Rules." Early on, he encountered a firestorm of opposition when he tried to change NASA's charter by shifting a small amount of funds to encourage commercial space ventures. "Not many people know that Brown helped me draft the language to get the bill passed," says Walker. "In a way he's been my mentor."

For Walker, the Science Committee has been "fascinating and exciting." He told us that he was "not a preeminent science student in either high school or college. I've now had 18 years of graduate education. I've not only had the chance to hear some of the best scientists in the country but I've exchanged ideas with them on science policy. I'm ready for the next part of the journey of discovery."

When Gingrich arrived in 1979, Walker was beginning to carve out a floor role for himself as a Republican activist. In 1983 Gingrich, Walker, Connie Mack of Florida, Vin Weber of Minnesota and Trent Lott of Mississippi organized the Conservative Opportunity Society, which promotes views well outside mainstream Republicanism. Walker became one of Gingrich's most loyal allies. In fact, he and Gingrich and several others recruited many of the House's 73 Republican newcomers, now known as "Newtoids."

Walker's vision of the future is remarkably similar to that of Gingrich. Walker's recent reading includes the same futurists on Gingrich's list: Alvin and Heidi Toffler, John Naisbitt and John Diebold. An automobile buff, Walker reads *Car and Driver* and *Motor Trends* and owns a 1991 Corvette, which he calls his "toy." He claims to be the only licensed race-car driver in Congress, racing Formula 2000 rear-engine cars once or twice each year on paved tracks in Pennsylvania. While Walker is an avid sports fan, he has little time to even watch games, unlike his brother, who makes his living as general manager of the Seattle Supersonics basketball team.

Does he think of himself in his new chairmanship as something of a general manager of science policy? "That would be presumptuous and wrong," says Walker.

IRWIN GOODWIN

Without President to Voice R&D Agenda, PCAST Seeks Relevance and Receptivity

Barely an hour after President Clinton left the White House on the morning of 25 October to bless the Mideast peacemakers at the Israel–Jordan border, the President's Committee of Advisers on Science and Technology assembled for its initial meeting. So instead of hearing firsthand the President's agenda for science and technology, PCAST members spent more than an hour of their one-and-a-half-day session with Vice President Al Gore in his ornate ceremonial office in the Old Executive Office Building, discussing the Administration's R&D programs and plans. The rest of their meeting was also somewhat anticlimactic.

GORE (extreme left) and GIBBONS (extreme right) engage Clinton's science advisers.

Appointed almost a year after Clinton announced he would form a White House science council similar to those anointed by every president since Eisenhower, PCAST consists of 18 celebrated experts in a variety of specialties (see PHYSICS TODAY, September, page 81). Because their first meeting took place nearly halfway into Clinton's term, most science and technology policies were fully in place without the advice of PCAST. Nonetheless, when John Gibbons, director of the White House Office of Science and Technology Policy and cochair of the committee with John Young, former president and CEO of Hewlett–Packard, invited PCAST members to the meeting, it was implied that they would be asked to suggest any mid-course corrections as well as some new departures. But as the meeting progressed, some members sensed that there was little they could offer, no matter how useful they wanted to be to the President and his aides.

On the first day of the meeting, PCAST was briefed by Gibbons and all four OSTP associate directors. Gibbons almost immediately departed from the traditional topics of Presidential advisory committees on science and technology. He proposed that PCAST examine the nation's investment strategies, which involve, among a dizzying array of questions, whether Washington should encourage joint public–private R&D partnerships, stimulate more investment capital for new technological ventures, shift the R&D budget to more utilitarian approaches and support more domestic and global economic "greening" in such areas as sustainable development, biodiversity, desertification, climate change and human health hazards.

