to contain at least one binary pulsar: discovered in 1974 by Princeton's Joseph Taylor, it consists of two 10-kilometer balls of dense nuclear matter—neutron stars—whirling around each other in a close circular orbit. This system is almost certainly a powerful emitter of very low frequency gravity waves, says Thorne. No one has detected the radiation directly, of course. But the neutron stars are clearly losing orbital energy, drawing gradually closer together. And after 16 years of monitoring, Taylor still finds that the rate at which they lose energy is precisely the rate at which Einstein's theory says they should—assuming that all the energy is going into gravitational radiation.

"If you follow this system for a few hundred million years," says Thorne, "the neutron stars would eventually spiral together and merge in a violent, dynamical way." Conceivably, he says, they could even coalesce into a black hole. In any case, during the last few minutes of this death spiral the frequency of the gravitational radiation would get high enough for LIGO to detect it above the background seismic noise.

Now obviously, says Thorne, 100 million years is too long to wait for a signal. But binary pulsars are thought to be reasonably common objects on a cosmic scale. So if LIGO achieves the sensitivity that he and his colleagues hope, says Thorne, then its range would encompass so many galaxies that it would see several such death spirals per year.

Each time this happened, he says, the target masses at the end of LIGO's arms would first begin to undergo a sinusoidal motion, which would rapidly increase in amplitude and frequency as the neutron stars drew inward. Then, at the instant of the merger itself, the masses would be tossed about by a violent outburst that nobody knows how to calculate. And finally, in the aftermath, they would undergo a fading sinusoid as everything on the newly merged pulsar or black hole settled down. The resulting signal profile would be a treasure trove for the theorists, says Thorne. It would tell them a great deal about the structure and behavior of nuclear matter in extremis. And it would likewise tell them about the behavior of gravity when space and time are being very drastically curved—a much more stringent test of Einstein's theory than of gravity waves themselves.

Meanwhile, says Thorne, LIGO should also be seeing other sources. Supernovas, for example: if these cataclysmic explosions generate gravity waves as strongly some theorists think, then LIGO could detect about a dozen of them per year. Or ultramassive black holes: these enormous, billion-solar-mass objects seem to lie at the core of every quasar, generating the quasar's fierce luminosity by gulping down huge quantities of stars and gas. Even many normal galaxies (including ours) are thought to harbor million-solar-mass black holes. Whatever collisions and mergers produced these behemoths, says Thorne, some of them likely produced such strong gravity waves that LIGO could see them anywhere in the observable universe. These events could come as frequently as once per year.

And then there's Weiss' personal favorite: the Big Bang. According to some scenarios for what happened in the very early universe, he explains, there should be residual gravitational radiation that LIGO could detect. If so, it would provide clues as to what went on during the first 10^{-43}seconds after the Big Bang—the so-called Planck era, which many physicists believe can only be described by the unknown laws of quantum gravity. "It's very speculative," he admits, "but *that's* the experiment I want to get to."

Speculative or otherwise, the potential scientific payoffs from LIGO were sound enough to win it strong support within the NSF hierarchy, up to and including outgoing director Eric Bloch. The LIGO group submitted its conceptual design to NSF in December 1989. The foundation accordingly listed LIGO as a new start in its fiscal year 1991 budget request, asking Congress for $47 million as a down payment on a 4-year construction program.

And Congress, acting predictably enough in an era of high-anxiety deficits, balked. The question was not one of science so much as priorities: How can we justify giving so much money to one experiment?

Vogt, who has spent quite a bit of time lately arguing LIGO's case on Capitol Hill, replies that that is a question only the political system itself can answer. "It's not up to me to decide what the country's priorities are," he says. "It's only up to me to offer the country beautiful choices."

That said, however, he takes strong exception to calling LIGO "one experiment." "That's like calling the Palomar telescope a single experiment," he says. "I'm building an astrophysical observatory, and it's going to operate in an observatory mode for 50 years." In particular, LIGO has been designed with room in the vacuum tubes for multiple laser beams, so that several groups of experimenters can be testing out new optical systems and new detector technology at the same time that others are taking data.

