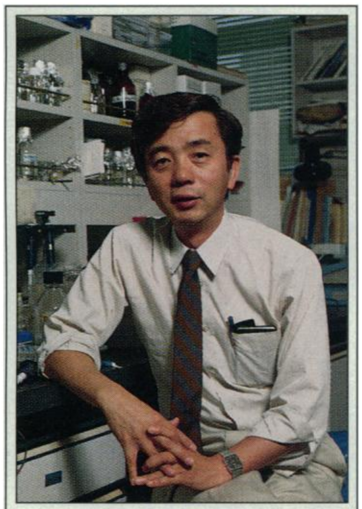
PROFILES

Diversity Flourishes in Japan's Research Labs

Japan may look homogenous but the pace of change has actually created a people of extraordinary diversity. Scientists educated before the war at the elite "Imperial" universities are different from those born a few years later; those who experienced postwar poverty are not the same as those born into riches a little later; researchers in wealthy industrial labs see the world differently from their poorer colleagues at the universities; and scientists who have lived abroad for a long while change their perceptions for ever. Below, *Science* talks to Japanese scientists of different ages and different experiences in a wide variety of disciplines: Among them are a Nobel Prize–winner, an ex-student radical, one of Japan's most powerful scientific leaders, an eccentric genius–and some older people who remember Japan's problems and younger people who see Japan's opportunities.

Radical Thinker

If you told Tadatsugu Taniguchi 20 years ago that he would become one of Japan's best-known molecular biologists, he would probably have laughed at the notion. At that time, he was at the point of dropping out of science. Yet over the past couple of years he has published a string of highly cited papers on interleukin-2 and its receptor, after winning the race to clone the gene in 1983.



EIJI MIYAZAWA/BLACK STAR

Tadatsugu Taniguchi

As Taniguchi tells it, after beginning his scientific career at Tokyo University of Education (which later became the University of Tsukuba) with a rush of youthful enthusiasm, he got caught up in the "student troubles" of the 1960s. The politics of the student movement in Japan was complex: The signing of the U.S.-Japan Security Treaty and the Vietnam War were issues, but overcrowded, hierarchical universities, poor teaching, and remote professors were often the problems that enraged the baby boomers of the 1960s.

Taniguchi came to Tokyo from a small village near Osaka: "It was a big dream for me coming from the countryside," he says. "I chose Tokyo University of Education because that was where Professor Tominaga [Japan's second Nobel Prize–winner] was, but then it was a big disappointment. I thought scientists and professors were above the clouds. It was naive of me to think so, some professors were good, but many turned out to be ignorant."

After a spell on the barricades, Taniguchi, like many others, became disillusioned with the student movement. He decided to leave Japan—and that is when instead of becoming a dropout he got lucky. A sympathetic professor steered him to Professor M. Libonati's molecular biology lab in Naples. "I had no intention to become a scientist but thought the new experience would be good for my life," says Taniguchi.

The Italian lifestyle worked its magic. Along with concerts, Taniguchi found in Naples that his childhood enthusiasm for science returned. Libonati passed Taniguchi onto his distinguished friend Charles Weismann at the University of Zurich, who taught him how to "discuss his work and cooperate with others," and, most important, gave him confidence that he could accomplish something big. Five years later, Taniguchi was back in Japan at the Japanese Foundation for Cancer Research where he successfully cloned the human interleukin-2 gene.

Now at Osaka's Institute of Molecular and Cellular Biology, Taniguchi is an engaging mixture of '60s beliefs, European tastes, and old-fashioned Japanese modesty—crediting his luck and his mentors in Italy, Switzerland, and Japan for his successes. He still meets up occasionally with old friends from student days who never returned to research: "Sometimes," he says, "I think how competitive they would all be if they were working in molecular biology."

–A.A.

The Power of Mathematics

"A nest of communists is how they used to describe us," says Jiro Kondo with a chuckle. The description hardly seems to fit the organization Kondo, 76, now heads: the Science Council of Japan—a mass scientific association on a scale without parallel in the Western world, representing 560,000 Japanese scientists through 915 academic societies and 180 subject committees. Kondo, who graduated in mathematics from the University of Kyoto in 1940, explains that for a couple of decades when the council's leaders were directly elected, active and well-organized communist groups took considerable power. As a result, the organization fell into disfavor with the government. Now, following voting reforms in 1985—the year Kondo was elected president—the council has a powerful voice in Japanese science policy. "The government listens to us again," says Kondo, who also heads the new Research Institute of the Earth, which is trying to develop new technology to combat global warming (*Science*, 22 May 1992, p. 1144).