This was a perfect segue into the

briefing by M. R. C. Greenwood, OSTP's associate director for science, who launched into a rosy depiction of the economic benefits of investing in "intellectual capital for the future." When Greenwood turned to improving public education and literacy in science, Young interrupted to observe that "the last time I looked at this, some 60 000 high school teachers were unqualified to teach science." Lionel ("Skip") Johns, associate director for technology at OSTP, cautioned PCAST members against suggesting increased funding for the science agencies, because the Administration is committed to reducing both the Federal budget and the fiscal deficit. When PCAST broke for lunch, the members listened to Alice Rivlin, director of the White House Office of Management and Budget, deliver an even grimmer view of the President's spending requests for the science agencies in the fiscal 1996 budget, which will be sent to Congress this month.

Sustaining stability

Jane Wales, OSTP's associate director for national security and international collaboration, spoke of the high priority the Administration is giving to scientific and technological cooperation with six countries "that have the indigenous capacity to produce weapons of mass destruction and the means of their delivery"—namely, Russia, China, India, South Africa, Argentina and Brazil. The countries were selected not only for their nuclear weapons capability, said Wales, but because each possesses scientific and technological capabilities that could attract foreign investment, and each could be a vast market for US products and services. But the best reason for US investment in these countries, she said, is to strengthen and stabilize them. She noted that the scientific and technological communities in these countries were a force for stability and democracy. Peter Raven, director of the Missouri Botanical Garden and home secretary of the National Academy of Sciences, observed that the US has about 5% of the world's population and 20% of the world's wealth. "If we don't do something to sustain nations like Russia, China and India, they will not only be poor markets but they will be strategic risks," said Raven.

Gibbons proposed that PCAST examine and evaluate the Energy Department's defense and nondefense nuclear fusion programs in an effort to comply with a Senate Appropriations Committee report accompanying the 1995 Energy and Water Development Act. The Senate report, directed by J. Bennett Johnston, a Louisiana Democrat, specifically requested that PCAST provide advice "that will help shape the direction of the nation's effort" on magnetic and inertial confinement fusion. Another Senate Appropriations Committee report, this one dictated by Barbara Mikulski, a Democrat of Maryland, called for PCAST to study ways of renewing the academic infrastructure.

During the course of the meeting it became clear that PCAST would meet only three times a year and that there would be little or no staff to provide research or secretarial help. Gibbons noted that the Pentagon's allocation for its Defense Science Board amounted to three times the $150 000 per year available for PCAST. Despite such limitations, Gibbons stated that PCAST's advice would need to be received by April 1995 to have any impact on the fiscal 1997 budget.

Still, said Gibbons, he would like to call on members individually and in small groups to advise his office on some of the Administration's most troubling policy issues. Among those he listed were such unsurprising topics as R&D investments, global conflicts, technology transfers from government laboratories and universities to industry, new roles for the government labs involved with nuclear weapons and military research, health research, and precollege education. Gibbons also said he would welcome PCAST's thoughts on technology and the changing nature of employment, a subject raised by Robert M. White, president of the National Academy of Engineering, in a pessimistic talk at the academy's 1993 annual meeting. In his address White speculated that the creation of new industries may not be adequate to offset jobs lost because of improvements in productivity brought about by computers, telecommunications and robotics. White asked: "Does the current rate of change caused by the introduction of new technology far exceed the political, social and economic capacity for social change?"

Gibbons's shopping list of issues led PCAST members into a discussion on what could be expected of them. Philip Sharp, chairman of MIT's biology department and a Nobel Prize winner in molecular biology, posed the question bluntly: "What output do you want from us?" John Holdren, professor of energy and resources at the University of California, Berkeley, observed that the panel's diversity enabled the participants to look at many matters, but they could not produce a national R&D strategy in the four or five months that Gibbons had given them. In response, Gibbons urged PCAST to develop an agenda of its own. The members decided to restrict their deliberations to five broad issues: education, environment, health, investment in science and technology, and national security and international affairs. In addition they agreed to serve as peer reviewers, in smaller groups of three or four, of the strategy papers that would be prepared by the nine panels of the National Science and Technology Council, the President's Cabinet-level policy group. And there might even be time for PCAST members to comment on three different reviews that are currently being conducted of the national labs supported by the Departments of Energy and Defense and by NASA.

