see the reorganization as the first step in a weeding-out process.

MOST controls just 35% of the government's $2.5 billion R&D budget. (Industry funds the major part of the country's R&D.) The rest of the publicly funded research is divided among the other 15 ministries, which are forever squabbling about jurisdiction. The ministries of information and trade, for example, each want to control research on high-capacity computers. MOST vies with the defense ministry to control research on spy satellites. Another ministry spars with MOST over aeronautics. "Somebody should have an overall responsibility," says Joon.

That somebody will be President Kim, who will chair a new National Science and Technology Council to be created after the National Assembly opens in September. The council is seen as a forum for debate on overall science and technology policy, with the president as arbiter and MOST as administrator.

However, many observers are skeptical. "They're always rediscovering the wheel," says Han Moo Young, editor of the Internet-based Korean-American Science and Technology News (www.phy.duke.edu/~myhan/B_KASTN.html) and a physicist at Duke University. But "everything turns to dust" when it comes to implementation, he adds.

Internally, the institutes also need overhauling. Bad researchers aren't fired and good ones aren't rewarded, say Korean and Korean-American scientists who requested anonymity. Cronies are often chosen over qualified candidates for top positions, they add, and research proposals are sometimes judged by scientists from other fields. "Koreans never say 'I don't know.' You're supposed to know everything," says one scientist. The Science and Technology Policy Institute, a government-supported think tank, has recently adopted changes in hiring and promotion practices that are seen as a possible model for the country.

In the meantime, efforts are under way to strengthen the scientific infrastructure. Last year, for example, Korea began a $25 million Creative Research Initiative with large grants for what the government calls "very imaginative but highly uncertain" projects in fields ranging from genetics to nanofabrication.

To complement this investment in basic research, officials are considering a proposal to establish 10 to 15 new S&T universities. The 4-year programs would emulate Germany's dual system of awarding academic and professional degrees and England's "sandwich system" by allowing students to spend their sophomore year getting credit while working in industry. "The problem is the quality, not the quantity, of our graduates," says Kang. "It's very important to shorten the [skills] gap between what universities produce and what industry needs."

The government also plans to offer dual citizenship to ethnic Korean scientists now holding foreign citizenship. Lack of citizenship is a barrier for those seeking top positions at national institutes and universities. Kang hopes the new rules also will be a signal to domestic students planning to go overseas that they are always welcome to return.

Ironically, the economic crisis itself may be the biggest harbinger of reform. Although the government is increasing R&D spending relative to other programs, this year's overall budget was cut by about 13%, and industrial R&D is expected to drop by 16%. Even bigger cuts are in store if the banks need a massive recapitalization. If that happens, greater efficiency—the reformers' rallying cry—could also become the most important measure of success in trying to remake Korean science.

–MICHAEL BAKER

Michael Baker is a writer based in Seoul.

STRUCTURAL BIOLOGY

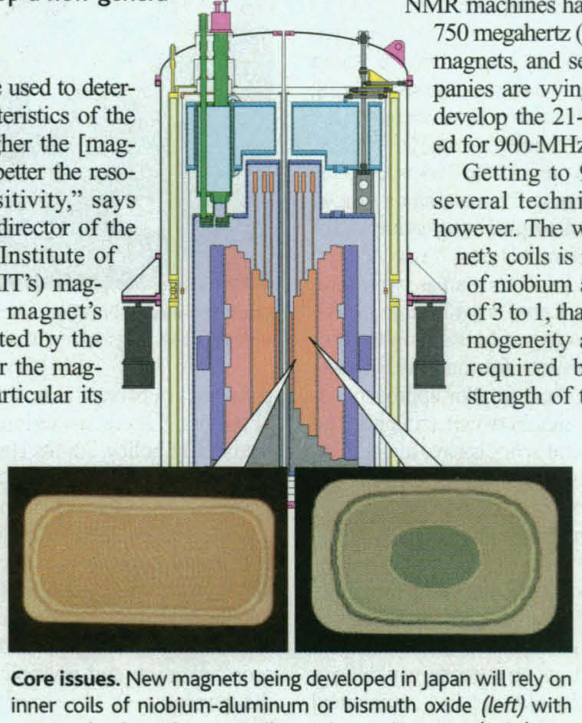
Race for Stronger Magnets Turns Into Marathon

Researchers are pushing magnet technology to develop a new generation of nuclear magnetic resonance (NMR) machines

TOKYO—U.S. spectroscopist Paul Ellis has developed a strong attachment to magnets. In 1994 his group at the Pacific Northwest National Laboratory (PNNL) in Richland, Washington, ordered a superconducting magnet from Oxford Instruments in Britain for what will be the most powerful NMR spectrometer ever built. This superconducting magnet will generate a field of 21 tesla (T), more than 400,000 times stronger than the magnetic field of Earth and 20% more powerful than in the best commercially available NMR machines. The machine is now more than a year overdue, however, and won't be delivered for several more months. The delay reflects the challenges facing magnetmakers as scientists demand ever more powerful tools to explore molecular structures in unprecedented detail.

