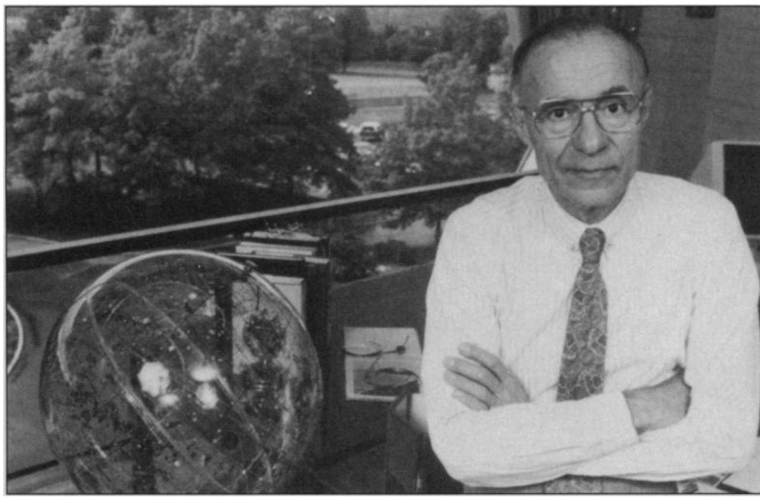
Bell Labs: Shakeout Follows Breakup

A long-dreaded reorganization at the lab last fall has left some investigators happier—but many basic researchers feel the luster is gone from AT&T's "crown jewel"

PHYSICIST ROBERT DYNES REMEMBERS THE time when the corridors of AT&T Bell Labs were bursting with history in the making. "I remember Memorial Day 1970," says Dynes, who in 1990 left the lab to become a professor at the University of California, San Diego, "when Mort Panish and Izuo Hayashi got their first continuously running room-temperature gallium arsenide laser going, and came running down the halls dragging whoever was around out of their offices as witnesses. You knew immediately this thing was going to have an impact on the world. That's the kind of place it was."

Lately that feeling has been rarer at the big Murray Hill, New Jersey, complex. The main reason: a sharp recent shift in the lab's organization and priorities, which came as a delayed response to the breakup of the Bell companies in 1984. For several years following divestiture, things remained relatively stable at the lab, which was the foremost example of a basic research lab in an industrial setting—indeed, something very much like a national industrial research laboratory.



Captain, my captain. *Lab director Arno Penzias: After divestiture, Bell Labs could have become a "sinking ship," but "we've fixed the hull."*

Sharon Guynap

Then, last September, the long-expected—and dreaded—realignment finally took place under the direction of Arno Penzias, vice president for research of AT&T Bell Labs and lab director. The aim was to reduce duplication in research and align it with the activities of the business units, to orient research toward the near term (defined as just beyond the planning horizon of businesses, about 3 to 5 years), and to streamline the flow of information within the company from basic research through development and manufacture. "We adjusted the food chain," says Penzias, likening Bell Labs to an ecosystem.

In the eyes of some Bell Lab watchers, these changes constitute a new "paradigm" for the running of a large research laboratory. Within the lab, reactions to this new paradigm vary, depending on temperament and field of research, with basic researchers tending to lament a loss of freedom. But even many of those who felt strongly enough to leave acknowledge that Bell had little choice, because the lab's existence now depends on the company's survival in an intensely competitive international marketplace. In fact, they marvel that Bell was able to support what amounted to a national research facility as long as it did after divestiture. The real problem, observers say, lies not with Bell but with overall U.S. research policy, which without conscious choice allowed a key national research facility to be dismantled.

Ironically, one of those who initially thought that divestiture would kill Bell Labs was Arno Penzias himself. In testimony during U.S. vs. AT&T, the 1981 trial that preceded divestiture, Penzias said that a breakup would make Bell Labs a "sinking ship." But today, Penzias doesn't even flinch when the remark is recalled. "If we'd done everything in the old way, we probably would have sunk," he says. "But we've fixed the hull. We're back to a healthy operation." Penzias himself admits, though, that the repairs required emergency measures that tested the stamina of his crew.

In predivestiture days, AT&T was the regulated monopoly responsible for the nation's telecommunications network, and the amount of profit it could earn was fixed by law. As AT&T's research and development arm, Bell Labs was treated as part of the cost of maintaining and upgrading the network, and the funds that supported it did not come out of profit but were written off as a business expense. That made it essentially a nationally supported laboratory, financed by a tax on every coin that clinked into a phone booth and every check written to pay a phone bill. This arrangement created the long-term stability vital to effective basic research teams. AT&T's "crown jewel," the lab was called.