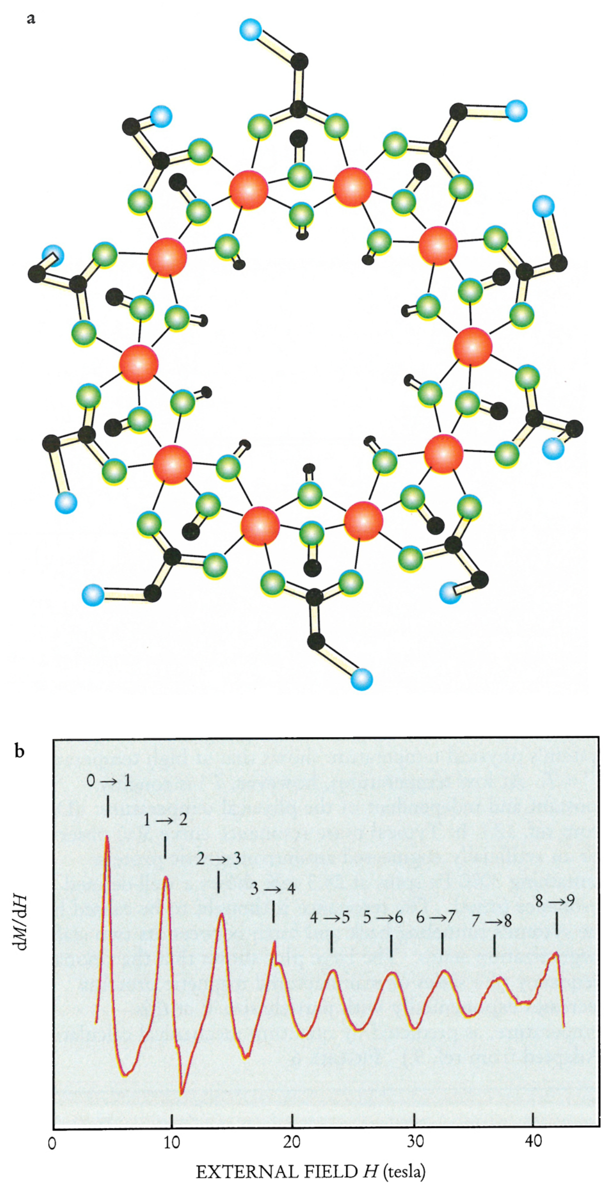
Another Nobel laureate, Murray Gell-Mann, emeritus professor of physics at Caltech who now spends most of his time at the Sante Fe Institute, recalled his service on Nixon's Science Advisory Committee. It had monthly meetings, an ample budget for all contingencies and its own staff, said Gell-Mann, so the group did "deep studies" that often wound up as book-length panel reports.

An intellectual tennis game

Another historical perspective was provided by David Z. Beckler, who served as executive director of every White House science advisory committee from 1957, under Eisenhower, until 1973, when Nixon abolished his science advice. Asked by Gibbons to comment on PCAST's proceedings, Beckler recalled that soon after Eisenhower's first election in 1952, I. I. Rabi, a Columbia University physicist, asked Ike, who had been the university's president, if a group of scientists might help him in making decisions. According to Beckler, Eisenhower told Rabi he would welcome science advice on what technologies would be most useful to meet a military threat. Accordingly, said Beckler, the committee Rabi assembled was assured of Eisenhower's "receptivity." Beckler asserted that the success of any Presidential panel depended on relevance and receptivity. Without these, he warned, the work of such advisory groups was "just an intellectual tennis game."

The warning did not go unnoticed. As Young told members: "If we're a Presidential panel, we should meet with the President." The next chance that PCAST will have for this is its second meeting, scheduled for 27–28 March.

