are already under way: Scientists are now using mtDNA sequences to distinguish between populations of southern and eastern black rhinos. But this appears to be the first time that a biotech firm has leaped into the field as a partner. "It's encouraging to see a major molecular biology company putting effort into conservation research," says William Jordan of the Institute of Zoology in London.

The CRES-Amersham team will exploit what may be the world's biggest collection of DNA samples from endangered species: cell lines from more than 4300 individuals representing 370 species and subspecies. Since 1976, CRES staff have been snipping pea-sized patches of skin from animals in the zoo and extracting fibroblasts, tissue-repairing cells that happily divide in the test tube, even after being stored for years in liquid nitrogen. The research effort has helped solve some puzzles in captive breeding. For instance, CRES researchers, frustrated that a dwarf antelope called the dik-dik often produced sterile offspring, found after examining the animal's chromosomes in the late 1980s that two outwardly indistinguishable dik-dik species at the zoo were attempting to mate. Putting them in separate pens by chromosome type fixed the problem.

The new effort will specialize in the underdogs of the animal kingdom. "We'll choose rare species over common ones," says CRES geneticist Oliver Ryder. Obvious choices, he says, include the peccary, the okapi, and the three-banded armadillo. CRES's Frozen Zoo, with DNA from more than 100 mammalian families, will provide a strong foundation. "To start from scratch would take years and years," says Ryder. And his group is forging collaborations with other centers to find DNA from mammals poorly represented in the Frozen Zoo. For instance, Robert Baker's laboratory at Texas Tech University in Lubbock has agreed to provide DNA samples from select rodents and bats.

The team expects it will take about a year to generate the mtDNA sequences, which run to about 16,000 base pairs each. All the data will be made freely available to the public. Shining a spotlight on rare animals could aid conservation efforts, says Wildt: "The project will help increase public awareness of the need for much more biomedical research directed at wildlife species."

According to Ryder, the sequencing project points up the value of DNA banks, which he and several colleagues have urged the scientific community to expand through an ambitious effort to compile DNA samples of all endangered animal species (*Science*, 14 April, p. 275). He emphasizes, however, that gathering genetic data on endangered species must go hand-in-hand with measures to preserve habitats. "That is the only way to really save species," he says.

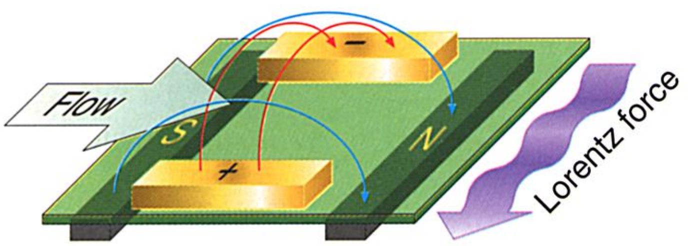
Amersham declines to reveal how much it plans to invest in the project. But even though Amersham is giving away the data, says Robert Feldman, production sequencing and collaborations manager, the high-throughput DNA sequencing company does have something valuable to gain: experience. "We're looking to work on as many different kinds of DNA as we can get our hands on," he says. "That will help us understand our customers' needs better"—not to mention the needs of peccaries, okapis, and three-banded armadillos.

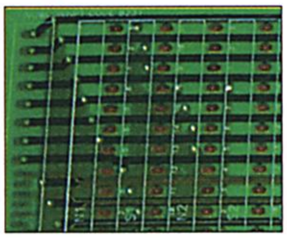
–RICHARD STONE

HYDRODYNAMICS

Electromagnetic Tiles May Cut Turbulence

Turbulence is as expensive as it is inevitable. Whether it is a submarine sneaking around the bottom of the ocean, an airplane bouncing overhead, or oil bubbling through a pipeline, the turbulent eddies that form when a fluid streams over a fast-moving surface drag against the surface like sandpaper scraping over wood. Overcoming this drag force requires fuel, and fuel costs money—lots of it. By some estimates, a general method of reducing turbulent drag by 10% could save billions of dollars and eliminate tons of burnt-fuel pollutants.





Making waves. Electrodes and magnets create turbulence-busting forces where tile meets water.

With that kind of money at stake, many scientists are searching hard for such a method—so far, with little success. But on page 1230 of this issue, mechanical engineer Yiqing Du of the Massachusetts Insti-

CREDITS: (TOP) A. HARPER/CENTER FOR ASTROPHYSICAL RESEARCH IN ANTARCTICA; (BOTTOM, INSET) G. KARNIADAKIS ET AL./BROWN UNIV

ScienceScope

Pole Researcher Dies A young astrophysicist has died at the South Pole. The loss has devastated the remaining nine scientists, who are part of a 49-member team wintering over at the pole, and has left a telescope out of operation.

