VIRTUAL FISHTANK
PRESS

the
computer
museum


the computer museum
VIRTUAL FISHTANK

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the gala opening of

THE VIRTUAL FISHTANK

Thursday, June 11, 1998
6:30PM to 9PM
Black tie

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the computer museum

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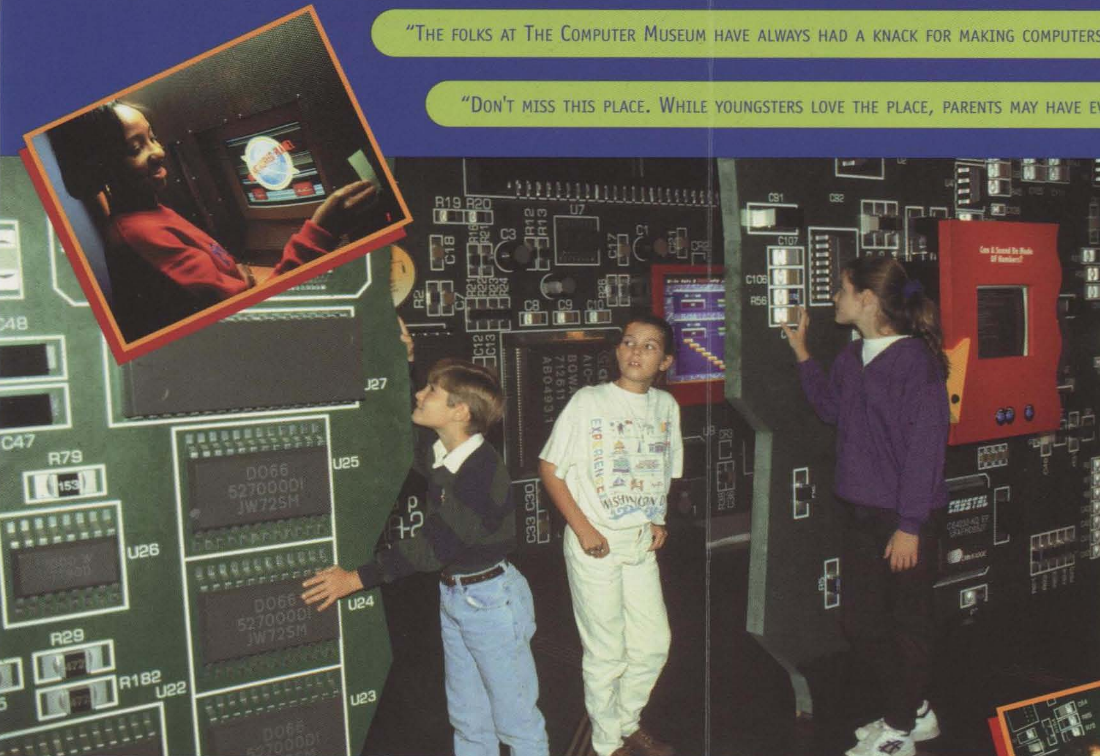
"Don't miss this place. While youngsters love the place, parents may have even more fun." *-Washington Times*



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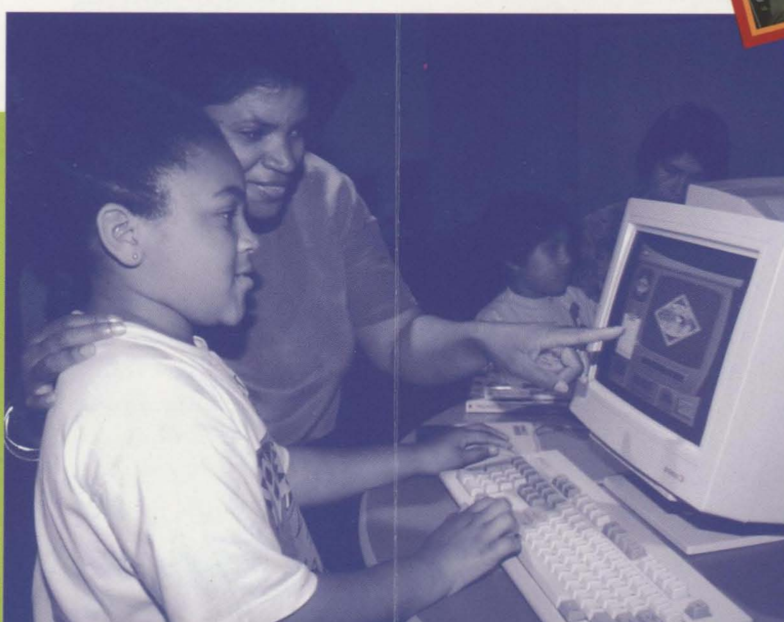

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"*The Computer Museum Network* <www.tcm.org> gives a glimpse of the future interactivity on the Web." -*Vint Cerf, Internet co-inventor*

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Plentiful parking available. Discount parking at the Farnsworth Street Garage, two blocks east of the Museum, with validation.

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5 minutes from South Station

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information

The Computer Museum
300 Congress Street
Boston, MA 02210

Information:
(617) 423-6758

Offices::
(617) 426-2800

Web Address:
www.tcm.org

hours

Winter:
Tues–Sun, 10am–5pm
Closed on Mondays except during holidays, summers, and Boston Public School vacations.

Summer:
Daily, 10am–6pm

admission

Members:
Free

Adults:
$7.00

Children, Students, & Seniors:
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Children 2 & under:
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robots

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history

TRAVEL THROUGH TIME TUNNELS TRACING TODAY'S PERSONAL COMPUTERS BACK TO THEIR GIANT ANCESTORS.

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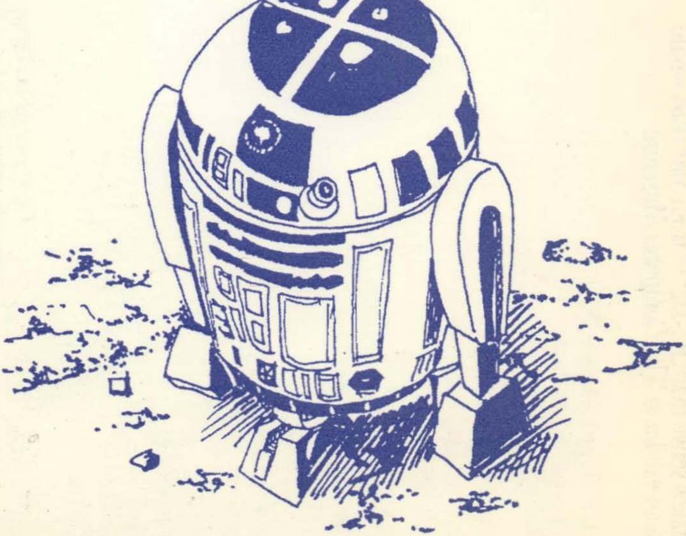
after traveling the galaxies,
Saving the Princess
and defeating the evil empire,
guess Where he landed?



It only makes sense that "R2-D2"™ from *Star Wars* would end up in an exhibit at The Computer Museum!

The Computer Museum's galleries are filled with over 125 easy-to-use, hands-on computer exhibits that inform and inspire.

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Educational Activities Packets* are available in both English and Spanish when group reservations are made!

Don't miss out this year. Make your reservations now!

The Computer Museum
Museum Wharf
300 Congress Street
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THE COMPUTER MUSEUM

more fun than humanly possible!

****Before your scheduled group visit, present this postcard at our Front Desk to receive free admission and an Activities Packet for you and a guest.***

expires 5/31/94

TIME CAPSULE

Welcome to the Time Capsule of Computer History!

Inside this box, you will find real computer artifacts from The Computer Museum. This guide tells you a little bit about each artifact, and provides activities to explore each one.

Now you are ready to uncover the past...a time when computers were *hundreds* of times larger and more expensive than today's desktop computers—but ten times less powerful!

The Computer Museum, 300 Congress Street, Boston, MA 02210

Punched Card

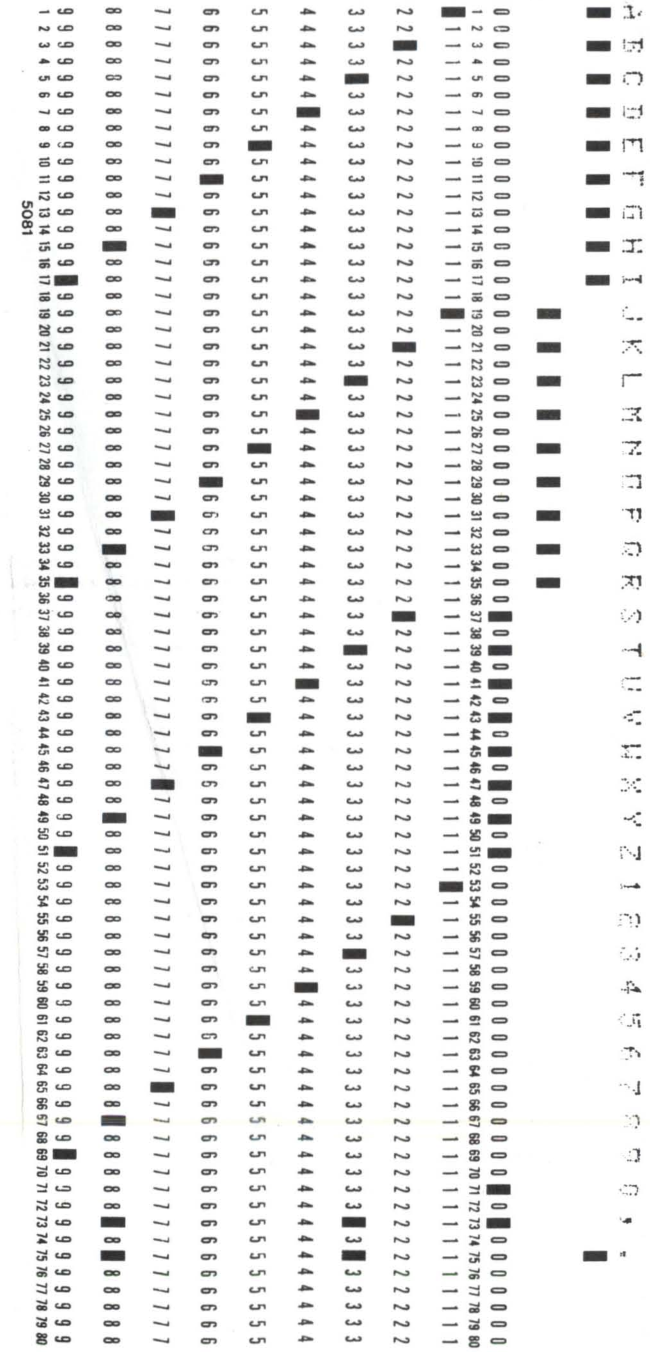
The punched card is a relic that dates back to before computers were invented. One of the first uses of a punched card was to store patterns for weaving a piece of cloth.

In the 1930s, the United States government used punched cards to record people's names and social security numbers.

The first computer for sale, UNIVAC I, read information from punched cards. That was in 1952. Can you believe a Porky Pig cartoon around that time showed him trying to use a UNIVAC I computer!

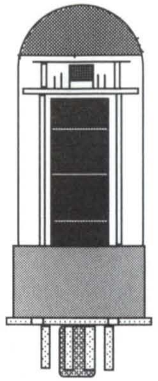
The card to the right shows the code used on standard punched cards. The black spots are holes.

ACTIVITY: Use this code to try to read the message on the real punched card in your Time Capsule.



Vacuum Tube

Vacuum tubes are glass tubes, somewhat like light bulbs. They can act like switches—they can be turned on or off by electric pulses. The first generation of computers, like the Whirlwind computer, did their calculations using vacuum tubes!



The Whirlwind computer, completed in 1951, contained 5,000 vacuum tubes. It filled an entire room.

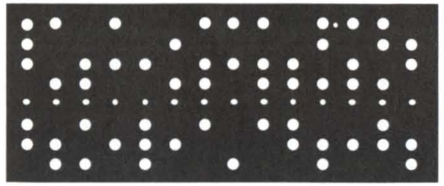
Inside your time capsule, you will find a postcard with a picture of the Whirlwind computer's vacuum tubes.

As you might guess, vacuum tubes cannot clean rugs. They are called *vacuum* tubes because there is less pressure inside the tubes than outside of them. (Scientists call a space with low pressure inside a *vacuum*.)

ACTIVITY: Do you know anyone who was living during the 1940s or 1950s, when the first generation of computers were built? Try talking or writing to them to ask if they know other ways that vacuum tubes were used.

Paper Tape

Paper tape could store programs and other computer information. The punched holes on the tape were a code that the computer could read.



Paper tape and punched cards both used holes to store information. However, paper tape and punched cards used different codes.

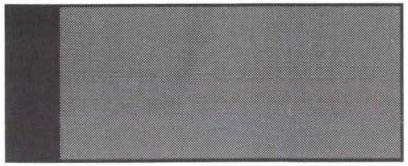
Another difference between punched cards and punched tape was that the order of punched cards could easily be changed by shuffling the cards around, but paper tape could not be changed. If you accidently dropped a program written on a big stack of punched cards, you would have to get them all back into the right order again. If you dropped a program on a piece of paper tape, you could just bend down and pick it up.

Like punched cards, paper tape was actually invented before computers. Paper tape was used on some of the first computers in the 1940s, and continued to be used through the 1970s.

ACTIVITY: You may want to try making up your own code using punched holes. If you have a hole puncher and index cards, you could use them. Otherwise, a pencil and a paper will work! You may want to get ideas from looking at the punched card.

Magnetic Tape

Magnetic tape stored programs and other information in many early computers, such as UNIVAC I. In your Time Capsule is a piece of magnetic tape from a 1950s computer.



ACTIVITY: You can use iron filings (little pieces of iron) to see the magnetic pattern on your magnetic tape, by following the directions below:

1) ***Find the small bag of iron filings and the piece of shiny tape in your Capsule.***

2) ***Put a piece of newspaper down to cover the area where you are working. (Be careful to keep the iron filings away from computer disks and electronic devices!)***

3) ***Carefully spread a small amount of the iron filings on the darker side of the tape.***

4) ***Gently shake the loose pieces off onto the newspaper. Can you see the pattern on the tape?***

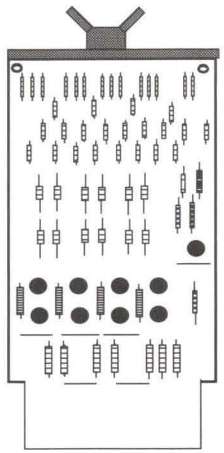
5) ***Make sure to throw away all the loose filings on the newspaper.***

The iron fillings stick to the places on the tape that have a positive (+) magnetic charge. They fall off the places on the tape that have a negative (-) magnetic charge. The information on the tape is coded as positive and negative charges. For example, the letter "B" was coded as - + - - - - + - .

Minicomputer Module

In your Capsule is an actual piece of a 1960s minicomputer. Computers in the 1960s, such as the PDP-8, did not have vacuum tubes in them. Instead, they used smaller electronic parts called *transistors.*

The invention of the transistor meant computers could be built much smaller. It meant they were light enough to be built into rockets and sent into space. Transistors were more reliable than vacuum tubes—they didn't burn out as easily. Also, they didn't get as hot.



ACTIVITY: See if you can identify these three basic electronic parts on your minicomputer module. These parts are still used today in electronic devices.

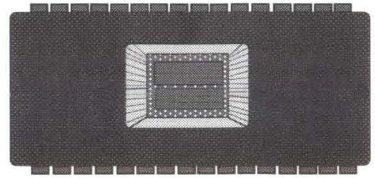
Transistor
(Acts like a switch.)

Resistor
(Reduces the amount of electricity flowing through the wire.)

Capacitor
(Stores a small electric charge.)

ROM

The most modern piece of computer history you have in your Capsule is a ROM chip. ROM (pronounced *rawm*) is a kind of computer memory chip. Almost all computers today come with a ROM chip inside.



In the window of this ROM chip, you can see the small rectangular piece of silicon. That is the actual computer chip. The rest of the ROM is just wires and a case. Tiny, tiny transistors are etched into the ROM chip.

The ROM chip holds the most basic instructions the computer needs, such as what to do as soon as it is turned on.

ROM stands for *Read-Only Memory*. *Read-Only* means you can't change what is on it. The information stays on the chip, even when the computer is turned off.

This ROM chip holds as much information as...
12,480 punched cards
8,640 feet of punched tape
417 feet of magnetic tape
or a book 400 pages long.

As you can see, in less than 60 years, computers have become much faster, cheaper, and more powerful!

ACTIVITY: Try making your own time capsule for future generations to learn about you and your life. What do you want to put inside?

the **computer** museum

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news release

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FOR IMMEDIATE RELEASE

Computer Museum to Unveil a Giant Virtual Aquarium Where Visitors Build and Interact With Their Own Fish

Boston, Mass. (June 2) — Starting June 13, 1998, Computer Museum visitors venture inside a 2,200-square-foot virtual undersea world, *The Virtual FishTank*™. In the exhibit, visitors create and interact with their own virtual fish to discover new insights into how complex living systems work. The exhibit is a collaboration with the MIT Media Lab and Nearlife, Inc. The Museum is building this compelling, simulated aquatic environment, combining the latest techniques in 3-D computer graphics and real-time interactive character animation.

"*The Virtual FishTank* presents important new ideas about the way the world works, and how we think about it," says Oliver Strimpel, the Museum's executive director emeritus and a *FishTank* project co-leader. Designed for people of all ages, the *FishTank* offers firsthand experiences in creating artificial life forms and reveals how simple behavioral rules can produce complex (and surprising!) results.

"One of the best ways to learn is by building things," says Mitchel Resnick, professor of research in education at the MIT Media Lab and a *FishTank* project co-leader with Strimpel. "In this case, you build behaviors for your own artificial fish, then observe the patterns that emerge as your fish interacts with others in the giant tank. It's an engaging learning experience," says Resnick.

Twelve large projection screens form windows into a spectacular 400-square-foot central tank, populated by nearly 100 brightly-colored, cartoon-like fish. At three Build Your Own Fish stations, visitors design behaviors for their fish, telling it how to react to other fish, human beings, food and water depth. These choices affect the shape and shade of various body parts to give visitors an easy graphical way to identify the rules guiding their fish. After visitors explore various fish designs, they tag and launch their creations into the tank, and then experience how the few rules they used to design their individual fish lead to complex behaviors and patterns for whole groups of fish.

By cranking a wheel, visitors also feed the fish, while sensors and a digital video camera enable the fish to react to human movement. At four Schooling stations, visitors interact with entire groups, including predator, friendly and deep-sea fish. While a fish school may seem to have a leader, local interactions among all the individual fish actually determine their behavior. Six Diving Deeper stations reveal that this phenomenon is also true for insect colonies, highway traffic, and market economies.

The $1.2 million exhibition is being developed with a $600,000 grant from the National Science Foundation — the largest ever to the Museum — and funding from The Ernst & Young Center For Business Innovation, the Kapor Family Foundation, Sun Microsystems, anonymous gifts and other donations, including substantial in-kind support. Major In-Kind Sponsors include Bay Networks, Inc.; Diamond Multimedia Systems, Inc.; MicroTouch Systems, Inc.; Mitsubishi Electronics America, Inc.; Sony Electronics Inc.; and the Volition™ Cabling System from 3M. In-Kind Sponsors include auto•des•sys, Inc.; Barbizon Light of New England; Bose Corporation; Chromacolor; Lightscape Technologies, Inc.; Motorola, Inc.; NEC Technologies, Inc.; Racore Technology Corporation; and Stewart Filmscreen Corporation. The project represents the most complicated software development of an exhibit that the Museum has ever undertaken.

Nearlife, Inc., an MIT Media Lab spin-off, is providing the exhibit design, art direction, visuals and software for *The Virtual FishTank.* Combining the Museum's expertise in creating large-scale, immersive educational experiences and the Media Lab's knowledge of artificial life and decentralized systems, the *FishTank* has been germinating for five years. But recent advances in software technology, such as Nearlife's Directable Characters™ now enable the virtual fish to interact with visitors and other fish in real time. "We are thrilled to work on a project that so tightly integrates design and technology to educate and entertain," explains Tinsley Galyean, president, Nearlife, Inc.

"To enter and interact with such a graphically-rich, sophisticated virtual world is compelling," says Mitchell Kapor, founder of Lotus Development Corporation and president, Kapor Enterprises, Inc. "It wouldn't have been possible on PCs without the latest graphics rendering tools and technology used in this exhibit."

The Virtual FishTank is driven by 22 graphics-equipped Sony computers connected over a high-speed fiber optic network. The network uses the Volition™ Cabling System from 3M, Bay Networks Layer 3 switching products, and Racore's Ethernet network interface cards to allow the fish to swim from one screen to another. High-speed Diamond Multimedia graphics accelerator cards using Mitsubishi chips allow the graphically rich, yet real-time, animation of the fish. The software developed by Nearlife uses the latest technology from Sun Microsystems, including Java Development 1.2, Java 3D, Java 2D, Swing and the Java Shared Data Toolkit. The *FishTank* is the most substantial implementation of the new Java 3D architecture to date. This technology allowed Nearlife to write 3D applications in Java, which will facilitate transformation into a future Web-based exhibit. A traveling version is also planned.

