measured to determine their isotopic composition. These instruments have enabled researchers to date the oldest minerals on Earth (*Science*, 22 December 2000, p. 2239) and to recognize the isotopic traces of the oldest signs of life (*Science*, 3 January 1997, p. 38). Christopher House of Pennsylvania State University, University Park, and his co-workers had recently adapted ion microprobes to measure the carbon isotopes found in individual microbes. "We went to a system where we dried the microbes on a piece of glass, and we found that it worked quite well," he explains. House teamed up with the researchers from Woods Hole and the Monterey Bay Aquarium to put the newly discovered archaea-bacteria aggregates in the sights of a microprobe.

For the first time, the researchers succeeded in identifying the microbes and then directly measuring their carbon isotopes. And, as they report in this issue, those isotopes clearly show that these specific archaea feed on methane and that the bacteria in turn get most or all of their carbon from the archaea.

Previous research on these microbes "was compelling, but this one is convincing," says Reeburgh. All that remains now is to determine exactly what sort of chemistry goes on between the two microbes. "We still don't know what chemicals are being processed. But I keep telling people, we're on the right street, we're approaching the house, and we're about to knock on the door."

These methane-eating microbes—once thought to be impossible—now look to be profoundly important to the planet's carbon cycle. Hinrichs and Boetius estimate that they devour 300 million tons of methane every year, about as much as humans now inject into the atmosphere with agriculture, landfills, and fossil fuel burning. But on early Earth, these microbes might have been even more significant. Atmospheric scientists have suggested that methane levels in the atmosphere may have been 1000 times higher than they are today, created initially by volcanoes and later by methane-producing microbes (*Science*, 25 June 1999, p. 2111). At first, this methane may have been beneficial, creating a greenhouse effect that kept the planet from freezing. But if the rise in methane had gone unchecked, Earth might have become too hot for life, as Venus is today. We may have the evolution of methane-eating archaea to thank for saving us from that grim fate. "If they hadn't been established at some point in Earth's history," says Hinrichs, "we probably wouldn't be here." **–CARL ZIMMER**

Carl Zimmer is the author of *Parasite Rex* and *At the Water's Edge*.

PROFILE

A Man and His Archive Seek Greener Pastures

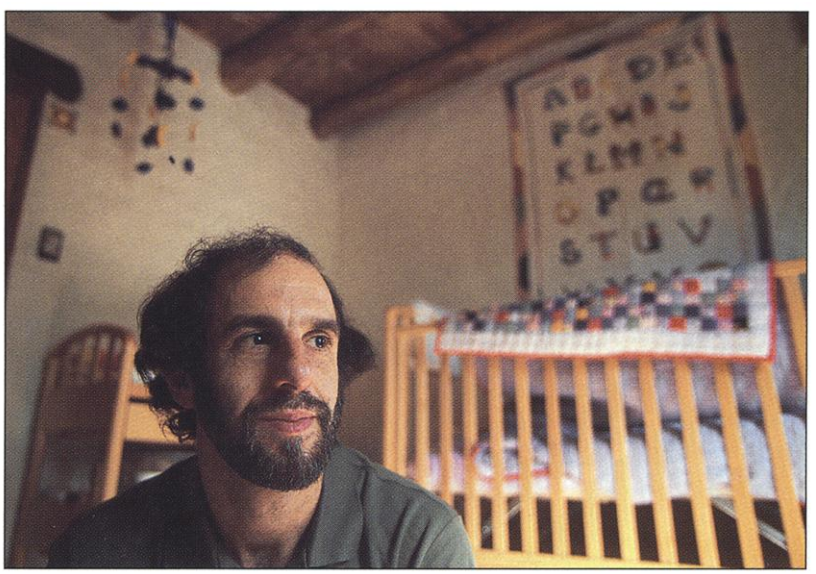
Paul Ginsparg started the wildly successful Los Alamos Electronic Preprint Archive. Now, he and his creation are headed to Cornell

HOUSTON—For 10 years Paul Ginsparg thrived as an anomaly at Los Alamos National Laboratory (LANL). A high-energy physicist who founded a revolutionary electronic system to store and disseminate research findings, he was also a vociferous advocate for the open exchange of scientific information from inside a top-secret nuclear weapons laboratory. But that special status isolated him from the rest of the lab, generating a burden that eventually proved too heavy to bear.

