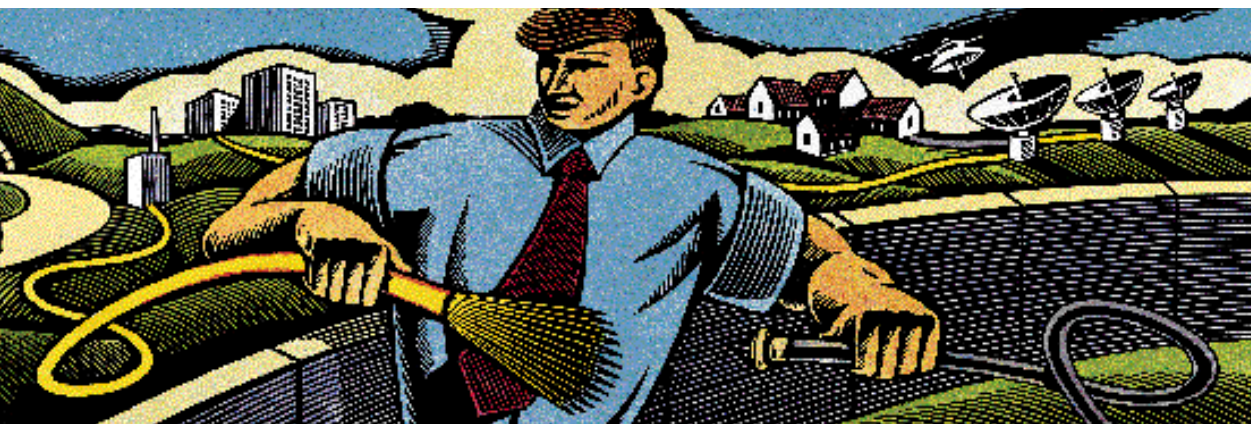


Incubating Entrepreneurs at Caltech

Of all the research groups housed within the walls of the California Institute of Technology in Pasadena, one of the most innovative and successful in producing entrepreneurial spinoffs has been the group led by Amnon Yariv, the Martin and Eileen

ultimately capitalized on the demand for fiber-optic components in the telecommunications and cable-television industries. Today, Ortel is a publicly traded NASDAQ corporation with more than 500 employees, occupying seven buildings in the same loca-

invented new signal-processing algorithms for improving the visual image qualities of such displays while he was laid up with a sprained ankle, and he converted his discovery into a successful business venture. "Basically we make a chip that enables us to



replace conventional CRTs with something 1-inch thick that looks better and costs only marginally more," he said.

George Rakuljic, another former student of Yariv, co-founded a company with him in 1990 called AccuWave Corp. (Santa Monica, CA), which was based

Summerfield Professor of Applied Physics and Professor of Electrical Engineering.

Over the last 30 years, Yariv's research group has worked on a broad range of theoretical and experimental research related to optical devices and semiconductors, frequently inventing advanced technologies in the process. For example, his group was the first to work in the field of integrated optoelectronic circuits, which combine optics and electronics monolithically on single crystals. The group also invented and developed the distributed feedback semiconductor, which is used to power most of today's fiber-optical links.

A series of start-ups

Part of the work in semiconductor lasers enabled the forming of Ortel Corp. (Alhambra, CA) in 1980 by Yariv and two former students, Nadav Bar-Chaim and Israel Ury. "We found that the semiconductor lasers we were designing were just as good as the commercial products available, and we figured we could be competitive," said Ury. Sustained by government research contracts during the crucial R&D phase, the company

tion where they started out 16 years ago with two employees.

Although Ury admits that attempting a start-up company just out of graduate school is at best a risky venture, he believes that their chosen core technology was sufficiently unique to offer a good chance of success. Although opportunities still exist for start-up companies, Ury emphasizes the importance of adopting both short- and long-term business strategies. "There's an old adage that to reach the long term, you have to survive the short term," he said. "We were several years ahead of our time and used the government contracts to keep our business going until the markets caught up with the technology."