As president of the Science Council, Kondo has automatic right of membership on the highest government science advisory body, the Council for Science and Technology. That enables him to convey the opinions of rank and file scientists directly to the prime minister on such issues as participation in the U.S. Superconducting Super Collider and Strategic Defense Initiative programs.

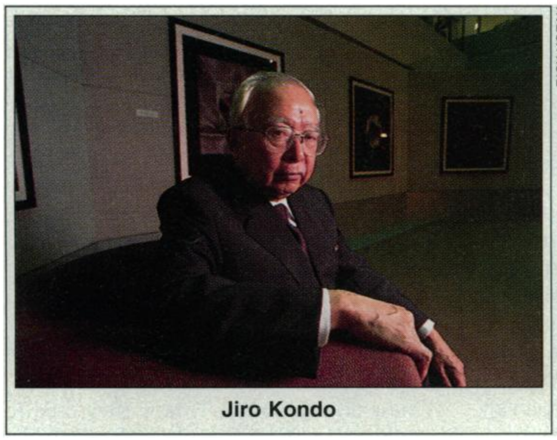
Such heights are nothing new to Kondo, who has been at the forefront of almost every one of the changing phases of Japan's scien-

Consistently Hot Groups

M. Yanagisawa & T. Masaki	University of Tsukuba	Endothelins
T. Kishimoto & T. Hirano	Osaka University	Interleukin-6
S. Nakanishi	Kyoto University	Receptor Structure
T. Taniguchi, M. Hatakeyama & T. Kono	Osaka University	Interleukin-2
S. Numa & H. Takeshima	Kyoto University	Receptor Structure
A. Miyajima & Ken-ichi Arai	University of Tokyo	GMCS factor
T. Nakamura & K. Matsumoto	Kyushu University	Hepatocyte Growth Factor
T. Miyamura, K. Takeuchi & colleagues	Natl. Inst. of Health	Hepatitis Virus

INSTITUTE FOR SCIENTIFIC INFORMATION

Consistent performers. Japan's most competitive research teams stand out in an analysis designed to identify papers that are being cited at monthly rates higher than those from competitors. All eight groups above have managed at least two such papers in the past 2 years; Yanagisawa's group at the University of Tsukuba has produced five such papers, and Kishimoto's group at Osaka University and Nakanishi's group at Kyoto University have each produced three "hot" papers.



Jiro Kondo

RICK KOZAK

tific development. Even the setbacks seemed to have turned into opportunities. At the end of the Second World War, Kondo won a post at the University of Tokyo's elite Department of Aeronautics. The job quickly vanished: "Research related to anything military was prohibited [by the U.S. Occupation Forces], and the Department of Aeronautics was abolished," he explains. The move had an unexpected effect: The top Department of Aeronautics engineers who had helped design the Zero fighter went on to revolutionize Japanese engineering, aiding the design of products from the bullet train to automobiles. Kondo was part of that trend. He joined the Bureau of Statistics and created a mathematical foundation for U.S. professor W. Edwards Deming's ideas about quality control—ideas that helped transform Japanese industry into a sophisticated producer of high-quality goods.

After the Aeronautics Department was re-established in 1952, Kondo went on to study transonic flow, work on the design of an aeroplane (the YS-11 twin turbojet), serve as dean of the Tokyo University Engineering School, and write books on managerial science, high-speed aerodynamics, mathematical modeling, and supercomputing, among 50 others. "The common background, the center of my spirit, is mathematics," says Kondo. He even managed to analyze mathematically the Battle of Iwo Jima. "The very fierce battle on the ground can be easily described by an exact differential equation. I studied it as a hobby," he explains, adding as he returns from his bookshelf with a large volume, "and I wrote a rather thick book about it."

"Now I'm trying to write a book on the global environment," he says. Japan has already made a big contribution to protecting the earth from climate change by developing energy-efficient technology, Kondo says. In the future, he believes Japan will play a key role in providing resources to developing countries so they can use that technology.

