Douglas fir and eats its pine needles, was another, as was the flying squirrel, who with the tree vole, is a favored prey item of spotted owls. The Pacific yew, whose bark is currently being tested as an anticancer drug by the National Institutes of Health, is a shade-tolerant tree very closely associated with old growth.

"But in general there are far fewer species dependent on old growth than conventional wisdom suggested," says Ruggiero. "We're not seeing the dramatic differences we expected."

One problem with the research program was that the wildlife biologists looked only at young, mature, and old-growth forests that were "natural." They did not compare the relative robustness of species diversity in managed and natural forests. Most forest ecologists suspect that the managed stands, with their evenly spaced rows of same-age Douglas fir, will prove to be barren habitats.

The recent research suggests that what is important to many species is not the age of the stand, but its structural components. Many species were strongly associated in all ages of forest with coarse woody debris, downed logs, and dead standing snags. "In the natural forest, structural complexity is maintained throughout the succession from young forest to old growth," says Ruggiero. "So in a sense, old-growth structures, like downed wood and snags, permeate the natural system. It's really kind of a 'Eureka!' It may not be so much the age of forest, but its components."

Proponents of the so-called "New Forestry" are asking that the federal caretakers of the national forests use the recent research findings to attempt to mimic some of the complexity of the natural forests in their managed stands.

During the conference, there were numerous suggestions. When an area is harvested, many biologists recommended that clusters of green trees be allowed to survive, as these trees will slowly age with the young stand and provide dead snags and rotting logs in the future. Says Franklin: "Decadence in moderation is probably a very useful thing."

The biologists also suggested leaving downed logs in the clearcuts, since this rotting wood serves as a nursery for many tree seedlings that cannot compete with the herbs and forbs of the forest floor. Franklin also wants to see some downed wood allowed to collect in the streams, thereby providing habitats for organisms that live in the riparian world.

Asks Franklin of his peers: "Are we going to develop a new way to do forestry or are we going to be technicians tending a long-growth row crop on a dwindling amount of land?" ■ William Booth

Confirmations Heat Up Cold Fusion Prospects

Researchers are having fun trying to reproduce a report of room-temperature fusion, and even more fun trying to explain it

Three weeks after the highly publicized claim of a revolutionary fusion discovery, reports of confirmation are beginning to appear. One of the most convincing came on Monday this week, when scientists at the Texas A&M University System reported heat production from simple electrochemical cells similar to the ones that were used in the original experiment. However, even if the heat production is shown to be real, the question remains of whether it is actually fusion that is producing the heat, or something else, perhaps some unknown chemical reaction. If it is indeed fusion, it is proceeding by a path that is completely mysterious.

On 24 March, electrochemists Stanley Pons of the University of Utah and Martin Fleischmann of the University of Southampton started the current furor when they told a press conference they had done the seemingly impossible—created a sustained fusion reaction at room temperature with very modest equipment. Their setup consisted of a palladium and a platinum electrode immersed in heavy water (water in which hydrogen is replaced with deuterium, a hydrogen isotope with one proton and one neutron). When a current was passed between the electrodes, deuterium was absorbed into the palladium electrode and there, the scientists said, it underwent fusion, producing heat as well as a small number of neutrons.

The claim that the experiment produced neutrons—an expected byproduct of deuterium fusion—was quickly confirmed by Steven Jones at Brigham Young University. He announced that in independent experiments very similar to that of Pons and Fleischmann, he had seen neutrons of the expected energy. (For details of the somewhat heated rivalry between the two groups, see last week's *Science*, p. 27.) Little more than a week later, two physicists at Kossuth University in Hungary reported they too had observed neutron production.

This Monday, Kenneth Marsh, Bruce Gammon, and Charles Martin offered a confirmation of Pons and Fleischmann's heat production. Marsh and Gammon are director and associate director of the Thermodynamics Research Center at the Texas Engineering Experiment Station, and Martin is a professor of chemistry at Texas A&M. Marsh said that calorimetric measurements showed their fusion cell, modeled after the ones at the University of Utah, had a heat output 1.6 to 1.8 times that of the electrical input going into the cell. That output-to-input ratio is well below the 10-to-1 that Pons has reported, but the palladium electrode used in the Texas A&M experiment was much smaller than the Utah researchers used, and Pons has said the size of the electrode can affect the heat output. The Texas A&M group has not yet tried to detect neutrons.

The Texas researchers were careful not to say that they have shown fusion is taking place in the cell, only that they are getting a positive heat production. Assuming that both the neutron and heat measurements are correct, the question remains: What is going on in these cells?

The presence of neutrons indicates that at least some deuterium fusion is taking place. If so, theorists must describe how fusion can proceed in palladium electrodes at room temperature when fusing two deuterium atoms normally requires tremendous heat and pressure. A second question is why the heat measured from the Utah cells is a billion times what is expected by the number of neutrons detected. If it is fusion and not some unknown chemical reaction generating the heat, then scientists must specify what type of fusion reaction could be producing so few neutrons.

Walling's hypothesized mechanism would be a nearly perfect way to do fusion.

Peter McIntyre, a physicist at Texas A&M University, suggested that the answer to the first question might hinge on the role electrons play in bringing deuterium nuclei together. Inside the palladium electrode, electrons can behave as if they are much heavier than in free space—their effective mass could be ten or more times higher, he said—and such heavy-seeming electrons might pull two deuterium nuclei much closer than they could otherwise come. Bringing the deuterium atoms nearer could allow them to fuse at a rate consistent with what Jones has measured, he said.

