might be able to link the factor IX gene to more powerful regulatory sequences that can push synthesis of the clotting factor more powerfully than the viral sequence used by the Baylor group. Alternatives might be to improve the infection rate of the existing vector, or to find a better vector.

Some other experts in the field think finding a better vector is, in fact, the key. Based on his own group's experiences, molecular biologist Inder Verma of the Salk Institute, who is also trying to do gene therapy for hemophilia B, is skeptical that the retrovirus used by Woo and his colleagues will prove up to the job. Although his approach was different—Verma took the indirect route of putting the factor IX gene into myoblasts and then transplanting the cells into animals—he also used the same virus. But after disappointing results in dogs, Verma says he has switched to a different type of virus, a modified adenovirus that is now under investigation as a gene transfer vehicle in several labs.

Assuming that adequate factor IX production can be achieved, there will still be another major issue to resolve: Is the procedure safe? Aledort points out that the Baylor team's procedure would have to be performed before a child reaches 2 years of age to prevent joint degeneration. And removing part of the liver from a hemophiliac child could be dangerous. In addition, researchers will have to show that whatever viral vector they use will not reacquire the ability to infect other cells or activate oncogenes.

Of course, current clotting factor treatments carry their own risks, so a gene therapy wouldn't have to be perfect to be preferable to the methods now available. Heating clotting factor preparations kills the AIDS and the hepatitis B viruses, which infected many hemophiliacs before manufacturers began using heat treatments. Not all viruses are killed, however, so some risk of contracting a viral disease remains present. Clotting factors made by recombinant DNA technology eliminate this risk, but many patients can't afford to use recombinant materials, which cost about twice as much as the already-expensive products made from human blood. "Any treatment that would get [hemophiliacs] off the need for blood products would be tremendous," says Carol Letendre, associate director of the Division of Blood Diseases and Resources of the National Heart, Lung, and Blood Institute.

Researchers will have a way to go before that's possible, given the modest successes of the gene therapy work so far. But as Brinkhous notes, it reminds him of another modest start: "When the Wright brothers took off at Kitty Hawk, they only went a few hundred feet." So sometimes small beginnings can lead to great things.

–**Jean Marx**

ASTRONOMY

Are Dark Stars the Silent Majority?

Last week, two groups of astronomers announced the first hints of what may be a silent majority in our galaxy—starlike objects too puny even to shine. These stellar duds, which are thought to form a huge invisible halo around the galaxy, are known by the ironic acronym MACHOs, for Massive Compact Halo Objects. And it took some astronomical moxie to search for them: monitoring the brightness of several million stars night after night for months, waiting for a star to flicker as a MACHO eclipsed it.

That doggedness could have a big payoff. If the two groups—an American-Australian team led by Charles Alcock of the Lawrence Livermore National Laboratory and a French group led by Michel Spiro of the National Center for Scientific Research at Saclay—can find more examples to support their interpretation, they may have done much more than add another exotic creature to the zoo of celestial objects. They may also have accounted for some or all of the invisible "dark matter" that is thought to make up the bulk of our galaxy.

Both groups admit that the small number of examples—three in all—makes them uneasy, but some other researchers are already betting that MACHOs are here to stay. "Any alternative explanation [of these observations] would be even more spectacular," say Princeton University astronomer Bohdan Paczynski, who conceived the search strategy used by both teams. "I think this is definitely the discovery of the year."

Although MACHOs sound exotic, they're actually the least outlandish explanation for a long-standing puzzle. Twenty years ago astronomers noticed that the movements of stars in our galaxy and others could only be explained if there is some 10 times more celestial matter around than can be seen through telescopes of any kind. Since then, researchers have proposed many candidates for this mysterious invisible stuff: rocks, black holes, or mists of elusive particles. MACHOs, stone dead or weakly glowing bodies ranging between the size of Jupiter to about one-third the size of the sun, seemed the most likely candidate, says astronomer Jeremiah Ostriker of Princeton University. Astronomers are already familiar with objects that qualify as MACHOs, he explains—dim stars that only show up because they lie in our immediate vicinity.