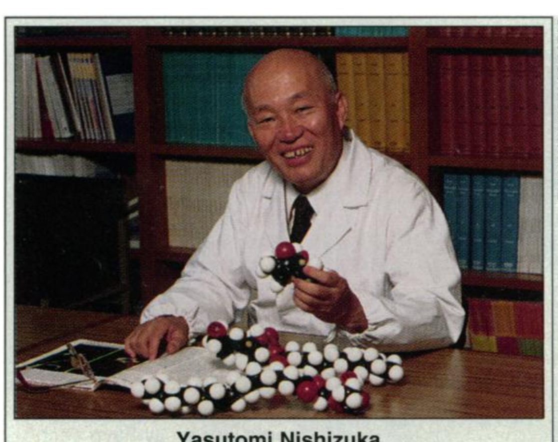
–A.A.

Japan's Most Cited

Back in the middle of the last century, when Japan first opened its doors to the West, a few score strong-minded, adventurous, young Japanese set off for Europe to learn science. Several succeeded in producing a stream of highly original work, published in the most prestigious journals of the day.

Yasutomi Nishizuka seems to be one of the same breed. Consistently following his own ideas and working at Kobe University—not one of Japan's biggest universities—Nishizuka's discovery and characterization of protein kinase C and its role in intracellular transduction systems has given him a staggering total of five out of the 10 most cited Japanese papers of the past decade, and the most cited papers in the world in both 1984 and 1986.

Although easy to spot in a crowd of Japanese scientists (as Nishizuka puts it with a laugh, "You can easily find me, I'm the one without any hair"), Nishizuka avoids publicity. And like those scientists from an earlier era, he keeps to the old-fashioned rules of Japanese politeness, modestly attributing his success to others, from the scientists who inspired him during the year he spent at Rockefeller University in 1964 to editors who polish his English.



Yasutomi Nishizuka

EIJI MIYAZAWA/BLACK STAR

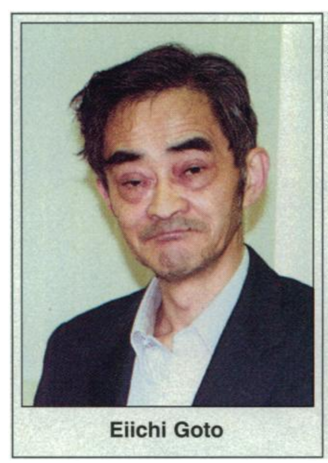
Journalists are not his greatest love, at least in part because of the Japanese paparazzi's habit of staking out his laboratory at Nobel Prize announcement time, just in case he is picked. When he won the prestigious $360,000 Kyoto Prize earlier this year, Nishizuka says, "I rejected all interviews....Science is not a horse race. Communication and friendship are the most important things. Science is not easy to do, it's very personal."

For young Japanese he offers the advice "travel frequently," adding that "Japan is much influenced by the United States, but remember that many good ideas come from Europe." Japan, he says, has many disadvantages: "Language is a terrible disadvantage and so are the distances," but the most important thing, he says, "is to feel yourself a member of the scientific community." To that end, he is constantly telling MESC that it "should spend a lot of money for young people on communication, on traveling, on going to meetings at Cold Spring Harbor, at FEBS, everything."

–A.A.

Battling Against Entropy

Dressed in a rumpled suit, unshaven, and gaunt to the point of emaciation, Eiichi Goto may not look like a giant of Japanese physics. But don't be deceived: He has been among the world's top physicists since he was a graduate student at the University of Tokyo back in 1954. At that time, the newly invented junction transistor was still too slow for use in computation, so Goto devised a transistorless resonant circuit he called the parametron that could be used to carry out logical computations. (In the United States, mathematician John von Neumann independently invented the same circuit.) It proved so successful that companies like Fujitsu, NEC, and Hitachi cooperated in building working parametron computers. But better materials soon made the integrated circuit possible, and the parametron became obsolete in mainstream computing.



