17.47	1462
Institute for Molecular Science	9.89	1471
Nippon Telegraph and Telephone Corporation	8.50	2400
RIKEN	6.50	1439
University of Tsukuba	6.09	2784
Hiroshima University	5.58	2666
300 to 1000 publications		
NEC Corporation	10.86	354
National Research Institute for Metals	9.78	401
National Instit. for Research in Inorganic Materials	8.87	679
Sagami Chemical Research Center	8.72	361
Electrotechnical Laboratory	7.84	948
Fujitsu Labs Ltd.	7.57	577

Data on output of scientific papers and their frequency of citations at large, medium and small-sized institutions in Japan, show that the big national universities still dominate basic research. Newer institutes, like the Institute for Molecular Science and the National Institute for Basic Biology, both set up in Okazaki in the 1970s, come out top among smaller institutes and, as part of a new trend, small industrial labs, like that at NEC, prove their abilty to produce high-quality basic research. But in comparison to U.S. institutions (shown in blue), the impact of Japanese research is still modest—citation rates are roughly half those in the United States. [Source: ISI Science Indicators Data Base. Listing compiled from 1200 journals in the life sciences and 800 journals in the physical, chemical, and earth sciences. Clinical medicine, applied science, agriculture, and engineering were excluded. To obtain more detailed rankings of several hundred Japanese institutions please fax *Science* at (202) 408-8015 and request Japanese citation data.]

vanced Studies in Yokohama. One by one he lists the key reports that have come out over the past year calling for Japan to increase its spending on the universities and basic research, including one from the powerful Keidanren (an association of corporate chiefs akin to the U.S. Business Roundtable). And there is Nagakura's own report, produced in July by a committee he chaired for MESC. "Look," says Nagakura, underlining key paragraphs in the document, "it's a big change. We are recommending that funds for facilities and research grants should be doubled 'as soon as possible.' I hope it will be done within 3 to 4 years."

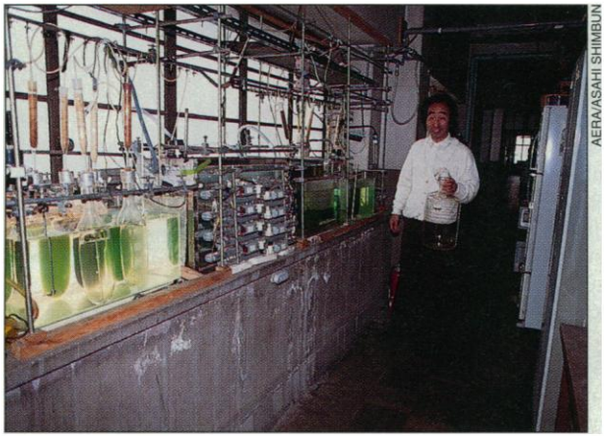
Lending real hope to all this activity is a vital cabinet policy document released in April. Among some of the key statements: "The government will double its own R&D investment as soon as possible...will make efforts to increase the number of students in master courses and doctor courses...will systematically renew the facilities and equipment of universities and national research institutes as soon as possible...will increase the mobility of researchers...will improve the environment to allow females to easily continue science...will expand various types of research funds offered under a competitive system...will promote better treatment of brilliant researchers based on a proper evaluation." Every ill in the university and basic research system gets a mention. But there is a little catch—the various efforts will "take account of prevailing financial conditions." And what exactly does "as soon as possible" mean?

"Yes, it's just advice," concedes Nagakura, folding up his report with a sigh. "It's very difficult. Sometimes it takes 10 years for a decision to go through. But the wind is changing. I'm optimistic." Allowing for the Japanese tendency toward understatement, that's about as positive a statement as you can hope to hear.

The view from the trenches

This sense of optimism has not yet fully penetrated the laboratories, however. Just look at the overall level of research funding, says Yasutomi Nishizuka, the Kobe University molecular biologist who is Japan's most cited scientist by far (see page 574). "A couple of years ago I calculated that the entire budget for research grants was about equal to the budget of Johns Hopkins University," he says. In 1992, the research grant budget stands at ¥64.6 billion ($516 million); the goal of the most optimistic government reports is to raise it to ¥100 billion ($800 million)—a sum equal to about 13% of the combined research grant budget of the National Institutes of Health and the National Science Foundation. (For comparison, Japan's GNP is 62% that of the United States.)

