moved from the National Institute of Mental Health in Bethesda, Maryland, to Loyola University Medical Center in Mayrood, Illinois, and his colleagues provided what might be a gain of function for mutant *PS2*.

They found that the mutant protein induced apoptosis, or programmed cell death, in cultured nerve cells under conditions in which normal PS2 had no effect. If mutant PS2 has a similar effect in the brain, the enhanced apoptosis could lead to the nerve cell loss of Alzheimer's. Other researchers are skeptical, however, primarily because mice carrying mutant *PS* transgenes have so far remained healthy. The animals "have no problem even if you grossly overexpress the presenilins," Selkoe says. Wolozin responds that while he understands the skepticism, the transgenic mice made so far may not be optimal for seeing apoptosis problems because the methods used for generating them may have selected for cells that can withstand the *PS* mutations. Like many others, he is now turning to *PS* gene constructs that can be turned on after development to see what effects they have.

So despite all the recent progress on the proteins, researchers still have plenty of work to do in trying to understand exactly what the normal and mutated presenilins do. But their apparent involvement in an important developmental pathway, combined with their link to a major feature of Alzheimer's pathology, guarantees that their turn on stage is just beginning.

–Jean Marx

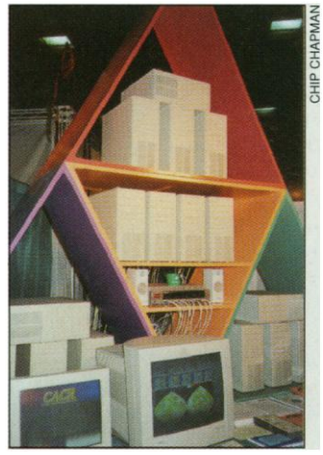
COMPUTING

Do-It-Yourself Supercomputers

The November Supercomputing '96 convention in Pittsburgh was a showcase of flashy technologies of the future. So what were a 3-meter pyramid and a rack of industrial shelving, both containing what looked like—and indeed were—piles of personal computers, doing in this setting? The two displays constituted two homemade supercomputers, built only of Pentium processors and other components that anyone with a link to the Internet and a credit card number could purchase for less than $60,000. Both machines, called Hyglac and Loki after figures in Norse mythology, can run over a billion operations a second (gigaflops)—a realm of processing speed formerly open only to supercomputers based on clusters of workstations and costing several hundred thousand dollars or more. The future, it seems, is not only here, but it's also affordable.

Called "pile of PCs," the technology is the poor scientist's version of clusters of workstations, says the California Institute of Technology's (Caltech's) Thomas Sterling, who is the father of what he is calling the Beowulf class of supercomputers because they are "lean and mean, and fighting something bigger." The strategy takes advantage of the extraordinary improvement in personal-computer processors over the past half-dozen years. PC processor performance has increased four times as fast as that of the workstation processors that power most supercomputers today, and high-end Pentium Pro chips now rival workstation processors for many types of calculations. At Supercomputer '96, both Hyglac and Loki, the former a product of Caltech and the latter from the Los Alamos National Laboratory, matched or exceeded the performance of a cluster-based supercomputer costing six times as much.

Sterling notes that users seeking raw computational power may still do better with the workstation-based machines, and that limitations in the networks linking the chips mean that not all software will run well on a pile of PCs. But he and others expect the strategy to catch on. While some computer scientists think piles of PCs are ripe for commercializing, Sterling himself is developing software infrastructure and a how-to manual, so that scientists can put together their own low-cost systems. Because the creators of cluster-based supercomputers like to describe their efforts as akin to picking the low-hanging fruit, says Sterling, "what we're akin to is digging up potatoes. We can stoop lower than anything else."



CHIP CHAPMAN

Piling them on. Sixteen Pentium Pro processors, linked by a local area network, make a gigaflops supercomputer, a strategy embodied here in a machine called Hyglac.

The approach sprang from a 3-year-old program at the NASA Goddard Space Flight Center in Greenbelt, Maryland, to develop a gigaflops-scale workstation, able to analyze enormous satellite data sets, for under $50,000. Sterling, who was at Goddard at the time, took on the challenge, and the Beowulf machines were born. When Sterling moved to Caltech last summer, he joined computational astrophysicist John Salmon, who was collaborating with Mike Warren and Wojciech Zurek at Los Alamos on large simulations of galaxy evolution. The astrophysicists had been thinking of building a commodity-based supercomputer at Los Alamos, and so Loki was born there, inspired by Sterling's machine, while Sterling and Salmon put together Hyglac at Caltech.

> **"What we're akin to is digging up potatoes. We can stoop lower than anything else."**
>
> **—Thomas Sterling**

Both groups started in the early autumn, says Salmon, "scouring the networks and computer magazines for the best price and performance we could lay our hands on." By mid-November, they had put together the two computers from the same basic ingredients: 16 200-megahertz Pentium Pro chips, the kind of connections used for local-area networks, and Ethernet software written by Don Becker of NASA Goddard. "It's hopefully nothing terribly unique," says Sterling—"a system anyone can put together."

That should appeal to scientists hoping to get supercomputing into the labs on a shoestring budget, says Rick Stevens, a computer scientist at the Argonne National Laboratory. These first two demonstration machines "prove you can take commodity stuff—freeware software, freeware compilers—and anybody in any country can get on the Web, order the parts, have them shipped air express, and build this ensemble and get performance comparable to a high-end supercomputer."

Salmon, who plans to use Hyglac for his galaxy-evolution studies, adds that the advantages go beyond price. Each Beowulf-class supercomputer can be constructed from technology only weeks old, while vendor-bought machines can suffer a technology lag of years. And by building their own machine, scientists can have exclusive access to it 365 days a year. "Personally," says Sterling, "I'm old enough to believe that gigaflops is still supercomputing, and I believe that any scientist can afford $50,000. If you accept those two statements as true, it's fair to say that the pile of PCs has come of age."

–Gary Taubes