The first museum in the world devoted solely to people and computers, The Computer Museum in Boston features 170 interactive exhibits that explore the history, technology, applications and impact of computing. The Computer Museum History Center in Silicon Valley is home to the most comprehensive archive of computing artifacts in the world. BOSTON LOCATION: Museum Wharf, 300 Congress St. ADMISSION: Adults $7.00. Seniors, students and children $5.00. Kids two and under and Members free. HALF PRICE: SUNDAYS 3pm to closing. WINTER HOURS: OPEN TUESDAY-SUNDAY, 10am-5pm. SUMMER: DAILY 10am-6pm. For more information, call: (617) 426-2800 or visit the Museum's website: www.tcm.org.

THIS ORGANIZATION IS FUNDED IN PART BY

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A Walk-Through *The Virtual FishTank™*

As visitors venture inside *The Virtual FishTank*, they are immersed in a 2,200-square-foot virtual undersea world. Lights shimmer on the waves of perforated metal above as if sunlight were hitting the water's surface. Bright blue gravel covers the virtual ocean floor spilling out onto a carpet of deep sea blue. Twelve large projection screens form windows (each measuring 12 square feet) into a spectacular 400-square-foot central tank, populated by nearly 100 bold-colored, cartoon-like, mechanical fish. The windows are edged in metal plate riveted together with nuts and bolts, simulating a wall built to hold back the aquatic environment. The sounds of waves, water dripping, bubbles, and fish swimming by and being gobbled up by predators infuse the exhibition space.

The Virtual FishTank presents important new ideas about the way the world works, and how we think about it. Designed for people of all ages, the *FishTank* offers firsthand experiences in creating artificial life forms and reveals how simple behavioral rules can produce complex and surprising results. One of the best ways to learn is by building things. In this case, visitors use computers to simulate the movements of lots of fish and then to explore the kinds of patterns that emerge from the interactions of the fish.

EXHIBIT ACTIVITIES

The Virtual FishTank offers a variety of educational activities that help visitors make connections between the behavior of the fish they observe in the giant tank and the rules governing each fish. In the exhibit, visitors create and interact with their own virtual fish, watch how these fish interact with each other, with their environment and with visitors themselves, to discover new insights into how living systems work.

The exhibit includes four areas: 1) a Build Your Own Fish activity enabling visitors to connect directly to the exhibit by personalizing the behavior and appearance of their own fish and then seeing how the rules they choose affect their fish's behavior in the tank; 2) a Change the Environment area enabling visitors to alter the undersea environment and affect their fish in other ways; 3) a Schooling activity that is central to the exhibit's educational experience, letting visitors select or modify the rules governing an individual fish and see the changes in the group's behavior; 4) a Diving Deeper area that features examples of other complex systems to show that what is true for fish is true of many other situations in the world.

Build Your Own Fish

At three Build Your Own Fish stations, using computers, visitors design behaviors for their own artificial fish in a small virtual aquarium, telling their fish how to react to other fish, human beings, food and water depth. As visitors adjust the rules that govern their fish's behavior, the changes also alter many different parts of the fish. This one-to-one correspondence between the look of the fish and its behavior gives visitors an easy graphical way to identify the set of rules guiding their fish once it's in the big tank (though, of course, things don't work that way in the real world). On each station's monitor, social rules are paired with face features; curiosity with fin shape; and water-depth preference with over-all body shape. For example, if a visitor moves the "fear" slider on the touch-screen to "more terrified," the fish's eyes grow much bigger as if it's afraid.

After visitors explore various fish designs, they can tag and release their creations into the giant tank through big metal pipes, and then experience how the behavioral rules they used to design their individual fish lead to complex and often surprising results.

Change the Environment

Three stations link visitors physically to the virtual aquatic world. By cranking a big iron wheel at the Feeding station in front of the center of the tank, visitors release virtual pellets into the water from the food dispenser, and the fish react according to how much hunger they have been endowed with, weighed against their degree of fear. (They risk being gobbled up by predators lurking near the Feeding station.) Cranking a lever at the Air station on the left side of the tank gives a virtual diver in the tank more air, making more bubbles, which the fish react to, according to their set of rules. Cut off the air supply completely, and the diver expires! If visitors step into the People Sensing station in front of a window at the far right, sensors enable the fish to detect the presence of humans and, via a digital video camera, to react to their movements.

Fish Schooling
On a raised central platform, at four Schooling stations, visitors interact with entire schools of fish and watch as the fish react to their commands. Each station works with a different school of fish, including the friendly Phil A.s, the charming Angels, the predatorial Sharky's, and the bottom-feeding Flash Gortons. Visitors modify the rules for the individual fish and then see changes in the characteristics of the overall school. When visitors touch the images and controls on the station's monitor, each of the fish in the big tank immediately responds. These individual responses result in overall changes to the way the fish school. While a fish school may seem to have a leader, visitors discover that local interactions among all the individual fish actually determine their behavior.

Diving Deeper
Six Diving Deeper stations reveal to visitors that the phenomena they observe in the central tank can also be seen in the workings of other complex systems such as insect colonies, highway traffic, and market economies.

Termites
This station simulates the behavior of termites, the master-builders of the insect world. Visitors watch a colony of 100 virtual termites gather wood chips into piles — without guidance from a centralized leader. Each virtual termite follows a simple routine: wander randomly; when you bump into a wood chip, pick it up; wander randomly some more; when you bump into another chip, put the chip you're carrying down nearby; do it all again. With these simple rules, the virtual termites succeed in gathering all of the wood chips into one pile. Visitors control the speed of the termites, and can scatter the wood chips to start the termites working again.

Traffic Jam
By controlling the number of cars on a highway and whether or not to have a radar trap, visitors explore how traffic jams can form without any "centralized cause," but just from simple interactions among cars. Visitors won't be surprised that a traffic jam forms around the radar trap, since each car slows down for the trap. But traffic jams can also form without any trap at all.

Turtles
This station simulates red and green turtles living together in a pond. Each red turtle wants to live near some other red turtles, and each green one wants to live near some greens. Even when each individual turtle has only mild preferences, the overall pond ends up very segregated. Visitors control the preferences of the individual turtles, then observe how the overall group patterns change.

Behavior Labs
On two stations, visitors select and change rules of behavior for three species of virtual creatures, then observe the resulting patterns. Each creature can react to other creatures in its world and also to the motion of the visitor's finger on the screen. Visitors decide how each creature should respond. Should it move toward or away from the other creatures? For each new set of rules, new patterns emerge. Visitors can also erase all the rules and create their own.

Exploring Emergence
This "active essay" demonstrates how complex patterns can emerge from simple interactions among simple objects. The text guides visitors through a series of simulations in which visitors select simple behavior rules and observe the patterns that result. This station is for visitors interested in greater depth and complexity than what is offered at the other stations.

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How *The Virtual FishTank* Works

The Virtual FishTank is driven by 22 graphics-equipped Sony Electronics VAIO PCV 200, 210 and 220 computers connected over a high-speed fiber optic network. The network uses the Volition™ Cabling System from 3M, Bay Networks Layer 3 switching products, and Racore's Ethernet network interface cards to allow the fish to swim from one screen to another. The screens are displayed in such a way that the fish swim from one to another seamlessly. In total, 10 million pixels are rendered in real time, generating twice the resolution of a typical movie screen! The screens appear to be populated with nearly 100 computer-generated fish, a diver, a treasure chest and a ship wreck.

The giant virtual fish tank images are created by connecting 12 of the SONY PCs to high-resolution Mitsubishi LVP-X100A LCD projectors. Each of the projectors displays the imagery on a Stewart Filmscreen riveted into the wall. High-speed Diamond Multimedia graphics accelerator cards, using Mitsubishi Electronics America graphic chip sets with dramatic graphic acceleration and rendering capability, allow the graphically rich, yet real-time, animation of the fish.

Eight other computers linked to the fish-building, schooling and sensing stations allow the visitors to interact with the fish in the giant tank and create their fish. The server allows all of these stations to communicate and maintains the computer-based simulation of the entire fish tank's state. The server holds the master model or database of the whole fish tank, getting information from the Build Your Own Fish, Schooling and Sensing stations, applying thousands of rules per second to calculate the fish behavior, then distributing the results to the 12 rendering computers behind the giant tank. Each rendering computer calculates the image for one projection screen projector (or window into the central tank), animating the fish currently within view at a rate of 10 to 15 frames per second.

When visitors create a new fish and release it into the large tank, the Build Your Own Fish station sends the new fish to the server. As visitors change the rules for schooling fish, those stations continuously send updated information to the server. Visitors interact directly with the fish tank through levers at the Air and Feeding stations. The information at the Sensing station is also sent to the server. The server takes all this information and continuously adjusts the fish simulation so that the fish behave appropriately.

All of the software was developed by Nearlife, Inc., using the Java programming language from Sun Microsystems. The applications use the latest technology from Sun, including Java Development 1.2, Java 3D, Java 2D, Swing and the Java Shared Data Toolkit.

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Building *The Virtual FishTank*

The $1.2 million exhibition was developed with a $600,000 grant from the National Science Foundation — the largest ever to the Museum — and funding from the Kapor Family Foundation, Sun Microsystems, anonymous gifts and other donations, including substantial in-kind support and services. This compelling, simulated aquatic environment, combines the latest techniques in 3-D computer graphics and real-time interactive character animation. The project represents the most complicated software development of an exhibit that the Museum has ever undertaken. The exhibit is a collaboration with the MIT Media Lab and Nearlife, Inc., an MIT Media Lab spin-off. To enter and interact with such a graphically-rich, sophisticated virtual world wouldn't have been possible on PCs without the latest graphics rendering tools and technology used in this exhibit.

While several software companies have developed simulations of fish and other natural systems, they usually do not allow users to create or change the models or rules underlying the behaviors. *The Virtual FishTank* enables visitors to create the rules so they can see the connection between rules for each individual fish and the resulting emergent behavior. Also most commercial software is for individuals, while this large-scale immersive exhibit offers a social context that encourages people to share ideas about what they experience.

Nearlife provided the exhibit design, art direction, visuals and software for *The Virtual FishTank.* The six stand-alone Diving Deeper stations were created by the MIT Media Lab, and are based on StarLogo, a massively parallel programming language and modeling environment developed at the Media Lab.

Combining the Museum's expertise in creating large-scale, immersive educational experiences and the MIT Media Lab's knowledge of artificial life and decentralized systems, the *FishTank* has been germinating for five years. But recent advances in software technology, such as Nearlife's Directable Characters™, the engine driving the fish, now enable the virtual fish to interact with visitors, other fish and their environment in real time. In addition to being written in Java, the Directable Characters technology can distribute information selectively over a network and enables interactivity in the virtual world and between that world and the real one, often leading to unexpected outcomes. The fact that the user interface is implemented in Java facilitates transformation into a planned Web-based exhibit.

The user interface, created by Nearlife to run on the Schooling and Build Your Own Fish stations, displays and changes the screen graphics in response to the visitor's touch, then communicating these changes to the server and other computers. The changes appear immediately in the giant tank in the case of the Schooling station and as soon as the fish is launched at the Build Your Own Fish stations.

Nearlife used the auto•des•sys *Form-Z* software modeling program and *3D Studio Max* to build and animate 3D models of the fish characters, and some of their basic body motions (how each fish character bites, blinks its eyes, and wiggles its fins, for example). Those animations are then used and manipulated by the Directable Character™ technology to adapt and interact with the environment. Directable Character technology choreographs the activities of all the fish in the tank and provides everything from the locomotion to the behavior simulations in real time.

The Virtual FishTank
F. Y. I

Educational First....

• *The Virtual FishTank* marks the first attempt to make the new field of complexity studies accessible to the general public. With a $600,000 grant from the National Science Foundation and others, The Computer Museum is building what is arguably the biggest virtual aquarium, and the only permanent museum-based educational installation, to enable visitors to discover how the complex patterns they see in the world — as fish schools, traffic jams or economic trends -- can arise from simple interactions and simple rules.

• The $1.2 million exhibit is not just about how computers can do new things but about how computers can help us think about the world in new ways. The *FishTank* presents a different dimension of computing -- not applications but a new intellectual domain -- the field of complexity studies which has been brought about by computers.

Besides that, *The Virtual FishTank* is:

Big...

• a 2,200 square foot simulated undersea world featuring 12 large projection screens that form windows into a spectacular 400-square-foot central tank, populated by nearly 100 brightly-colored, cartoon-like fish, a shipwreck and treasure chest.

Not just educational but fun...

• One of the most engaging ways to learn is by building things. Here, you build behaviors for your own artificial fish, then observe the patterns that emerge as your fish interacts with others in the giant tank.

• It's interactivity is whimsical: Crank a big iron wheel to release virtual food into the tank and if you told your fish to be hungry, it will eat but also risk being gobbled up by a shark nearby who's hungry too! Crank a lever at the Air station to cut off a virtual diver's air supply, and the diver expires! Step into the People Sensing station and the fish will react to whatever you do.

Technical firsts....

• The exhibit driven by networked PCs. To enter and interact with such a graphically-rich, sophisticated virtual world wouldn't have been possible on PCs without the latest graphics rendering tools and technology used in this exhibit. The 12 screens are displayed in such a way that the fish swim from one to another seamlessly. In total, 10 million pixels are rendered in real time, generating twice the resolution of a typical movie screen!

• Advances in software technology, such as Nearlife's Directable Characters™ now enable the virtual fish to interact with visitors and other fish in real time. Nearlife, an MIT Media Lab spin-off, whose staff includes an Academy-awardwinning computer graphics designer, provided the design of the exhibit space, art direction and software. *The Virtual FishTank* is a collaboration of The Computer Museum, the MIT Media Lab and Nearlife.

The Virtual FishTank™

Special Note to Media re Role of Sponsors

The development and creation of this $1.2 million exhibition would not have been possible without the generous support of foundations, corporations and individuals. In your coverage of *The Virtual FishTank*, we ask that you acknowledge this support, when and if it is at all possible.

Thank-you.

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The Computer Museum
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Boston, MA 02210
(617) 426-2800

Oliver Strimpel

Oliver Strimpel, The Computer Museum's executive director emeritus," has been the visionary force behind innovative exhibits and programs that have transformed the Museum from a small Boston-based, collecting museum into an international institution with a visitorship of 135,000. Since Strimpel's arrival from The National Museum of Science and Industry, London, in 1984 as director of exhibits, The Computer Museum's interactive exhibits have grown from 25 to 170, its visitorship and budget have more than doubled, and the historical collection has tripled. Since 1990, when Strimpel became executive director, the Museum has launched six major permanent exhibitions, including its flagship *Walk-Through Computer*, a giant working model of a computer. Strimpel also oversaw the creation of the Computer Clubhouse program for inner-city youth, which won the Drucker Award for Nonprofit Innovation in 1997.

The idea for The Computer Museum's newest exhibit, *The Virtual FishTank*, was born 10 years ago, when Strimpel envisioned a large virtual aquarium that visitors would experience as an inviting, interactive "frontispiece" to their Museum visit. In 1995 The Computer Museum decided to make it a priority and joined forces with Professor Mitchel Resnick at the MIT Media Lab. Resnick had been thinking about a simulated aquarium as place to explore and present his ideas about decentralized systems and emergent behavior, and the Museum and the Media Lab jointly submitted a proposal for funding to the National Science Foundation. In September 1996, with a $600,000 NSF grant, its largest ever to the Museum, the Museum secured additional funding from two individuals and Sun Microsystems, and launched development, signing up Nearlife, Inc., to do exhibit design and programming.

Strimpel earned his D. Phil. in Astrophysics from Oxford University in 1979 and holds an M.Sc. in Astronomy from Sussex University and a BA in Natural Sciences from Cambridge University.

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He earned his D. Phil. in Astrophysics from Oxford University in 1979 and holds an M.Sc. in Astronomy from Sussex University and a BA in Natural Sciences from Cambridge University.

Mitchel Resnick

Mitchel Resnick, associate professor at the MIT Media Laboratory, studies how new techological tools can help bring about deep changes in how people think and learn. Resnick has developed a variety of "computational construction kits," including LEGO/Logo and StarLogo. He is co-founder of the Computer Clubhouse, an after-school learning center for youth from under-served communities. Resnick earned a BA in physics at Princeton University (1978), and MS and PhD degrees in computer science at MIT (1988, 1992). He worked for five years as a science/technology journalist for *Business Week* magazine, and he has consulted widely on the uses of computers in education. Resnick was awarded a National Science Foundation Young Investigator Award in 1993. He is author of the book *Turtles, Termites, and Traffic Jams*, published by MIT Press in 1994.

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Tinsley Galyean

Tinsley Galyean received his Ph.D. from the Interactive Cinema Group at the MIT Media Lab, where he worked to bring cinematic storytelling techniques to virtual environments. This included creating animated 3-D characters, building computational plot structures, and looking at the issues behind introducing cinematic "cuts" to virtual reality. In addition to a BS in computer science from the University of Colorado, Boulder, and an ScM in computer graphics from Brown University, his education includes extensive work in the visual arts.

While at the MIT Media Lab, Galyean produced a short animated piece that was theatrically released, directed a virtual reality exhibit for the Chicago Museum of Science and Industry, and published in the fields of computer graphics, human computer interfaces and artificial intelligence. After leaving the Media Lab, Galyean was a freelance new media designer working on location-based entertainment concepts, museum exhibits, and interactive 3-D Internet products. His unique mix of skills allows him to develop concepts and content for his clients while also delivering the technical means by which these ideas can become a reality. He founded Nearlife whose focus is to take these new media experiences and related development tools to the market place.

The Computer Museum

Founded in 1982 as a nonprofit organization, The Computer Museum in Boston is the first institution in the world devotedly solely to people and computers. The mission of the Museum is to inspire people of all ages and backgrounds from around the world about computers through its exhibits and education and preservation programs. The Museum features more than 170 interactive exhibits that explore the history, technology, applications and impact of computing.

In 1996, The Computer Museum History Center was established in Silicon Valley to further fulfill the Museum's mission as an international resource on the history of computing. The History Center is home to the most comprehensive archive of computing artifacts in the world.

In addition, The Computer Museum enables thousands of inner-city youths in Boston, New York, Ohio, and Germany to expand their horizons via its Computer Clubhouse after-school program (winner of the 1997 Drucker Award for Nonprofit Innovation). The Computer Museum Network (www.tcm.org) reinterprets Museum's elements for the global audience of the Internet through Java-enabled, interactive exhibits, a historic timeline, educational materials, and a store.

The Computer Museum
300 Congress Street
Boston, Massachusetts 02210
(617) 426-2800
www.tcm.org

MIT Media Lab

The MIT Media Lab is internationally recognized as a leader in the study, invention, and creative use of new digital technologies. Within the Media Lab, Mitchel Resnick directs the Epistemology and Learning Group, which develops new technological toys and tools to help people (especially children) learn new things in new ways. The E&L group explores how these tools can help bring about change in real-world settings, such as schools, museums, and under-served communities. The E&L group has worked closely with the LEGO company in developing "programmable LEGO bricks" (due on the market later this year). In collaboration with The Computer Museum, the E&L group has helped organize the Computer Clubhouse project, a network of after-school learning centers for youth from under-served communities. The Clubhouse was awarded the Peter Drucker Award for Nonprofit Innovation in 1997.

Nearlife, Inc.

Nearlife is in the business of conceptualizing and creating new products that redefine the way people interact and are entertained. This means developing and defining products that integrate cutting edge technology with the value of established entertainment techniques. These products include all kinds of interactive media-Internet/On-line virtual environments and location-based "experiences." Here at Nearlife we believe that to reach a mass audience, interactive entertainment needs to be infused with elements of character, story and plot that will guide and enrich the interactive experience. Our goal then is to create products that have the entertainment punch of a sit-com or movie combined with the compelling social interaction of chat rooms and virtual worlds, all the while giving you the adrenaline rush of a good video game.

To do this, Nearlife brings to bear upon every project world-class technical expertise and exhibit design talent, which is uniquely positioned to supply both technology and creative assets. Our team includes an MIT Ph.D. widely published in the fields of computer graphics and animation, a previous head of research and development at R/Greenberg Associates, an Academy Award-winning software engineer from Industrial Light & Magic, as well as architects, animators, and writers. Our projects have included award-winning computer animation, location-based entertainment products (LBEs), museum exhibits, and on-line, interactive virtual spaces.

We work with many high profile clients — Intel, Mitsubishi, IMAX, Sun Microsystems, The Computer Museum of Boston, and the Chicago Museum of Science and Industry — to apply our core technologies and concepts in a number of interactive and location-based entertainment environments. Our deep understanding and experience base in both technology and entertainment gives Nearlife its ability to design and produce compelling entertainment experiences as well as developing the technologies needed to make them a reality.

For more information, visit our website: www.nearlife.com.

The Java 3D™ API provides a set of object-oriented interfaces for applications that require high-performance, interactive 3D graphics. With Java 3D API, developers can take advantage of a simple, high-level programming model that enables them to build, render, and control the behavior of 3D objects and visual environments. By leveraging the inherent strengths of the Java language, Java 3D API extends the concept of *Write Once, Run Anywhere*™ to developers of 3D graphics applications. With the introduction of the Java 3D API, developers are more easily able to incorporate high-quality, scalable, and platform-independent 3D graphics into Java-based applications and applets.