But not all researchers—particularly those outside the universities—believe more money will provide a solution to the universities' problems without thoroughgoing reform. "It will make no difference if you double their funds—all university professors will do is to share out the money equally amongst themselves so there is no reward for originality," was the cynical off-the-record comment of one renowned telecommunications researcher who manages a multimillion-dollar corporate laboratory.



Hard times. Kyoto University's labs are just as run down as those at Tokyo.

Such cynicism is widespread: Japanese academics and their traditional ways are also a favorite target for newspaper columnists and for Japanese scientists who have found fame and fortune in foreign countries. The critics draw a bead on two key targets: the "koza," or chair system, and its associated system of lifetime tenure, and the way research grants are handed out.

The koza is the basic academic unit, copied from the old German system, consisting of a powerful full professor and a surrounding corps of two assistant professors and one or more lecturers and assistants. Each koza receives an automatic (albeit small) budget for research regardless of merit and without review—which means that researchers can carry on slowly even if they never bother to compete for peer-reviewed research grants. And within the koza, all the posts are tenured, so that even a 25-year-old working as an "assistant" at the bottom of the group has a job for life.

It's a comfortable system to work in, but many university professors say it needs a massive shakeup. Mitsuhiro Yanagida, a professor at Kyoto University, is one of them. He has a top international reputation for his work on the yeast cell cycle and he's also gone to press with forthright criticism of the university system—not something many Japanese professors will risk. Without much prompting, he'll open a drawer and pull out his own plans for university reform. Along with the predictable increases in funds for research (a tripling is needed, he says), he would end the koza system, abolish tenure for all but full professors, make appointments purely on merit, and privatize one-third of the present national universities. Radical stuff? "I'm not a politician," Yanagida laughs. "I can say these things irresponsibly."

If Yanagida were a politician the first place he'd have to turn would be MESC, the ministry that nearly all Japan's university scientists love to hate. "In Japan," explains Ken-ichi Arai, professor of molecular biology at the prestigious Institute of Medical Science of the University of Tokyo and a visiting scientist at the DNAX research institute set up by Paul Berg close to Stanford University, "MESC controls from elementary school to the highest level of the research system. This is a major problem. High research is like art—it's a mistake for it to be under the control of one bureaucratic system. We have to have maximum flexibility—but you cannot have this within a single bureaucratic structure."

A prime complaint is that the ministry jealously guards its turf from encroachment by any of the other ministries with money to spend on science. "It's a miniature Soviet Union," says Arai of the way different ministries operate independently. "The economy here operates on free trade, but the universities have been frozen for over 20 years." Others agree: "MESC was set up to support research, but after World War II it changed to controlling research," says renowned semiconductor researcher Junichi Nishizawa, a long-time critic of the government's unwillingness to let universities run their own affairs and now president of Tohoku University, one of Japan's most prestigious universities.

A consequence of MESC's unwillingness to relax strict control is that there is no simple way for researchers to obtain funds from other sources. Those who join one of the Science and Technology Agency's ERATO (Exploratory Research for Advanced Technology) projects end up having to set up two separate labs, one of their own on university property and one for ERATO, off university property. "We can never put the money together," explains Ken-ichi Matsubara, professor at Osaka's Institute of Molecular and Cellular Biology. "It's one of the craziest situations in Japan."

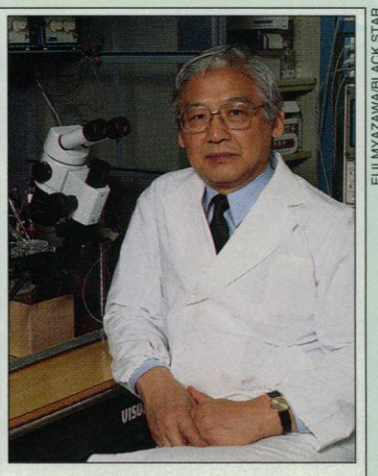
Group mentality

For foreign visitors, the grant system is—if not crazy—at least a little odd. Total funds provided by MESC to support research are very small to begin with—just $516 million in 1992. But a significant part of that money then goes to a half-dozen or so grant categories including applied research, publication of research data, and even support of projects by school teachers. The 60% that is left comes

Breaking Barriers and Expanding Frontiers

If officials at the Ministry of Education, Science, and Culture (MESC) want to see a different model for research from the traditional academic system they support, they need look no further than the Science and Technology Agency and its pair of innovative programs, ERATO and the Frontier Science Program.