"The facility may be Big Science," agrees Weiss, "but I envision the work itself to still be in the style of small science, with four to six people in a group."

It remains to be seen whether such arguments will carry the day. If the Senate okays the money this autumn, the House may be persuaded to go along in conference committee, in which case LIGO could start construction almost immediately. If not, then the project will be delayed for at least another budget cycle while the LIGO team waits and waits, refining their technology even further on the lab bench.

■ M. MITCHELL WALDROP

Merck–Du Pont Venture: Prescription for Success?

Two corporate giants recently formed a joint venture that may set trends for years to come in the world of pharmaceutical research

AFTER WALL STREET CLOSED for trading on 25 July, the nation's leading drug company sent out a press release containing a bombshell. Merck & Company, the announcement said, was teaming up with chemical giant Du Pont to form a joint venture: a new pharmaceutical firm. Although the $51-billion American drug industry has gotten used to mergers and liaisons, this was a surprise—both because of the size and success of the companies involved and the innovative nature of the venture, which leaves the parent companies' operations separate.

The next morning pharmaceuticals analysts mumbled over their copies of the *Wall Street Journal* as they puzzled out the deal, which observers say could become a trendsetter. The analysts understood the tough economic environment that prompted the venture. But they wondered what was in it for the partners—particularly Merck, which has been far more successful in pharmaceuticals than Du Pont has.

The stated reason for the joint venture was that the companies are pooling their resources to offset the high cost of bringing a drug from the lab bench to the pharmacy shelf. That process takes a decade and $230 million on average—and that cost is being

steadily driven up by new regulations and legal costs, among other factors. As costs rise, drug companies find it difficult to make the profits shareholders have become accustomed to, which are based on annual sales increases of 10 to 20%. "The reasons companies are banding together is that it's tough, and getting tougher," says Robert Taber, director of pharmaceutical and biotechnology research at Du Pont.

One strategy for recouping R&D investments is selling drugs in as many countries as possible—particularly in Europe and Japan. But changes in the European community in 1992 will make it easier for European companies to compete there without lowering the barriers for U.S. companies. And at the same time, Japanese pharmaceutical companies are gearing up to sell products in the United States and Europe. So U.S. drug companies are trying to get a firmer foothold overseas now.

	MERCK & COMPANY	Du PONT PHARMACEUTICALS
Drug sales	$6 billion (human & animal health)—1989	$550 million—1989
R&D spending	$855 million—1990	$200 million—1990
Research staff	4500 (1100 Ph.D.s & M.D.s)	1500 (400 Ph.D.s & M.D.s)
Sales staff	7000 worldwide	500 worldwide
Key drugs	(Top money-makers) Vasotec & Mevacor (cardiovascular); Pepcid (anti-ulcer); Indocin (anti-arthritis); Timoptic (anti-glaucoma)	Coumadin (anti-clotting agent); Hespan (plasma volume extender); Percodan & Percocet (analgesics); Ethmozine (anti-arrhythmic)

	Du PONT MERCK PHARMACEUTICALS
Drug sales	$700 million—1991 (estimated)
R&D spending	$230 million—1990
Research staff	1500 (400 Ph.D.s & M.D.s)
Sales staff	650 (by 1996)
Key drugs	All of the above drugs from Du Pont, plus the marketing rights to Merck's Sinemet (anti-Parkinsons); Moduretic (cardiovascular); Finasteride (prostate treatment)

"Everyone is looking to see if they can expand for economic reasons," says P. Roy Vagelos, a physician who is chief executive officer at Merck. "Once a product is identified and developed, you're much better off if you can launch it all over the world." And therefore, Vagelos adds, a critical part of the joint venture "is to build a global company that will be a major player in Europe and the rest of the world."

