The 1987 Nobel Prize for Physics

In one of the fastest awards on record, the prize goes to the discoverers of high-temperature superconductivity less than two years after the discovery was made

On 14 October, the 1987 Nobel prize in physics was awarded to Johannes Georg Bednorz and Karl Alexander Mueller of the IBM Zurich Research Laboratory for their recent discovery of high-temperature superconductivity in copper oxide ceramic materials.

In announcing the award, which this year is worth $340,000, the Royal Swedish Academy of Sciences noted that Bednorz and Mueller's work had directly inspired "the explosive development in which hundreds of laboratories the world over commenced work on similar material." Indeed, the sense of excitement in the physics community goes beyond anything in recent memory. Potential applications of the new materials range from superconducting microelectronics to high-speed levitated trains; researchers and investors alike have been fired by the vision of superconductivity being applied on a massive scale. Furthermore, since the ceramics seem to achieve their superconductivity through a fundamentally new mechanism, which is still not understood, no one can yet rule out the possibility of superconductivity at room temperature.

"Bednorz and Mueller opened our eyes to a new class of compounds and changed the way we think about superconductivity," says Bell Laboratories' Robert Cava, who is himself a leading researcher in the field. "I think it's very exciting that the recognition came so quickly after the discovery."

The Swedish Academy confirms that this is in fact one of the quickest Nobel prizes on record, if not *the* quickest; Bednorz and Mueller's discovery was made less than 2 years ago, in January 1986, and it only received widespread acceptance by the rest of the physics community late in the year.

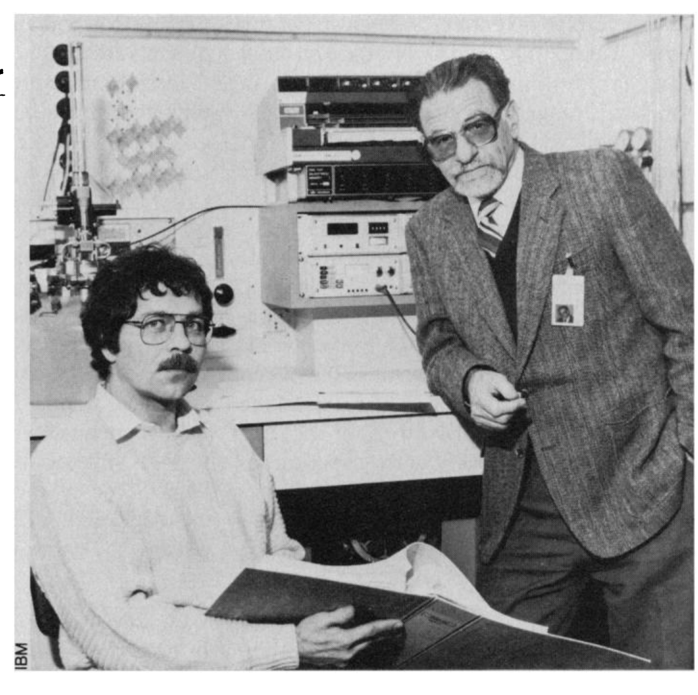
Their work grew out of a general frustration with the lack of progress in more conventional superconducting materials. The best of these materials were alloys of various metals with niobium. Even within this family, however, the record highest superconducting transition temperature was only 23.3 K. And that had only been achieved after decades of effort. Moreover, it seemed unlikely that any further effort was going to make much of a difference. What was needed was a new class of compounds.

The 37-year-old Bednorz and the 60-year-old Mueller were led to consider oxide compounds by the fact that several were already known to be superconductors, albeit at very low temperatures. Mueller had already spent more than two decades studying them in other contexts. They proceeded under the working hypothesis that an increase in the density of charge carriers in the material—either in the form of electrons or of positively charged "holes"—would lead to a corresponding rise in the transition temperature. Since nickel- and copper-containing oxides seemed to offer just such an increase, the Zurich researchers undertook a systematic search of those compounds starting in the summer of 1983. On 27 January 1986 they found what they were looking for: a certain form of barium lanthanum copper oxide that showed evidence for the onset of superconductivity at temperatures as high as 35 K, some 12 degrees over the previous record.

The initial response of the solid-state physics community was skeptical, to say the least; the conventional theory of superconductivity was thought to limit the phenomenon to well below 35 K. That skepticism vanished in October of 1986, however, when Bednorz and Mueller's result was confirmed by independent groups at the University of Tokyo, the University of Houston, and Bell Laboratories. The confirmation led in turn to the worldwide rush of laboratory work cited by the Swedish academy.

The superconductivity researchers contacted by *Science* were unanimous in praising the award. However, many did express surprise that the Nobel committee had not included Houston's Ching-Wu (Paul) Chu. It was Chu and his colleagues who discovered in February 1987 that a related class of ceramics—a certain form of yttrium barium copper oxide—remained superconducting up to 94 K. This was the event that made superconductivity front-page news: these newest superconductors only needed to be cooled with liquid nitrogen, which boils at 77 K and which is much cheaper and easier to work with than 4 K liquid helium. After February, it suddenly seemed possible to imagine superconductivity being used on an industrial scale.

Chu himself was not available for comment after the awards were announced. On the other hand, most of the researchers contacted by *Science* agreed with Stanford University's Theodore H. Geballe: "Chu made a major discovery, but I can certainly understand why the committee members chose as they did," he says. "Bednorz and Mueller had the big discovery. It was clearly unexpected and it changed everyone's life. If they hadn't done it then nothing might have



J. Georg Bednorz (left) and K. Alexander Mueller

Making an informed guess about how to find higher transition temperatures, the two physicists began a systematic search of nickel and copper oxides in 1983. In January 1986, they found what they were looking for.

happened for 10 years. But if Chu hadn't done what he did, somebody else might have done it the next week."

