sent the problem graphically by etching a map of London onto a glass chip. They then covered the etched part of the chip with another piece of flat glass to create a network of pipes. They also fixed tiny electrodes to the chip so that they could apply a voltage to various locations.

The researchers then pumped low-pressure helium into the chip through open channels along one edge and filled the pipes. Using the electrodes, they could then apply an electric voltage between two points on the chip. The electric field would then guide an electric discharge along the shortest route between the two points, making the helium glow like a fluorescent tube just along that route. The answer to the problem literally lights up. The team members say the method can at present be used to find the way out of a maze and the shortest route between two points, but they hope to develop it for the more complex TSP and network flow problems. "We had really good fun doing this," Manz says.

Manz concedes that the technique has limitations, such as the fact that once a layout is etched onto a device it cannot be changed. But the team hopes to scale up to much more complex problems soon. "With present knowledge about plasma discharge in narrow capillaries, we can assume to be able to work with 5-micrometer capillaries instead of the current 250-micrometer channels in this example," says Manz. This would allow them to stud a 6-cm^2 chip with 1 million electrodes, providing $2^{1,000,000}$ routes across the chip.

Next the researchers hope to find a way to control the opening and shutting of channels on the fly. That would enable them to create a variable chip that could solve a range of problems by changing the network each time to represent a different maze, map, or network layout. "The new digital wave of technologies has opened up a variety of possibilities that will be very hard to surpass," Manz acknowledges. Still, he says, "this technology would benefit from open-minded engineers with a good feeling for where the future lies in computing."

Whether glass chips can rival a digital computer remains to be seen. "There is no doubt that [this is] a clever piece of work," says computer scientist Paul Purdom of Indiana University, Bloomington. "It is an interesting physics problem to determine whether it can be made to work more rapidly than a traditional computer." Beebe thinks racing a digital computer is pointless. But "I'll bet there are other applications … that none of us have thought of yet," he says.

–DAVID BRADLEY

David Bradley is a writer based in Cambridge, U.K.

ENDANGERED SPECIES ACT

Cherished Concepts Faltering in the Field

Scientists at the U.S. Fish and Wildlife Service (FWS) thought they had finally won a measure of respect from their peers after adopting two major revisions in their approach to endangered species: setting aside critical habitat, and taking a big picture, or whole ecosystem, view in writing recovery plans. Now they must be feeling like the Rodney Dangerfields of ecology. A clutch of papers in the June issue of *Ecological Applications* suggests that FWS's new approach is faltering. At stake is the success of a series of high-profile initiatives, including the agency's ambitious plan for protecting the Florida Everglades and its 68 imperiled species.

Postcards from the edge. Unlike the peregrine falcon, the Florida panther remains in grave danger.

CREDITS: (TOP TO BOTTOM) TOM AND PAT LESSON/PHOTO RESEARCHERS; JEFF LEPORE/PHOTO RESEARCHERS

Not that the old modus operandi—essentially viewing an endangered species in a vacuum—was a smashing success. Of roughly 1000 species listed in the United States as endangered, only 13—including the American peregrine falcon and the American alligator—have rebounded enough to warrant removal from the list. For years, sympathetic voices blamed this disappointing record on a welter of litigation that siphoned away FWS funding for implementing recovery plans. "They're getting eaten alive by the day-to-day issues," says James Michael Scott, a University of Idaho, Moscow, zoologist who works extensively with FWS. Critics, however, have derided the agency's grip on current science.

For a sweeping review of protection strategy, FWS and the Society for Conservation Biology launched a massive data-crunching project in 1998 involving more than 300 people at 19 universities. An army of students led

ScienceScope

Eisenstein Leaves NSF The head of the National Science Foundation's biggest directorate surprised colleagues last week by stepping down from the job. Sources say he felt he had lost the confidence of NSF director Rita Colwell.

Robert Eisenstein, assistant director for mathematics and physical sciences (MPS), announced that he plans to spend the next 12 months on professional leave at CERN, Europe's particle physics laboratory near Geneva. A nuclear physicist, the 60-year-old Eisenstein joined NSF in 1992 and has served for 4 1/2 years as head of MPS, a $920 million program that funds several large facilities as well as providing grants to individuals and groups.