ERATO (Exploratory Research for Advanced Technology) has been around the longest and was deliberately set up to try to break down every one of the barriers that critics say hamstring research in the universities (see main text). ERATO projects bring together researchers from universities, industry, and different government sectors; young people are given big opportunities with almost all the 20 or so researchers on each project under 35 years old; foreign participation is actively sought; and ERATO laboratories are independent, well-funded, well-equipped, and have a finite lifetime set at just 5 years.



EIJI MYAZAWA/BLACK STAR

Laboratory experiment. Masao Ito's Frontier Program tests new forms of organization.

In contrast to MESC's emphasis on group- and project-oriented work, all of ERATO's projects are built around single brilliant individuals and many are risky—even eccentric. Genya Chiba, who dreamed up ERATO in 1981 and still runs the program, believes each project should put originality first and avoid any conventional assessment of progress. "We have started 33 projects over the past 10 years—although I prefer to speak of them as 'playgrounds' rather than projects," he explains nonchalantly. "And we try *not* to evaluate them, because premature evaluation does more harm than good. Nonorthodox ideas are never accepted by orthodox scientists."

Chiba refuses to rate his projects at all ("Whether they are successful or not I can't say, but they are certainly interesting," he says coolly), but curiosity in the United States ran high enough for the National Science Foundation's Japan Technology Evaluation Program to check out ERATO in 1989 and give it very high marks. Among the projects praised: Tokyo University physicist Eiichi Goto's daring attempt to build Josephson junction computers (see page 574) and Osaka Bioscience Institute molecular biologist Osamu Hayaishi's study that established a wider role for prostaglandins as physiological signals than anyone had suspected.

If ERATO has ever had difficulties it has been in persuading its rivals at MESC to cooperate fully. "When we started ERATO in 1981, at first we had lots of problems with MESC," says Chiba, "but things are going smoothly now. We can get people from universities on loan." What they haven't been able to do, however, is to change the laws that stop ERATO projects from being carried out on university property.

New frontiers. The Frontier Science Program is only a little more conservative than ERATO. Based at the famed Institute of Physical and Chemical Research outside Tokyo, the program, which was established in 1986, is run by Tokyo University neurobiologist Masao Ito. Once again, the way the program is run turns traditional university practices on their heads.

"The classical university system is still very closed," explains Ito. "Here we have a flexible system open to foreigners. We wanted to show how things could work." The result is a set of three projects—on nanomaterials, biohomeostasis, and brain mechanisms—with a distinctly cosmopolitan flavor: Four of the 11 labs that make up the set of projects are run by foreigners and 27 out of the total of 98 researchers are foreign. Even more surprising is that Frontier researchers make a point of holding all seminars in English. "Sometimes it happens that there are no foreigners at a seminar and I say, 'Let's speak Japanese,'" explains Ito laughing, "but the speaker always looks insulted and continues in English."

Just like ERATO, Frontier favors young researchers (average age of the 35 researchers in the brain program is just 33) and hands out annual contracts running for 5 years instead of tenure. But unlike ERATO, Frontier projects are subjected to regular and severe evaluation: "Two programs were destroyed in an international review last year," says Ito, adding with a laugh, "Luckily, my own brain research program got through its midterm review and won another 3 years funding."

The combination of lack of tenure and strict review is a first. "It's revolutionary in Japan," says Ito, "the researchers can be kicked out....We may even be too drastic. When a program is reorganized, people can just get fired." Researchers are willing to take this risk, however, for they are given spacious new laboratory buildings and equipment that could be beaten by few labs in the world.

