BIODIVERSITY

Up for the Count?

An odd combination of high-tech gurus and senior taxonomists is planning an ambitious—some say quixotic—effort to catalog and describe all species on Earth

BOSTON—Making big lists is big science today. Backed by the latest in high-tech tools and millions of dollars in public and private funding, molecular biologists are busily pinpointing tens of thousands of genes, while astronomers are mapping millions of galaxies. So pity the taxonomists, who have yet to organize something equivalent for their field: a comprehensive, well-funded, highly coordinated effort to count and describe Earth's species.

But that will change if a small group of San Francisco high-tech movers and shakers has its way. Allied with senior researchers in the field, including Harvard professor emeritus E. O. Wilson and Peter Raven of the Missouri Botanical Garden, they are brainstorming an ambitious listmaking effort that could surpass the Human Genome Project or the Sloan Digital Sky Survey in complexity.

Their goal is to count every last animal, plant, and microbe on Earth, including the undiscovered ones that account for perhaps eight in 10 living species. Creating this biological master database, they estimate, would take at least 20 years, cost some $20 billion, and require the help of thousands of researchers and amateur naturalists around the world. "The idea is simple: a Web page for every species," says Kevin Kelly, who started *Wired* magazine and who chairs the new All Species Foundation dedicated to the task.

The foundation assembled two dozen scientists last week at Harvard to help figure out how to tackle such a mammoth endeavor. As was clear at the meeting, the bold proposal is raising both the hopes and hackles of taxonomists. "This is well intentioned but incredibly naïve," says Cristián Samper, deputy director of the Smithsonian Tropical Research Institute in Panama. Not only is the proposal impossibly ambitious, said many, but unlike counting genes or galaxies, counting species involves complex political, educational, and legal issues—ranging from the shortage of trained researchers in developing countries to concerns about biopiracy. And gaining public and private support for a $20 billion project—particularly during an economic downturn—strikes some as quixotic.

But the assembled scientists were also excited by the prospect of new funding, advanced computer tools to handle huge amounts of data, and an aggressive attempt to interest the public and politicians. And they clearly welcome any assistance Silicon Valley has to offer. "Systematic classification of biodiversity is at the beginning of a technology-driven revolution that will take it into the mainstream of science," Wilson told the participants. "If we build it, they will come."

The all-species-count concept sprouted not from a meeting of taxonomists but from a San Francisco dinner party in the spring of 2000. Former Microsoft chief technology officer Nathan Myhrvold invited friends such as Kelly of the All Species Foundation and Stewart Brand, who created the Whole Earth Catalog and now directs the Global Business Network, to discuss which philanthropic ideas might be worthy of large donations. Kelly tossed out the biological inventory idea, "but I assumed it was already being done," he says.

CREDIT: ISABELLA KIRKLAND

On the ascent. Isabella Kirkland's painting combines a host of invader species, such as the ring-billed gull, crowding out biodiversity.

Bits and pieces are. Ecologist Daniel Janzen of the University of Pennsylvania in Philadelphia made a start 7 years ago in a project—the All Taxa Biological Inventory—to catalog every life-form in one part of Costa Rica, but the effort fell apart amid disputes over funding and other issues. Now an international project called Species 2000 is working to inventory the 1.75 million known species by drawing on existing databases. So far, with funds from public and private sources, the project has completed 250,000 and hopes to reach 500,000 by 2003. In Copenhagen, the Global Biodiversity Information Facility, a new international organization, is gearing up to add new biodiversity data online.

But nobody had proposed a single effort to count all the world's species by a particular deadline, Kelly and Brand learned when they consulted the experts. They were also astonished to learn of the low-tech nature of the field. "Taxonomy is still done the same way it was during Darwin's day," an incredulous Kelly told *Science*.

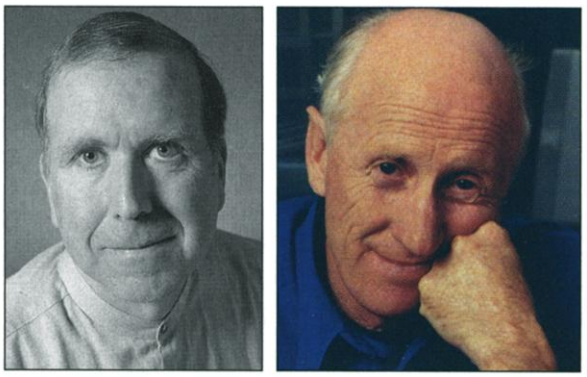
Kelly and Brand have set out to change that—by making taxonomy "cool," Kelly says. With support from members of the California Academy of Sciences, they launched the foundation last year. Brand and his wife, foundation business consultant Ryan Phelan, kicked in about $40,000 and Kelly about $20,000. They have since won a $1 million grant from a wealthy entomologist. They also recruited Brian Boom, former vice president of botanical science at New York's Botanical Garden, to be the foundation's chief executive officer. "The refrain is think big, start small, act now—and don't deliberate it to death," says Boom. They've picked a target of 25 years to complete the effort.

At the Harvard meeting, taxonomists suggested they start by taking on some manageable but still ambitious projects. For instance, the foundation could support four or five intensive surveys in particular countries; alternatively, it could take a novel approach and focus on a single species, such as the wood rat or the salmon. The idea is to catalog all the species that live in, on, or around the chosen animal. Along with yielding valuable scientific data, that approach could capture the public's imagination, said Kelly and Boom, who are counting on outside help.