Rodney Marks (right), 32, died on 12 May of heart failure hours after experiencing breathing problems that began as he walked from a research building to the station. Marks had passed all physical exams before heading to the pole last October, and he had wintered over before, in 1998. The cause of death won't be known until his body is flown out in November, when the station becomes accessible.

Marks was the sole operator of the Antarctic Submillimeter Telescope and Remote Observatory (AST/RO), which is mapping emissions from atomic carbon and carbon monoxide in the Milky Way. Before he died, Marks had been fixing a tricky problem with one of the telescope's receivers, which must be chilled to near absolute zero. "We don't yet know how hard it will be for others to put things back into working order," says AST/RO project manager Adair Lane of the Smithsonian Astrophysical Observatory in Cambridge, Massachusetts.

The Science of Diplomacy Acting on the recommendations of a National Academy of Sciences panel, Secretary of State Madeleine Albright this week announced that her agency will do more to stock up on science-savvy diplomats. Last October, the panel's report concluded that technical controversies were moving to the top of the diplomatic agenda just as the State Department was losing knowledgeable staff (*Science*, 15 October 1999, p. 391).

To reverse that trend, on 15 May Albright released a plan for following up on the panel's dozen recommendations, including appointing a top-level science adviser and completing by this fall a study that will identify embassies in need of scientific talent. But improvements could take years, she cautioned: "It doesn't take a physicist to know that change is harder than inertia." Indeed: Several candidates have already turned down the adviser's job, sources say.

Contributors: Michael Balter, Robert Koenig, Erik Stokstad, David Malakoff

tute of Technology and applied mathematician George Karniadakis of Brown University propose a novel approach that harnesses electromagnetic fields to nip the eddies in the bud. In computer simulations of turbulent ocean-water flows, their method cuts the drag force by almost 30%. If the simulations are borne out by upcoming experiments, says Richard Philips of the Naval Undersea Warfare Center in Newport, Rhode Island, it will be a tremendous advance in fluid dynamics.

Turbulence is more a process than a thing. As ocean water streams past a submarine's hull, for example, the flow splits up into pairs of fast- and slow-moving ribbons of current called "streaks." Loops, or eddies, of current circulate between the two halves of each streak. These loops grow rapidly until they burst, exerting a force that vibrates the hull and slows down the submarine's progress.

Turbulence is tough to counteract largely because a turbulent flow is very stable. "The flow does not want to be changed," explains Mohamed Gad-el-Hak, a mechanical and aerospace engineer at the University of Notre Dame in South Bend, Indiana. "Brute force does not work." Instead, Gad-el-Hak has been exploring the use of a kind of "smart surface" that senses the presence of turbulent eddies. A control system then activates many tiny, pistonlike actuators that morph the surface, pressing it against the fluid in a way that inhibits the developing turbulence. Computer simulations and laboratory-scale experiments show that this approach could work in the real world, but the actuator power must be carefully rationed, or else "the amount of energy needed is more than you save by suppressing the turbulence," says Gad-el-Hak.

Others have been trying to reduce drag by vibrating the surface at a specific frequency. This approach is called "predetermined control," because the frequency of the vibration does not respond to changing conditions in the fluid. Although it reduces turbulence, Karniadakis thinks the cure may be as bad as the disease. "Imagine that you are flying over the Atlantic, and the pilot turns on the 'shaker' to damp turbulence," he says. Either way will make nervous fliers jittery.

Instead of wiggling the walls to push the fluid around, Karniadakis and Du's method applies the force directly to the fluid. In their simulations, predetermined electromagnetic pulses from tiles on the surface of a submarine hull induce a force perpendicular to the direction of the streaming—and electrically conductive—salt water. They found that the additional force prevents "streaks" from forming along the hull, so the explosive current loops never have a chance to form. "We cut the legs off the turbulence," says Karniadakis.

Du and Karniadakis have demonstrated electromagnetic tiles in the lab but have yet to measure their effect on turbulent drag. "The proof of the pudding is if they can demonstrate this effect experimentally," says Philips. Karniadakis has recently received a grant to test both predetermined and reactive turbulence control. Gad-el-Hak, for one, is curious to see how it turns out. "In the past, predetermined control methods have not been very successful," he says, "but George is the best in his field; it may be that he has hit the jackpot." —MARK SINCELL

Mark Sincell is a science writer in Houston.