Price of success. Revolutionary though their programs may look now, both Chiba and Ito are conscious that their days may be numbered. "I'm afraid I'm going to be told, 'You were historically meaningful but we don't need you any more,'" Chiba says. The reason? The success of ERATO and the Frontier Science Program are persuading other Japanese institutions to take a similar route. "Many of the Ministry of International Trade and Industry's programs have shifted toward being individual-centered rather than organizational-centered, and they get people from all sectors, including industry, government, and abroad. They are lookalikes! And even MESC is finally thinking about multichannel funding," says Chiba. Ito agrees: "We have unique features but the universities are catching up," he says. "One big change is a new emphasis on publication. Each university wants to hunt really good people."

How long before the universities don't need to be prodded by an open, flexible, international, nontenured, peer-reviewed system? "After 10 years we may disappear," says Ito, "but I'll be satisfied by that."

–A.A.

in two blocks. One—a mere $177 million—is the entire source of support for the peer-reviewed grants familiar in the West. With the total so small and the number of researchers so large, the ministry has adopted a policy of giving out large numbers of very small grants. Most applicants (around 500 a year) will receive a 3-year grant of only around $50,000, which is not nearly enough to keep a research group going. The frustrating result for laboratory chiefs is that they must divide up their research activities and spend their time trying to collect enough small grants for a reasonable project. Very little money is reserved for research that could have a major impact: Each year, there are fewer than 10 individual grants in the $500,000 for 5-year range.

Almost all of the remaining large chunk of money ($131 million) goes to team projects on preset topics and to group grants, a category that is uniquely Japanese—and much criticized. "The most important thing to change is the group research project," says Tokyo University's Oishi. "The system is

unique, and reflects Japanese culture...but personally I prefer the kind of individual application like in the United States, with a fair review system."

Oishi explains Japan's group grant system as follows: "Professors get together, form some kind of project—molecular biological studies of DNA repair, for example—then bring it to the ministry. A panel of judges reads the various proposals and picks one project out of three or four, meaning 15 to 20 projects get $2 million each. Then these groups distribute the money among their scientists." The result, says Oishi, is that projects tend to win money based on their general importance or popularity, many areas and individuals don't get any money, and there is a feeling that "you're safe within a group but your vision of research is always restricted or confined."

Other returnees from abroad are just as critical of the system. "Distributing grants for group work is very good in the stage of catching up with other countries," explains Junichi Tomizawa, who returned to Japan 3 years ago to head the National Institute of Genetics in Mishima after 17 years at the National Institutes of Health: "I think we're out of this stage now, we should use more the originality and uniqueness of the individual scientist."

Wasted youth?

With group and earmarked grants dominating the Japanese research system, and the koza system dominating promotion, there is little chance of quick recognition for a brilliant young researcher—and that may be yet another reason why Japan's universities are dogged by a poor reputation for developing original ideas.

The notion of providing freedom for young researchers is still quite new: The Japanese government didn't offer any postdoctoral fellowships at all until the 1980s; now it has just 1000 to cover all subjects. (In comparison, NSF/NIH offer 9800.) But the grants are not popular. The reason? Postdoctoral fellowships "don't really fit well to Japanese society," explains Hiroto Okayama, an Osaka University professor who recently returned from a 10-year stay at Stanford and NIH. "The problem is that a temporary position is seen as inferior."

The alternative, a position at the bottom rung of the university system, provides real security—even though there is little scope for independence. But young Japanese don't necessarily expect freedom: "Japanese students are not trained to do independent work. U.S. schools encourage independent development, but here we don't," says Okayama. Even given the means, youth will be inhibited by cultural factors from seizing the opportunities.

EIJI MIYAZAWA/BLACK STAR

Mitsuhiro Yanagida. Too little diversity in Japan.