The Java 3D API takes advantage of existing hardware accelerators via its use of low-level APIs such as OpenGL® and Direct3D®. This layering allows applications written using the Java 3D API to run on any platform with a Java virtual machine (JDK™ version 1.2 or higher) and an OpenGL or a Direct3D implementation. Support for run-time loaders is included to allow Java 3D API to accommodate a wide variety of file formats. Java 3D API benefits developers in a diverse set of application areas including scientific visualization, animation, web site design, virtual world construction, simulations, training, games, and design automation. Java 3D API is an integral part of the Java Media APIs, providing developers the ability to better integrate 2D & 3D graphics, video, audio, image processing, and other multimedia and visualization features in a single application.

Java 3D (jä´ və thrē dē) n. **1.** 3D graphics API for Java™ technology programmers **2.** Interface for 3D graphics programmers to use Java technology **3.** High-level scene-graph programming model **4.** Network-centric interface for collaborative, 3D applications **5.** An integral part of the Java Media and Communication APIs **6.** Revolutionary 3D graphics API

Simplification of 3D Graphics Application Development

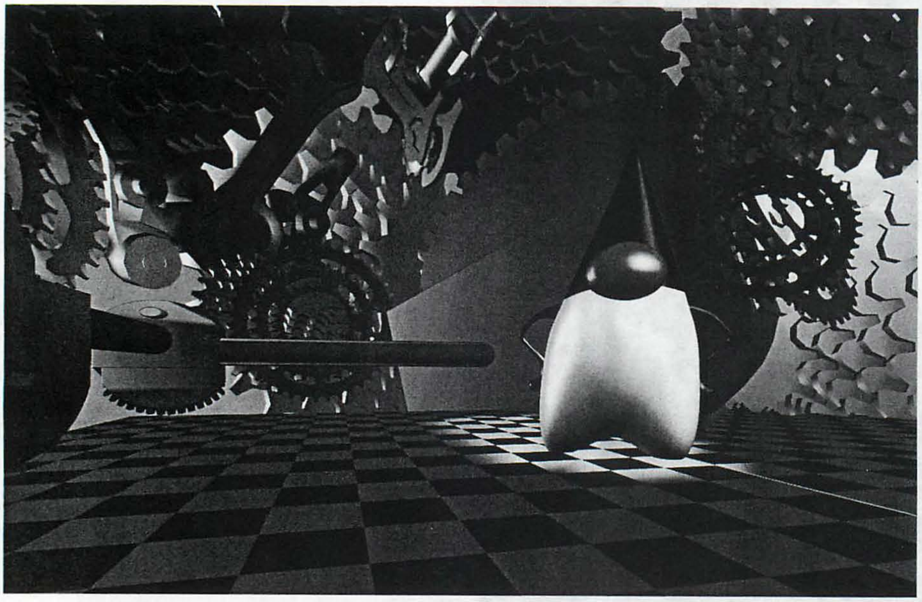
Java 3D API incorporates a high-level model that allows developers to focus on the objects and the scene composition. This allows for rapid application development by freeing the programmer from spending time and effort designing specific geometric shapes and writing rendering code for the scene display. No longer are you constrained by having a handful of graphics gurus doing your 3D development. Java 3D API enables a much broader range of developers to create sophisticated 3D applications.

Ideal for Intranet & Internet Visualization Applications

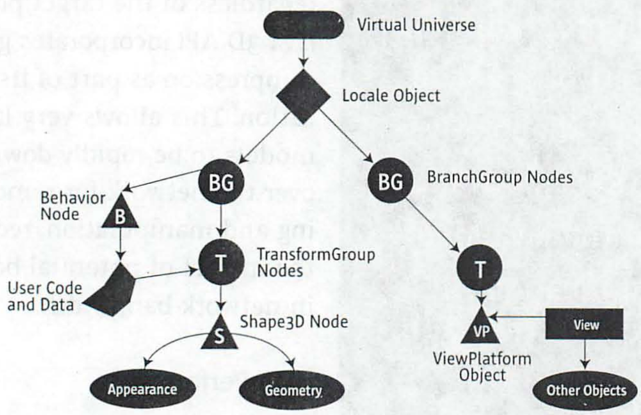
The Java platform was designed from the ground up to be a network-centric computing environment. The Java platform includes a full suite of Java enterprise APIs and technologies such as JavaBeans™ component which enables objects to be exchanged over the network. Java 3D API builds on this by giving developers the ability to do high-end 3D visualization over the network -- regardless of the target platform. Java 3D API incorporates geometry compression as part of its specification. This allows very large 3D models to be rapidly downloaded over the network for remote viewing and manipulation, reducing the impact of potential bottlenecks in network bandwidth.

High Performance

Java 3D API simplifies the application developer's job by allowing the API to perform many mundane tasks such as scene graph traversal or attribute state management. This allows Java 3D API implementations to tune and scale the application's scene graph to the underlying hardware for high performance. Java 3D also provides three different rendering modes for optimizing an applications execution: immediate mode, retained mode, and compiled-retained mode. In addition, implementations of Java 3D API are layered to take full advantage of the most appropriate rendering API for a given platform, namely OpenGL or Direct3D, delivering



Simple Java 3D Application Scene Graph



native graphics acceleration. Java 3D API delivers the performance needed for visualization and manipulation of very large 3D models through features such as view-frustum culling, execution culling, and multi-threading (MT-hot).

Other Advanced Features

Flexible Viewing Model: An application or applet written using the Java 3D API view model can render images to a broad range of display devices including flat screen displays, stereo displays, portals/caves, and head-mounted displays, all without modification to the code.

Integrated 3D Sound and Graphics: Java 3D API supports spatial sound as an integral part of the API, providing an immersive experience to the viewer.

Level of Detail (LOD): Java 3D API includes support for multiple levels of detail, enabling the end-user to view the nearest or most important objects at increased resolutions, thereby improving both application performance and the user experience.

Support for continuous action devices: Java 3D API can accept input from continuous action devices such as trackers used in immersive caves and portals, increasing the interactive capabilities of Java 3D API applications.

Competitive Advantage

Since Java 3D API is written for the Java platform allowing developers to mix Java 3D API and other Java APIs in a single application, developers can take maximum advantage of the Java programming language. Early feedback from application developers indicates that the use of the Java language significantly increases the productivity of their programming staff. This results in reduced time to market which, when combined with the advanced feature set of Java 3D API, provides developers a considerable advantage in the marketplace.

For More Information

For more information on Java 3D API, please visit our web site at **http://www.sun.com/desktop/java3d.**

All information contained in this document is subject to change. Development of the Java 3D API specification was coordinated by JavaSoft™ in cooperation with leading technology vendors.

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Bay Networks

BAY NETWORKS PRODUCTS SUPPORT THE COMPUTER MUSEUM *VIRTUAL FISH TANK* EXHIBIT

Bay Networks Virtual Fish Tank Installation

The concept of the Virtual Fish Tank exhibit combines the latest techniques in 3D computer graphics and real-time interactive character animation. A network such as this requires large amounts of data to be transmitted at high speed from the end user PC workstations through the network center. Bay Networks has donated a BayStack 350 Series workgroup switch to connect the individual PCs to the network. From the BayStack switch, the Bay Networks' Accelar 1200 is installed to provide the high-speed Layer 3 core of the network, where data can be processed in excess of 7 million packets per second. The entire network is managed by Bay Networks Optivity network management software.

Accelar Routing Switches

Routing switches are a new class of product that incorporate the intelligence of routing with the speed of switching. Bay Networks' Accelar routing switches provide dramatic performance improvements in today's networks because they are optimized to route IP. Accelar product family capabilities include protocol-sensitive VLANs which allow on-going support for legacy protocols; priority queuing which provides support for Quality of Service and Class of Service applications; and IP Multicast support. These features enable existing enterprise networks to migrate easily to high-speed, high-function intranets without requiring a costly and disruptive backbone overhaul.

BayStack Ethernet Switches

BayStack is a family of switches, hubs, routers and Internet access products that deliver enterprise-class quality and performance at industry-leading prices. BayStack products provide a seamless growth path from small workgroups to the enterprise backbone. Bay Networks pioneered the 10/100 autosense workgroup switch market with the introduction of its award-winning BayStack 350 Series 10/100 Autosense switches in April 1997, and continues to lead the market today.

Optivity Network Management Software

Both the Accelar 1200 and the BayStack 350 Series products are fully integrated into Optivity® Network Management software from Bay Networks, enabling complete Simple Network Management Protocol (SNMP) and RMON monitoring and control. Network administrators can manage their entire network, including all hubs, switches, and routers, from a single management station. Using Bay Networks Optivity can dramatically reduce the total cost of network ownership.

About Bay Networks, Inc.

Bay Networks -Where Information Flows™. Bay Networks, Inc. (NYSE: BAY) is a leader in the worldwide networking market, providing a complete line of products that serve corporate enterprises, service providers and telecommunications carriers. The company offers frame and ATM switches, routers, shared media, remote and Internet access solutions, IP services and network management applications, all integrated by Bay Networks' Adaptive Networking strategy. With headquarters in Santa Clara, California, Bay Networks markets its products and services around the world, providing 7x24 support coverage. For additional information visit the company's World Wide Web site at http://www.baynetworks.com or call 800-8-BAYNET.

MicroTouch

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TECHNOLOGY BACKGROUNDER

MICROTOUCH® FAMILY OF CAPACITIVE TOUCHSCREENS

Comprehensive Product Family Provides Unmatched Levels of Durability, Speed, and Clarity

MicroTouch® Systems, Inc. offers the most comprehensive family of durable touchscreen solutions – including ToughTouch™, the latest touchscreen from MicroTouch – that leverages the company's expertise in implementing a broad range of capacitive products. The following explains some of the principles behind capacitive technology and summarizes MicroTouch's offerings in this market.

A Closer Look at Capacitive Technology

Capacitive touchscreen technology provides fast and reliable operation. At the core is an all-glass sensor with a transparent, thin-film conductive coating fused to its surface. For ClearTek® and ToughTouch, a glass overcoat is applied over the conductive coating to completely protect and seal the sensor. Along the edges, a narrow, precisely printed electrode pattern uniformly distributes a low-voltage field over the conductive layer. When a finger touches the screen, it "capacitively couples" with the voltage field, drawing a minute amount of current to the point of contact.

-- MORE --

The current flow from each corner is proportional to the distance from the corner to the finger. The touchscreen simply calculates the flow proportions to locate the touch. The result is a fast, reliable, clear touchscreen that is also extremely durable. Using a solid-state sensor, capacitive technology provides tremendous durability and extremely fast touches as quick as three milliseconds.

MicroTouch's Family of Capacitive Touchscreens at a Glance

- **ClearTek®** – ClearTek capacitive touchscreens have been deployed around the world for more than 10 years – an unequaled record of reliability and adaptability in all types of applications in numerous environments. Their acclaimed performance stems from the unique combination of speed, clarity, and durability for uninterrupted performance in the face of on-screen contaminants, chemicals, grease, dirt, or water. ClearTek's superior protective glass overcoat resists scratches and chemicals. ClearTek also provides unmatched sensitivity, high accuracy, and high resolution. Fast, light touches – as little as two ounces for less than three milliseconds – are recognized instantly with accuracy of more than 99 percent.

- **ToughTouch™** – ToughTouch is MicroTouch's newest touchscreen solution that brings shatterproof durability to touchscreens deployed in unattended or high-threat environments. ToughTouch consists of a layer of toughened glass laminated to the back of a flat ClearTek capacitive sensor. ToughTouch's clarity and durability are an ideal combination for automated customer applications such as ATMs, vending machines, and vandalproof kiosks.

- **ThruGlass™** – ThruGlass is MicroTouch's most durable touchscreen solution aimed at outdoor applications and other extremely harsh environments. Using an innovative "projected capacitive" technology, users never actually touch the sensor – just the durable front surface. The ThruGlass sensor safely resides behind up to an inch of glass, plastic, Lexan® – or other non-conductive surface. The ThruGlass sensor projects a capacitive field. As a finger approaches the front surface, the projected field recognizes the disturbance and registers a touch. ThruGlass enables engineers and designers to bring the power of touch to new environments without worries about weather, vandals, or harsh contaminants. What's more, users can input touches with gloves, tools, or other styluses.

About MicroTouch Systems, Inc.

MicroTouch Systems, Inc. is the world's leading provider of complete computer touch-input solutions. Its touchscreen hardware and software technologies have consistently led the industry in numerous innovations and standards. Founded in 1982, MicroTouch reported sales of $128.5 million in its most recent fiscal year. With its headquarters and ISO 9001 certified manufacturing plant in Methuen, Mass., MicroTouch also maintains manufacturing facilities in New York, the United Kingdom, Japan, Taiwan, and Australia, along with sales offices and distributors in numerous other countries. Visit the MicroTouch Website at **http://www.microtouch.com**.

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Turtles, termites, and traffic jams

Explorations in Massively Parallel Microworlds

Complex Adaptive Systems series
A Bradford Book
March 31, 1997
6 x 9 — 184 pp. — 15 illus.
$12.50 paperback
ISBN 0-262-68093-9

Mitchel Resnick

Mitchel Resnick is Assistant Professor in the Media Laboratory at the Massachusetts Institute of Technology.

Decentralized models are increasingly being chosen for the organizations and technologies they construct in the world, and for the theories they construct about the world. But even as ideas about decentralization spread throughout the culture, there is a deep-seated resistance to them. *Turtles, Termites, and Traffic Jams* examines how and why this is so and describes innovative computational tools and activities that can help people (even young children) develop new ways of thinking about decentralization, with examples from many domains.

"Resnick's book is a little treasure."
Terry Jones,
Complexity

"[Philosophical] observations make the book essential reading for anyone who cares about where we are and where we're going."
Richard Mateosian,
IEEE Micro

"Mitchel Resnick's book is one of the very few in the field of computing with an interdisciplinary discourse that can reach beyond the technical community to philsoophers, psychologists, and historians and sociologists of science."
Sherry Turkle, Professor,
Program in Science, Technology, and Society,
Massachusetts Institute of Technology

"Resnick's work provides a rare glimpse of what I am sure will become a new paradigm for research in education."
Seymour Papert

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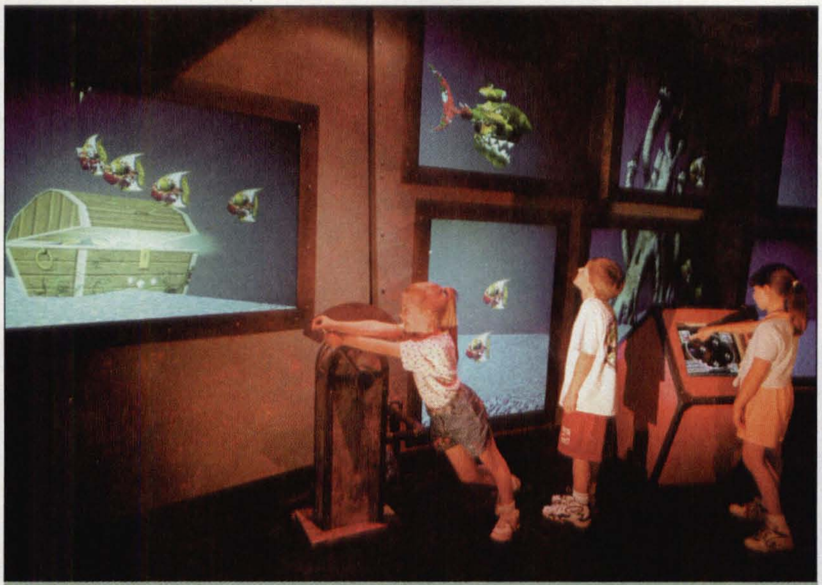
GAMES

X-Files, The CD

FOR FANS WHO haven't had their fill, there's a new digital installment of "The X-Files." Fast on the heels of the TV-cliffhanger finale and just before its

'X' file: Scully's dossier

big-screen companion comes The X-Files Game ($54.95; www.foxinteractive.com). This live-action CD-ROM includes a new investigation that teams Mulder and Scully with you—a junior FBI agent. Together, you interview witnesses and examine evidence in realistic-looking morgues, motels and 30 other locations. For X-philes, this is required clicking.



Don't just stand there: This high-tech fish tank changes at your command

MUSEUMS

Fish Out of Water

THE FISH IN THE BOSTON Computer Museum's new aquarium are fake, but have the advantage of being programmable. The Virtual FishTank, created with MIT and a company called Nearlife, consists of 12 large projection screens, a multitude of computer-animated fish and interactive stations at which visitors can experiment with artificial life. You can design your own fish and set them loose in the tank. You can also observe how an informally constructed system, like a school of fish or a traffic jam, organizes itself by tweaking its rules, one at a time: for example, expand the distance between fish in a pack and watch it dissipate. The exhibit opens June 13.

TECHNOLOGY

Fancy Displays, At a Price

MONITORS ARE GETting skinnier, and better. Pioneer's new 50-inch plasma displays—available in the fall—produce a bright, almost photo-quality image. The wall-mountable screen is a mere four inches thick, but at $25,000, it's hardly a consumer item (a 40-incher is $13,000). We'll

Pioneer's slim screen

probably first see them at airports and stadiums and as touch-screen displays in stores. Once the price goes down, families can use the screens for a variety of purposes, toggling seamlessly from HDTV to the Internet.

SOFTWARE

Web Print

WEB PAGES THAT read great on the screen often translate poorly on paper. But Hewlett Packard's new Web PrintSmart software (www.hp.com/go/webprintsmart) lets you print a collection of links, avoiding printer glitches like single lines on one page. If you visit numerous news sources each morning, program the links you want and PrintSmart will process a daily customized news-

News that's fit to print

paper, complete with a table of contents and page numbers, ready with your coffee. The software is free, but there's one catch—they've tested it only on (surprise) HP printers.

ROBOTS

Soccer, Cyber Style

SOCCER PLAYERS won't be the only ones kicking back this summer. While national teams descend on France this week for the start of the World Cup, more than 60 oth-

Geared up for the games: Last year's robo-cup action

er teams of researchers and their robots will be gathering at Paris's Cité des Sciences et de L'Industrie for a different kind of soccer series. The annual Robot Football World Cup pits machine against machine as much for science as for sport. While they're programmed to score, the ultimate goal, say organizers, is to help scientists fine-tune robotics and artificial-intelligence programming for more than just fun and games.

BETH KWON *and* ARLYN TOBIAS GAJILAN

CLOCKWISE FROM TOP: LINDA HAAS—COMPUTER MUSEUM, COURTESY PIONEER, PHILIPPE PLAILLY—EURELIOS-PHOTOTAKE, NO CREDIT (3), COURTESY FOX INTERACTIVE

Livi Arts

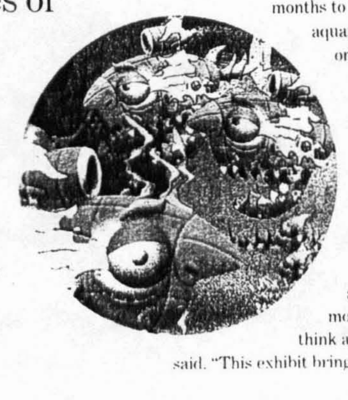
THE BOS UNE 13, 1998

fish *on* chips

Make creatures of the sea swim in Computer Museum's 3-D 'aquarium'

By M. R. Montgomery
GLOBE STAFF

Somebody, meaning several people working in concert, finally figured out how to do something interesting with a computer besides blow up monsters and surf the Web. Not surprisingly, the team includes the Computer Museum in Boston and the MIT Media Lab. They hired a local start-up company, Nearlife Inc., whose dozen very smart techies have been pulling all-nighters at the keyboard for the last six months to create the Virtual FishTank. This aquarium made of pixels opens tomorrow on Museum Wharf, and it's a piece of work. That trite word "interactive" suddenly has meaning.



Oliver Strimpel, just-departing executive director of the Computer Museum, for whom the FishTank is the culmination of a 10-year dream, calls it a "real exhibit of virtual reality."

"This is becoming a computer age when people are doing things remotely – in time and in space – and I think a museum should do the opposite," he said. "This exhibit brings a large group of people into a big.

FISH, Page C4

Computer Museum's fish on chips

■ FISH
Continued from Page C1

shared space. Here's this giant wall of a virtual aquarium and visitors can change the behavior of the fish in the tank; they can make up their own fish that have their own behaviors and put them in the tank and see what happens. This isn't just playing a computer game. People have a maternal-paternal interest in the fish they build."

There are several computer stations, all touch-controlled, in the virtual aquarium room. Visitors to the museum (300 Congress St.; 617-423-6758) can change the behavior of the four schools of fish that roam the tank, while at four other stations visitors create one-of-a-kind fish and drop them into the water. The whole aquarium can hold up to 20 of the programmed, visitor-made fish at the same time, a number that will be rarely achieved given that one of the resident fish schools is severely sharky and the rather innocent-looking fish in the bottom-feeder school can suddenly develop an appetite for hapless fish.

What truly astonishes a visitor is the amount of three-dimensionality on the screens (basically created from a new Sun Microsystems program, Java 3D). An exaggerated vanishing-point perspective comes into play as sharks gobble little fishes: Moving sideways, the sharks look greedy; racing straight toward the screen, their open mouths gape like very bad dreams.

The visitor-built fish "allow you to put something of yourself into the fish tank," Strimpel explained. "It will give you some sense of what programmers enjoy about their work. You give the fish some orders – some commands, so to speak – and stand back and see what happens."

Mitchel Resnick, an MIT professor and head of the charmingly named Learning and Common Sense section at the MIT Media Lab, collaborated on the concept of the Virtual FishTank, although the complicated graphics and programming required the work from Nearlife. He remarked that his group, and a start-up enterprise, Toys of the Future, were trying to move computer use from passive interaction and simple game-playing. "I call it cotton-candy computing power," Resnick said. "A lot of fancy equipment and what do you get, intellectual spun sugar.

