theory suggested, the interactions can completely overcome the thermal jiggling of the lines, producing a sudden phase transition in which the flux lines freeze. The resulting "vortex glass"—so named because the vortices would be locked in random positions—might very well allow the material to act as a true superconductor.

The theory was far from an overnight sensation, however. For one thing, the model had some gaps that made it difficult to wring predictions from it. For another, some of the predictions it did make about how the materials' resistivity should change with changing temperature and magnetic field were at the limits of voltmeters' sensitivity at the time—though experiments by IBM researcher Roger Koch and collaborators provided a bit of support. "At first," recalls Harvard theorist David Nelson, "there was tremendous resistance to the whole idea."

Since then, theory and experiment have risen to the challenge. Daniel and Matthew Fisher and Bell Labs researcher David Huse carved out a more complete version of the vortex glass model, published last January in *Physical Review B*, that predicts in some detail how high-temperature superconductors' resistivity should vary with changing conditions. Meanwhile, AT&T Bell Laboratory researchers Peter Gammel, David Bishop, and collaborators carried out experiments with a new "picovoltmeter" that, they say, provides data six orders of magnitude more precise than before. Prediction and experimental result jibed nicely. "Now we can say for sure these materials become superconducting in a magnetic field at a finite temperature," says Bishop.

The discovery of the vortex glass state probably won't spark any immediate progress in applications. But at least now physicists know what they're dealing with. "Trying to understand how these materials behave in a magnetic field without knowing about the vortex glass phase transition would be like trying to understand silicon without asking whether it was a liquid, solid, or gas," says Bishop. Next physicists need to determine how well the vortex glass model applies to high-temperature superconductors other than the yttrium-based materials on which most of the work has been focused. "It's not completely clear yet that bismuth-based materials [another broad class of high-temperature superconductors] have this transition, though there is some evidence for it," notes Daniel Fisher. "We need to take a closer look at other materials, too."

But Bishop is confident the efforts will eventually pay off. One likely role for the new insight: guiding researchers who are attempting to tailor the locations and types of impurities and faults in samples—by bombarding them with neutrons or ions, for example—so as to hasten the onset of the vortex glass phase. "I couldn't say for sure that this work will result in a better wire 5 years from now," he notes. "But I have a religious belief that if you have a better understanding of the fundamental principles of these things, you can take advantage of it in engineering." ■ **DAVID H. FREEDMAN**

David H. Freedman is a free-lance science writer in Brookline, Massachusetts.

Getting a Handle on Ras Activity

Take a walk around any cell, says protein chemist Henry Bourne of the University of California at San Francisco School of Medicine, and you will inevitably bump into a member of the large superfamily of proteins known as GTPases, which are enzymes that split guanosine triphosphate (GTP) into guanosine diphosphate and phosphate. The members of this family, which seems to grow larger almost every day, act as "on-off" switches in some aspect of almost every cellular activity. But just how those "on-off" signals are converted into changes in cell activities has remained mysterious for most of these proteins. Now comes Bourne with a new proposal about how at least one GTPase, a protein known as Ras, may transmit its signals to the cell interior.

Bourne himself describes his suggestion, which he presented last month at the annual meeting of the American Society for Cell Biology in Boston, as "very preliminary" and "highly speculative." But if it's right it will upset current notions of how Ras controls cellular activities.

How Ras exerts its effects is an especially urgent question. In its normal form, the protein is a key component of the pathways transmitting growth stimulatory signals into cells. If it's mutated, though, its GTPase gets stuck in the "on" position, leading to uncontrolled cell growth and paving the way for cancer development. But researchers haven't been able to figure out what comes next after the Ras GTPase is turned on, Bourne says.

The assumption is that active Ras binds to another cell protein, thereby transmitting the signal to it. But that protein, called an "effecter," hasn't been identified, and, Bourne explains, no one will really know how Ras works until it is. And that won't happen, he says, until biologists locate the precise site where Ras binds the effecter molecule. So the Ras puzzle has become a sort of molecular Catch-22. The effecter can't be identified until its binding site on Ras is known, and the binding site can't be pinned down until the effecter is located.

Although the effecter-binding site hasn't been pinpointed for sure, evidence from several labs suggests that it may be near the known binding site for a second protein that goes by the name GAP (for GTPase-activating protein), which is necessary for turning on the Ras GTPase activity. Indeed, the Ras effecter might even bind to the GAP protein, rather than to Ras itself. What Bourne is now proposing, however, is that the Ras effecter doesn't bind anywhere near GAP, but at the other end of the Ras molecule entirely.

To reach this conclusion, Bourne took advantage of some GTPase family resemblances. While the effecter-binding region of Ras is unknown, its three-dimensional structure has been solved in both the "on" and "off" positions. The exact opposite is true for another GTPase, called G_S. Its functional regions, including its effecter-binding site, have been identified, while its three-dimensional structure has not yet been solved. So Bourne and his colleagues lined up the structurally related regions of the proteins, in effect superimposing the three-dimensional image of Ras over the G_S sequence to find where on the Ras molecule its effecter region might be. This led them to a surprising conclusion: the effecter-binding site is on the "posterior" side of the molecule, near where Ras binds to the cell membrane and well away from the GAP-binding site, which is on the end of Ras that projects into the cell cytoplasm.

Since the effecter should be transmitting signals to the cell interior, that looks like the wrong site for effecter action. Still Bourne says, "I am willing to bet you that the true Ras effecter does not bind to the so-called effecter domain where GAP does bind." But while much of his proposal is "compatible with the data," he concedes that it's not necessarily the only conclusion to draw. Family members, after all, often behave in unpredictable ways. ■ **MICHELLE HOFFMAN**