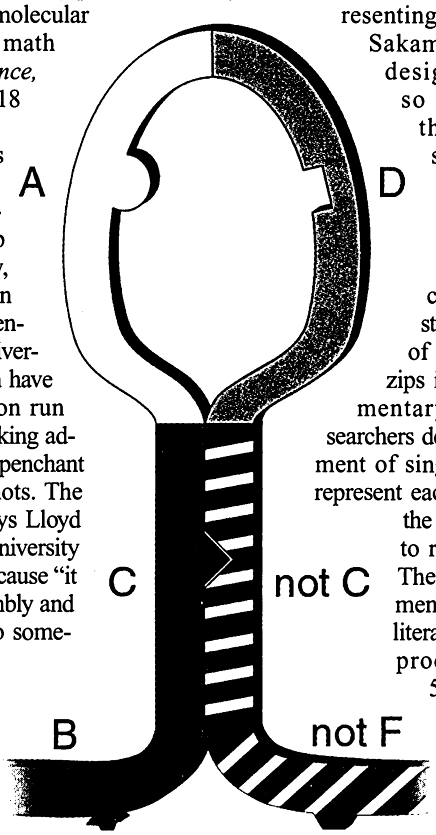
DNA COMPUTING

Hairpins Trigger an Automatic Solution

DNA, the alphabet of life, can also spell out the solutions to tough computations. Not only can its jumbo molecules store huge amounts of information, but, when mixed into a chemical soup, they react in so many ways at the same time that they can perform many calculations in parallel. Spurred by such promise, computer scientists and molecular biologists have already performed DNA- and RNA-based "molecular computations" to solve math and logic problems (*Science*, 17 October 1997, p. 446; 18 February, p. 1182).

So far the experiments have required lots of old-fashioned, shake-the-test-tube lab work for each step in the calculation. Now, however, as reported on page 1223, biochemist Kensaku Sakamoto of the University of Tokyo and his team have made a DNA computation run more or less by itself by taking advantage of the molecule's penchant for twisting itself into knots. The new method is elegant, says Lloyd Smith, a chemist at the University of Wisconsin, Madison, because "it takes the idea of self-assembly and puts it under control to do something for you."

Sakamoto and colleagues tackled a version of the satisfiability problem in Boolean logic, a form of reasoning in which "literals"—statements and their opposites—are linked together with *or* and *and* to form complicated formulas. In the type of problem they considered, two or more literals link together with *or* to form a clause, and the clause is true if any one literal is true. Two or more clauses then link together with *and* to make the complete formula, which is true only if every clause is true. The problem is to find a string of literals that makes the entire formula true.



Hairpin turn. Single-stranded DNA binds to itself when caught in a logical contradiction.

Any string that makes each clause true is a potential solution. But there's a catch: The string cannot contain both a statement and its negation. For example, consider the formula "(I exist *or* I sleep) *and* (I do not exist *or* I dream)." Even glum, distracted Prince Hamlet knew it was possible to sleep and (perchance) to dream, and the phrase "I sleep *and* I dream" satisfies the formula. On the other hand, it's logically impossible to be *and* not to be simultaneously. To solve their problem, a whopping formula of 10 clauses of three literals each, Sakamoto and colleagues set things up so that, of the tens of thousands of potential solutions, all but two dozen tied themselves into just such logical knots.

To translate the problem into molecules, the team began as other researchers have done, with a large assortment of DNA strands, one for each possible solution of the puzzle. But whereas others mixed in one enzyme after another to cut up the strands representing the wrong answers, Sakamoto and colleagues designed their strands so that, when cooled, the wrong answers spontaneously folded over and stuck to themselves to form molecular "hairpins."

DNA naturally comes in two matching strands, so every stretch of single-stranded DNA zips into a unique complementary strand. The researchers designed a 30-base segment of single-stranded DNA to represent each statement and used the complementary strand to represent its opposite. They then linked 10 segments, one representing a literal from each clause, to produce the more than 59,000 potential solutions to the formula. The problem was formulated so that each wrong-answer strand had to contain at least one statement and its negation, and hence one segment and its complement. Therefore, when the researchers lowered the temperature of their soup in just the right way, complementary sequences locked together,

ILLUSTRATION: C. CAIN