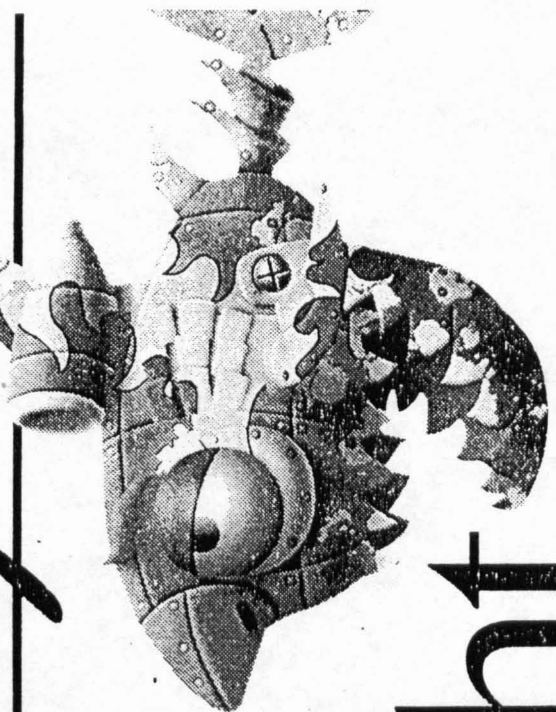
"We're trying to get 'learning by experience' into the computer world, and not by learning how to do technical programming, but just getting games and toys out there where *you* get to change the rules," he added. "I think the FishTank is an example." Resnick said Toys of the Future would introduce, through the Lego company, a programmable block that could become the motor drive for Lego constructions. "It's interesting that the entertainment and toy industry are driving the computer business; that's where the fancy graphics and really indestructible computer components are coming from." The Media Lab has six learning stations at one end of the aquarium exhibit, where some of the principles of the giant fish tank can be worked out in a less complex environment.

Tinsley Galyean, founding president of Nearlife, spent this week, like the last six months, on the case in the virtual aquarium. He's still happy in his work. Nearlife's specialty is software that makes critters move, well, as if they nearly were alive, and Galyean occasionally does speak of the characters on the aquarium projection screens as if they really were, and had minds of their own.

When they were tuning up the particular screen where visitor-made fish are introduced to the tank, they added a shark, which would occasionally eat one of the new arrivals. Galyean pointed to the virtual pipe through which the virtual fish virtually swim into the virtual aquarium and said, "The shark, after a while, figured out that it didn't have to swim all over the tank, it could just swim up to the pipe and snap them up the minute they came out." Naturally, this shark has been, as they say of human fanatics, "de-programmed."

It should be an interesting exhibit even for grandparents who have no interest at all, or who won't admit to any interest, in building their own fish or programming their own school of predators and prey. With a dozen large screens, with at least 40 or 50 fish doing something interesting, with bright colors, sharp graphics, and the sound of waves, water, and snapping teeth, it's a show for couch potatoes and wannabe programmers alike.

Schools of thought



'Virtual' fish teach ecosystem lessons at Computer Museum

By STEPHANIE SCHOROW

The sharks are eating too much. "They're ravenous," mutters Tinsley Galyean, his weary eyes on the luminous creatures gliding by, unaware a few keystrokes could curtail their gluttony.

Turning to his computer, Galyean tweaks an unusual water world, one populated by fish and small fry, by predators and meals on fins. It's a place that obeys predetermined biological rules, yet works in unpredictable ways. Computers run it, but don't control it.

"We prefer to call it artificial life, not artificial intelligence," explained Oliver Strimpel, director emeritus of Boston's Computer Museum, as sleep-deprived programmers made last-minute adjustments to the museum's newest permanent exhibit, created with MIT's Media Lab.

"The Virtual FishTank," a computer-animated undersea environment that opens tomorrow, is not, as Media Lab associate professor Mitchel Resnick insisted repeatedly, "just about fish."

Yet it is the riotous three-dimensional fish — a melding of Mother Nature and Dr. Seuss — that demand attention in a wall-sized "tank," created by 12 high-resolution screens. What happens to the fish depends on the museum's visitors.

At three touch-screen workstations,

Turn to next page

Computer Museum explores water world with 'FishTank'

From preceding page

kids (and adults) can design a fish, tag it with an initial and release it into the tank. You can make your fish more or less hungry (its mouth gets bigger) or fearful (its eyes bug in and out) or friendly (it smiles more).

The more than 2,000 combinations are fully animated in 3-D — no matter what you create, it moves and turns in whatever form you select. "There's no embarrassing hollow at the back," Strimpel noted.

After releasing your fish into the tank, you can follow its progress — eat or be eaten — as it interacts according to your specifications with other designed fish, plus four museum-designed fish schools: the Phil A.s, Angels, Sharkeys and Flash Gortons.

Turn a mechanical wheel, and virtual fish food pours out. Or, in a designated spot, tap the "glass" and friendly fish will wander by. Other work stations let you program the group behavior of the four fish schools.

Dare we say it? *It's life, Jim, but not as we know it.*

Software for The Virtual FishTank was developed by Nearlife, a Cambridge start-up company, using the latest Java 3D programming language from Sun Microsystems.

Two days before the opening, Nearlife co-founder Galyean and a team of animators and programmers, fueled by adrenaline and fast-food forays, were still adjusting the school fish.

"It's like a big ecosystem," said Galyean, as he worked at one of the 21 graphics-equipped Sony Electronic computers that run the $1.2 million exhibit.

But the Virtual FishTank isn't New England Aquarium Dry. The computer fish are designed to be a teaching tool on biological patterns and behavior and what is dubbed "decentralization." The cyber fish show how real fish can school (or birds flock or cars merge, for that matter) without a leader or traffic cop in control. As each entity follows individual rules, patterns of group behavior emerge.

"You're designing the behavior. You understand much more than by just observing," said Resnick.

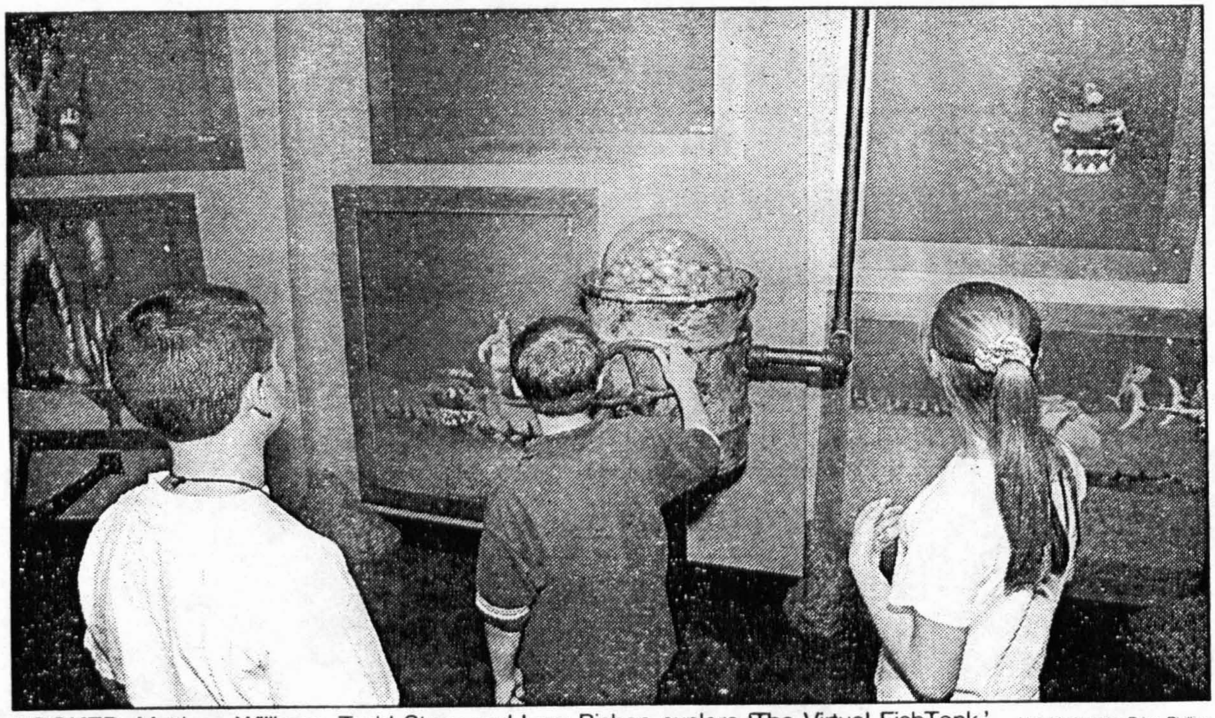
Let's say you program your fish to be hungry because you want to watch it eat. Unfortunately, the predator fish also hang around the food source. *Chomp.* Your fish's life may be well-fed — but short. Kids can learn to create balance in their fish to keep them hungrier — and alive longer.

"The computer is helping us get a better idea of how living systems work," Resnick said.

At the exhibit's more intensive "Diving Deeper" work stations, visitors can manipulate programs to study traffic jams, insect colonies — even market economies. Resnick is particularly tickled by a program that illustrates attraction among groups. It can explain how housing patterns emerge — or why men and women tend to segregate at cocktail parties.

Certainly, computer programs can't cover the complexity of human and animal behavior. But, Resnick said, the exhibit may get people to wonder what rules of behavior govern a moth around a flame — or baseball fans doing "the wave."

"The Virtual FishTank" opens tomorrow at the Computer Museum, Museum Wharf, 300 Congress St., Boston. General admission: Adults $7, seniors, students and children $5, kids under 2 free. Open daily 10 a.m.-6 p.m. Call (617) 426-2800 or visit www.tcm.org.

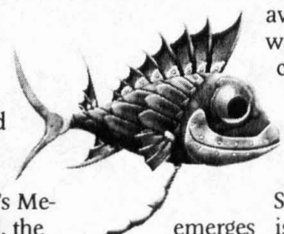


HOOKED: Matthew Williams, Todd Stacy and Lara Bishop explore 'The Virtual FishTank.' Herald photo by Brian Phillips

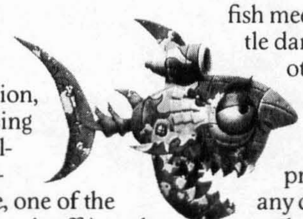
20,000 bytes under the sea

COMPARED with the giant aquariums in cities such as London and Sydney, the new Boston FishTank, which opens on June 13th, is a bit of a tiddler. To make matters worse, it doesn't even have any water—or, for that matter, any fish. Instead, it has computers. There are 22 of them: top-of-the-range PCs equipped with the finest 3D-graphics software that money ($1.2m of it) can buy.

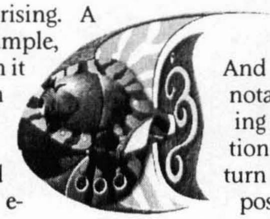
The new non-aquarium's full name, not surprisingly, is the Virtual FishTank. It is the joint brainchild of Mitchel Resnick, a researcher at the Massachusetts Institute of Technology's Media Lab, and Oliver Strimpel, the executive director emeritus of Boston's Computer Museum, where it is located. Its purpose, besides entertaining the paying public, is to show how complex patterns of activity can result from fairly simple rules of behaviour.



Visitors will be able to play God (or act as agents of natural selection, if you prefer) by choosing their own brightly coloured, cartoon-like "e-fish" (designed by Nearlife, one of the Media Lab's commercial spinoffs) and equipping them with behavioural rules of thumb they think will improve their creations' chances of survival (swimming away from predators and towards food are two good choices). They then release them into the "tank"—a bank of 12 screens with a total area of some 37 square metres (400 square feet).



Some of the behaviour that emerges is hardly surprising. A school of e-fish will, for example, generally split into two when it meets an obstacle, and then rejoin on the other side, just as a real school would. Other behaviour is cute and unpredictable. When two e-fish meet, they might do a strange little dance back and forth with each other; or an e-fish might follow its creator around the tank.



But none of these behaviours has been specifically programmed in, nor is there any central control.

The e-fish, however, truly are behaving like their flesh-and-blood counterparts in the sea. Schools of real fish may appear to have a leader, but the impression actually arises because each fish follows a set of simple rules such as matching velocity and keeping a safe distance from others.

The same principles extend to other "self-organising" entities, from insect colonies and flocks of birds to gaggles of traders on stockmarkets. There, too, individuals herd together and follow each other around. And stockmarkets share another notable characteristic with schooling fish. A sudden change in direction can leave those who do not turn fast enough looking very exposed indeed.

THURSDAY, JUNE 11, 1998

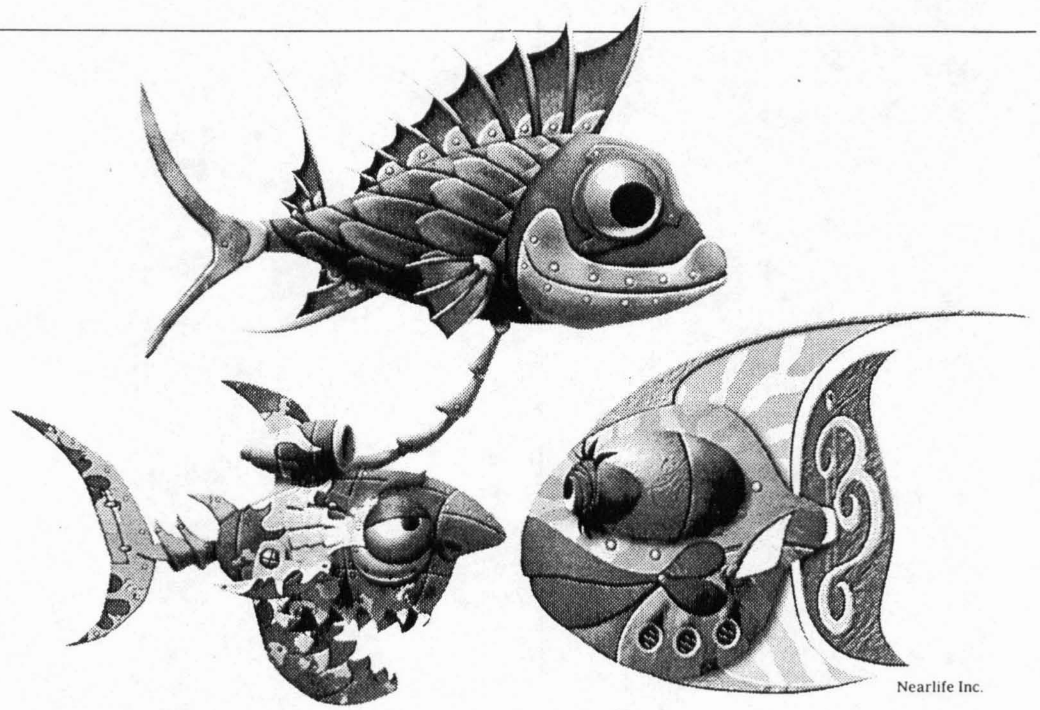
Circuits

The New York Times

Circ: 1.11 million

NEWS WATCH

Katie Hafner



Nearlife Inc.

In a Boston Museum, Fish Don't Need Any Water to Swim

The six-year-old Computer Museum in Boston will open a giant virtual aquarium on Friday that will let visitors create and program their own fish and then watch them interact. The exhibit, developed with the Massachusetts Institute of Technology Media Laboratory and Nearlife of Cambridge, Mass., will show how patterns arise through simple interactions and rules.

Using high-performance graphics display hardware and high-speed processors, the 2,200-square-foot, $1.2 million "Virtual Fish Tank," which is financed by the National Science Foundation, Sun Microsystems and others, has 12 large projection screens that form a 400-square-foot "tank" populated by nearly 100 boldly colored, cartoonlike, mechanical fish.

Visitors design behaviors for their artificial fish, instructing them how to react to other fish, human beings, food and water depth. "When people see patterns in the world, like a school of fish, they generally assume some type of centralized control, such as a leader fish," said Mitchel Resnick, an associate professor at the M.I.T. Media Lab. "But as people design their own fish here, they learn how orderly patterns can arise without a leader, just from simple interactions among neighboring fish."

A people-sensing station, equipped with sensors, enables the fish to detect the presence of humans and, through a digital video camera, to react to their movements.

Circulation: 4.48 million

CYBERSCOPE®

GAMES

X-Files, The CD

FOR FANS WHO haven't had their fill, there's a new digital installment of "The X-Files." Fast on the heels of the TV-cliffhanger finale and just before its big-screen companion comes The X-Files Game ($54.95; www.foxinteractive.com). This live-action CD-ROM includes a new investigation that teams Mulder and Scully with you—a junior FBI agent. Together, you interview witnesses and examine evidence in realistic-looking morgues, motels and 30 other locations. For X-philes, this is required clicking.

'X' file: Scully's dossier


Don't just stand there: This high-tech fish tank changes at your command

MUSEUMS

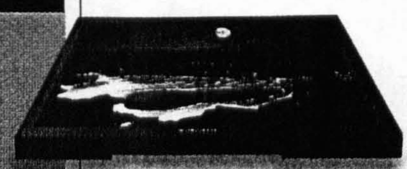
Fish Out of Water

THE FISH IN THE BOSTON Computer Museum's new aquarium are fake, but have the advantage of being programmable. The Virtual FishTank, created with MIT and a company called Nearlife, consists of 12 large projection screens, a multitude of computer-animated fish and interactive stations at which visitors can experiment with artificial life. You can design your own fish and set them loose in the tank. You can also observe how an informally constructed system, like a school of fish or a traffic jam, organizes itself by tweaking its rules, one at a time: for example, expand the distance between fish in a pack and watch it dissipate. The exhibit opens June 13.

TECHNOLOGY

Fancy Displays, At a Price

MONITORS ARE GETting skinnier, and better. Pioneer's new 50-inch plasma displays—available in the fall—produce a bright, almost photo-quality image. The wall-mountable screen is a mere four inches thick, but at $25,000, it's hardly a consumer item (a 40-incher is $13,000). We'll probably first see them at airports and stadiums and as touch-screen displays in stores. Once the price goes down, families can use the screens for a variety of purposes, toggling seamlessly from HDTV to the Internet.


Pioneer's slim screen

SOFTWARE

Web Print

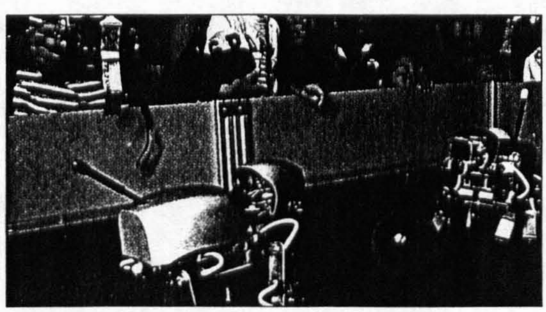
WEB PAGES THAT read great on the screen often translate poorly on paper. But Hewlett Packard's new Web PrintSmart software (www.hp.com/go/webprintsmart) lets you print a collection of links, avoiding printer glitches like single lines on one page. If you visit numerous news sources each morning, program the links you want and PrintSmart will process a daily customized newspaper, complete with a table of contents and page numbers, ready with your coffee. The software is free, but there's one catch—they've tested it only on (surprise) HP printers.

News that's fit to print

ROBOTS

Soccer, Cyber Style

SOCCER PLAYERS won't be the only ones kicking back this summer. While national teams descend on France this week for the start of the World Cup, more than 60 other teams of researchers and their robots will be gathering at Paris's Cité des Sciences et de L'Industrie for a different kind of soccer series. The annual Robot Football World Cup pits machine against machine as much for science as for sport. While they're programmed to score, the ultimate goal, say organizers, is to help scientists fine-tune robotics and artificial-intelligence programming for more than just fun and games.


Geared up for the games: Last year's robo-cup action

BETH KWON *and* ARLYN TOBIAS GAJILAN

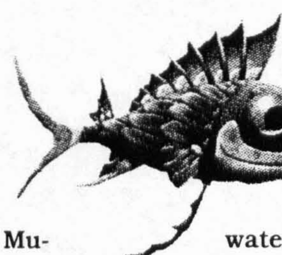
CLOCKWISE FROM TOP: LINDA HAAS—COMPUTER MUSEUM, COURTESY PIONEER, PHILIPPE PLAILLY—EURELIOS-PHOTOTAKE, NO CREDIT (3), COURTESY FOX INTERACTIVE

Thursday
July 2, 1998

THE CHRISTIAN SCIENCE MONITOR
IDEAS
Currents in Contemporary Thought

Whatever . . .

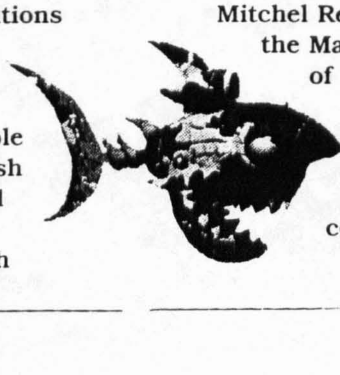
Where the Little Fish Eat the Big Fish



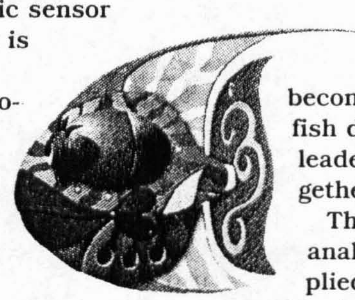
Welcome to the aquarium of the future. No tanks, no water, and no real fish.