Directly detecting these small, dark objects in the far reaches of our galaxy was out of the question, but in 1986 Paczynski proposed an indirect technique: Look at stars outside our galaxy—for example, in the Large Magellanic Cloud, a neighboring galaxy—and watch for signs that they were being eclipsed by MACHOs. You might expect light from the eclipsed star to dim, but Paczynski realized that the star would get brighter because of an effect known as gravitational lensing. Because of its mass, the MACHO would warp the surrounding space into something like a vast magnifying glass, intensifying the background light.

Paczynski's method posed a daunting technical problem, though: Even if our galaxy were swarming with MACHOs, alignments of MACHOs and ordinary stars would be rare in the vast volumes of space. The lensing effect would be so rare, in fact, that astronomers would have to monitor a million stars for months see it happen even once. Says Alcock, "His article attracted almost no attention at the time because it was not technically feasible." But in a couple of years star-monitoring and data-processing technology had advanced enough for both groups to take on the challenge (*Science*, 23 April, p. 492).

The American-Australian team started taking usable data in mid-1992 at the Mount Stromlo and Siding Springs Observatory in Australia, while the French, observing from the European Southern Observatory in Chile, didn't start until early this year. But both groups say they found their first lensing candidates within the last 3 weeks. The Livermore group reported that a computer analysis of their digital CCD images revealed a single star brightening by a factor of 7. The French group, which relied on traditional photographic plates, reported two stars that brightened, one by a factor of 2.5, the other by a factor of 3. The magnitude of the brightening, say the researchers, suggests that the eclipsing objects have between 3% and 30% as much mass as our sun, putting them in the expected size range of MACHOs.

Both groups admit, however, that they may be seeing something else—not gravitational lensing by a massive body but some sort of stellar flares. "We can't exclude that it's some pathological stars," says Spiro, who says he would rather not have announced the results to the public at this stage. The reason for the haste, he says, is that the two groups caught wind of the other's results and agreed that to ensure joint credit for the discovery, they would both announce at the same meeting, in Gran Sasso, Italy, send out press releases at the same time, and publish simultaneous papers (now in press at *Nature*).

In spite of his reservations, Spiro notes that neither his nor Alcock's events fit the profile of any known variable or flaring star. Alcock explains that in his group's event, the star brightened uniformly across the spectrum, just as you would expect from gravitation lensing. Flaring stars, in contrast, generally get hotter and therefore should brighten more at shorter wavelengths.

The real test, say both Alcock and Spiro, will come when they've collected a sample of 10 to 20 events. If the brightening results from some new type of stellar explosion, it should tend to take place in a single type of star. If it's really lensing by MACHOs, the distribution of stellar types should be random.

If the putative MACHOs survive these tests, the next question will be how prevalent they are, and how much of our galaxy's dark mass they can account for, says Christopher Stubbs of the Livermore team. But even if MACHOs can explain all our galaxy's missing mass, notes Ostriker, they may not solve the full riddle of dark matter.

Many theorists believe that in addition to the extra mass needed to explain how stars move within galaxies, the universe contains still more dark matter between galaxies—so much extra, in fact, that its gravitational pull will slow and eventually stop the expansion of the universe. If so, as much as 99% of the universe may be invisible. Astrophysicists believe that the Big Bang simply can't have produced that much ordinary matter—which means that the additional dark matter would have to be made of something far more exotic than MACHOs. In that case, our galaxy's silent majority would be just a minority in a larger dark universe.

–Faye Flam

MATERIALS SCIENCE

High-T_C Superconductors Get Squeezed

Squeeze most things hard enough and they'll say "uncle." Ceramic superconductors are no exception. In last week's *Nature* and this week's *Science*, two laboratories independently report that mercury-containing ceramic superconductors, when squeezed unimaginably tightly between the jaws of diamond or tungsten carbide vises, yield to researchers' wishes and become superconducting at 150 degrees Kelvin—surpassing previous records by 15 degrees.