Divestiture didn't immediately cloud that jewel's brilliance. Before divestiture, AT&T had a million employees, of whom it lost two thirds to the regional phone companies created by the breakup. Bell Labs, however, lost only a few thousand of its workers: from 25,900 employees before divestiture, it fell to a postdivestiture low of 19,300 in 1984 and 1985. Thereafter, the number of employees slowly rose, now standing at 22,900. (Some 7000 more are officially AT&T Bell Labs employees but are paid for by the business units.) The lab budget, too, remained relatively stable; it was $2.02 billion in 1982, dropped to $1.9 billion in 1984 and 1985, and has climbed steadily since, to $2.9 billion in 1990. Some long-term projects with payoffs thought to exceed a decade, such as research in Josephson junctions, liquid crystal displays, and magnetic bubble memories, were discontinued, but otherwise basic research was relatively unaffected. But worry persisted. The lab's good fortune in an era of cost-cutting "created an air of uncertainty," says department head Greg Blonder. "If nothing happened to us one year while the rest of the company was shrinking, we'd say, 'The ax is sure to fall next year!'"

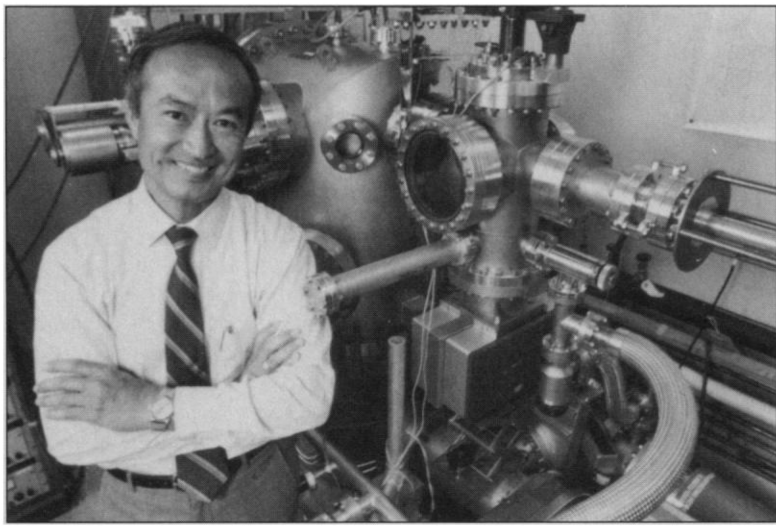
At the end of the summer, the expected major change finally came—not as the fall of an ax but as a reshuffle. The research organization consists of four divisions each with 34 laboratories of about 100 people; laboratories in turn consist of 57 departments of a dozen or so scientists. In the reshuffle some labs were eliminated and new ones created. The most significant change was in the physics division. There, a laboratory devoted to basic research in chemical physics (headed by Dynes) was disbanded, and a new silicon electronics lab was created. Basic physics research, previously scattered throughout several laboratories, was consolidated into one, the Physical Research Laboratory. A third laboratory in the physics division, Compound Semiconductors, already existed and was relatively unaffected. Related, somewhat less dramatic changes were experienced in other divisions; in the communications systems division, for instance, an electronics research laboratory was eliminated.

"Astute observers here were picking up the message that something was going to happen about a year before the actual reorganization," says Jeffrey Bokor, a researcher in the new silicon electronics lab, among those whose work was most strongly affected. "It was clear the size of basic physics research would be scaled back and software-related research increased. What's surprising is how long it took AT&T to figure out that what they were really funding all this time was a national basic science laboratory, and that the financial benefit to the company was incommensurate with the expense."

The reorganization, still in shakedown mode, amounted to a new research paradigm for a laboratory in an industrial setting. The elements of the paradigm are threefold. The first is a redistribution of the kinds and amounts of basic and applied research; a shifting of the balance of activity from one part of the "food chain" to its terminus. The second element consists of "concurrent engineering," or trying to speed up the food chain by shrinking time between product conception and introduction. The third element is stepping up the information flow between various parts of the company; making sure that each part of the chain knows about the others, to facilitate the forging of new links. Each element in this new research paradigm draws kudos and criticisms from within and without the lab.