The virtual fish tank exhibit at Boston's Computer Museum has aquatic life of the computer-generated kind. Hundreds of colorful byte species swim across 12 large projection screens as underwater sound fills the viewing room.

But unlike a real aquarium, onlookers can take charge of the way the fish interact. While schools of "Sharkys" swim by with looks of hunger on their faces, changing the "rules" of their school at one of the four computer stations can mean Sharkys are no longer gobbling their neighbors.



Viewers are also able to design their own fish with an individualized set of "rules." Giving your fish a thin mouth means it won't eat much, but huge chompers make for a ravaging appetite. There are also options to affect the way your fish will react to other fish, human beings, and water depth. An electronic sensor detects whether a human is near the tank.



Oliver Strimpel, the project's co-creator and the executive director emeritus of the museum, says, "I wanted a way for the general public to interact with the computer world. I found the fish world to be the most engaging."

Developed by Mr. Strimpel and Mitchel Resnick, a researcher at the Massachusetts Institute of Technology's Media Lab in Cambridge, Mass., the project was conceived of as more than just a fun computer experiment. Seeing how your fish interacts with its companions, given the rules they've been programmed with, is part of the educational experience behind the fish-tank concept, Strimpel says.

Many people would assume that when fish congregate into schools, there is a definite leader, a central control. But as one observes the schools, it becomes clear that the fish don't need a leader to stay together.

This fish-school analogy can be applied to other aspects of society, such as market economics and traffic jams. These situations illustrate complex patterns, or patterns that occur with no obvious leader, merely many individuals each following their own set of rules.

As Strimpel puts it, "There are many things in the world that look like they have a central control but don't."

– Kerry Flatley

INTERNATIONAL HERALD
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AMERICAN TOPICS

A Farewell to Angst: Writer Discovers the Ideal Garret

Like all writers, William Elliott Hazelgrove yearned for a clean and pleasant place in which to pursue his craft. He had drafted novels in a storage room, a coffee house, various basements and a bakery, reports the Los Angeles Times.

So when, one dark March afternoon last year, he noticed a light in the garret of a turreted, white framed house while walking home in Oak Park, Illinois, a light popped on in his mind: The house, now a museum, was the site of Ernest Hemingway's birth in 1899. "God, that'd be a great place to write," he remembers thinking.

Mr. Hazelgrove approached the Ernest Hemingway Foundation, which, after initial skepticism, came around to the notion that having a writer at work in the attic when visitors pass through the house was not such a bad idea.

The place, Mr. Hazelgrove said, has proved to be enormously inspiring, even if Hemingway lived there only to the age of 6. When Mr. Hazelgrove stops to ponder, he looks up — directly into the level gaze of the great American writer, photographed as a young boy.

Mr. Hazelgrove is now polishing a novel titled, aptly, "Hemingway's Attic."

Short Takes

Mayor Willie Brown of San Francisco thinks that his city's water is so good he wants to bottle and sell it. "It's as good as Calistoga," said Mr. Brown. "It's as good as Evian."

The water comes by aqueduct directly from the Hetch Hetchy Valley in Yosemite National Park, about 125 miles (200 kilometers) east of the city. It is pure enough that federal and state regulators do not require it to be filtered.

The idea of selling the city's water is not without precedent. Calistoga-brand bottled water comes from a geyser in Napa Valley, California, near the town of that name.

Other cities bottle their water, but mainly for promotional purposes. Toledo, Ohio, sells filtered water from Lake Erie under the name of — what else? — "Holy Toledo."

The giant aquarium at the Computer Museum in Boston contains some voracious-looking fish, but feeding them costs nothing. The fish in the 2,200-square-foot "Virtual Fish Tank" — actually 12 large projection screens — are boldly colored, cartoonlike creatures. Visitors to the exhibit, which was developed with the Massachusetts Institute of Technology and Nearlife of Cambridge, design their own fish, instructing them how to react to other fish, to humans, to food and to water depth. Sensors enable the fish to detect the presence of humans and react to their movements. Mitchel Resnick, an MIT professor, told The New York Times that the exercise allows people to study fish behavior and learn "how orderly patterns can arise without a leader, just from simple interactions among neighboring fish."

The Viagra phenomenon has produced a mini-boom in business for the legal brothels of Nevada, according to some owners.

Men as old as their mid-90s, who have been rejuvenated by the little blue impotence remedy, are said to be flocking to the establishments to relive younger days, the Philadelphia Daily News reports.

"It totally has changed their self-esteem," said "Lief," a prostitute at the Moonlight Bunny Ranch, near Carson City. "They are paying more, staying longer."

George Flint, head of the Nevada Brothel Association, which represents the 30 legal houses of prostitution in the state, took exception, saying the talk of a Viagra-driven boom is greatly exaggerated.

Don't tell that to Suzette Gwin, who manages the Moonlight Bunny Ranch. "This," she said, "is the best thing since prostitution was legalized in 1970."

Brian Knowlton

Emerging **Business**

A REPORT ON NEW ENGLAND'S GROWING COMPANIES

Fish and computer chips

With virtual fauna, company hopes to catch next big wave

By Christopher Muther
GLOBE CORRESPONDENT

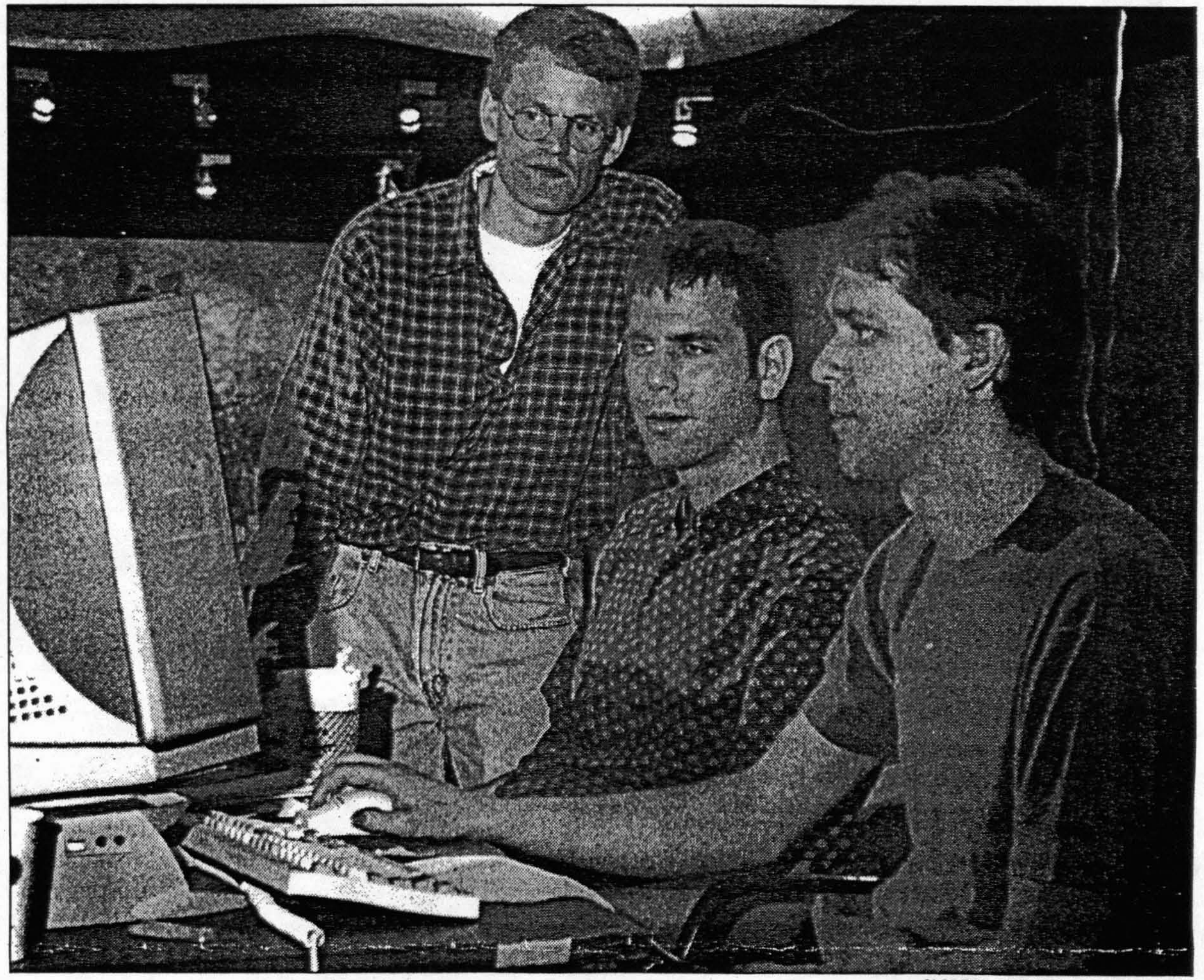
THE FISH NEARS THE GLASS front of the tank, eyes the human visitor suspiciously, and skittishly swims off. Another swims up to the glass, playing to the growing audience.

But these fish aren't in an aquarium. In fact, they're not even real. They're computer-generated, part of the Virtual FishTank, an exhibit set to open June 13 at the Computer Museum in Boston.

Instead of water, the 400-square-foot tank holds 20 computers. Visitors can watch and interact with 100 synthetic species in four schools of 3-D fish. A series of 12 rear-projection screens, each measuring 12 square feet, will display the continuous activities of the fish along a 40-foot wall in a resolution twice as sharp as a movie.

The Virtual FishTank, which cost $1.2 million and is the most complex display the museum has undertaken, seamlessly blends the virtual and physical worlds. But the permanent exhibit is more than a platform to show off the latest in computer graphics. The fish that live in the Virtual FishTank have personalities.

The company that produced the display, Cambridge-based Nearlife Inc., is pioneering a technology it calls "directable characters." The characters – in this case the fish – are programmed with specific personality traits



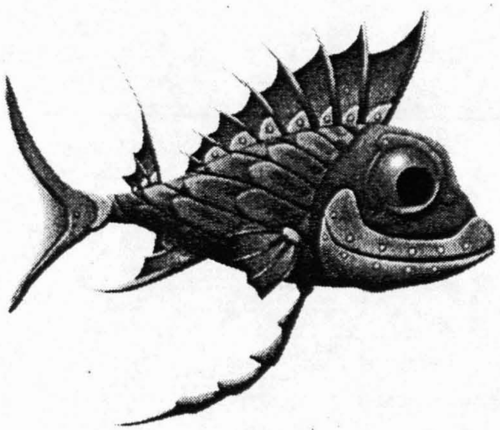
GLOBE STAFF PHOTO / JOHN BLANDING

ıh – are programmed with specific personality traits ıd then let loose in their parallel universe, reacting ith one another and visitors, and making decisions ısed on their personality traits.

"The idea is that our technology represents not only ıe 3-D visuals and the animated abilities of those char-cters to breathe and move about in real time, but ıere's also an ability to plug-in a high-level behavioral epresentation," said Tinsley Galyean, president and hief executive of 2-year-old Nearlife.

While watching and feeding the fish, and designing ıeir own unique breeds of fish, visitors to the Virtual ishTank also learn how complex systems interact. The lea for the tank took shape when Computer Museum xecutive director Oliver Strimpel joined forces with IIT professor Mitchel Resnick. Based around Resnick's ork, the fish tank demonstrates how simple rules of be-avior among individuals can have repercussions over ıe entire group.

"I've found that people have a hard time understand-ıg how lots of things interact, whether it's a bird flock r a traffic jam," Resnick said. "People don't have good ntuitions for understanding hose systems. They assume here's someone or something ı charge when they see a lock of birds. But in reality here's no leader. It's the same rith schools of fish."



The fish, with their distinct ersonalities, provide an easi-r way to understand how the heory of complexity works rithout sitting down and solv-ıg a series of differential quations. Visitors can create heir own fish by choosing rom eight personality traits ınd then watch how their fish ares among the group.

"You can adjust how hungry they are, how skittish hey are, or what depth they like to swim at, and there's ı visual impact. The mouth size and eye size changes ıased on the characteristics. You can look in the tank ınd identify your own fish, and you can look at another ish and have a sense of the rules governing those fish," Galyean said. "You can also see the results of your :hoices in action. If you create a fish that's hungry and loesn't care about predators, you could be setting it up o become shark food."

The interaction is not limited to the fish. At one window of the tank, the fish can detect the motion of visitors and react accordingly. There's also a hand crank feeding station, where museum-goers can watch the fish gather for food. Strimpel said a touring version of the tank is in the planning stages for museums and aquariums across the country.

GLOBE STAFF PHOTO / JOHN BLANDING

With a click of the mouse, Nearlife executives at the Computer Museum in Boston "stock" their tank with such fish as the one below. From left are president Tinsley Galyean, Henry Kaufman, and Brian Knep.

Nearlife, an off-shoot of Galyean's work at the MIT Media Lab, not only created the technology used to fuel the display but also designed every aspect of the fish tank, from the whimsical, mechanical-looking fish down to the exterior of the tank that holds them.

The tank and its inhabitants are not intended to look life-like. Galyean explains the look of the tank is inspired by "all the tastefully kitschy things that were in your childhood fish tank." There are mountains of bright blue gravel, plastic-green plants, a bubbling diver, and atreasure chest dotting the landscape.

Nearlife's combined technical ability and strong design background not only helped it land the Computer Museum display, but it is also helping the company secure development deals to create entertainment concepts for theme parks and restaurants.

The majority of the company's seven full-time employees have backgrounds in both design and technology. Galyean received a Ph.D. from the Interactive Cinema Group at the MIT Media Lab, and also has degrees in computer graphics and computer science. Brian Knep, the head of development at Nearlife, was an employee at special effects giant Industrial Light and Magic, where he worked on the production of "Jurassic Park" and "Star Wars: Special Edition."

By bringing together art and technology, the company has carved out a unique niche in a market where the two skills rarely intersect, said Galyean, 33. Because of nondisclosure contracts, Galyean and his wife, Sherri, director of creative development at Nearlife, were unable to discuss many of their specific projects.

"The kind of things we're working on would allow you to think of going out to dinner as taking a three-hour vacation," he said. "We orchestrate the entire experience and take people to a place they normally couldn't get to in three hours, or a place that just doesn't exist."

Even before founding Nearlife, Galyean designed a display called the Virtual Reality Laboratory at the Chicago Museum of Science and Industry. The laboratory, which is still on display at the museum, takes visitors on a journey through four different worlds.

More recently, the company developed a program in conjunction with Intel called Derinda's Room. The 3-D demonstration, commissioned by Intel to show the power of its processors, features a teenager with a personality. She bangs on the monitor to get the attention of the computer user, then proceeds to use her own computer to gather useful information, or listen to her stereo. According to Galyean, the company is currently developing products that would take characters like Derinda from a demonstration model and create more entertaining and practical uses, such as interactive storytellers and Web site hosts.

While there is a demand for the technology behind Nearlife's directable characters, Galyean said, he is not interested in marketing the technology unless it is through a partner. The company, he said, is strictly interested in developing its technology and characters for its own entertainment projects or working as a consultant on outside projects. Galyean declined to reveal the annual revenues or profits for the private firm, which was launched with money from the Galyeans.

While the technology is growing, few companies focus on the same market, and Galyean said the company has no direct competitors. MIT's Resnick said that although the concept of having computer-generated characters interact with others has yet to fully penetrate the mainstream, it is an idea that will gain momentum.

"Nearlife is one of the companies that's at the forefront of taking these ideas that have been in the academic community and making them available in entertainment applications," he said. "We're going to see this type of approach showing up more and more as movies, television, and the Web begin to overlap."

As the Virtual FishTank demonstrates, Nearlife is hoping to further blur the lines between the virtual and real worlds. Although there is no water in the tank, the sounds of bubbles and drips can clearly be heard. The virtual blue gravel even spills out of the tank and into the physical world.

"It was a real effort to break down that barrier between what's in the virtual world and what's in our world," Galyean said. "We softened that edge, so you feel like you're walking into a different world."

Just when you thought the SimTrend was over, the Computer Museum in Boston is opening the US$1 million Virtual FishTank. The 3-D simulated world stretches across 12 projection screens and measures 400 square feet. Codeveloped with the MIT Media Lab and its spin-off Nearlife, the exhibit incorporates principles of artificial life and emergent behavior. Visitors can design a fish and watch it interact with fellow swimmers and react to its environment in real time.

"The tank shows how complex patterns arise from simple, local interactions," says MIT professor Mitchel Resnick. Schools of fish, like ant colonies and market economies, are "organized without an organizer." More information on the project, as well as its travel schedule, is available at *www.tcm.org/*. – *Jessie Scanlon*


SimTank

DAILY TELEGRAPH

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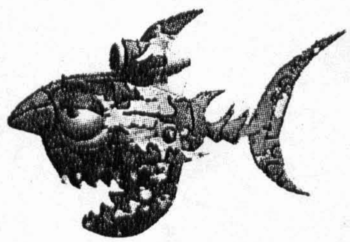
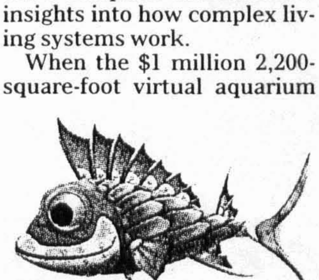
Underwater clues to the way the world works



A fish tank is giving pointers to behaviour patterns, says **Roger Highfield**

A virtual undersea world, dubbed The Virtual Fishtank, is to give visitors to Boston's Computer Museum new insights into how complex living systems work.

When the $1 million 2,200-square-foot virtual aquarium opens in June, it will enable visitors to create artificial life forms to reveal how changing simple behavioural rules can produce complex, often surprising, results.



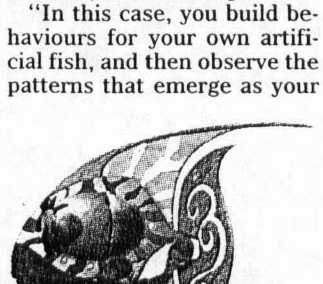
The patterns in the fishtank are everywhere, in the behaviour of ants, immune systems, economic patterns, and activity on the Internet.

The exhibit, the result of a five-year collaborative venture with the MIT Media Lab and Nearlife Inc, will simulate an aquatic environment by combining the latest techniques in 3D computer graphics and real-time interactive character animation.

"The Virtual Fishtank presents important new ideas about the way the world works and how we think about it," says Mitchell Kapor, founder of Lotus Development Corporation and president of Kapor Enterprises.

"One of the best ways to learn is by building things," says Mitchel Resnick, professor of research in education at the MIT Media Lab and a Fishtank project co-leader with the museum's executive director, Oliver Strimpel.

"In this case, you build behaviours for your own artificial fish, and then observe the patterns that emerge as your fish interacts with others," says Resnick.



Twelve projection screens form windows into the central tank, which measures 400 sq ft. In this fanciful watery world, more than 100 brightly coloured, computer-generated fish swim past plants, treasure chests, even a deep-sea diver.

At three "Build Your Own Fish" stations, visitors design fish, selecting behaviours such as appetite and responsiveness to temperature, humans and other fish.

Then the fish are launched into the tank, and their creators observe how the few simple rules they used to design their fish lead to complex behaviours and patterns for the entire ecosystem.

Six "Diving Deeper" stations reveal that this behaviour phenomenon applies not only to fish, but also to other systems as well: insect colonies, highway traffic, market economies and political moods.

$35 in Free Tickets to Museums

MUSEUMS BOSTON

$3.95
Volume 2, Number 2
Summer 1998

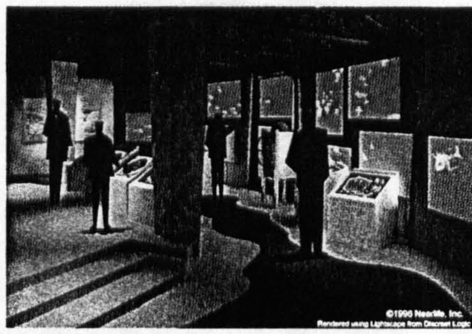
(Circ 120,000)

Gone Fishing

Cross the mysteries of the deep with a cutting-edge computer software program, and what do you get? If you're **The Computer Museum**, you end up with ***The Virtual Fish Tank***, a new 2,200-square-foot permanent exhibition that may just be the most sophisticated computer program—and coolest new toy—in town.

Designed for all ages and interest levels, from the computer-averse to the can't-get-enough, *The Virtual Fish Tank* invites visitors to create their own virtual fish and then release them into a giant virtual aquarium, where the fish interact with each other *and* their human visitors. At the "Build Your Own Fish" computer station, you'll choose not only characteristics like color and shape (generally bright and cartoon-like), but behavior, too: how your finned ones will react to other fish, to human beings, and to environmental cues like food supply and water temperature. Then let 'em go, and watch how those few simple choices per fish add up to complex behavior patterns for the whole ecosystem.