In aiming for that goal Merck and Du Pont rejected familiar formulas, such as a merger (the route recently taken by Bristol-Myers and Squibb) or a liaison with a hot new biotech company (Hoffmann–La Roche's move in buying into Genentech). Instead, they arrived at an innovative agreement. Under its terms, on 1 January Du Pont's pharmaceutical division will become a new company called Du Pont Merck Pharmaceuticals Company. The company, owned 50–50, will include Du Pont's entire research staff of 1500, who will continue working in Du Pont buildings in Wilmington, Delaware.

Merck's contribution will consist mostly of money and expertise. Merck will add some $100 million, analysts say (Merck won't release the figure). Du Pont vice president Joseph A. Mollica will be chief executive officer, but he will be guided by a six-member board, composed half of Merck management, and a research advisory board that includes key Merck scientists, such as Edward Scolnick, president of Merck's Sharp & Dohme Research Laboratory.

For Du Pont, the logic of partnership with Merck is obvious. "Du Pont's spent very heavily on the R (of R&D), but failed to transfer that into development," says Paul Brooke, managing director at Morgan Stanley.

Furthermore, the Du Pont sales force of 500 is too small to be an effective international player. Hence, for Du Pont to become a major competitor, it would have to lay out a great deal more—to expand its pharmaceuticals division and build an international sales force, moves that may not be a priority for a firm whose main thrust is chemicals, not drugs. "In some sense, you can argue that the joint venture provides a graceful exit from the drug industry for Du Pont," says Brooke.

Merck, on the other hand, is one of the top pharmaceutical companies in the world, with many profitable drugs and a worldwide sales team of 7000. So it hasn't been quite as easy for analysts to see the benefits for that company. One theory is that Merck is also feeling the pressure to grow as competitors enter into mergers and some biotech firms enter the economic big leagues. What's more, patents on many of Merck's biggest money-makers expire by 2000, leaving them vulnerable to competition from generics.

So Vagelos took a look at Du Pont, and he liked what he saw: Development there may not have been a roaring success, but research has been right on the money. For example, Du Pont's research group scored a major success recently when it beat out several other companies, including Merck, in the discovery of a new drug for high blood pressure called angiotensin II. This novel compound blocks the receptor, designated A II, on blood vessels before a peptide called angiotensin can dock there and constrict the blood cell, which forces the pressure to go up inside. The drug is already in clinical trials.

"That proved they're a very, very capable and important research group," says Vagelos. And when he took a closer look, he found that Du Pont's research pipeline carries a dozen other drugs that look promising but have yet to be tested. Those drugs give Merck more diversity in its drug candidates, increasing its chances for producing some big winners in the next decade.

If the prospects for both companies seem bright, the future for the researchers involved—and for corporate research directions—is less clear. There won't be any research jobs created by the deal, at least at first. And at Merck, there probably won't be much impact at all, Scolnick says, because Merck research will remain separate from the new venture.

At Du Pont, researchers are resigning from the parent company (probably with severance pay) and joining the new venture, which will have a bigger research budget than Du Pont's pharmaceutical division would have had on its own: beginning with $230 million in 1991 and ratcheting up to more than $400 million in 1995.

As far as research directions at the new company, Scolnick says, "Initially, the emphasis at the joint venture should be on what they're strong in"—drugs aimed at diseases of the cardiovascular and central nervous systems. Two particularly promising drugs now in clinical trials include DUP 785, an antimetabolite that could be important in treating as many as ten different cancers, and DUP 996, a central nervous system drug that seems to enhance release of acetylcholine, which could be important in treating Alzheimer's disease. Says Taber: "We have a compound in the pipeline in each of the major therapeutic areas in which we've done research, and that includes the inflammatory disease area, the central nervous system, infectious disease, and cancer."

Promising as they are, though, the new drugs will be entering a field packed with products from other companies, some newly beefed up by mergers and other liaisons. Still, if the Merck–Du Pont arrangement prospers, it could set a trend. "These kind of business deals tend to have a faddish structure," says Mary Ellen McCarthy, U.S. pharmaceutical analyst for Shearson-Lehman Brothers. "We went through a merger period, now maybe we'll go through a joint venture period."

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