Arithmos Inc. (Santa Clara, CA), a semiconductor-chip design firm founded in 1993, grew out of work on electronic VLSI (very large-scale integrated circuit) chips for neural networks, which was outside the Caltech group's usual focus. The company designs chips for use in liquid-crystal, flat-panel displays. Co-founder Chuck Neugebauer, an electrical engineer who became involved with Yariv's group as an undergraduate at Caltech and remained for his graduate studies,

on his thesis research in photorefractive materials and their applications. He left the company in 1994 to found Arroyo Optics (also in Santa Monica) with another of Yariv's former students, Anthony Kewitsch. Rakuljic will say only that the fledgling company is "in the fiber-optics area." Another former research fellow, Shlomo Margalit, went on to found an additional successful NASDAQ company called MRV Communications (Pasadena, CA), but Yariv had no involvement in the venture.

Even those students who find themselves at major industrial research laboratories after graduating still retain something of the independent entrepreneurial spirit. Chris Harder, who graduated and then returned to his native Switzerland to work in IBM/Zürich's applied physics laboratory, used his thesis research to develop a high-powered semiconductor laser with emissions at 980 nm.

That venture nearly ended in 1991, when IBM chose to downsize and focus on software design, but the laser turned out to be ideal to pump erbium-doped fiber amplifiers, which were just emerging in the telecommunications industry. The company

set up a small laser-manufacturing site in Zürich to accommodate the market demand, establishing it as an independent business unit in April 1996, with Harder heading a small group in the research division. IBM/Laser Enterprises expects to produce some 20,000 lasers this year, according to Harder, and is working to develop the next generation of higher power lasers.

Secrets of success

Former students have plenty of theories about what makes Yariv's approach so conducive to encouraging entrepreneurial instincts in his researchers. For instance, unlike many universities that undertake large research projects and assign graduate students to small pieces of the projects for their thesis work, Yariv assigns his students to single projects for which they are responsible from start to finish, giving them an overview of the entire process.

Neugebauer recalls being asked regularly to give presentations or "practice pitches" on his work to visiting scientists and technologists. It provided valuable experience for when he had to raise funds to found Arithmos, a task made easier by the fact that he chose to focus on a market easily comprehended by the investment community. And Ury found the large number of postdoctoral students in the group, with their considerable research experience, helped alleviate competition among the graduate students for cutting-edge thesis topics and fostered many fascinating interchanges of ideas.

Several former students cite Yariv's willingness to let them pursue research outside the group's usual focus as another key factor. "Amnon could really care less about someone trying to figure out the value of pi to a few more decimal points. He's not interested in evolutionary work, but in revolutionary work," said Rakuljic. "He doesn't let students get completely lost, but he does give them enough freedom and flexibility to explore whatever topic interests and excites them." Because of this approach and the atmosphere it breeds, many students who

are attracted to Yariv's research group are naturally prone to taking initiative and risks in their work, and they are highly rewarded for doing so.

However, Rakuljic attributes the increasing number of start-up ventures by Yariv's graduates in recent years to the stagnant job market for many Ph.D. scientists. "Starting in about the late 1980s, the only traditional employment options available to most graduates, including myself, were very uninteresting," he said, prompting many to look to less conventional opportunities. Still, opting to invest in a start-up company is not for everyone. "If you like riding roller coasters, it can be very exciting," said Neugebauer.

Despite past successes, Yariv's model of translating basic research into marketable inventions could be at risk if current funding trends continue. Although federal funding overall has increased, the field of semiconductor optoelectronics is beginning to mature and competition for funds is much stronger as his students become professors and researchers in their own right, also in need of funds. Today, nearly every major U.S. research university has a program in optoelectronics and quantum electronics, compared to only three or four 30 years ago.

There are also fewer unencumbered funds dispersed from federal funding agencies, according to Yariv. "Today they want you to design a system or describe the specifications of what you want to do, and give them a definite timetable," he said. "That is completely inconsistent with the free investigation which leads to inventions. If we were required to describe all our inventions in advance, we would never have made them."

At the same time, many industrial laboratories are drastically reducing or shutting down their basic-research programs. "American companies are becoming system companies, and young professors, just to survive, have to build and deliver systems, leaving them no time to do basic work from which inventions flow," said Yariv. "So there very likely will be far fewer groups like ours 10 years from now, in spite of our successes." 