host galaxy is apparently too faint to have been detected by the Keck telescope.

Bloom and his colleagues submitted their results to *Nature* on 23 March 1999 (the paper was published on 30 September). But despite *Nature*'s embargo policy, they also made the paper available on the Internet on 24 May. As they wrote in an accompanying note, they did this "given the rapid progress in the field of gamma ray bursts." Other teams quickly took a closer look at their own data.

Sure enough, within a month, a similar supernova signal was detected in the afterglow observations of GRB 970228, the very first gamma ray burst for which an optical counterpart had been found (*Science*, 21 March 1997, p. 1738). In a paper to appear in *Astrophysical Journal Letters*, Daniel Reichart of the University of Chicago claims that his analysis of GRB 970228 "is the strongest case yet for a GRB/supernova connection." A still more extensive analysis of the GRB 970228 data by a team led by Galama leads to the same conclusion. Galama and his colleagues have submitted their results to the *Astrophysical Journal*.

Both Woosley and Wheeler believe these new findings add credence to the claimed link between GRB 980425 and supernova 1998bw. "Three data points is enough to convince me," says Woosley, although he admits that he has a theoretical prejudice. Moreover, two more possible coincidences between gamma ray bursts and supernovae have been revealed over the past few weeks. Lisa Germany of Mount Stromlo and Siding Spring Observatories in Australia and her colleagues have submitted a paper to the *Astrophysical Journal* saying that GRB 970514 may have been related to the unusual supernova 1997cy. And last week, in a circular of the International Astronomical Union, a team led by Roberto Terlevich of the Institute of Astronomy in Cambridge, United Kingdom, noted a possible link between the very recent supernova 1999eb and a gamma ray burst that flared on 2 October. However, in both cases the evidence is circumstantial, because the positions of the bursts aren't known very accurately.

The stengthening supernova connection is likely to lead to a new burst of theorizing. Wheeler and his colleagues have also published theoretical models of massive supernova explosions that produce gamma ray bursts. But unlike Woosley, who believes the formation of a black hole is crucial, Wheeler thinks that even more modest supernovae that result in a collapsed neutron star are able to produce powerful flashes of gamma rays. Little is known about the precise mechanism, however. "We have to put some flesh on these bones," says Wheeler. "We need a lot more statistics." Woosley adds, "You have to look at the right time ... we now know when the right time is: 2 or 3 weeks after the burst. People are going to look harder."

–GOVERT SCHILLING

Govert Schilling is an astronomy writer in Utrecht, the Netherlands.

TECHNOLOGY TRANSFER

Japanese Faculty Show Signs Of Catching Start-Up Fever

New government policies and additional funding are helping scientists brave an environment that shuns risk-taking

TOKYO—When molecular biologist Fukashi Murai returned home after spending a year at the University of California, San Diego, in the mid-1990s, he was bitten so hard by the entrepreneurial bug that he did something highly unusual for a Japanese scientist: He quit his job at pharmaceutical maker Sankyo Co., nurtured ties with Japan's handful of venture capital firms, and scoured university labs for marketable ideas. "I found it just amazing" that U.S. academics were so eager to turn their discoveries into businesses, he says. "I couldn't understand why it didn't happen [in Japan]."

Murai eventually hooked up with University of Tokyo molecular biologist Shiro Kanegasaki, who in 1997 had discovered a human protein involved in regulating inflammatory reactions. The pair spent nearly a year crafting a business plan to develop the protein into an anti-inflammatory drug, followed by 6 months of intense negotiations with a venture capital firm that netted them $500,000 in start-up funds. They set up a small company, Effecter Cell Institute Ltd., rented lab space in a university-affiliated incubator, and opened a tiny office in a nearby apartment building. "I hadn't thought of starting a company," says Kanegasaki, who retired this spring after reaching the mandatory retirement age of 60. "But it's a good time to try."

Indeed, government officials, business leaders, and editorial writers are trying to boost the sluggish economy by exhorting scientists like Kanegasaki and Murai to take the plunge into the business world. Three agencies have requested $85 million in the fiscal year beginning 1 April for a package of subsidies, tax breaks, and loans to nurture new companies, particularly "bioventures," in the hope of expanding the country's minuscule presence in commercial biotechnology. This planned surge of money is the latest in a series of steps—from loosening regulations covering stock offerings to clarifying intellectual property rights—aimed at generating more start-ups, particularly from university and national institute labs. As a result, a few companies like Effecter are beginning to dot the landscape. But Japan's scientific community still has a long way to go to match the entrepreneurial vigor of U.S. researchers. Fostering a true venture business culture in Japan, says Yoshihiro Ohtaki, a molecular biologist who now heads Biofrontier Partners, "could take 10 years."

On their own. Shiro Kanegasaki (right) teamed up with Fukashi Murai to form a biotech company based on Murai's university research.

CREDIT: D. NORMILE

One sign of progress, in a country where the establishment still holds enormous sway, is the participation of some senior scientists in these start-ups. This spring, for example, Kenichi Matsubara, professor emeritus of molecular biology at Osaka University and a key figure in Japan's early human genome research efforts, joined a dozen colleagues to establish DNA Chip Research Inc. The company hopes to develop DNA chips for diagnostic purposes before tackling the technology needed to characterize the subtle genetic differences among individuals known as single-nucleotide polymorphisms. These differences are expected to help scientists trace disease genes and develop drugs tailored to those characteristics. Observers estimate that a dozen or more start-ups, covering everything from computer-based rational drug design to improvements in NMR techniques, have sprung from work at the Institute of Physical and Chemical Research (RIKEN) outside Tokyo, the Universi-

ty of Tsukuba, and other schools.