Eiichi Goto

DAVID P. HAMILTON

Work on the parametron continued in superconducting electronics, however. Goto, for instance, has just completed a 5-year ERATO project on Josephson junction circuits built with his "quantum flux parametron," or QFP, a superconducting version of his original parametron. His bullish conclusion: "There are no theoretical or technical obstacles" to building superconducting supercomputers. (Hitachi Ltd., which took over the project once the ERATO funding ran out, seems to agree.) Press Goto for details of his project, however, and he retreats into vague generalities, preferring to show a flashy video about the project's accomplishments to discussing them himself.

But ask Goto about the thermodynamics of something called "reversible computing" and he leans forward in his chair, his features light up, and he focuses intently on his questioner. Reversible computing remains a contentious topic among information theorists even now, 30 years after IBM physicist Rolf Landauer first argued that whenever a computer erases information, it must inevitably dissipate heat and increase entropy—a proposition that reconciled information theory with thermodynamics. With surprisingly un-Japanese bluntness, Goto dismisses this conclusion. "They have made an elementary mistake," he says.

That mistake, Goto says, is to equate local heat transfer with heat dissipation. While dissipation necessarily increases entropy, transfer does not—and Goto claims that a QFP circuit can erase informational bits while storing the heat produced by the gate in its liquid helium bath and then transferring it back again, resulting in a net heat transfer of zero—and no increase in entropy. If correct, Goto's argument would have profound consequences. Computers could process information "for free" in thermodynamic terms, meaning that users could theoretically reverse other entropic processes at will—as in, for instance, cooling a room by programming a sophisticated computer to exclude fast-moving (hot) air molecules while restraining slow-moving (cool) ones.

Not surprisingly, Goto's ideas have met with a cool reception themselves. Landauer himself insists that Goto's ideas are "totally and completely wrong." "The whole proposition that we can freely throw away information is against the second law of thermodynamics," he says. But Goto went head-to-head with Landauer at an international conference in 1989 and came away unpersuaded. He's now writing a comprehensive paper on the subject in which he plans to show that even big, well-established ideas like Landauer's are far from invulnerable.

–D.P.H.

Return of the Prodigal Son

Leo Esaki has become a master at managing transitions. That was the case in 1957, when as a graduate student at Tokyo University he invented the Esaki tunnel diode, a device in which electrons jump from one side of a potential barrier to the other via a quantum mechanical "tunnelling" effect. It proved true again when Esaki left Sony after 4 years to join IBM's Thomas J. Watson Research Center in Yorktown Heights, New York, where he won the 1973 Nobel prize in physics for his tunnel diode.


PANA

Leo Esaki

Esaki is now in the middle of another transition. Early this year he left IBM after living in the United States for 30 years to become president of the University of Tsukuba. It was not a move he had anticipated: The call came when a group of young Tsukuba professors became convinced that their university—built in 1973—had not lived up to its promise as a new style institution that would spark original thought and creative inter-laboratory collaborations. Esaki, they believed, could provide the new leadership they needed. Tsukuba faculty, who elect their president, put his name on the ballot and got him elected, upsetting many older professors.

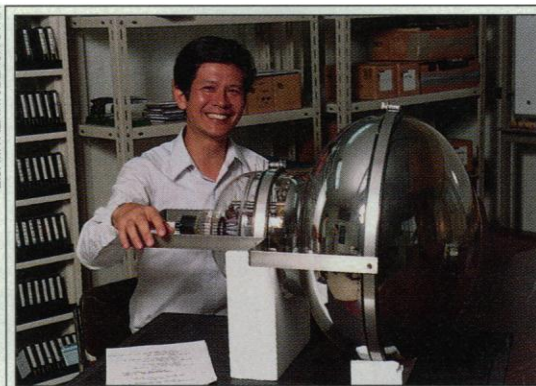
"This is almost a 'forbidden transition,' going from industry to academia—especially in Japan," Esaki says of his move to Tsukuba. And he's aware that people may worry that he's turned too American: "Many people think I am returning after 30 years and might have a hard time fitting in. But for the last 15 years I have been working closely with IBM Japan and have been coming here at least five to six times a year. So I have actually been keeping very close contacts and relations to things happening in Japan," he says. His work with IBM Japan should turn neatly to his advantage at Tsukuba: "I know how to manage the bureaucracy and politicians," he says. Just as important, he says, it's given him considerable experience in building industry-university relations.