Cultural roots

It is just those kinds of cultural differences that infuriate Tohoku University's Nishizawa. Nishizawa built a powerful reputation for original discoveries before taking on the post of president of Tohoku University. He sees Japan's weaknesses in original research as partly coming from an over-regimented education system. "Japan is a great power and now all over the world, Japanese are expected to have opinions," he fulminates angrily, "but what do Japanese look like—they look like robots with dictionaries in their heads." Nishizawa has already launched a major shakeup of his university's first 2 years of liberal education, building new departments of information sciences and international culture in an attempt to change young people's way of thinking. But he thinks that to really boost future Japanese researchers' capabilities, changes must be made much further down the education system. "Now everyone is concerned about the graduate course and research, but the undergraduate course is a bigger problem, and the most serious problem of all is the 'juku' [the cram schools for students preparing for the examination hell]," he says.

Other agree that there are cultural factors at work that limit how quickly Japan can attain scientific excellence: "We can only learn the behavior of scientists from older people and in that sense our history is too short," says Kyoto University's Yanagida. "We have no immigrants. We have no Jews. Our weakness is lack of heterogeneity. If you look at the variety in our academic society, it is not rich."

The lack of foreigners—and the stimulation and different ways of thinking they bring—is a criticism that is echoed time and again in laboratories in Japan. Part of the problem is that while Japanese labs welcome visitors, very few universities see themselves as part of the international community, recruiting the best scientists in the world.

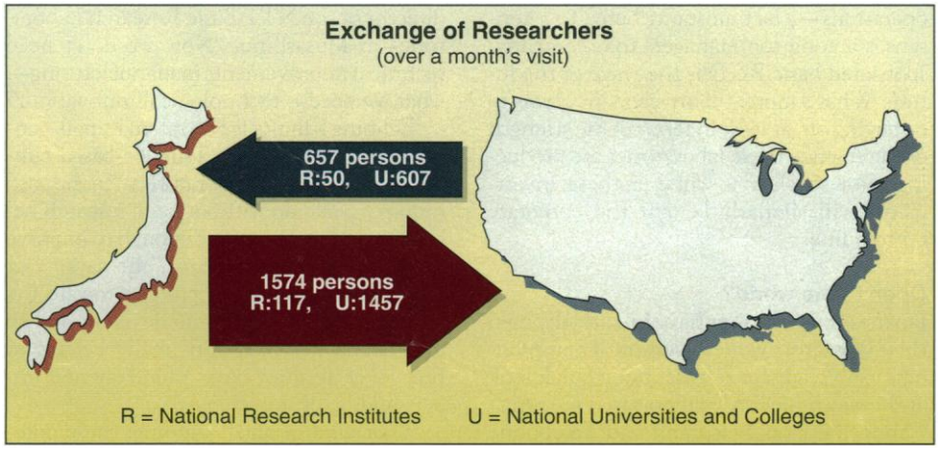
Government regulations—changed in 1987 to permit foreigners to obtain permanent university appointments—are not exactly welcoming. The regulation states that foreigners should in principle be taken on for a fixed term but "in unavoidable cases" can be hired permanently. Most of Japan's top universities have interpreted that regulation to keep tenured staff "Japanese only"—they will not offer a foreigner more than a 3-year contract.

Rather than offer foreigners equal treatment, the Japanese government has been trying to entice Westerners to visit by offering ever larger numbers of fellowships. But not enough talented people are taking them. "People feel coming to Japan is a waste of time for their careers," is the blunt explanation given by the National Institute of Genetics' Tomizawa. "We need to raise the level here first," he says. "Coming here has to have scientific merit." Oishi agrees: "Japanese science has still not reached the stage where it is competitive enough to attract foreigners; people in highly competitive fields in their late thirties or early forties could lose a whole year coming to Japan." That puts Japan in a double bind: An influx of top foreign scientists might help raise the level of Japanese science, but top scientists won't come until the level is higher.

Even Tokyo University's ever feisty and optimistic Arima argues that it is impossible to change Japan quickly. History must take its course. "It takes time," he says. "Look at Germany. The first phase is a boom for technology. It takes 100 years. Then when technology is thriving, the next phase is developing our own originality. Japan is just now passing out of the first phase."

And how long before Japanese originality flowers? "Let me have 30 years," says Arima.

–Alun Anderson



Trans-Pacific currents. More Japanese scientists visit the United States than U.S. scientists visit Japan. In 1989, a Science and Technology Agency survey showed that the ratio was 2.4:1.