And more are on the way. Megumi Takata, director of the Center for Advanced Science and Technology Incubation Ltd. (CASTI), the licensing organization affiliated with the University of Tokyo that helped to set up Effecter, expects another company to be formally established this year and several more by next spring. Officials of the licensing organization affiliated with the University of Tsukuba know of at least three groups working on business plans. And Biofrontier's Ohtaki says he is getting inquiries "from all over Japan."

These new entrepreneurs are taking advantage of a raft of changes in government policies. "There wasn't just a single bottleneck," says Ohtaki. "It was more like a jigsaw puzzle with too many pieces missing." In the past few years financial regulations that made it nearly impossible for start-ups to raise money and offer shares to the public have been relaxed, restrictions on the use of stock options loosened, and tax incentives created for financial "angels" to get behind venture businesses. Earlier this year, legislators enacted what is seen as the Japanese version of the 1980 Bayh-Dole Act, the U.S. law that gives universities the right to commercialize publicly funded research. But there's one big difference: In Japan the rights go directly to researchers. To help national university and institute researchers patent and market their discoveries, the government has also authorized special technology licensing organizations.

Although these regulatory moves are important, scientists say, a shift in attitude among both private sector researchers and university professors will be essential. It's still extremely rare for someone like Murai to give up a well-paying, secure position at a big company for a risky start-up. And even a decade ago it would have been "considered unseemly for academics to engage in commercial activities," says Matsubara. Most faculty at top schools join a university after receiving their doctorate and spend their careers climbing the ladder. Indeed, a pool of retired but still active professors may be a key to success: Kanegasaki says he would not have given up his professorship to start a business before reaching retirement age, and Matsubara also retired before launching his business career.

A distaste for business shows up at every stage of the process. Kanegasaki says opposition from his former colleagues at University of Tokyo's Institute of Medical Science, for example, prevented him from renting lab space for his fledgling company. Many start-ups even try to retain an academic flavor by using "institute" or "research laboratory" rather than "company" in their corporate names. And few professors plan to take their companies public, says Kazunori Kondo, who studies venture businesses at the National Institute of Science and Technology Policy. Such privately held businesses, he argues, are less likely to become powerful engines of economic growth.

Those who break through these prejudices face a different set of problems. Whereas faculty members can license rights to their discoveries, their active participation in private companies is still strictly limited. They cannot serve on a corporate board, for example, although they can serve as scientific advisors. And mid-career moves are still a lot more treacherous in Japan than in the United States, says Takata. "This makes it difficult for the start-ups to find the bench-level researchers they need to turn a discovery into a product," he notes. One bright spot may be the growing ranks of researchers entering the scientific workforce after completing postdoctoral appointments (*Science*, 3 September, p. 1521). An even bigger problem, Ohtaki warns, may be a shortage of managers capable of building companies from the ground up. "There isn't such a pool of managers in Japan now," he says. The only answer, he says, is to start more businesses so that potential managers can get the necessary on-the-job training.

Good management principles are uppermost in Murai's mind, too. Sitting in his office at a conference table that once served as a kitchen table, he explains that his company's immediate goal is to show that the protein Kanegasaki discovered really has the potential to be developed into a drug. At that point, he says, the company could sell stock to the public and use the proceeds to conduct clinical trials or hook up with an established drug firm. But long before Effecter gets that far, Murai says, it's going to need a second round of venture financing.

Even while spouting the language of a venture business manager, however, Murai is carrying out his share of the lab work. While that combination may be rare—"I don't think there are many like me in Japan yet," he says—he believes that his training is right for the job: "I think it's going to be easier for researchers to learn about starting businesses than for business managers to learn about biotechnology." –DENNIS NORMILE

COMPUTER GAMES

Physics Meets the Hideous Bog Beast

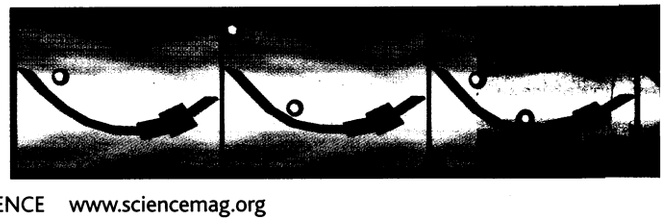
Programmers are turning to physics to add more reality to computer games, but so far the early market tests have been disappointing

When you slime a hideous bog beast with your laser blaster in real life, the beast doesn't consult a table to figure out which way it is supposed to fall. In the virtual world of most computer games, however, that's exactly what happens. A programmer has carefully scripted each potential event—like the fall of the blasted bog beast—long before you tear the shrink-wrap off your new game. If a particular combination of causes and effects isn't found in the programmer's predetermined table of allowed possibilities, it just doesn't happen.

While this approach worked well enough when Pong was the state of the art in video games, many game designers think the traditional scripted game is becoming too restrictive. Their attempts to exploit advances in computer technology and inject more natural behavior into gaming have given birth to a whole new form of interactive entertainment: physics-driven computer games.

So far only one physics-driven game, Trespasser, has made it to market—where it flopped. Nevertheless, several companies are now spending millions of dollars developing new games and the software engines to drive them. In one sense, the computer game industry is driven by novelty, and the potential payoff of the first truly physics-driven game is huge. "We are all looking for the next big thing," says David Wu of Pseudo Interactive Inc., a Toronto-based game design company, "and physics is the biggest frontier in gaming right now."

Computer games are all about movement: prowling through a dungeon in search of treasure, skidding around corners in a high-speed chase, or sending an opponent tumbling with a well-placed flying drop kick. In a scripted game, movement is like a



Balancing act. Simulation calculates forces exerted by two balls on a bridge to determine movements of individual planks. (See www.mathengine.com)