The harder question is why Pons and Fleischmann can get so much heat. Normally, when two deuterium atoms fuse to form a helium-4 atom, the energy of the helium-4 causes it to split apart immediately. It breaks into either a helium-3 atom and a neutron, or a proton and an atom of tritium—the isotope of hydrogen with one proton and two neutrons. Judging from the amount of neutrons and tritium detected in the University of Utah experiments, the fusion cells should be producing only one-billionth of the heat that they are, so something other than normal deuterium-deuterium fusion must be taking place.

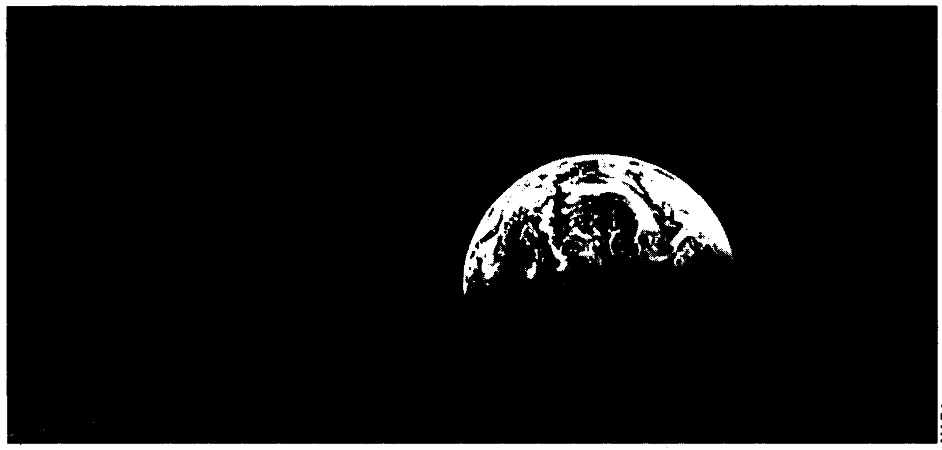
Chevis Walling, a chemist at the University of Utah, hypothesized that almost none of the helium-4 inside the palladium electrode is splitting into fragments. Instead, he suggests, the helium-4 is somehow transferring its energy to the lattice of palladium atoms, which heats up the electrode but produces very few neutrons or tritium atoms. The acid test, of course, will be to measure how much helium-4 is inside the palladium electrode after the "fusion" takes place. "There's no evidence for it at this point," Walling said, but the Utah group is gearing up to look for helium-4 now.

Walling's mechanism would be a nearly perfect way to do fusion. Each fusion reaction between two deuterium atoms would create seven times as much energy as the reactions in which the helium-4 split apart, so that less fusion would create more energy. Further, there would be no waste. One of the major problems with fusion is that although it does not produce as much radioactive waste as fission, it does produce plenty of neutrons. Finding a way to produce fusion power without neutrons would be a dream come true.

For now, however, whether that dream comes true seems almost beside the point for the scientists involved. As Walling puts it, "We're having fun with this."

Utah is also having fun—it plans to spend $5 million on a fusion center to capitalize on the discovery. Bud Scruggs, chief of staff to Governor Norm Bangerter, said the plans would not be dampened even if the fusion manuscript, which has been submitted to *Nature*, failed the peer review process. "We are not going to let some English magazine decide how state money is handled," he said.

■ ROBERT POOL



NASA

Does Chaos Permeate the Solar System?

As faster computers allow celestial mechanicians longer looks at the behavior of the planets, chaos is turning up everywhere

CHAOS FIRST SEEPED INTO THE SOLAR SYSTEM when Jack Wisdom, then a graduate student at the California Institute of Technology, began looking at how meteorites are being slung from the asteroid belt toward Earth. No one at the time could understand what would drive enough meteorites from their orbits. Using a new shortcut that eased the burden of calculating the gravitational interaction between bits of asteroid and Jupiter, Wisdom found that a periodic gravitational nudge from Jupiter could sometimes, without warning, send asteroidal rock careening off toward Earth.

It seemed that a soon-to-be meteorite was so sensitive to its initial conditions—its orbital motions in relation to Jupiter's—that its future behavior could not be predicted no matter how precisely those initial conditions were known. Its behavior became chaotic.

Wisdom, now at the Massachusetts Institute of Technology, went on to point out other chaotic behaviors in the solar system, such as the chaotic tumbling of the small Saturnian satellite Hyperion, but he also joined the 200-year-long effort to test the long-term stability of the planets themselves. The advent in recent years of faster computers is pushing analyses of solar system stability to longer and longer time spans until chaos is now appearing in the behavior of the planets, not just in the odd bits of the solar system.

Recently, J. Laskar of the Bureau des Longitudes in Paris reported that his numerical simulation of the orbital motions of the solar system reveals chaos throughout, especially among the inner planets, including Earth. This does not necessarily mean that Earth could at any second fly off into the Sun or interstellar space. The survival of a fairly regular system of planetary orbits for 4.5 billion years would argue against that. But if confirmed, Laskar's results would mean that, no matter how exactly present planetary motions are known, motions over geologic time cannot be predicted accurately. Such sensitivity to initial conditions may have played a role in shaping the solar system of today.

Laskar's is one of several approaches to detecting chaos that depend on the new power of computers. Wisdom teamed up with computer-builder Gerald Sussman of MIT in taking the long, hard route of calculating each and every motion of the four massive outer planets and Pluto with only the most minor of approximations, such as ignoring general relativity. Calculating new arrangements of the outer solar system every 32.7 days over 845 million years took them 5 months on a uniquely designed computer called the Digital Orrery that is dedicated to the calculation of solar system motions. They showed that the orbital behavior of Pluto, the most minor of the major planets, is chaotic and unpredictable beyond 20 million years into the future (*Science*, 20 May 1988, p. 986).

Laskar had nothing like the Orrery, and