Be that as it may, a great deal still needs to be done before high-temperature superconductivity becomes a practical tool. For example, what is the mechanism?

"The community has yet to converge on an appropriate model," says Bell Laboratories' Cava. "The only one that is definitely *not* true is the standard model." In that picture, named the BCS theory after its creators, John Bardeen, Leon Cooper, and Robert Schrieffer, the supercurrent is carried by pairs of electrons bound together by their interactions with the crystal lattice. The model works quite well for conventional superconductors—and indeed, won a Nobel Prize for its inventors in 1972—but it seems to fail for the 90 K class of ceramics. It predicts that a substitution of oxygen-18 for oxygen-16 in the compound should subtly change the transition temperature, when in fact no such change is seen.

The one common theme in all the alternative models is that the crystals contain long chains of copper and oxygen atoms that have a fortuitous overlap in their electron orbitals. This overlap in turn seems to produce a metallic bond. "That's very unusual," says Cava. But at this point, no one can say for sure what it means.

Meanwhile, a major obstacle to practical use of the 90 K class of superconductors is that the superconductivity ceases in the bulk material when the current density exceeds about 1000 amperes per square centimeter. And yet for large-scale applications such as power transmission, the materials will need to support currents up to one million amperes per square centimeter. "It could take several years to do better," says Cava. On the other hand, thin films of the material have already displayed current densities in the latter range, which means that small-scale applications in microprocessors and data transmission may be much closer.

And finally, what about superconductivity at even higher temperatures? There have been innumerable reports of very high transition temperatures, says Cava, "but the results are almost universally not reproducible in other labs." Many of the materials that people are trying are unstable when exposed to air or water. Their crystalline structure is very sensitive to how they are prepared. And yes, many of the experiments have been sloppy. "The community is hopeful, but skeptical," says Cava.

"The Nobel Prize closes the door on the first chapter, the first hectic year," he adds. "Now it's time to take a few days off, catch our breath, and see what happens." ■

M. MITCHELL WALDROP

Measuring Cholesterol Is as Tricky as Lowering It

A federal panel has issued precise recommendations on how and when to treat elevated cholesterol levels, but determining those levels is trickier than generally acknowledged

THE federal government, in combination with more than 20 health organizations, has launched an aggressive campaign, through the National Cholesterol Education Program, to convince physicians and the population at large of the dangers of high cholesterol. The first salvo is a new report, issued earlier this month, that provides physicians with the most precise guidelines to date on how and when to treat elevated cholesterol.*

At a press conference releasing the report, Claude Lenfant, director of the National Heart, Lung, and Blood Institute, speculated that, if adopted, these recommendations could result in 300,000 fewer heart attacks each year. About half a million Americans die of heart attacks each year.

This new report is one of a slew of studies on the subject released over the past few years. In 1984 the National Institutes of Health (NIH) consensus conference attempted to lay to rest any doubts about the role of cholesterol in heart disease. The consensus panel urged the entire nation, including children over age 2, to adopt a low-fat diet to reduce cholesterol and recommended diet and, in some cases, drug therapy for individuals with moderate to high cholesterol.

Despite widespread publicity, the nation's physicians have been slow to follow these guidelines. A recent survey by the Heart Institute revealed that only 50% of the nation's physicians use dietary therapy to treat patients with cholesterol levels of 240 milligrams per deciliter, and more than 75% do not use drugs to treat patients with levels of 260, as the consensus panel recommended. Hence the new initiative.

Just how much to reduce cholesterol—especially among the "normal" population with moderate levels and no other risk factors—is still the subject of considerable debate. Some of the more sweeping recommendations of the past few years, such as putting the entire nation on a low-fat diet, have been criticized for exaggerating the benefits and ignoring possible risks.

But with its more limited purview—it addresses cholesterol levels that most experts agree constitute high risk—this report largely escapes those criticisms. Rather, the problem several people have with the general approach outlined in this report is that it underestimates the difficulty of determining cholesterol levels with any accuracy, given the substantial variation in cholesterol tests from both biological causes and from testing inaccuracies.

The panel urges all Americans to have their cholesterol checked and then ties treatment to precise cholesterol levels. In keeping with earlier reports, the panel defines total blood cholesterol levels below 200 milligrams per deciliter of blood as desirable, levels from 200 to 239 as "borderline" high, and levels above 240 as high. What distinguishes this report from earlier ones is that the aggressiveness of treatment depends on the presence of other risk factors, at least for the borderline group. Also, in an effort to simplify the guidelines, the cutoff points are the same for adults of all ages.

Intensive medical intervention—diet and, if necessary, drug therapy—is urged only for individuals at high risk, that is, those with cholesterol levels above 240 or those in the borderline group who have two or more additional risk factors. Risk factors include being of the male sex, hypertension, cigarette smoking, diabetes mellitus, severe obesity, low levels of high-density lipoprotein (HDL) cholesterol (the "good" cholesterol), and a family history of premature coronary heart disease. If patients in the borderline category do not have additional risk factors, then the panel recommends that they simply be given general dietary advice and rechecked in 1 year.

For high-risk patients, treatment should be based on their levels of low-density lipoprotein (LDL) cholesterol, not total cholesterol, the panel says. LDL cholesterol, the "bad" cholesterol, appears to be the major cause of clogged arteries, whereas HDL cholesterol seems to aid in removing cholesterol deposits. A separate and more expen-

**National Cholesterol Education Program: Report of the Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults*, draft (NIH, Bethesda, MD 1987.)