Magnets are the key element behind NMR spectroscopy, which makes use of the fact that a magnetic field can set some atomic nuclei wobbling like a spinning top. Changes in the wobbles caused by a second oscillating magnetic field can be used to determine the characteristics of the nuclei. "The higher the [magnetic] field, the better the resolution and sensitivity," says Robert Griffin, director of the Massachusetts Institute of Technology's (MIT's) magnet lab. But a magnet's strength is limited by the material used for the magnet's coils, in particular its current-carrying capacity and its ability to withstand the electromagnetic forces being generated.

Ellis's group, which studies the molecular structure of proteins produced by chemically damaged DNA, knew that their demands would require "a new level of magnet." But they also knew that the quest for greater resolution has fostered a steady upward march in magnet strength and field oscillation. The top commercially available NMR machines have frequencies of 750 megahertz (MHz) and 17.6-T magnets, and several other companies are vying with Oxford to develop the 21-T magnets needed for 900-MHz machines.



NRIM, JAPAN

Core issues. New magnets being developed in Japan will rely on inner coils of niobium-aluminum or bismuth oxide *(left)* with outer coils of a niobium-tin alloy with tantalum core *(right)*.

Getting to 900 MHz poses several technical challenges, however. The wire for the magnet's coils is made of an alloy of niobium and tin, in a ratio of 3 to 1, that provides the homogeneity and stable fields required by NMRs. The strength of the field depends on the current carried by the wires and the size of the coils. But the current-carrying capacity of a given material can itself be degraded by high magnetic fields. Although wiremakers have gradually increased the current capacity of Nb_3Sn, 900 MHz "is right on the edge of the ability of niobium-tin to carry current," says Steven Van Sciver, director of magnet science and technology at the U.S. National High Magnetic Field Laboratory (NHMFL) at Florida State University, in Tallahassee.

A second limiting factor is the electromagnetic force, which pushes outward on the coil. That puts a tensile load on the individual strands, which increases with field strength, current, and the radius of curvature of the coil. Because 21-T magnets create a force far beyond what the Nb_3Sn alloy can resist, magnetmakers must reinforce the subcoils, typically with bands of stainless steel wires.

Then there are a host of engineering details that must be resolved. It's a slow process, says Van Sciver, involving gradual improvements in such things as winding techniques and the epoxy resins used to fill the voids in the coils. Oxford Instruments spokesperson John Kearns agrees, although he says proprietary concerns prevent him from providing details: "It's just par for the course when you're pushing the forefront of a technology."

Both the Florida lab and the National Research Institute for Metals (NRIM) in Tsukuba, Japan, are working on 900-MHz NMRs, but as a steppingstone to more powerful machines. Rather than one coil, NMR magnets use a series of coils nested within coils, "like juice cans nested within coffee cans," says Van Sciver. Lab scientists hope to use stronger coils made from new materials within or in place of the innermost coils of the magnets in their 900-MHz machines to reach the next level. NRIM has set its sights on a 1000-MHz, or 1-gigahertz (GHz), machine, which would require a field of 23.5 T, while NHMFL is aiming for a 25-T magnet to power a 1.066-GHz machine. NRIM is also planning to wrap wires with the Nb_3Sn conductor around a tantalum core for strength. "It will be a more compact magnet," says Tsukasa Kiyoshi, who heads the NRIM group. The technique is also expected to improve the efficiency of the coil-winding operation and lower costs.

Oxford officials say the company expects to deliver the magnet to PNNL by the end of the year, while the NHMFL group hopes its 900-MHz machine will be ready by the end of 1999. Next year NRIM also hopes to produce a 920-MHz machine using an improved Nb_3Sn wire for the innermost coil. A test coil made of the new wire recently set a world-record field of 21.7 T for niobium-tin alloys. The national labs are making their machines for in-house use, but both also have corporate partners.