"Let the rest of the world become naturalists, with the Web as the unifying glue," says John Pickering, an ecologist at the University of Georgia in Athens. Amateurs could build "life lists" of new species seen or discovered, much as bird watchers do today, forming a critical base for research.

Counting all species would indeed re-

quire legions of taxonomists and parataxonomists as well as massive but user-friendly computer databases. And those legions would have to be concentrated in the most biodiverse parts of the world—the developing countries—where both trained naturalists and computer access are scarce. The foundation hosted a meeting in Mexico City earlier this fall to underscore its desire to involve developing-country scientists. But good intentions have failed before—such as in Costa Rica. And developing nations are concerned that Western countries might take advantage of their biodiversity for profit's sake (*Science*, 9 May 1997, p. 893).



Whole-species catalog. High-tech gurus Kevin Kelly and Stewart Brand are behind the push for a total species count in 25 years.

And then, of course, there's the money. Whether the odd combination of high-tech gurus and academic taxonomists can ratchet a modest foundation into a multibillion-dollar international effort remains to be seen. Kelly hopes to raise $10 million by the end of 2002, mainly in large chunks from foundations and wealthy individuals. Phelan adds that the goal is to raise $50 million to $100 million in the next 3 years. "If we can deploy $3 million next year, we could kick-start things and get some traction," she says.

Ultimately, the scale of the effort will require national and international funding. In the United States, at least, that may be hard to find: Biologists are still smarting from congressional rejection of the proposed National Biological Survey. Lawmakers feared a species inventory could ultimately infringe on the rights of owners of private property. But Raven, who moderated a session at the Harvard meeting, says that Kelly's foundation is an encouraging step. "The All [Species Foundation] effort is a publicity gold mine, if played right," he says.

Many of the taxonomists at the Harvard meeting scoffed at the idea that an all-species count could be done in 25 years. But whether or not the California high-techies can pull it off, senior researchers welcome the nascent foundation and its infusion of funds. "People are spread out, underappreciated, and consider themselves fly or beetle or butterfly people rather than taxonomists," says Scott Miller, entomology department chair of the Smithsonian's National Museum of Natural History. The big-list idea and help from Silicon Valley might prove just the tonic needed to give purpose, direction, and unity to a tradition-bound field.

–ANDREW LAWLER

INFECTIOUS DISEASES

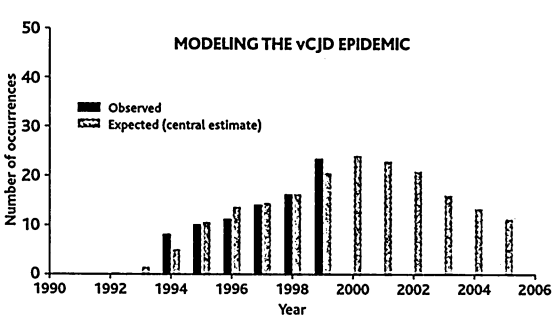
Uncertainties Plague Projections of vCJD Toll

Two mathematical models of the epidemic come up with very different results. Researchers may soon know if one is right

Since 1996, when a new human disease linked to eating beef from cattle infected with bovine spongiform encephalopathy (BSE)—"mad cow disease"—first emerged, the British public has been gripped by one question: How bad will the epidemic be? By late September 2001, 107 people living in the United Kingdom had died from variant Creutzfeldt-Jakob disease (vCJD), an invariably fatal neurodegenerative malady. But just how many more it might claim remains unclear.

Although an estimated 750,000 BSE-infected cattle were eaten by humans between about 1980 and 1996, no one knows how many people actually became infected, nor how long it takes for an infected person to become sick. Past projections of the possible death toll have not relieved the uncertainty. The most authoritative estimate to date predicts that cases could range from a few hundred to more than 100,000. The waters became even murkier last week when a study concluding that sheep might also have been infected with BSE—a possibility health officials have long feared—was pulled from publication at the last minute when it turned out that the scientists might have been analyzing brains of cattle rather than sheep (see sidebar).

In the midst of this confusion, two well-respected teams have been refining their projections—and they are coming up with different conclusions. A new mathematical analysis of the epidemic by researchers at the London School of Hygiene and Tropical Medicine provides some encouraging news. The study, published online by *Science* on 25 October (www.sciencexpress.org), concludes that the epidemic might be nearing its peak and that the maximum number of cases might number no more than "several thousand." The team, led by epidemiologist Peter Smith, believes that the real numbers could turn out to be much lower than that. Moreover, says veterinary epidemiologist Mark Woolhouse of the University of Edinburgh in Scotland, the new study's more optimistic predictions might be "very testable in the short term." But these hopes are challenged by epidemiologist Roy Anderson's group at Imperial College in London. This group's newly completed but still unpublished analysis, which uses different mathematical techniques, comes up with maximum estimates that are "substantially higher," says team member Neil Ferguson.



Good news? If one mathematical projection is correct, the number of human cases may soon peak.

The fact that different mathematical models produce different results is not surprising, researchers say. Because reliable tests for BSE infection in humans do not yet exist, it is impossible to know how many people were actually infected and when. Without such data, modelers must rely on "arbitrary mathematical assumptions to guide the extrapolations," says epidemiologist Peter Bacchetti of the University of California, San Francisco.

Until now, the most oft-cited projections were those reported by Anderson's team in the 10 August 2000 issue of *Nature*. Anderson and his colleagues explored more than 5 million combinations of parameters based on a wide range of assumptions, including the likelihood that an infection would result from eating

CREDITS: (TOP) (KELLY) MICHAEL SEXTON; (BRAND) TOM GRAVES