period in all fields, Bell Lab researchers earned an average of 7.4 citations per paper, while the comparable number at NTT was only 2.9. And the gap widened over the span. AT&T's citation impact (number of citations divided by number of papers) rose steadily through the 1980s before leveling off in the 1990s, while NTT's has stayed relatively flat.

Ikegami defends the company's research efforts, singling out a body of recent work in optoelectronics and studies of quantum effects in semiconductor devices that has attracted worldwide attention. Chavez-Pirson's group, for example, reported in 1994 that it had pushed lasers to new levels of minuteness and efficiency with the world's first quantum wire microcavity semiconductor.

Yasuaki Masumoto, a professor of physics at the University of Tsukuba, says it is hard to generalize about NTT's labs overall, but he agrees that the groups working on nanometer-scale semiconductor devices "are very strong, even when looked at from a global perspective." Izuo Hayashi, a recently retired physicist and a pioneer of the field of optoelectronics while at Bell Labs in the 1970s, says "NTT has been making some contributions to the advancement of [optoelectronics]." But he doesn't think those contributions match what Bell Labs was doing 10 to 20 years ago.

Ikegami readily acknowledges that NTT's research labs have a long way to go before they match the quality of work done at AT&T. "AT&T has a legacy of outstanding research," he says. "We are still striving to match that standard of work."

A basic challenge

Regardless of the quality of NTT's research, there is a widespread perception that Japan is seriously lagging behind other countries—particularly the United States—in the use of information and communication technologies. The Telecommunications Council noted that, on a per capita basis, the United States has six times the number of e-mail subscribers as Japan, three times the number of computer databases, and 11 times as many host computers connected to the Internet. It also cited a 1994 survey by Japan's Science and Technology Agency that found a majority of high-tech corporate executives believe that Japan is seriously lagging the United States in the communications and electronics sectors. "Japan had been emphasizing the wrong set of technologies," says Jiro Kokuryo, assistant professor of information systems at Keio University Business School. "Use of smaller computers, rather than mainframes, lagged in Japan; consequently the related research lagged." Adds Stanford's Yamamoto, who still serves as an adviser to NTT, "Japan's R&D in computers and networks is 10 years behind the U.S., [although] NTT is not solely responsible for this."

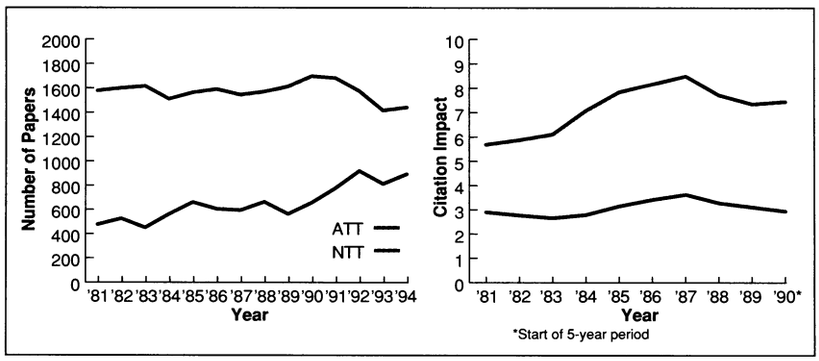
In early 1994 NTT took a few steps to help close the gap by forming a Multimedia System Laboratory Group to study software, networking, and technologies aimed at expanding use of the Internet. NTT has also agreed to develop future interactive technologies in partnerships with Silicon Graphics Inc. and Microsoft Corp.

But the Telecommunications Council would go much further. Its plan would split NTT into three separate companies, one a long-distance carrier and two to provide local phone services, with the dividing line just west of Tokyo. The report envisions NTT's R&D facilities as being "mostly inherited" by the eastern regional company, apparently because most of NTT's present research labs happen to be located in that region, although the western regional company would contribute to the research budget.

NTT supporters believe such an arrangement would doom basic research. Ikegami fears the research labs could eventually go the way of Bellcore, which was formed to serve the research needs of the new regional phone companies. Bellcore has recently been put on the market (*Science*, 2 June 1995, p. 1268), a victim of the regional companies' divergent strategies.

Even if union opposition sinks this particular plan—so far, none of Japan's political parties seems willing to take it up—NTT may still face wrenching changes that could affect its research activities. The Telecommunications Ministry, politicians, and industrial leaders all support further deregulation, and the fear is that this new competition will squeeze out research that does not directly—and fairly quickly—contribute to the bottom line. "We want to maintain our support for basic research," Ikegami says, "but it's likely to be an increasingly difficult challenge to do so." Bell Labs and Bellcore have already found that out.

–Dennis Normile



Playing catch-up. Although the smaller NTT is closing the gap with AT&T on overall output, the average NTT paper is cited much less often.

A $3 Billion Slice of AT&T

While Japan debates the merits of dividing up Nippon Telegraph & Telephone and its research labs, its U.S. counterpart continues to splinter. Last week AT&T completed the largest initial public stock offering in U.S. history as it launched Lucent Technologies Inc. On 4 April the public bought 112 million shares of the new company, which controls most of the old Bell Laboratories, spending a record $3.025 billion.

Lucent takes with it approximately 75% of the roughly 27,000 research and development experts at Bell Labs, the famed R&D arm of AT&T that introduced such technological benchmarks as the transistor and laser. It will be based in Murray Hill, New Jersey, and its primary focus will be to supply equipment to the telecommunications industry. The remaining 25% of Bell Labs will remain with AT&T, forming the heart of AT&T Laboratories, which will focus its research in areas such as wireless communications and cryptography. That research outfit has yet to select a permanent home. The remaining piece of the one-time monopoly, AT&T, will operate long-distance telecommunications networks. Last fall AT&T announced it would split into three companies by the end of 1996.

Bell Labs, once an oasis for corporate basic research, has dramatically reduced long-range research in recent years in favor of near-term, product-oriented projects. Industrial research analysts say that Lucent will need to do well to allow researchers to continue a variety of projects in fundamental areas ranging from software development to high-speed electronics. If the company falters, predicts Richard Solomon, associate director of the Massachusetts Institute of Technology's research program on communications policy, "the first thing they'll squeeze is R&D."

–Robert F. Service