His main goal now, he says, is to kick-start the culture of the university—and of Tsukuba itself—by encouraging research collaborations and scientist exchanges between the university and Tsukuba Science City's numerous corporate labs and government research institutes. "It will take much time," he says. "Tsukuba [City] now has no culture, but neither does it have so many senior people. It is open to change."

On that old question of whether there is some cultural barrier inhibiting scientific originality in Japan, Esaki—with his 30 years in America—says jokingly: "The Japanese are good listeners—like good soldiers, obedient, attentive and diligent. But there are no officers. In the United States, however, everybody is an officer—there are no soldiers there." With the young soldiers of Tsukuba ready and willing to listen to Esaki, expect some fireworks in the future.

–F.M. and D.P.H.

Neutrino Power


EIJI MIYAZAWA/BLACK STAR

Yoichiro Suzuki

In his abandoned mine, 1000 meters under a mountain in the center of Japan, Yoichiro Suzuki is brimming with confidence. Four years from now, work here will be complete on the world's largest nucleon detector, a behemoth called SuperKamiokande, and Suzuki and his colleagues will begin what he calls "neutrino astronomy"—monitoring tell-tale signatures of neutrinos streaming from the Sun and far-off supernovas. SuperKamiokande will also push to new limits efforts to detect proton decay, one of the key uncomfirmed predictions of physics' Grand Unified Theories. "It is very exciting," says Suzuki. "With our new facility we will have a research capability that nobody else can approach. We will have no competition."

Just 42 years old and an associate professor of physics at the University of Tokyo's Institute for Cosmic Ray Research, Suzuki is the man at the heart of SuperKamiokande. He is responsible for the electronics and computing facilities that snatch data from passing neutrinos. As an old neutrino hand, with a half-dozen years research experience at Brookhaven National Laboratory on top of a dozen years research work in Japan, the job doesn't worry him but it keeps him busy: He says he works until 11:00 every night and "just recently started to allow myself to stay at home on Saturdays."

SuperKamiokande builds on successes with an earlier detector, Kamiokande-II, which first made neutrino astronomy look possible in 1987 when it picked up a burst of neutrinos from the supernova in the Large Magellanic Cloud. The new detector, which is expected to cost $72 million, is essentially a gigantic tank containing 50,000 tons of ultrapure water. The tank is lined with 11,200 specially crafted photomultiplier tubes poised to detect the tiny flash of light emitted on the rare occasions—just 30 events a day—when one of the estimated 60 billion or so neutrinos passing through each square centimeter of the tank each second collides with an electron surrounding an atomic nucleus.

SuperKamiokande's size and design will make it far more sensitive than any other machine in the world. "The large number of events and greatly improved statistics will allow researchers to carry out detailed studies on the time variation of the solar neutrino flux and also to pinpoint a solution of the MSW effect [the neutrino oscillation effect]," says Suzuki.

The new detector should also be able to pick up the flash of light when—or rather, if—a proton decays. Given the sensitivity of SuperKamiokande's detectors and the huge volume of water they observe, experimenters should be able to catch protons in the act of decay even if the proton half-life is $10^{33\text{-}34}$ years. That covers the range in which most Grand Unification Theories predict the proton must decay, making it possible for SuperKamiokande to test directly the most fundamental theories of physics. It's an exciting prospect, but not one Suzuki intends to keep to himself. U.S. collaborators will be welcome. In fact, in August they were already over in his laboratory, planning experiments.

–F.M.

Home From America

For an insider's view of Japan from the outside—or maybe an outsider's view of Japan from the inside—there is no better person to talk to than Hiroto Okayama, a young professor of molecular genetics, currently at Osaka University but about to move to Tokyo. After spending "a quarter of my life in the U.S.A.," as he describes his 10 years at Stanford and the National Institutes of Health, Okayama has acquired a relaxed manner, an easy laugh, a family, a collection of antique American pocket watches, "how to straighten my logic through argument in the U.S. style," and some rare insights into Japan. "In America I must have seemed just like any typical Japanese," he says with a chuckle, "but after experiencing the U.S. system I really began to understand the Japanese system."