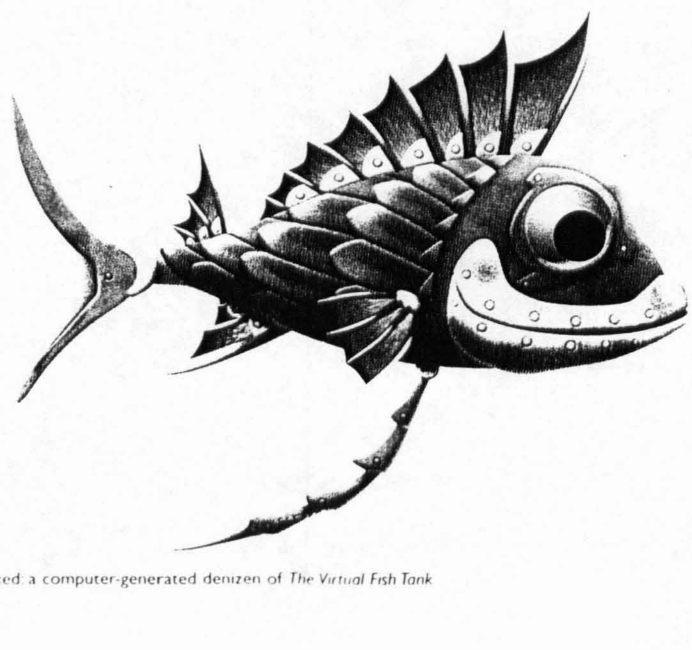
This is one aquarium where visitors are encouraged to feed the fish, who come equipped with sensors that react to human movement. At "Schooling" stations, you can interact with whole groups of fish, from predators to more friendly types, while getting a look at the way individual interactions affect the behavior of the whole school. The "Diving Deeper" station reveals how this kind of group behavior applies to flocks of birds, insect colonies...even highway traffic, market economics, and the latest fashion craze. As a way of learning about everything from computer science to human nature, it's a fascinating fishbowl. Opens June 13.



The Computer Museum

Build your own: *The Virtual Fish Tank* at The Computer Museum

The Computer Museum



Virtually hooked: a computer-generated denizen of *The Virtual Fish Tank*

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I Scream "Ice Cream!"

When Marco Polo returned from Asia with tales of peculiar ice-flavored goods it didn't take long to convince Europeans of the medium's possibilities. The recipe swiftly spread from the lips of the Italians into France and England and ultimately to the appreciative bellies of those lovable rebels across the ocean (that's us).

The creamy confection was introduced on a commercial level in Baltimore, Md. Ice cream sundaes were happily devoured until the cone hit the scene in 1904, assuring this frozen dessert a permanent home in the four food groups.

The reason for its lasting appeal? Perhaps it's the emotional bonds we create using ice cream as our bridge. Or the memories it conjures of chasing the neighborhood ice cream truck, a modern-day pied piper summoning children with spirited music and returning them safely with smiles and half-frozen treats. Or perhaps it has become a rite of spring—when the first sticky stream of banana fudge ripple, bubble gum or the ever-popular vanilla trickles down your arm, you know warm weather has arrived.

Whatever the reason, if you're screaming for ice cream, Boston's 16th annual **Scooper Bowl**—an indulgent ice cream and frozen yogurt fest—is answering your call *June 2-4*. The finest ice cream vendors including Ben & Jerry's, Häagen-Dazs and Edy's are waiting, scoops at the ready, to dish it out on an all-you-can-eat-and-still-keep-your pants-buttoned basis.

Proceeds benefit the Jimmy Fund, which, for more than 50 years, has raised funds for cancer research at the Dana-Farber Cancer Institute—so you can feel good about gorging.

Refer to *Special Events* in *Currently*.

One Fish, Two Fish, Red Fish...

Virtual Fish? Perhaps the millennium's answer to a popular children's story, but definitely a spectacular new exhibit *beginning June 13* at The Computer Museum. **The Virtual FishTank** plunges museumgoers into a simulated 2,200-square-foot aquatic world where patrons create their own fish and gain new insight into how complex living systems work.

Design your fish and its behaviors at one of three work stations. Is your fish passive? Friendly to other fish? Aggressive when in contact with humans? Is it an herbivore? A carnivore? Does it look like you? When you have considered these options your fish will take on shape, color and patterns accordingly. Once satisfied with your creation, your fish is ready to swim (or sink). Launch it into a virtual Cousteau-ian kingdom produced by 12 large projection screens that form windows into a 400-square-foot central tank and observe as your fish mingles with more than 100 other vibrant, cartoon-like fish.

Crank a wheel and feed the fish or stand in front of sensors and experience how fish react to human movement. Take a virtual scuba dive at "Schooling" stations where patrons interact with schools of friendly, predator and deep-sea fish.

This astonishing 'under the sea' exhibit is the brainchild of MIT Media Laboratory and Nearlife Inc., and implements the most complicated software development that the Computer Museum has undertaken. The Virtual FishTank's not-so-impossible mission is to unite design and technology to educate and entertain.

Refer to *Museums* in *Currently*.

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ıputer-generated fish swim amid sunken treasure and predators in the Computer Museum's Virtual FishTank in Boston.

Fishing for bytes

Tanks teach how computers work

• Learn how computers think with :he help of a few special fish.

3y Rosemary Ford
Eagle-Tribune Writer

Computers have evolved into staples of daily life, and it seems like they will not leave anytime soon.

But how many of us really know what makes :hese machines tick?

The Computer Museum in Boston wants to :each you, while letting you have a little fun.

The Computer Museum, the first of its kind in the United States, developed a $1.2 million Virtu- al FishTank to teach children and adults how computer systems work.

About 100 cartoon colored fish swim in a tank, viewed on 12 large screens. The undersea environment includes plant life, a diver, and a sunken ship.

The exhibit also gives participants a chance to design their own fish, develop its personality and send it into the virtual environment to see how it reacts to and with other fish.

"I think it's a good way to engage people in what a programmer might do without getting too technical," said Oliver Strimpel, executive director of the museum. "It's simple and it's fun. I think anyone could enjoy it."

Participants create fish using one of the exhibit's three touch-screen terminals.

The computer creates fish features based on how a child wants his or her fish to socialize, how curious the fish is and what temperature he or she wants it to swim at.

These features one selects for his or her fish dictate how the fish will look.

For example, if your fish is a coward, the computer makes a fish with bulging eyes. The more cowardice it has, the bigger the eyes bulge, making one goofy-looking fish.

IF YOU GO

Where: Computer Museum, 300 Congress St. in Boston

Summer Hours: Daily, 10 a.m. to 6 p.m.

Admission: $7, adults; seniors and students, $5

When one is done creating his or her fish, he releases the fish into the wilds of a virtual tank, where four schools of fish live.

Some of the fish are friendly, some aren't. All operate on a set of preconceived rules, with no visible leader — much like how computers work, with a decentralized system.

Participants can change the rules governing each species of fish in the tank through four mobile terminals, controlling how fish interact with their neighbors and what patterns develop.

At one area of the exhibit sensors detect movement near the screen, so that participants can interact directly with their virtual creations.

For example, if you wave your arms, some fish will swim towards you. Children and adults can also release food into the tank and give air or restrict air from a diver.

Also included in the exhibit are Diving D‹ er stations, where one can explore the ideas FishTank that show other decentralized sys tems, such as termite colonies and traffic ja on computer.

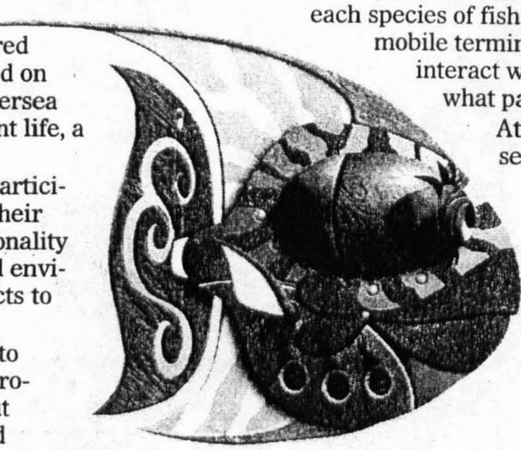
Participants manipulate the rules and se‹ how the colony or the traffic jams change shape, without having a leader giving direc orders.

While you're inside the museum, feel fre check out other exhibits.

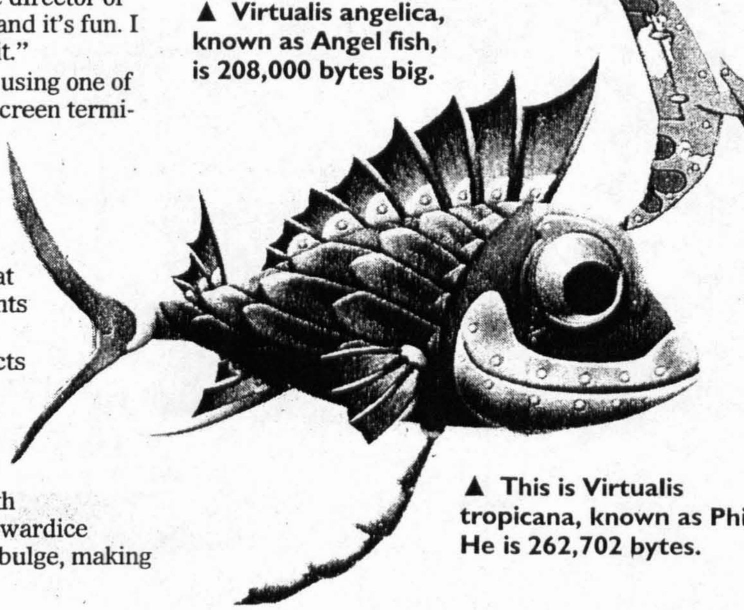
The museum boasts 170 interactive exhib including a two-story computer, a gallery o computer history, and a gallery on global c‹ puter networks.

Inside one gallery there are the 50 best ti in software for children. Participants can ty in a child's age and interests, and receive a unique list of titles based on the child's han on learning and long-time use.

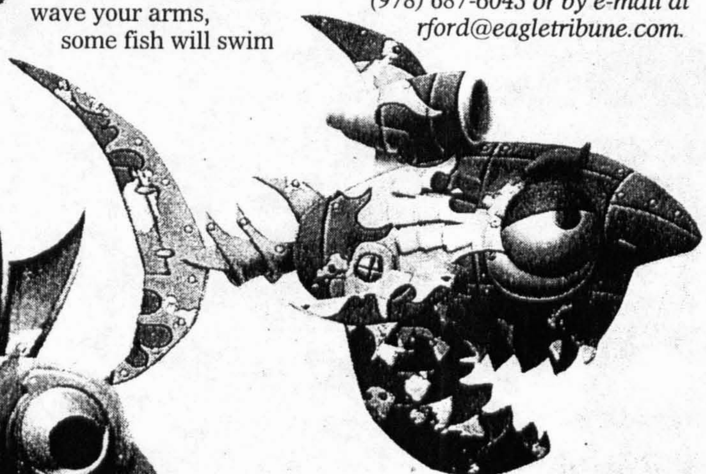
Rosemary Ford is the arts & entertainme reporter for The Eagle-Tribune. If you have questions or comments about this report pl contact her by phone at (978) 685-1000, by at Box 100, Lawrence, MA 01842, by fax at (978) 687-6045 or by e-mail at rford@eagletribune.com.



▲ Virtualis angelica, known as Angel fish, is 208,000 bytes big.



▲ This is Virtualis tropicana, known as Phil A. He is 262,702 bytes.



▲ This is Digatalis chompus, known as Sharky. Created at the Computer Museum in Boston, he is 132,664 bytes.

THE BOSTON SUNDAY GLOBE • JUNE 14, 1998

ARTS WEEK

A SELECTIVE GUIDE TO ACTIVITIES FOR THE WEEK OF JUNE 14-20

FAMILY AFFAIR

BOSTON AREA SPORT KITE CHAMPIONSHIP features individual and team competitions in 21 categories. Among them, kite ballet, in which arial movements are choreographed to music. Kite aficionado Jack Rogers will display his collection, which includes some of the largest kites in the world: a 130-foot-long octopus and a 200-foot-long wind sock. Lessons and demonstrations will be offered along with a designated flying area for families. Hours are 9:30 a.m.-4 p.m. at MDC's Hormel Stadium, on Route 16 in Medford. Admission is free. Telephone 781-595-7687.

...

VIRTUAL FISH TANK at the Computer Museum lets visitors create their own aquatic critters. Visitors can dictate behavior, then watch what happens as 3-D computer graphics simulate an aquarium. Discover how hunger or fear in a single fish could affect the entire environment – and gain insight into the workings of the real world. Today's hours are 10 a.m.-5 p.m. at the Museum Wharf, 300 Congress St. in Boston. Admission is $7; seniors, students, and children ages 3 and up $5; ages 2 and under free; half-price every Sunday after 3 p.m. Telephone 617-426-2800.

...

INDIAN RANCH offers a family fun day with country artists such as the Swamp Rockets, John Lincoln Wright, and Big Al Downing. There will be country line dance lessons for the kids, plus places to swim and picnic. Event time is 11 a.m.-6 p.m. at Indian Ranch, Route 16, in Webster. Admission is $7, ages 11 and under $1. Proceeds benefit the Children's Miracle Network. Telephone 508-943-3871.

BOSTON SUNDAY HERALD
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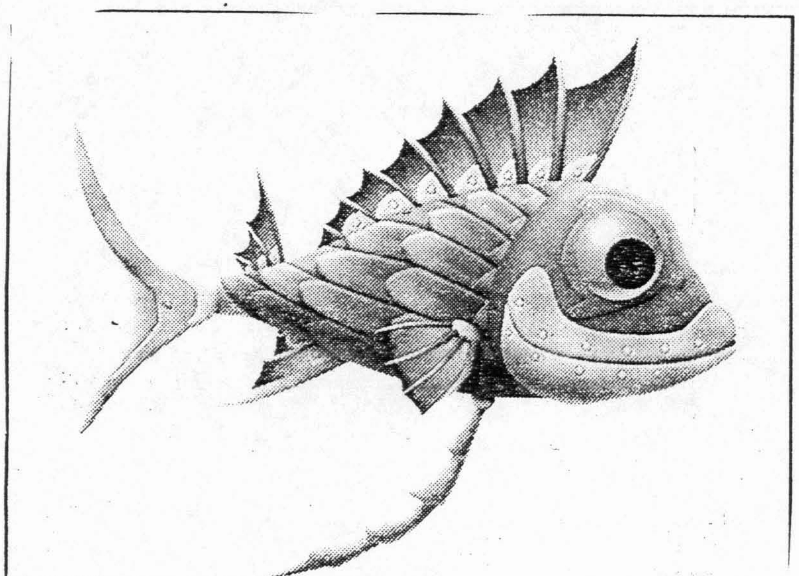
THIS WEEK AROUND THE HUB



VISUAL ARTS: Head over to the Computer Museum just for the halibut and take a stroll through 'The Virtual FishTank.'

VISUAL ARTS

■ It's an increasingly wired world we live in. Now the Computer Museum, 300 Congress St., invites visitors to stroll through **"The Virtual FishTank."** The exhibit opens Saturday and combines the latest in 3-D computer graphics with interactive character animation. Twelve large projection screens look into a central tank containing nearly 100 cartoonlike fish. With the touch of a few buttons, you can create your own fish, determining how much it will eat and how it will react to other fish. Admission is $5 to **$7. Call** (617) 426-2800, Ext. 630.

Beasty boy

Be the belle of the ball at Disney's smash-hit Broadway musical *Beauty and the Beast.* In its New England premiere at the Wang Theatre July 2-Aug. 23, the show boasts an Academy Award-winning musical score, has been nominated for nine Tony Awards including Best Musical, won a Tony for its costumes and secured the 1998 Olivier Award for Best New Musical. Talk about a roaring success. (800) 447-7400. Map I-12

Lose it at **Harborlights** when *Widespread Panic* hits the stage July 8. Or sign up for Mary Chapin Carpenter, July 9; the *Indigo Girls*, July 11; or *Ziggy Marley and the Melody Makers*, July 14. 423-NEXT. Map H-14

North Shore Music Theatre loves a good flashback. Check out the enduring sounds of singers Tom Jones (no panty throwing please), July 20; Johnny Mathis, July 21-22; and Kenny Rogers, July 24. Other tried and true performers include Steve Lawrence and Eydie Gorme, July 12 and comedian George Carlin, July 19. (978) 922-8500.

Hit her with your best shot (only figuratively, please) when Pat Benetar snares the spotlight at **South Shore Music Circus** July 15. Other notables gracing the tent are Clint Black, July 24; Gallagher, July 25; and Joan Rivers and Don Rickles, July 26. (781) 383-1400

CULTURE CLUB

Stamp your approval on the Museum of Fine Arts exhibition ***PhotoImage: Printmaking 60s to 90s*** on display July 7-Sept. 27. The exhibition explores the use of photographic and photoreproductive imagery in creative printmaking, from painter Robert Rauschenberg's first lithographs of 1962 to Andy Warhol's Marilyn to computer-driven ink-jet printing. Also of note at the MFA is ***New Paintings by David Hockney***. The revered British painter shows his bold and expansive landscapes through July 31. 267-9300. Map L-7

Titanic – The Exhibition docks at the World Trade Center July 1-Nov. 1, showing the largest collection of artifacts recovered from the Titanic wreck site. Among the more than 300 rare objects on display include: one of the ship's portholes which were ablaze with light until the final sinking, illuminating the night for those in lifeboats; a bronze cherub believed to have come from the area of Titanic's grand staircase; a gilded Spode dinner plate; and the ship's telegraph which linked the bridge to the engine room. (888) 744-7998. Map J-16.

CURTAIN CALL

Buff up on the tarnished side of tinsel town when Cyndi Freeman's one-woman show takes you behind the scenes of the soft porn industry, into the L.A. Coroner's Office and on a date with Brad Pitt's stand-in. ***Greetings from Hollywood***, winner of a "Best In Fringe Festival" at the 1997 New York International Fringe Festival shocks and delights audiences at the Charlestown Working Theatre July 9-12. 242-3285.

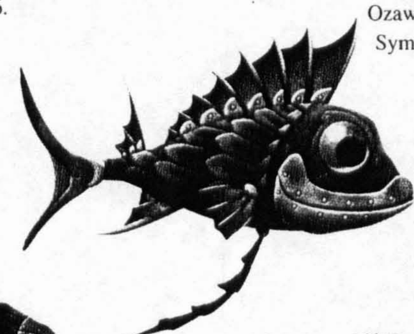
Spend an enchanting evening under the stars at the Publick Theatre's production of Shakespeare's ***Richard III*** July 9-26. Make an evening of it and pack a picnic dinner for the outdoor show along the banks of the Charles River. 782-5425. Map F-10

MUSIC & DANCE

What started as summer jobs for members of the Boston Symphony Orchestra has escalated into a picnicking cacophony of plaid blankets, paté-heaped crackers and silver-plated candelabrum. Though make no mistake, the outdoor concert experience is wondrous. Tanglewood Music Center, in the Berkshires, is about a 2 hr. drive from Boston, but well worth the trip. Catch such virtuosos as the Julliard String Quartet, July 1; Ray Charles, July 4; Conductor Keith Lockhart with the Boston Pops, July 14; Conductor Seiji Ozawa with the Boston Symphony Orchestra, July 18; and André Previn with the BSO, July 24. (800) 274-8499.
—Ally Bauder

PUPPET PLACE

It ain't over 'til the fat lady sings. Or, uh, is that the wooden lady? The New England Marionette Opera drops in at the Emerson Majestic throughout the month. The high class (dare we say?) puppets string up opera favorites *Madame Butterfly,* July 16-19; The *Barber of Seville,* July 23-26; and Mozart's Magic *Fantasy –A Journey Through Mozart's Magic Flute,* July 30-Aug. 2. 824-8000. Map I-12



Deep Sea Adventure

Sleep with the fishes at the Computer Museum's new permanent exhibit, The Virtual Fishtank. Guests create and interact with their own virtual cartoon-like fish through twelve large projection screens which form windows into a spectacular 400-square-foot central tank. Play God at three "Build Your Own Fish" stations where you design behaviors for your brightly colored creations, telling them how to react to other fish, human beings, food and water depth and then let 'er rip. Is your crew on a budget? Cast your line for half price on Sundays 3-5pm. 426-2800. Map I-14

Partylines

Computer Museum reels in a crowd at 'fish' preview

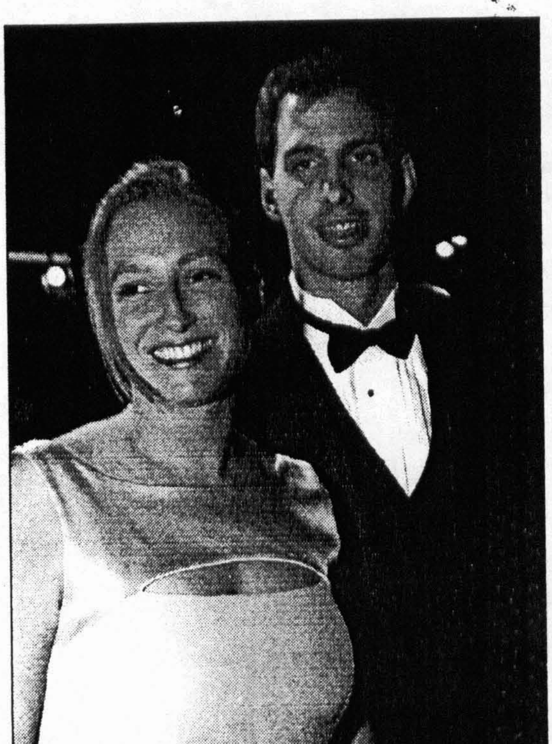
BOSTON GLOBE 6/15/98

By Julie Hatfield
GLOBE STAFF

Gather some of the best computer brains in the country, put them in a fish tank, albeit a virtual one, at the cocktail hour, and you'll never get them in to dinner. That's what nearly happened Thursday when Oliver Strimpel of Manchester-by-the-Sea, the Computer Museum's executive director emeritus, and his wife, Harriet, invited guests to play with the virtual fish at the preview of the Virtual Fish Tank exhibit.