Penzias (known throughout the company as Arno) insists that what's going on at Bell Labs is not an elimination of basic research, nor even a threat to it, but a remixing of basic and applied research to suit the needs of the business end of the company. "The key to running an effective basic research lab in an industrial setting is to find out which kinds of basic research have potential long-term payoffs for your business. It isn't that I cut up research to serve the business units. Rather, I look at the mix of businesses we're in and the needs they have, and try to distribute the kind of long-term research that goes on here accordingly."

But some worry that the quality of basic research will decline when driven by business activities rather than by research itself. One of them is research director Al Cho, coinventor of the molecular beam epitaxy (MBE) machine, an ultra-high vacuum crystal growth device able to create one atomic layer at a time that is now a standard instrument in laboratories all over the world and an indispensable piece of equipment for the semiconductor industry. "In the old days," Cho says, "we went out and hired the best people we could, turned them loose in a large room and said, 'Show us what you can do.' This provided the climate for good science and good technology." Cho cites his invention of the MBE machine, which culminated a dozen-year research project, as an example. "Today, it's more like putting you in a corridor. Within a corridor you can still do good research, but you are restricted to short-term projects. We went from three-dimensional research where success was defined by the discovery of new phenomena and the creation of new fields to one-dimensional research governed by what is cost effective and meets market needs. I'm not sure I could have arrived at the MBE machine in the same environment."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Disgruntled boatswain Al Cho: *"In the old days, we went out and hired the best people we could...and said, 'Show us what you can do.'"*

Cho, who lost his materials processing research lab in last year's reorganization due to an overlap with another division, admits the company can no longer afford duplication but is not sure resources are being well managed. "When you're working on making a material like gallium arsenide, you obviously need some fabrication capabilities or all you have is pieces of rock. When they cut my materials processing lab, research became much harder to do. What if you wanted a microscope and were told that you can't have one because all the microscopes are in the other division? In the reorganization people were reshuffled and relabeled, but what we really needed was a vision...and long-term commitment to certain avenues of research."

Cho worries about the signal the reorganization sent throughout the company. "It changed the reward system. It said it doesn't matter if you're a National Academy member or invented an important worldwide technology or are recognized by the scientific community. What matters is if you can sell your research as being able to make the company more profitable. And that affected people. They said, 'If they can do that to Al Cho, what can they do to me?' So some people went to places where they had more freedom to do research."

Others view AT&T as having had little choice, given the new environment in which it found itself post divestiture. "There's no fairy godmother out there who's going to step in and keep you in business," says Charles Shank, who left last year to become director of Lawrence Berkeley Laboratory in advance of the elimination of his electronics research lab. "You've got to address business reality. I think AT&T did what it had to for its survival."

While the remixing of basic and applied research is the first element of Bell's new research paradigm, concurrent engineering is the second. A new stress on applied research would be of little value without a concomitant tightening of its ties to basic research. "Once upon a time," says Robert Lucky, head of the communications research division, "you did your research, passed the results on to the development arm, which did its own set of investigations, which then passed its results on to manufacturing, and then you had your product. The pace of international competition means that you can't do it sequentially anymore."

In response, Bell Labs created teams staffed by individuals involved in various aspects of development and research who try to plot ahead of time the development of a new product all the way to market, and to see what can be done about speeding up the process. Last year, for instance, a team of Bell physicists was examining new methods of creating lasers by stacking up different layers of semiconducting material through vapor deposition. The work had potential applications in the products sold by one of the business units with a factory in Reading, Pennsylvania.

In years past, a breakthrough by the basic research team would have been followed by a memo to the business unit, which would then have done exploratory research followed by construction of appropriate manufacturing devices. No more. The physicists were doing their experiments at their Murray Hill site on a machine called a MOCVD reactor, for metal organic chemical vapor deposition, and a nearly identical reactor had been built at the Reading factory for manufacturing. When the breakthrough occurred, the MOCVD program was put on a computer disc, driven by car to Reading, installed in the other reactor, and within a few hours salesmen for the business unit were pitching customers about a new kind of laser chip being factory grown as they spoke. "That happened not because we shortened the term of our research," says physics division head Bill Brinkman, "but because we put ourselves in a position so that it could be adopted more rapidly."