"His departure leaves MPS with a big hole to fill," says chemist Billy Joe Evans of the University of Michigan, Ann Arbor, chair of the directorate's advisory committee. "Bob has done a great job, and his departure was totally unexpected."

NSF officials declined to comment on Eisenstein's decision. But Evans says that NSF deputy director Joseph Bordogna told the committee that the agency "is moving toward having a 5-year term limit for [assistant directors]." According to Evans, Bordogna also noted that NSF's widespread use of rotators—academics who come to Washington for a few years—strengthens NSF's management by allowing it "to change course quickly."

Eisenstein, who remains on NSF's payroll, called his NSF stint "a wonderful scientific opportunity." At CERN he will join a team planning the installation of Atlas, one of four detectors for the Large Hadron Collider.

Next Up The longtime director of the Smithsonian Astrophysical Observatory in Cambridge, Massachusetts, has agreed to do double duty for the beleaguered parent organization.

Last week, Smithsonian Institution secretary Lawrence Small named Ira Shapiro as the new interim undersecretary of science, a job embroiled in controversy since Small announced his plan last spring to reorganize Smithsonian research. Shapiro succeeds Dennis O'Connor, who is headed for the University of Maryland (*Science*, 12 April, p. 235).

A search committee will hunt for a permanent replacement for O'Connor, who has also served as acting director of the National Museum of Natural History.

Contributors: Mari N. Jensen, Michael Balter, Xavier Bosch, Cassio Leite-Vieira, Jeffrey Mervis, Elizabeth Pennisi

by ecologist P. Dee Boersma of the University of Washington (UW), Seattle, pored over 136 recovery plans, FWS's blueprints for endangered species under its jurisdiction, addressing some 2600 questions for each plan.

The fruit of this labor—"a huge and onerous spreadsheet," as one of the foot soldiers calls it—was not a total slam against the agency. The study lauds FWS for steadily improving its use of science, for instance, by adopting better defined measures of a species' status.

But several practices came under fire. Over the last decade, FWS has relied increasingly on recovery plans designed to preserve many species facing common threats in the same habitat. The analysis revealed that species in such plans are more likely to be in decline than are those in plans custom-built for their own survival, even after adjusting for when the plan was written. Probing further, the study found that FWS's multispecies plans tend to be lighter on biology than the single-species plans. That's "a very disturbing and unsettling trend," says UW's Alan Clark, who led this part of the analysis. He cautions that the study is not an indictment of multispecies plans in general. These may well work, he says, as long as they don't give short shrift to individual species.

Nevertheless, conservation biologists are chagrined that multispecies plans, so good in theory, are struggling in the field. The finding "caught me by surprise," says biologist David Wilcove of Princeton University. FWS, he notes, began drafting such plans in response to criticisms that the agency moved too slowly, and in a piecemeal fashion, in getting recovery efforts under way. "They are now vulnerable to the charge that they are providing inadequate analysis," Wilcove says. "For the FWS, it's a can't-win situation."

More disappointment comes from the study's critique of critical habitat, a designation that the Endangered Species Act provides to extend protection to a beleaguered species' home range. Lawsuits forced FWS to accelerate designations last year, bleeding time and money from the listing of new species and for little if any gain: The study concludes that critical habitat designation does not correlate with better data on the habitat or improved measures to preserve it.

FWS puts a positive spin on the analysis. The findings do not depict an agency failing in its mission, insists Martin Miller, recovery chief in FWS's endangered species division. He welcomes the criticisms and plans to incorporate them into new recovery guidelines now being prepared. And he pledges to build on FWS's newfound links with academia. "We see that as one of the most important benefits" of this exercise.