So last month, Ginsparg decided to resolve those contradictions by moving 3000 kilometers east. His decision to accept a tenured position at Cornell University in Ithaca, New York, bolsters the university's efforts to establish a world- class center for research in information science. The preprint archive will move with him, and Ginsparg says he hopes to expand it to include papers from disciplines other than physics, its current focus. He and others promise that users of the archive, which next month marks its 10th anniversary, won't notice the move.

Ginsparg, 45, is the father of the Los Alamos Electronic Preprint Archive (xxx.lanl.gov, recently renamed arXiv.org). Spawned by an offhanded complaint from a colleague at a summer workshop, the archive has grown to become a part of every physicist's daily routine. This year the archive expects to receive 35,000 papers across various fields in physics, math, and computer science (see graph). "It has completely revolutionized physics communication, and all for the better," says Gary Horowitz, a physicist at the University of California, Santa Barbara, and the author of the first paper submitted to the archive on 14 August 1991 ("Exact Black String Solutions in Three Dimensions"). "The first place I look [for papers] is the archives, not the library."

Long shackled by the slow pace of journals, physicists used to spend hundreds of dollars a year mailing around copies of not-yet-published papers, called preprints. E-mail, which scientists embraced years before the public had heard of AOL, eased the postal bills somewhat, but its value was limited by the puny storage capacity of most desktop computers.



CREDIT: CRAIG FRITZ/LIAISON AGENCY

Proud father. Physicist Paul Ginsparg did much of the initial programming for the Los Alamos archive in his infant daughter's room.

In June 1991, at the Aspen Center for Physics in Colorado, Ginsparg overheard physicist Spenta Wadia of the Tata Institute in India fret about the e-mailed preprints that flooded his disk while he was away. Realizing that it would be much more efficient to circulate only the abstracts and archive the full papers, Ginsparg spent that afternoon at the Aspen gym working out an automated preprint archiving and distribution system. He wrote the code later that month and opened the server in August.

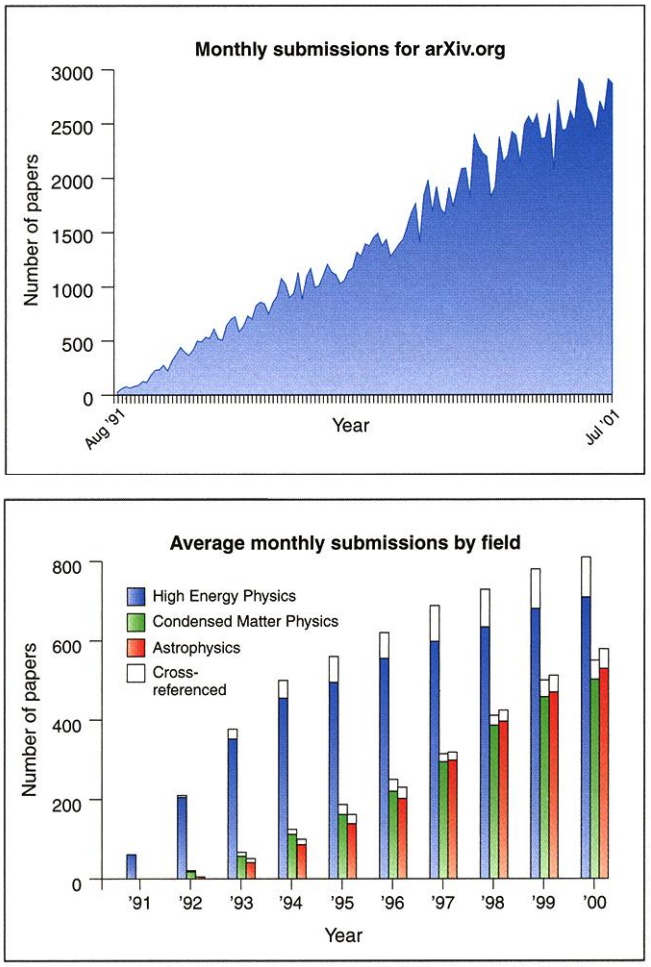
An instant and enduring hit with the physics community, the archive has

been a mixed blessing for LANL. "The lab is justly proud of supporting and developing the server," says LANL senior physicist Geoffrey West, another Ginsparg collaborator. But the server, which costs roughly $300,000 a year to run, didn't fit into any of the lab's core missions. And its relentless growth posed a problem. "The archive has wanted to expand to a much bigger natural size," says Ginsparg, "and too much time was spent trying to keep it from growing." Although the archive is supported by the National Science Foundation (NSF), the Department of Energy, and LANL, West says that "getting a stable source of funding has been a very rocky road."