Jumping ship. *Daniel Chemla* (left) *and Charles Shank leaped to another vessel: Lawrence Berkeley Laboratories.*

The episode reflects a new emphasis Bell places on teamwork between researchers and members of the business units. This emphasis was made quite tangible in Bell Labs' yearly performance review, in which everyone in the company is rank ordered. In recent years, the criteria on which individuals are ranked has changed sharply. Previously almost no credit was given for team projects whose output could not be clearly identified and which didn't result in a publication in an academic journal. Today, teamwork, near term research, and work that does not result in outside publications but that helps a business unit receive considerably more emphasis.

The new criteria, and the speed with which they were introduced, are not to everyone's liking. "The standards we used in evaluating research changed quite abruptly in certain cases," says Blonder. "It was sometimes unfair. One year a person would be told, 'You're number one, keep up the work,' and that person might do more of the same next year and wind up at the bottom."

The third element of the new paradigm is better communication between research teams and business units. That issue came to a head at an "Arno Staff Meeting" early in 1988 in the course of which Penzias went on and on about how the research organization needed to do more for the business side. Finally one director blurted out in exasperation, "But Arno, we don't even know what they want!" Penzias spent a few months mulling over the remark, and in June 1989 announced that, henceforth, each of his 15 directors and four executive directors would adopt one of the 19 business units, familiarize themselves with the work, and serve as liaison or "research contact person" between it and the rest of the research organization. "It dramatically changed the way things went around here," says Brinkman. "Within about a year, there was a lot more contact between the research and business people."

Like the other two elements, the stepped-up information flow has fans and critics. Blonder, for instance, took to it readily. The wall of his office is decorated with trophies of collaborations with individuals from other parts of AT&T; graphs of optical pulses from sea slugs, framed pictures of neural networks fashioned from mouse nerves glued to silicon wafers, snapshots of photonic devices, and the like. A few years ago, Blonder discovered an optical cavity effect with potential applications in optical disc recording. He found a few other people working in the area and joined a (short-lived) effort in that direction. "The reason I stay here," he says, "is that you have access to all this interdisciplinary stuff, there's all sorts of odd mixtures of things you can find. It's like a candy store in here!"

Other scientists—with different temperaments—don't have the same reaction. "You want me to tell you how things are different around here?" says one scientist who requested anonymity. "I know more about the rest of the company than I want to. I've been to more damn meetings than I ever have in my entire life. There comes a point where I don't want to know any more about the rest of the food cycle, I want to do my work!"

The three elements of the paradigm (redistributing applied and basic research, concurrent engineering, and increased information flow) seem to affect basic researchers more than others at the lab. "Basic science doesn't hold the same luster at Bell Labs that it used to," says recent Bell alumnus Dynes. "When I was there, all you had to do was really good research and be a leader in your field. Now you can still do good basic research, but the really important yardstick is its relevance for the company's business. But that's not AT&T's fault. It's a function of the lack of commitment to long-term investment in this country."

"The real question here does not concern the actions of AT&T but the actions of this country," says Daniel Chemla, a former Bell physicist who left last year to direct materials science at Lawrence Berkeley Laboratory. "At the same time all other countries in the world were trying to reinforce their telecommunications industries, the United States decided to break theirs up. Did they think AT&T could continue to support fundamental research the way it had? You can't cut a company by two thirds and expect it to keep supporting basic research to the same extent—mathematically, it's impossible! What was surprising was that AT&T continued to support the lab and its basic research for so long."

Charles Shank, Chemla's former boss at AT&T and current boss at Berkeley, says, "I remember hearing Senator Timothy Wirth (D–CO) say that what would be lost at Bell Labs would be easily made up in innovations in small companies. What people don't realize is that fundamental new advances come over time, and if you're going to invent something like the transistor or laser it requires an organization with size, not a startup company. Startup companies focus on rearranging existing technologies and developing marketing strategies; the result is companies like Apple Computers. But totally new things don't happen from small companies. The single most important thing to a thriving basic research lab is stability in terms of long-term commitment of resources. That's what creates a scientific culture, and it was the key to the success of Bell labs. You can't build up a scientific culture quickly, but you can sure tear it apart in a hurry. That's what we're seeing here. And the tragedy of this whole story is that American society hasn't realized what it's lost. AT&T easily could have been preserved and all of the competitiveness between the operating companies created. But the government didn't step in to save it."

■ ROBERT CREASE