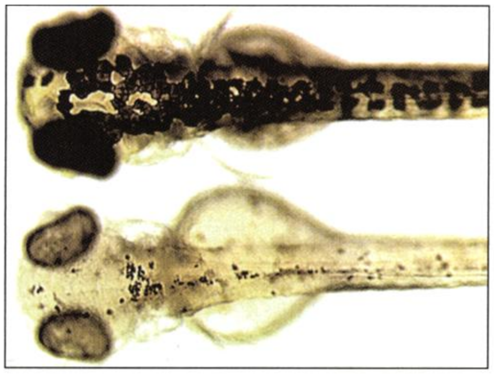
Jamie Clark, FWS director from 1997 to 2001, says the "thoughtful and incisive" study should help the agency shape its efforts, which she thinks should continue to feature multispecies planning and critical habitat designation. Devising sound plans is a struggle for an agency in perpetual crisis, she acknowledges. The key to success, she says, will be to "slow down the fire hose of everything else that's happening at FWS long enough to focus on science." **–BEN SHOUSE**

Ben Shouse is a freelance writer in New York City.

DEVELOPMENT

Mutations Reveal Genes in Zebrafish

To piece together an organism's blueprint, developmental biologists have to work backward. By deliberately disabling genes and watching what happens, researchers can discover the roles the genes play in development, gradually piecing together a building plan for an embryo. Even for a relatively simple fish, the task is daunting.



No stripes. A normal zebrafish (top) and a mutant fish with irregular coloring.

CREDIT: MARYANN HALDI/MIT

In a significant step toward a blueprint for vertebrates, a team of developmental geneticists has just published new results from a large-scale screen of zebrafish mutations. In a 13 May online publication by *Nature Genetics*, Nancy Hopkins, Adam Amsterdam, Gregory Golling, and their colleagues at the Massachusetts Institute of Technology describe 75 mutants and—unlike previous screens—the genes responsible for the deformities. The work is "a technological tour de force" that will speed the efforts of other researchers in the field, says developmental biologist Len Zon of Harvard Medical School in Boston.

Zebrafish are ideal models: They are easy to care for, they reproduce quickly, and their see-through embryos enable researchers to easily spot missteps in development. Essentially, scientists simply need to create genetic mutations, usually with a chemical, and then examine the embryonic wreckage. When they find an especially interesting phenotype —one eye instead of two, for example—the researchers then try to find the mutation that caused the abnormality. Such work began in earnest in the 1990s, and in 1996 groups in Tübingen, Germany, and Boston published dozens of papers describing a zoo of deformed fish (*Science*, 6 December 1996, p. 1608). But pinpointing a single mutated gene requires breeding hundreds of fish and can easily take more than a year. As a result, researchers have so far cloned genes responsible for only about 70 of the thousands of mutants the project created.

To speed the gene-tracking process, Hopkins and her colleagues used a genetically engineered retrovirus to create mutations. The virus enters the reproductive cells of parent fish and inserts itself into the genome—sometimes disrupting a gene. If the disrupted gene is crucial to development, the resulting offspring show the effects. Although the virus is not as efficient as chemicals in causing mutations, it has a key advantage: The affected genes are relatively easy to track down. The researchers use reverse polymerase chain reaction to locate the viral genes in the genome of the deformed embryo and then sequence the regions on either side of the inserted DNA looking for traces of the disrupted gene. About half the time, Hopkins says, the first attempt yields a likely gene at fault. The team has found some genes in as little as 2 weeks.

Consistent with earlier screens, two-thirds of the mutants had either an unusually small head and eyes or general central nervous system degeneration. Researchers usually ignore such nonspecific mutations, focusing their resources on abnormalities that affect a single process or organ system. But the Hopkins team gave all its mutants equal treatment. Many of the culprits behind the general deformities are so-called housekeeping genes that control basic cellular functions such as DNA repair and protein manufacture, as researchers had suspected. But this is the first time anyone has shown in such detail the developmental roles of those basic genes, Amsterdam says.

When the project is finished in 2 to 3 years, Hopkins says, the team will have identified roughly one-fifth of the genes required to make a 5-day-old larva, when the fish is "quite a significant little vertebrate animal," able to swim and search for food.

"The advantage of this screen is that it is comprehensive. It allows you to envision getting a phenotype for every gene expressed and functioning during embryogenesis," notes Marnie E. Halpern, a developmental biologist at the Carnegie Institution of Washington in Baltimore.

The project, partly funded by Amgen, will likely help human geneticists as well: All 75 genes described in the paper have human counterparts. **–GRETCHEN VOGEL**