Amid much discussion of his science, Okayama can set a foreign visitor right on a few points. Among them: First, things are getting much better for basic research in Japan, even though stay-at-home scientists may not have noticed. "When I came back [in 1989] the situation had very much improved," he says. "Thirteen years ago the opportunity to do good research was still greatly limited." Second, the slow pace of change may be an illusion: "The Japanese system is quite strange," he explains. "Once it starts to move, things move very fast, but it takes a huge time to start moving." He sees the numerous reports recommending increased funding for basic research as part of the ponderous activity preceding take off. And third, the much-maligned MESC is enigmatically Japanese, but not necessarily as bureaucratic as it looks: "For me its quite a nice system," he explains. "We have regulations but the regulations are often not strictly enforced. It's actually quite flexible but each person has to understand some unwritten laws." For example, a company has begun renovating his new lab in Tokyo, even though Okayama hasn't been given the money to pay for the job. It will all work out, Japanese style.

EIJI MIYAZAWA/BLACK STAR

Hiroto Okayama

The way different ministries fail to cooperate effectively seems to leave even Okayama perplexed, however. Along with his 20-person university lab, funded by MESC, he also runs a 15-person lab funded by the ERATO program in Kyoto—and that lab has to remain separate.

Even so, the two labs do give him some serious research power. "NIH was so crowded," he says laconically. "Here I have much more space." He'll probably need it. Okayama works in the highly competitive area of cell cycle regulation. Last year he identified a human gene similar to the *cdc25*$^+$ gene that controls passage through two phases of the cell cycle in fission yeast. "Simultaneously," he says, "David Beach isolated the same gene at Cold Spring Harbor." His next project? As he goes through his recent results he says, "You better not tell anyone about this, I'm submitting it to ****** "

–A.A.

Closing the Culture Gap

Hiroyoshi Rangu, general manager of NEC's Fundamental Research Laboratories in Tsukuba, is a mixture of different worlds and cultures. On one side, Rangu's business card identifies him as "Dr. Hiroyoshi Rangu," adding in parentheses the English name "Roy Lang." On the flip side, Rangu spells his name out again, this time in *kanji*, the Chinese characters normally reserved for names of Japanese origin. A glance at Lang—or "Rangu"—only confuses things further. From a distance, his medium height and straight dark hair might lead one to mistake him for a Japanese. Close up, however, his round cheeks and infectious, crooked grin betray his Western descent. "[Japanese] people always think I'm a foreigner when they meet me," Rangu says. "But in 5 minutes, they've usually forgotten."

DAVID P. HAMILTON

Hiroyoshi Rangu

With his European appearance (his father was a New Zealand missionary and his mother Japanese) and a fluent command of the Japanese language, Rangu moves comfortably between two cultures that historically have had great difficulty understanding one another. He is also able to bridge the gap between the worlds of basic and industrial research, with training in theoretical laser physics at MIT and the Center for Astrophysics in Boulder followed by some 15 years of applied research experience at NEC. With that background, Rangu seems admirably suited to run what is fast becoming Japan's most famous company lab devoted to fundamental research.

And it's perhaps no surprise that Rangu is trying to synthesize a new approach to managing the 8-year-old, 340-member laboratory—an approach that mixes Japanese and Western styles. Japanese industry normally manages its researchers strictly: "We evaluate and [give guidance to] our researchers quite frequently—monthly, weekly, sometimes daily," he says. He contrasts this with a Western basic research lab: "Once someone knows the fundamental direction of their research, they're free to pursue it for 1 to 2 years without interruption."

At NEC he is trying to strike a new "equilibrium" between the need to create new things and exploring the fundamental rules of nature. Researchers get far more freedom than they would in a normal industrial laboratory, but he asks them to find good fundamental topics that can satisfy the company's long-term needs. One management tool that helps: Rangu regularly asks his researchers to explain the significance of their work not just to their scientific peers but to upper-level management.

So far, Rangu can claim at least one outstanding success: physicist Sumio Iijima's surprising discovery last year of "carbon nanotubes," a buckyball spinoff consisting of carbon molecules in nanometer-wide helical tubes. Rangu says he's hoping to help along similar breakthroughs in other areas by encouraging "spontaneous" interdepartmental research collaborations, another unusual feature in normally hierarchical Japan. Other changes are likely to follow, but Rangu guardedly declines to describe them. "Because I believe long-term consistency is vital to basic research, I have so far avoided abrupt changes."

–D.P.H.