In 1995, the archive received NSF funding aimed at completing its development. With a mature piece of software in hand, Ginsparg hoped to end his all-encompassing involvement in developing the archive and hand over responsibility for its daily management. But reality intruded. "With the growth of the Web, the popularity of the Internet, and improving end-user hardware and software, it turned out instead to be a period of extraordinary transition," he says. Another obstacle was the lack of a trained successor.

Faced with the disheartening prospect of running harder to stay in place, Ginsparg started dropping hints that he might want to return to academia, where he had spent most of the decade preceding his arrival at LANL in 1990. There were other signs that the time was ripe to return. Cornell had just founded the Faculty of Computing and Information (FCI), an interdisciplinary program in scientific communication, and was looking for top-notch scientists like Ginsparg. "Paul is one of the most far-thinking people in the field," says Robert Constable, Cornell's dean of computing and information science. "He will be a nucleus we can build around."

Cornell's offer proved irresistible: a tenured position in computer science and physics, with the archive as a "special collection" in the FCI's digital library. The library staff will use university funds to take over the day-to-day administration of the archive, freeing up Ginsparg to apply the rest of an existing NSF grant to explore new directions for the archive. "A long-term commitment from the library was crucial," says Cornell computer scientist Bill Arms. "Paul wanted to make sure the future of the archive would not depend on him personally."



SOURCES: ARXIV

Growing knowledge bank. The appeal of an electronic preprint archive caught on quickly among high-energy physicists. More recently, it has spread to condensed-matter physics and astrophysics.

Indeed, Ginsparg sees his move east as a welcome break from the past. "Frankly I would have been more than happy to leave it all and start something entirely new," he says. "But the unanimous recommendation from various interested parties was that the main site should move with me." The move to Ithaca also brings him and his wife and young daughter close to his sister and her family.

His Los Alamos collaborators are saddened by his pending departure. "I feel a sense of tremendous loss for the institution and personally," says Rick Luce, the leader of LANL's "library without walls" initiative. But his former bosses aren't too surprised that he chose Cornell. "The opportunity that Cornell has created for Paul is uniquely suited for advancing his vision," says LANL Deputy Director William Press, adding that he expects the lab to remain involved. "Paul and Rick Luce are discussing continuing collaborations between Cornell and Los Alamos," says Press, "I have already heard some very interesting concepts emerging, and I commit Los Alamos to helping to support them."

Once he arrives on campus this fall, Ginsparg will have plenty to do. One of the most pressing questions to help Cornell think about is how to expand the electronic preprint server model into other scientific fields, particularly biology. So far, its adoption has been stymied by a lack of a preprint culture in biology and concerns about the open dissemination of research that could lead to a blockbuster drug or a change in patient care. "Our hope is that the library and the information program at Cornell will view this as a precursor to a more visionary digital scholarly solution that puts the institution and its scholars in better control of their intellectual property," Ginsparg says. The researchers know that this path is studded with landmines, as scientific publishers try to satisfy their customers without jeopardizing revenue sources.

And what about physics? Ginsparg says that he hopes to find time to return to his work on computational string theory and quantum gravity. "But if he doesn't, we will still be happy," says Peter Lepage, department chair.

Despite all the changes going on around them, regular users of the preprint archive should be able to continue with business as usual. "This is an Internet-based service with a worldwide network of access points," says Duke University mathematician David Morrison. "The physical location of the primary server should have very little impact on the operation." Even so, Ginsparg and Cornell are hoping that a change in scenery will lead to big improvements in the larger world of scientific communication.

–MARK SINCELL

Mark Sincell writes from Houston, Texas.