This aquarium-without-water was Strimpel's idea, and he joined forces with Mitchel Resnick, a professor at the MIT Media Laboratory. Resnick,

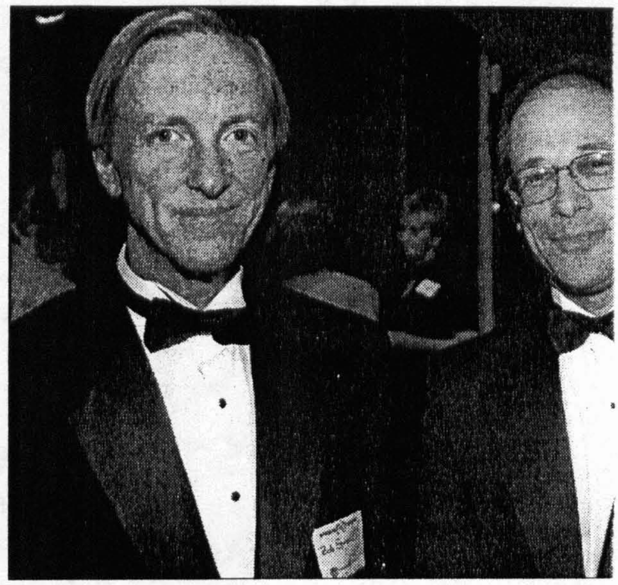
PARTY, Page D12



GLOBE STAFF PHOTO / BILL BRETT

Abby Smith of Brookline and Craig Murray of Framingham at the Computer Museum party on Thursday.

Above (from left), Brown University professor Talia Ben Zeev, Kyungmi Park and Scott Park, and Henry Kaufman, all of Providence.

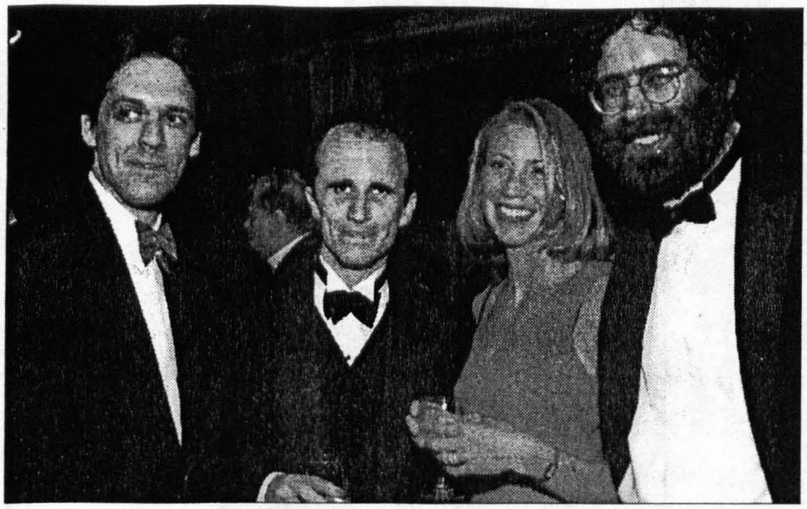


At right, Newton resident Bob Sproull of Sun Microsystems with Computer Museum executive director emeritus Oliver Strimpel of Manchester-by-the-Sea.

Playing fish; a worl

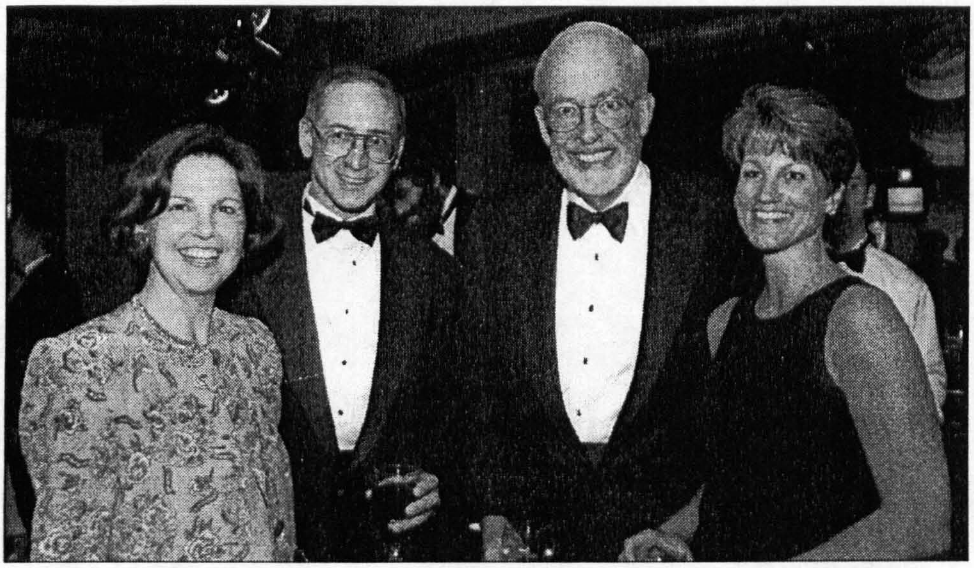
■ PARTY
Continued from Page D7

of Cambridge, couldn't stop playing with the "fish," along with the likes of Karl Sims of Cambridge, a MacArthur fellow whose company is Genetic Arts, and whose wife, Pattie Maes, is an associate professor at the MIT Media Lab; Brian Knep of Cambridge, an Academy Award-winning computer software designer; professor Joseph Bates of Newton, the father of computer-based interactive drama and founder of the company Zoesis; Lee and Bob Sproull of Newton – he's a fellow of Sun Microsystems, one of the sponsors of the exhibit; and Daren Bascome of Jamaica Plain, who did the graphic design for the new exhibit.



At left (from left), Brian Knep of Cambridge, Rick Borovoy of Boston, Colella Anessa of Boston, and MIT Media Laboratory professor Mitchel Resnick of Cambridge.

Catch of the day at Computer Museum



From left, Laura Morse of Wellesley, Leonard Shustek of Aportola Valley, Calif., with Gardner and Karen Hendrie of Southborough.

# of food; the rainbow room

ELOW, June 11: Underwater royalty **JOE ST. JEAN** nd **ERIN CROMWELL** preside at the Computer Mu- um's fishy party.

LEFT, June 11: **GEORGE BIRD** with **LINDA** and **NILE ZIEMBA** were ready to do some fishing at the Computer Museum unveiling party.

BELOW, June 11: **TALIA BEN-ZEEV** and **KYUNGMI PARK** are bubbly over the Virtual Fish Tank.

Fishy weekend

PEOPLE

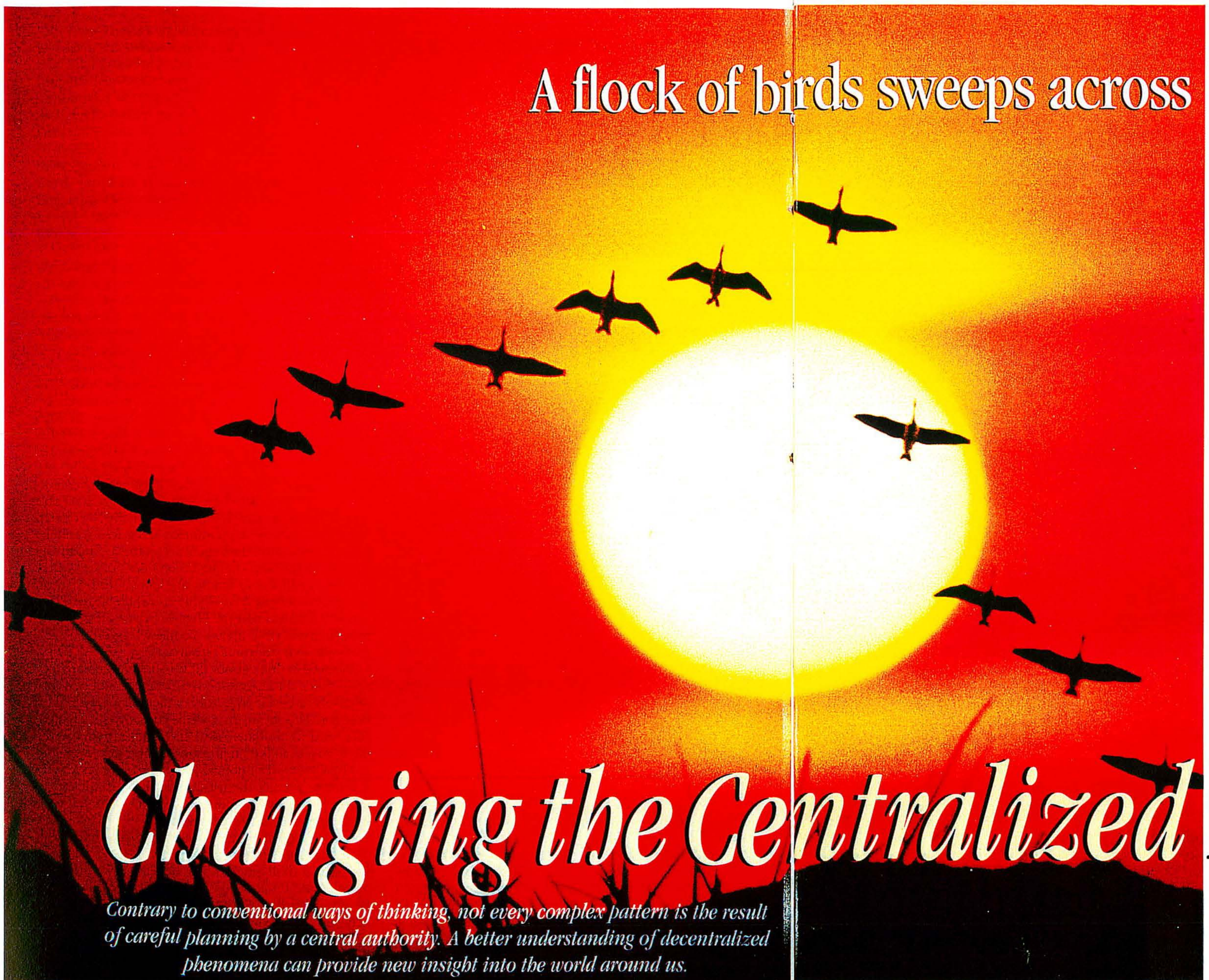
Photos by Leo Gozbekian

Something fishy is going on at Boston's Computer Museum — virtually fishy, that is. The Museum unveiled a 2,200-square-foot Virtual Fish Tank, designed by the MIT Media Lab and Nearlife Inc., at a gala last Thursday night. Now viewable as a permanent exhibit, the real-time, interactive undersea world is made up of 12 large projection screens displaying nearly 100 brightly colored fish that visitors create and interact with through museum work stations. After that aquatic cool-down, the Boston party scene heated up Friday night with a dose of Cuban dance music by Cubanismo! at The Roxy. The 15-piece orchestra led by trumpeter Jesus Alemany showcased a tropical blast of their unique brand of Latin jazz.

Changing the Centralized Mind

Contrary to conventional ways of thinking, not every complex pattern is the result of careful planning by a central authority. A better understanding of decentralized phenomena can provide new insight into the world around us.

By Mitchel Resnick



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A flock of birds sweeps across the sky. Like a well-choreographed dance troupe, the birds veer to the left in unison. Then, suddenly, they dart to the right and swoop toward the ground. Each movement seems perfectly coordinated. The flock as a whole is as graceful—maybe more graceful—than any of the birds within it.

How do birds keep their movements so orderly, so synchronized? Most people assume that birds play a game of follow-the-leader: the bird at the front of the flock leads, and the others follow. Indeed, people assume centralized control for almost all patterns they see in the world. But that's not necessarily so. In the case of bird flocks, most don't have leaders at all. Rather, each bird follows a set of simple rules, for example, matching its velocity to that of the other birds around it, and keeping a safe distance from the birds on either side.

A bird flock is

one of many phenomena organized without an organizer, coordinated without a coordinator. In ant colonies, trail patterns are determined not by the dictates of the queen ant but by local interactions among the worker ants, such as following a scent that their fellow ants emit when they find a source of food. In human societies, macroeconomic patterns arise from the haggling between millions of buyers and sellers in marketplaces and stock markets around the world. And in immune systems, armies of antibodies seek out bacteria in a systematic, coordinated attack—without any "generals" organizing the overall battle plan.

The Era of Decentralization

A growing number of people are now choosing these kinds of decentralized models for the organizations and technologies they construct in the world, and for the theories they construct about the world. One such case began to unfold on December 7, 1991, when Russian President Boris Yeltsin met with the leaders of Ukraine and Belarus in a forest dacha outside the city of Brest. After two days of secret meetings, the leaders issued a declaration: "The Union of Soviet Socialist Republics, as a subject of international law and a geopolitical reality, is ceasing its existence." With that announcement, Yeltsin and his colleagues sounded the final death knell for a centralized power structure that had ruled for nearly 75 years. In its place, the leaders established a coalition of independent republics and promised a radical decentralization of both economic and political institutions.

The next day, halfway around the world, another powerful institution announced its own decentralization plans. IBM chairman John Akers publicly announced a sweeping reorganization of the computer giant, dividing the company into more than a dozen semi-autonomous business units, each with its own financial authority and its own board of directors. The goal was to make IBM more flexible and responsive to the needs of rapidly changing markets.

The coincident timing of the above two events actually symbolizes a broad decentralization trend that is sweeping through many different domains. For example:

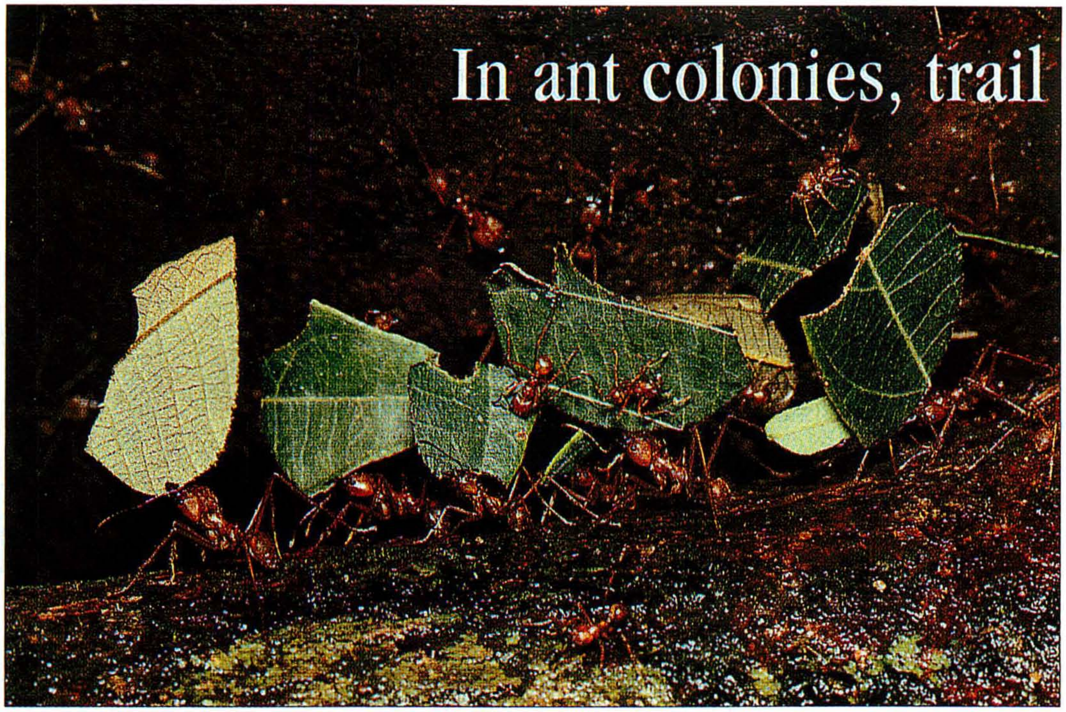
■ ORGANIZATIONS: All types of organizations—schools, companies, even countries—are pushing authority and power down from the top, distributing rights and responsibilities more widely. In U.S. education, for example, decentralization extends to several levels. School choice brings market-oriented thinking to the world of education, asserting that individual families—not state or local governments—should decide where their children go to school. Likewise, school-based management moves decision-making authority from state and district offices to individual schools. And child-centered learning, now adopted in many classrooms, transforms the teacher from a central authority into a catalyst, coach, and collaborator.

■ SCIENTIFIC MODELS: For 300 years, researchers' thinking has been guided by Sir Isaac Newton's model of the physical world as a clocklike mechanism. Newton's world is ruled by a centralized notion of cause and effect—one gear turns, which makes another gear turn, and so on. Now, a new set of decentralized models and metaphors is spreading through the scientific community and gradually into the culture at large. Researchers now view a wide range of systems—everything from bird flocks to immune responses—less like clockwork mechanisms and more like complex ecosystems controlled by decentralized interactions and feedback loops.

■ PSYCHOLOGY: Few concepts seem more obvious than the singular nature of the mind and self. Each of us experiences life as a single thread of consciousness, and each of us imagines our own mind as "I," not "we." But the idea of the unified, centralized mind, first challenged by Sigmund Freud, has eroded rapidly during the past decade. For example, Daniel Dennett, a professor of philosophy at Tufts University, proposes that there is no single stream of consciousness in the mind. He suggests instead that multiple narratives are simultaneously created and edited in different parts of the mind. Similarly, the field of artificial intelligence, once dominated by centralized models of the mind, now favors decentralization. Marvin Minsky, a professor at the MIT Media Lab, argues that the mind is a society of many simple agents that work together to accomplish complex tasks.

■ THEORIES OF KNOWLEDGE: For centuries, philosophers strove for "objective knowledge." They put great faith in the power of logic to systematize all knowledge, to find ultimate meaning and truth. Today, philosophers are moving away from the notion of a single unifying conception of knowledge, arguing instead that knowledge speaks not with a single voice but with many. For example, traditional theories of literary criticism assumed that meaning was created by an author and conveyed through the author's writings. According to this view, reading is a search for inherent meaning in a document, an attempt to decipher the intention of the author. But modern schools of thought—such as poststructuralism, reader-response theory, and deconstructionism—all focus on readers as the main constructors of meaning. In this new view, texts have little or no inherent meaning. Rather, meanings are constantly reconstructed by communities of readers

MITCHEL RESNICK, an assistant professor at the MIT Media Laboratory, specializes in the development of computational tools to help people learn new things in new ways. The ideas in this article are explored further in his new book, Turtles, Termites, and Traffic Jams: Explorations in Massively Parallel Microworlds, *published this month by MIT Press.*



In ant colonies, trail patterns are determined by the interactions among worker ants, such as when they follow a scent that their fellow ants emit upon finding a source of food.

through their interactions with the text. Meaning itself has become decentralized.

Centralized Thinking

Even as the influence of decentralized ideas grows in many disciplines, a deep-seated resistance to such ideas remains. People seem to have strong attachments to centralized ways of thinking, assuming that every pattern must have a single cause, an ultimate controlling factor. The widespread resistance to evolutionary theories is an example: Many individuals still insist that someone or something must have explicitly designed the complex, orderly structures that exist in the biological world. They resist the idea that complexity can be formed through a decentralized process of variation and selection.

Similarly, many view the workings of the economy in centralized ways, assuming singular causes for complex, decentralized phenomena. In interviews with Israeli children between 8 and 15 years old, for example, David Leiser, a psychologist at Ben-Gurion University, discovered about 10 years ago that nearly half of the children assumed that the government sets all prices and pays all salaries. Even children who said that employers pay salaries often believed that the government provides the money for the salaries. "The child finds it easier to refer unexplained phenomena to the deliberate actions of a clearly defined entity, such as the government," he wrote, "than to impersonal market forces."

The centralized mindset is not just a misconception of the scientifically naive. A similar bias toward centralized theories can be seen throughout the history of science, with scientists remaining committed to centralized explanations even in the face of discrediting evidence. The history of research on slime-mold cells, as told by Evelyn Fox Keller, a professor of science, technology, and society at MIT, provides a striking example. At certain stages of their life cycle, slime-mold cells gather into clusters. Scientists long believed that this aggregation process was coordinated by specialized slime-mold cells, known as "pacemaker" cells. According to this theory, each pacemaker sends out a chemical signal telling other slime-mold cells to gather around it.

In 1970, Keller and a colleague proposed an alternative model, showing how slime-mold clusters can form without any specialized cells. In this model, every individual slime-mold cell emits a chemical signal and follows signals produced by others. The result: aggregation without a leader. Nevertheless, for the following decade, other researchers continued to assume that pacemakers were required to initiate aggregation. As Keller writes, with an air of disbelief: "The pacemaker view was embraced with a degree of enthusiasm that suggests that this question was in some sense foreclosed."

It is not altogether surprising that people have strong commitments to centralized approaches. Many patterns and structures in the world are, in fact, organized by a central designer. When we see neat rows of corn in a field, we assume correctly that the corn was planted by a farmer. When we watch a ballet, we assume correctly that the movements of the dancers were planned by a choreographer. When we participate in social systems, such as families and school classrooms, we often find that power and authority are centralized, often

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excessively so. These phenomena reinforce the centralized mindset.