From there it will be on to 1 GHz. Both labs plan to replace the innermost Nb_3Sn coil of the magnets with another material. For this inner coil, the NHMFL group is relying on a bismuth oxide, a high-temperature superconductor already proven capable of carrying sufficient current under a high magnetic field. The outer Nb_3Sn coils will generate 20 T, with another 5 T coming from the inner bismuth coil. Unfortunately, the bismuth "is more challenging [to work with] than niobium-tin by a significant factor," Van Sciver says.

The Japanese are also working with the bismuth compound. But they are hedging their bets by developing a niobium-aluminum material that also promises to come close to carrying sufficient capacity under a high field to use in a 1-GHz NMR. "We'll develop [both alternatives] and then evaluate them," says Kiyoshi.

Van Sciver says his lab hasn't yet committed to a target date, but Kiyoshi hopes to have a working 1-GHz, 23-T machine by early in 2002. Ellis describes that as "indeed optimistic." And that 1-GHz milestone is far from marking the end of the road. "I'm looking forward to 2 GHz," says Griffin.

–DENNIS NORMILE

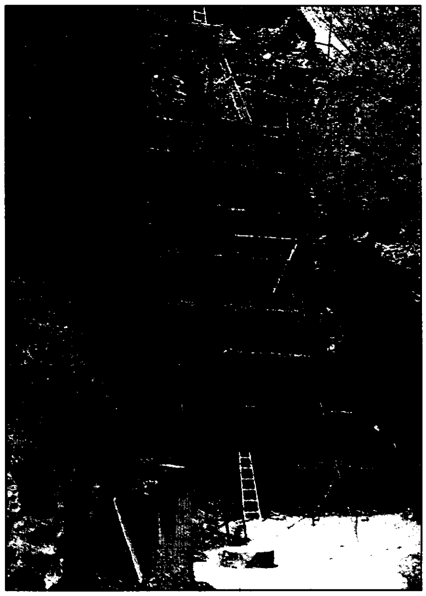
ARCHAEOLOGY

Geological Analysis Damps Ancient Chinese Fires

Studies of sediments at Zhoukoudian, China—long considered the site of the first use of fire—suggest that any flames there were not kindled by human hands

When and where did our human ancestors stop running from fire and start guarding and preserving it as a vital tool for survival? For the last half-century, nearly every archaeology textbook has offered a simple answer to that question: 500,000 years ago, in Zhoukoudian, China, where Peking man—*Homo erectus*—huddled around a hearth tending kindling and roasting deer.

But that answer is now up for revision, according to a reanalysis of the Zhoukoudian site presented on page 251 of this issue by an international team. "In a sense, we spoil the story," says the lead author, structural biologist Steve Weiner of the Weizmann Institute for Science in Rehovot, Israel. Applying a battery of techniques, Weiner and his colleagues did confirm that there are some burnt bones at the site about 30 miles southwest of Beijing, but those might have been burned naturally. And they found no evidence of controlled use of fire: no hearths, no ashes, and none of the unique chemical signatures expected from fires.



S. WEINER / WEIZMANN INSTITUTE FOR SCIENCE

In search of fire. Researchers worked atop a scaffold to study the Zhoukoudian site in China.

The signs of fire at Zhoukoudian are now no clearer than at dozens of older sites around the world. "The bones are burnt, but we don't have the smoking gun: the fireplaces which people assumed to have been there," says co-author geoarchaeologist Paul Goldberg of Boston University. That means there's no strong evidence of fire use until about 300,000 years ago and none definitively associated with *H. erectus*, the hominid that began to spread through Asia and into cold northern latitudes starting about 1.8 million years ago. Researchers must now consider that this colonization may have happened without fire. "We now have to reconsider *H. erectus*, their migrations, and their capability," says Huang Weiwen, an archaeologist at the Institute of Vertebrate Paleontology and Paleoanthropology (IVPP) in Beijing, who has worked extensively at Zhoukoudian.

The site was first excavated in the 1920s and '30s, when researchers found hominid fossils, stone tools, burnt bones, and what they described as ancient hearths preserved as layers of ash up to several meters thick. It all seemed to add up to solid evidence of human control of fire; some researchers even concluded that the thick ash layers represented continuous occupation over thousands of years.

The new study is the "first really systematic investigation since the early excavations," notes anthropologist Rick Potts at the National Museum of Natural History in Washington, D.C. In 1996 and 1997, Weiner's team revisited the site, a sheer cliff cut into