

## Simulated fish swim through virtual seas

They glide gracefully through water, group into schools, and scatter when pursued by predators. They eat, mate, and teach themselves to swim smoothly. And yet they don't exist physically.

Such artificial fish exist only in a computer netherworld. The fish, displayed on a color monitor, swim together within a supercomputer's processors. Each emanates from an autonomous computer program nested within a larger program, which generates a simple underwater ecosystem.

"Our algorithms try to emulate not only the appearance, locomotion, and behavior of individual animals, but also the complex group behaviors evident in some aquatic ecosystems," says Demetri Terzopoulos, a computer scientist at the University of Toronto. "Artificial fish learn to control internal muscles to locomote hydrodynamically and exhibit a repertoire of realistic behaviors, relying on their perception of a dynamic habitat."

Speaking last week at an "Artificial Life" conference in Cambridge, Mass., Terzopoulos described how each fish uses muscles and fins to avoid obstacles, other fish, and plants. Each fish explores its environment and searches for food. Large predator fish hunt down small fish, which form schools, take eva-

sive action, and scatter—as real fish do. Predators select, chase, and consume prey until satiated. Other fish forage for plankton and engage in mating rituals.

The "virtual" fish employ a perception system to detect their surroundings, a motor system to control movements, and a behavior system to coordinate relevant actions. An intention generator helps the fish to avoid collisions, evade predators, eat, mate, school, or wander. The researchers program each fish's affinity for darkness, coolness, and schooling, plus its level of hunger, fear, or desire to mate. Mimicking real fish, the virtual fish show courtship rituals; males dance, circle, ascend, and nuzzle female partners.

Undulating in a lifelike way, each fish's body is based on a computer model of 91 interacting springs in place of muscles. Hydrodynamic control systems sense virtual water and adjust simulated fins to send a fish where it wants to go. The fish, which do not know how to swim initially, learn with practice to move efficiently. In all, the computer-generated aquarium holds 10 fish, 15 food particles, and five plants.

"Some of these systems may at first look superficial, but they often provide biologists with insights into natural be-



Artificial fish in a virtual marine world.

haviors," says Christopher G. Langton, a computer scientist at the Santa Fe Institute in New Mexico.

Gene Levinson, a molecular biologist at the Genetics & IVF Institute in Fairfax, Va., agrees. "The fish presentation showed much more than just fancy computer graphics. The muscle system had a lifelike design that captured real biological complexity. The behaviors had a solid physiological basis, generating physical forces based on a body moving through a liquid."

"The simulated structures and behaviors strongly resembled what we see in nature," Levinson adds. "And that is scientifically interesting." —R. Lipkin

## Accord ends feud over AIDS blood test

In an attempt to quench the fiery debate over the distribution of profits from the AIDS blood test, the U.S. government this week reached a historic agreement with the Pasteur Institute of Paris. The new accord will give the French a better deal on royalties garnered from the worldwide sales of such tests, which are used to determine whether someone has been infected with HIV, the AIDS virus.

"The agreement aims to equalize the amount of royalties each country will receive from the worldwide sale of test kits," says National Institutes of Health (NIH) Director Harold Varmus. The pact represents the first official NIH acknowledgement that U.S. scientists, led by NIH's Robert C. Gallo, based their blood test on a French virus.

"Scientists at the NIH used a virus provided to them by the Pasteur Institute to invent the American HIV test kit," Varmus said.

A March 30, 1987, settlement between then-President Ronald Reagan and French Prime Minister Jacques Chirac gave equal credit for discovering the AIDS virus and developing the blood tests to French and U.S. scientists. Since that time, however, the United States has reaped about \$20 million in royalties (mostly from the sales of the

U.S. AIDS test), while the French have garnered just \$14 million. The imbalance occurred because of the wording of the 1987 settlement and because the U.S. AIDS test sells better than its French counterpart.

The new agreement attempts to equalize the profits from now until the patent expires in the year 2002. "If past experience holds, the new formula will give the French several hundred thousand dollars per year more than they would have gotten under the old formula," Varmus says.

The patent pact does not resolve the lingering issue of how the French virus came to play a starring role in the development of the U.S. blood test in the first place. As early as 1985, the Pasteur Institute's lawyers charged that the U.S. blood test was based on a French virus. In 1991, Pasteur scientists demonstrated proof of that allegation in a paper published in *SCIENCE*.

Soon after, Gallo acknowledged in a letter in the May 30, 1991 *NATURE* that the virus he relied on to create the U.S. AIDS blood test was indeed French in origin. However, Gallo said then—and still maintains—that his laboratory inadvertently used the French virus, which had contaminated the cultures growing in his NIH laboratory.

Critics continue to assert that Gallo misappropriated the French virus and knowingly passed it off as his own.

The official file on Gallo's conduct during and after the development of the AIDS blood test remains littered with contradictory conclusions. In January 1993, the Department of Health and Human Services' Office of Research Integrity produced a report concluding that Gallo was guilty of scientific misconduct (SN: 1/9/93, p.20). Later that year, the office, in response to new misconduct standards, dropped its case against Gallo (SN: 12/4/93, p.383).

The latest salvo in the Gallo case occurred last month, with a widely publicized HHS Inspector General report. That report, although it didn't provide any new information, reiterated a damaging chronology of events as they relate to the feud over the AIDS blood test.

With the dissemination of the Inspector General report, Pasteur Institute lawyers, who had threatened legal action if NIH did not come through with a more equitable patent agreement (SN: 7/18/92, p.46), stepped up their demands. On June 11, Varmus complied, and the new patent-sharing agreement was signed.

AIDS activist Martin E. Delaney, executive director of Project Inform in San Francisco, expressed relief that the feud may be over. "It's not a productive use of anybody's time to keep squabbling over this," he said.

—K.A. Fackelmann