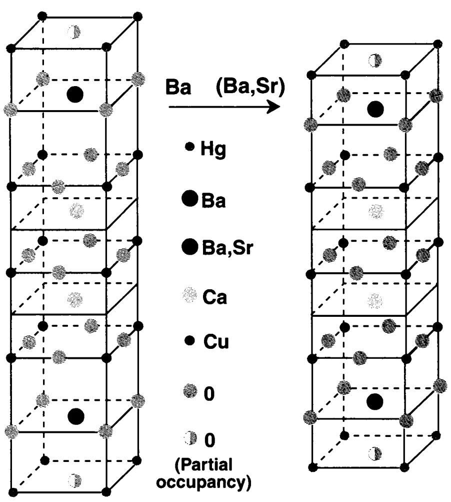
Because of the enormous pressures required, this result has no immediate practical value. Yet this result still "has very good psychological value," says Robert Cava of AT&T Bell Laboratories, a veteran of the search for new high-temperature superconductors. Adds Cava, "It gives some hope that the transition temperature can still go higher." By redesigning their compounds to have structures that mimic the mercury-containing compounds under pressure, investigators hope to achieve the same results—or still better ones—under normal conditions. That would inch the field toward one of its ultimate goals, a material that is superconducting at 300 K, room temperature.

From 1988 through last March, a thallium-containing copper oxide compound was at the top of the superconductor charts, with a transition temperature of 127 K. That material reigned so long that it was beginning to dim hopes of finding superconductors with still higher transition temperatures. The gloom lifted in March, when a Russian and French team, including two authors of this week's report in *Science*, reported in *Nature* that a new compound composed of mercury, barium, copper, and oxygen atoms becomes a superconductor at 94 K. That was lower than the thallium material, but the newcomer was just the first and simplest of a new mercury-containing superconductor family of unknown potential.

The new family grouping really began to show its mettle in May, when researchers at the Eidgenössische Technische Hochschule (ETH) in Zurich reported in *Nature* that a crystalline mix of mercury-containing compounds remained superconducting at 133 K—finally breaking the 127 K barrier (*Science*, 7 May, p. 755). Testing the mercury compounds at high pressures was the obvious next step, because researchers have known since the earliest days of high-temperature superconductivity that pressure affects the temperatures at which materials become superconducting.

Last week, physicist C.W. (Paul) Chu of the Texas Center for Superconductivity at the University of Houston and colleagues reported the results in *Nature*. They found that under pressures of about 150,000 atmospheres, one of the mercury compounds, called Hg-1223, which has mercury, barium, calcium, and copper atoms in a ratio of 1:2:2:3, started to make its transition to a superconducting state at 153 K. The material's resistance actually fell to near zero only when chilled to 135 K. Higher pressures would likely have raised that figure, say the researchers, but the tungsten-carbide vise they used could not squeeze any harder without breaking.

ILLUSTRATION: H. BISHOP



$HgBa_2Ca_2Cu_3O_{8+\delta}$

The big squeeze. Strontium in place of barium ions might mimic the effects of high pressure in this superconducting ceramic.

On page 97, physicist Manuel Nuñez-Regueiro of the Center for Research at Extremely Low Temperatures at France's National Center for Scientific Research (CNRS) in Grenoble and his colleagues confirm Chu's prediction that the higher pressures might produce even more impressive results. They show that their Hg-1223 samples, if squeezed to 235,000 atmospheres (the maximum pressure possible with their sintered diamond anvil vise), begin the transformation to a superconductor at 157 K and just about finish at 150 K.

Neither group can say why the high pressure boosts the transition temperature, because the samples cannot be salvaged for study when the pressure is released. They assume, however, that the pressure reduces the distance between adjacent layers of the crystal, a change that often increases the transition temperature of a ceramic superconductor. By substituting "chemical pressure" for mechanical pressure, the researchers hope to create a compound that would boast the same properties under normal conditions. Replacing the compound's relatively large barium ions with smaller ones such as strontium, they say, should pull the layers together, mimicking the effect of squeezing.

"It would be truly exciting" if a transition temperature of 150 K could be achieved outside a high-pressure cell, adds Venky Venkatesan of the University of Maryland. A material with a transition temperature nearly twice the temperature of its liquid nitrogen coolant, he says, would offer a welcome safety margin for cooling failures or fluctuations in both scientific measurements and applications. And Chu notes that such compounds could be chilled with coolants even cheaper than liquid nitrogen, among them the environmentally notorious Freon. On the negative side, as Cava points out, the mercury compounds are hard to make because mercuric oxide, one ingredient, normally decomposes at temperatures hundreds of degrees below those needed to form the ceramic. In the search for better superconductors, it seems, the pressure is still on.

–Ivan Amato