IRWIN GOODWIN ■



Molecular antiferromagnet. **a:** The "ferric wheel" consists of ten Fe^{3+} ions (red) bound into a ring structure, along with chlorine (blue), oxygen (green) and carbon (black). **b:** Plot of dM/dH versus applied magnetic field for Fe_{10} at 0.65 K resembles a sequence of phase transitions in the magnetic order of bulk layered antiferromagnets. The maxima represent crossovers to states of higher spin multiplicity. (Adapted from ref. 11.) **Figure 5**

stable indefinitely below the blocking temperature. However, quantum mechanics tells us that the states in the two potential wells can be coupled by tunneling, leading to strikingly different dynamics. Early suggestions of such effects were observed through relaxation of the magnetization in particulate media. A recent example, shown in figure 6a, involves measurements of $Tb_{0.5}Ce_{0.5}Fe_2$ containing a distribution of magnetic particle sizes centered around 15 nm.[12] Although the reversal of the magnetization in such systems is complicated because of the range of particle sizes and the range of interaction strengths between particles, one can model the decay of magnetization on reversal of the field above $T = 4$ K by an Arrhenius activation over a range of energy barriers. At lower temperatures, however, the magnetic relaxation does not freeze out, but behaves independently of temperature. The authors of this study have suggested that the rotation of the magnetic domains is accomplished by a quantum tunneling process in an asymmetrical potential well like that indicated by the dashed curve in figure 1. Such temperature-independent relaxation behavior at low temperatures has been noted in many other experiments.

One-dimensional barrier penetration is a misleadingly simple depiction of quantum tunneling of the magnetization; there is no simple Schrödinger equation that describes this process, since it is not an elementary particle that is tunneling, but a collective coordinate: the magnetization direction of a collection of spins. However, the classical micromagnetic theory of magnetic dynamics can be quantized within a path integral formalism.[13] This treatment predicts that the tunneling rate for antiferromagnetic particles should typically be much larger than the rate for ferromagnetic particles (because of the smaller "effective mass" of the antiferromagnetic particles) and that the tunneling rate is exponentially suppressed as particle size increases.

Because of its antiferromagnetic structure and small size, ferritin is a good candidate for such quantum tunneling. In zero applied magnetic field, the symmetric double-well potential of figure 1 leads to quantum mechanical behavior in which the magnetization tunnels *coherently* back and forth between the two wells. At temperatures below 200 mK this behavior produces a resonance line in the magnetic susceptibility and noise spectra.[14] Figure 6b shows an experimental measurement of this resonance and its dependence on protein volume. The frequency of the resonance line and its exponential dependence on the number of spins in the particle correspond reasonably well to theoretical predictions.[13] Experiments have also confirmed that the resonance disappears rapidly when a magnetic field is applied and the symmetry of the double-well potential is broken. This work has stimulated a number of theoretical investigations[15] on the effects of dissipation, including the role of nuclear spins in magnetic quantum tunneling, as well as on the feasibility of seeing quantum effects in larger magnetic structures.

Limitations or opportunities?

It might appear that all of these studies point to limitations and restrictions on the use of small magnetic structures for the storage of information: The switching of magnetic domains depends on a myriad of detailed features of the particles, and quantum effects ultimately limit the length of time that a magnetic bit can remain stable.[16] Nevertheless it seems equally possible that these investigations will provide fundamentally new ways of using magnetic structures in technology. For example, theoretical investigations of magnetic quantum tunneling led to the surprising discovery that a selection rule quite generally forbids quantum tunneling for particles with an odd number of electrons![17] This derivation led to a new understanding of Kramers's theorem within a path integral description. Thus limitations imposed by quantum effects may be overcome. Another area for new investigations concerns the use of magnetic systems not for memory but for logic. Some computational problems can be greatly accelerated in a "quantum computer" in which bits and gates are implemented at the level of individual