Another important factor is the way people think about themselves. Your mind (like all others) is composed of thousands of interacting parts. But you experience yourself as a singular being. This is a convenient, perhaps necessary, illusion for surviving in the world. When you do something like paint a picture or organize a party, you feel as if you are playing the role of the central actor. Only one entity seems to be in charge: you. So people naturally expect most systems to involve a central authority.

By clinging to this centralized mindset to explain all phenomena, politicians, managers, and scientists are working with blinders on, focusing on centralized solutions even when decentralized approaches might be more appropriate, robust, or reliable.

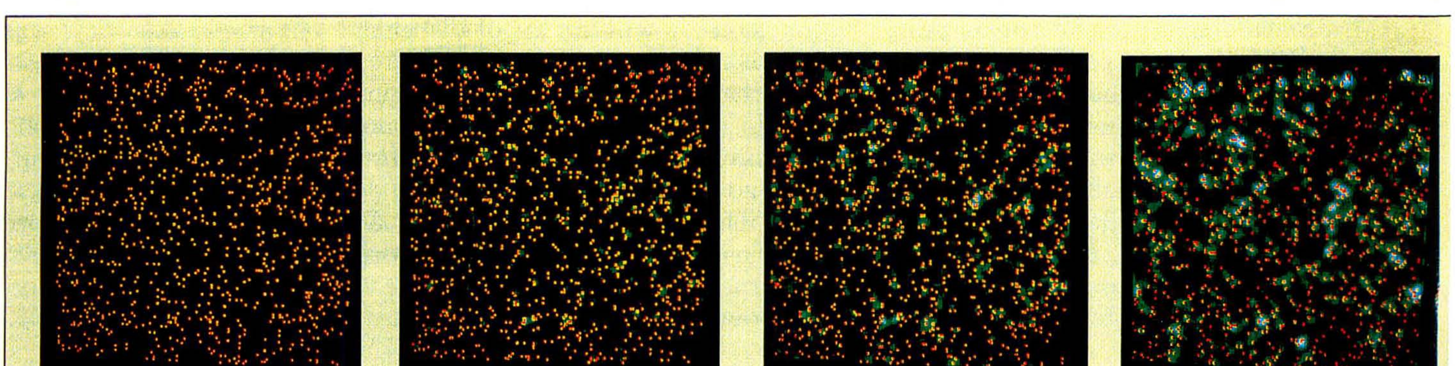
Decentralized Thinking Tools

To help people move beyond the centralized mindset and learn new ways of thinking about decentralized phenomena, I developed a new computer programming language called StarLogo. This language allows people to control the actions of thousands of graphic creatures on the computer screen. The user writes simple rules for the creatures and the environment in which they live and then observes the group behaviors that emerge from their interactions. For example, a user might write simple rules for individual birds, then observe how the flock behaves.

In one StarLogo simulation, inspired by the controversy over slime-mold aggregation, the artificial creatures follow two simple rules: they emit a pheromone (chemical attractant) and, after "sniffing" the local area, move in the direction in which the pheromone is strongest. At the same time, the environment causes the pheromone to diffuse and evaporate. With this simple strategy, the creatures quickly assemble into clusters. The reason: When a few creatures get near one another just by chance, they create a pheromone "puddle," which attracts even more creatures, making the puddle even bigger, and so on.

I have worked with several groups of high school students who have created decentralized "microworlds" using StarLogo. In one experiment, two students—Ari and Fadhil—wanted to study traffic jams. So they created a one-lane highway with a police radar trap to catch cars going above the speed limit. They then programmed each driver to follow three simple rules: If you come within two car lengths of the car in front of you, slow down. If no cars are within two car lengths ahead of you, speed up until you reach the speed limit. If you detect a radar trap (each car is equipped with a detector), slow down.

Both students expected that a traffic jam would form behind the radar trap, and indeed it did. As cars slowed down for the trap, the cars behind them were forced to slow down, creating a queue with roughly equal distances between the cars. When the cars moved beyond the trap,



nomic patterns arise not from a centralized authority but from haggling between millions of buyers and sellers in stock markets and marketplaces around the world.

they accelerated smoothly until they reached the speed limit.

I asked the students what would happen if they removed the radar trap. The cars would be controlled by just two rules: if you see another car close ahead, slow down; if not, speed up. They predicted that the traffic flow would become uniform; cars would be evenly spaced, traveling at a constant speed. When we ran the program, however, a traffic jam formed. Along parts of the road, the cars were tightly packed and moving slowly. Elsewhere, they were spread out and moving at the speed limit.

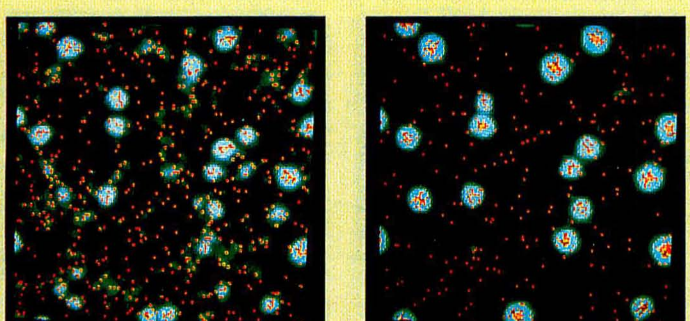
At first, the students were shocked. Their comments revealed the workings of a centralized mindset: They argued that traffic jams need some sort of centralized "seed," like a radar trap or accident, in order to form. They couldn't believe that simple interactions among cars could create a jam. But as they continued to experiment with the simulation—modifying the speed and starting positions of the cars—they developed an understanding of how the traffic jams formed. When a few cars, by random chance, happened to get near one another, they slowed down, making it likely that even more cars behind them would have to slow down, leading to a jam.

Another student, Callie, chose to use StarLogo to simulate the behavior of termites. Termites are practically blind, yet they are considered the master architects of the insect world. In fact, on the plains of Africa, termites construct giant moundlike nests containing intricate networks of tunnels and chambers. Many people assume that the queen of the termite colony tells the blind workers what to do. But, as in ant colonies, the queen is more of a mother to the colony than a leader. On the termite construction site, no one is in charge of a master plan. Rather, each termite carries out a series of relatively simple tasks, relying on its sense of touch and smell.

Termites are thus well suited for StarLogo explorations. Callie started with the following goal for her StarLogo termite colony: Termites should gather randomly scattered wood chips and put them into a few orderly piles. As with real termites, she didn't want to put one termite in charge. Instead, she programmed each termite to walk around randomly, obeying two simple rules: If you are not carrying anything and you bump into a wood chip, pick it up. If you are carrying a wood chip and you bump into another one, drop the chip.

At first, we were both skeptical that this decentralized strategy would work. The strategy did not prevent termites from taking wood chips away from existing piles. So while termites were putting new wood chips on a pile, other termites might be taking wood chips away from it. It seemed like a good prescription for getting nowhere. But we ran the program with 1,000 termites and 1,500 wood chips.

Much to our surprise, the number of piles steadily declined and the number of wood chips in each pile grew. After several program iterations—in each iteration every termite took a step or picked up or dropped a



A computer simulation shows that slime-mold cells (orange dots) can aggregate without a leader if they follow two simple rules. First, drop a pheromone (a chemical attractant shown in green) while wandering randomly. Second, while "sniffing" the area, move toward the strongest pheromone scent. When a few cells move near each other by chance, they create a pheromone puddle, prompting them to stay near the scent and release even more pheromone, thus attracting still more cells.

PHOTOS: ABOVE: COMSTOCK; BELOW: MITCHEL RESNICK chip—the wood chips had been gathered into hundreds of small piles. After 2,000 iterations, there were 100 piles with an average of 15 wood chips in each. After 10,000 iterations, there were fewer than 50 piles left, with an average of 30 wood chips in each pile. And after 20,000 iterations, only 34 piles remained, with an average of 44 wood chips in each pile.

The process was slow and frustrating to watch, as termites often carried wood chips away from well-established piles. But it worked. And as we watched the termites on the screen, it became obvious why this simple strategy is effective. Whenever the termites remove all the wood chips from a particular spot, the pile never restarts, since termites drop chips only where others already reside. The termites might drag chips back and forth between piles, but once a pile is gone, it is gone forever. So the total number of piles keeps shrinking.

Some Guiding Principles

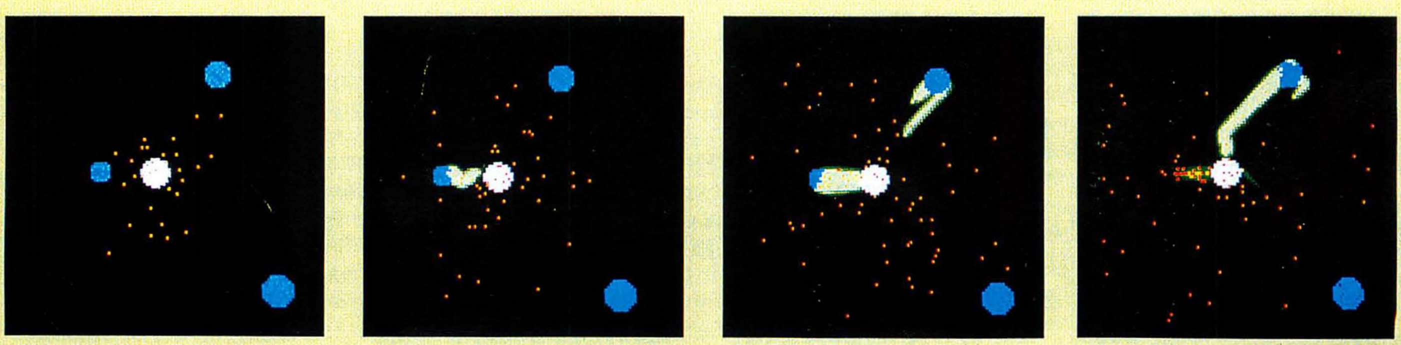
People are usually fascinated by such decentralized phenomena. But when they try to understand or create their own decentralized systems, they often slip back into centralized ways of thinking. Through my work with high-school students, I have developed several guidelines to help people make sense of decentralized systems, highlighting some pitfalls to avoid and some possibilities not to overlook. For example:

Positive feedback isn't always negative: Positive feedback is frequently symbolized by the screeching sound that results when a microphone is placed near a speaker. It is usually viewed as destructive because the situation often spirals out of control. By contrast, negative feedback is often symbolized by a thermostat that keeps room temperature at a desired level by turning the heater on and off as needed. It is thus considered useful because it keeps conditions under control. When I asked high-school students about positive feedback, most were unfamiliar with the term. But when I explained what it meant, the students quickly generated examples, most of which involved a loss of control, often with destructive consequences. One student talked about scratching a mosquito bite, which made the bite itch even more, so she scratched it some more, which made it itch even more. Another student talked about stock-market crashes: a few people start selling, which makes more people start selling, and so on.

Despite these negative connotations, positive feedback often plays a positive role in decentralized phenomena. Brian Arthur, an economist at the Santa Fe Institute, points to the geographic distribution of cities and industries as an example of a self-organizing process driven by positive feedback. After a small nucleus of high-technology electronics companies started in Santa Clara County south of San Francisco, an infrastructure developed to serve the needs of those companies. That infrastructure encouraged even more electronics companies to locate in Santa Clara County, which encouraged the development of an even more robust infrastructure. And thus Silicon Valley was born.

Randomness can create order: Like positive feedback, randomness has a bad image. Most people think randomness simply makes things disorderly. They view randomness as annoying at best and destructive at worst. But randomness plays a crucial role in many self-organizing systems by creating fluctuations that act as natural seeds from which patterns and structures grow.

At concerts or sporting events, for example, spectators sometimes join together in seemingly spontaneous synchronized clapping. How do they coordinate their applause without a conductor? Initially, when everyone starts clapping, the applause is totally unorganized. Even people clapping at the same tempo are wildly out of phase with one another. But through some random fluctuation, a small subset of people happen to clap at the same tempo, in phase with one another. That rhythm stands out, just a little. People in the audience sense this emerging rhythm and adjust their own clapping to join

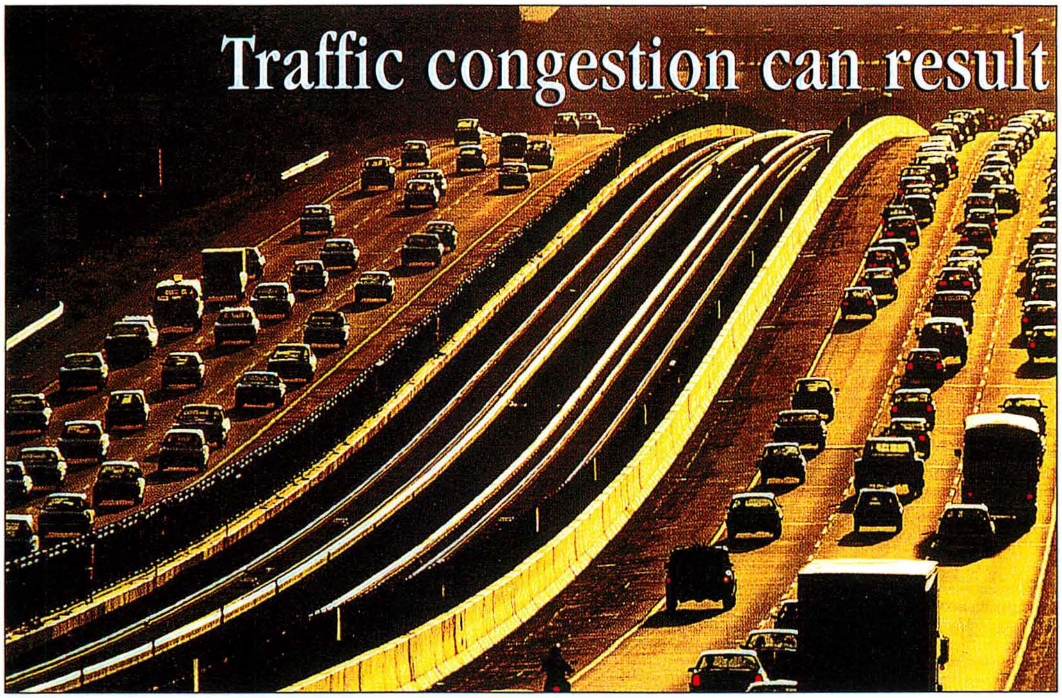


ANTS (ORANGE DOTS) WANDER RANDOMLY FROM THEIR NEST (WHITE) TO FIND FOOD (BLUE).

ANTS FIND CLOSEST FOOD, THEN LEAVE A PHEROMONE TRAIL (GREEN) AS THEY RETURN TO NEST.

AS FOOD NEAREST THE NEST DWINDLES, ANTS LOCATE THE NEXT CLOSEST FOOD SOURCE.

PHEROMONE TRAIL TO DEPLETED FOOD SOURCE EVAPORATES. PATH TO SECOND SOURCE WIDENS.

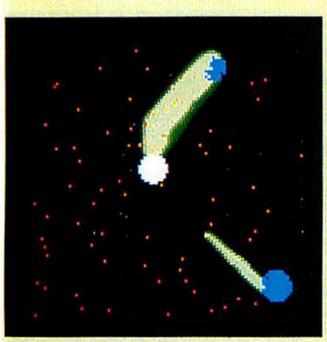


Traffic congestion can result from random interactions among individual vehicles, even in the absence of impediments such as an accident, a radar trap, or hordes of rush-hour commuters.

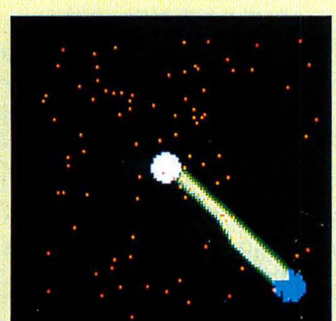
it. The emerging rhythm thus grows stronger and even more people conform to it. Eventually, nearly everyone in the audience is clapping in a synchronized rhythm. Amazingly, the whole process takes just a few seconds, even with thousands of people participating.

A traffic jam isn't just a collection of cars: It is fair to think of most objects as a collection of particular parts. For example, a particular chair might have four particular legs, a particular seat, and a particular back. But this is not so with objects like the termite wood-chip piles. The composition of the piles is always changing, as termites take away some wood chips and add other wood chips. After a while, few if any of the original wood chips might be in the pile, but the pile is still there. The wood-chip pile is thus an example of an "emergent object"—it emerges from interactions among lower-level objects. Similarly, a traffic jam is an emergent object, continuing to exist even though the composition of cars within it is always changing.

Students often have difficulty thinking about emergent objects. For example, two students, Frank and Ramesh, tried to use StarLogo to simulate an ant cemetery, in which ants gather their dead colleagues into neat piles. This problem was virtually identical to that of programming termites to create wood-chip piles. But Frank and Ramesh resisted the simple decentralized approach that Callie used for the termites. They were adamant that dead ants should never be taken from a cemetery once placed there. How can a cemetery grow, they argued, if the dead ants in it are continually being taken away? With this strategy, however, Frank and Ramesh ended up with lots of little cemeteries rather than a few big ones, simply because a cemetery, once started, could never disappear. If Frank and Ramesh had viewed the cemetery as an emergent object and allowed the composition of ant cemeteries to vary with



TRAIL TO THE MOST DISTANT FOOD BEGINS TO FORM AS THE SECOND FOOD SOURCE DISAPPEARS.



AS THE LAST LOCAL FOOD SOURCE IS DEPLETED, THE ANTS CONTINUE THEIR RANDOM FORAGING.

This simulation shows how ants seem to use a sophisticated foraging strategy—gathering food closest to the nest first and that farthest from the nest last. In fact, each ant follows a few basic rules: If an ant finds food, it leaves a pheromone scent as it walks back to the nest. If other ants sense the pheromone, they follow it to the food, thereby reinforcing the trail. When a food source is depleted, ants no longer drop pheromone, and the trail quickly evaporates.

PHOTOS: ABOVE: COMSTOCK; BELOW: MITCHEL RESNICK time, they would have had much greater success in creating large ant cemeteries.

The hills are alive: In his book *Sciences of the Artificial*, Herbert Simon, a Nobel laureate economist from Carnegie Mellon, describes a scene in which an ant is walking on a beach. Simon notes that the ant's path might be quite complex, but it does not necessarily reflect the complexity of the ant. Rather, it might reflect the complexity of the beach. Simon's point: don't underestimate the role of the environment in influencing and constraining behavior.

Many people seem to resist the idea of an active and influential environment. For example, when I told a student about a StarLogo program in which ants find food by following pheromone trails, he was worried that the trails would continue to attract ants even after the food source at the end of the trail had been fully depleted. In his mind, the ants had to take some positive action to get rid of the pheromone. In fact, he proposed an elaborate scheme in which the ants, after collecting all of the food, deposited a second pheromone to neutralize the first pheromone. It didn't occur to him that the first pheromone would simply evaporate away.

Foundation for Discovery

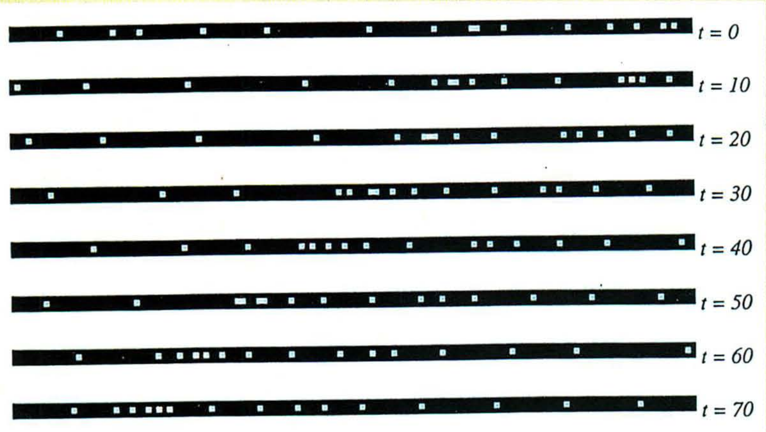
A friend of mine has a daughter named Rachel. By the time she was three years old, Rachel had already developed a theory about why it rains on some days and not on others. "The clouds rain when the thunder tells them to rain," she explained. In her mind, some type of centralized decision making was necessary. Thunder commanded, and the clouds obeyed.

It is not surprising that Rachel came up with a centralized explanation for the rain. Most likely, she was unaware that other types of explanations even existed. But as Rachel grows up, will she continue to rely on centralized explanations? If she takes a physics course in high school, will she understand gravity as two objects pulling on one another with equal force, or will she think of gravity as a one-way force, with one large object pulling on a smaller one? If she takes an economics course in college, will she understand that interests rates and money supply can affect each other, or will she assume that one is the cause and the other is the effect? If the unemployment rate rises dramatically, will she search for explanations with multiple, interacting causes, or will she immediately assume some type of evil conspiracy?

An elementary or high-school course that teaches Ten Golden Rules of Decentralized Thinking probably would not have much effect on someone with a firmly entrenched centralized mindset. Young students are likely to become comfortable with decentralized ideas only if they get opportunities to design, create, explore, and play with decentralized systems.

What's needed are computer-based construction kits that let children like Rachel create their own decentralized microworlds. At school, Rachel might create an artificial environment with giraffes, elephants, and her other favorite animals and program each to follow a few simple rules. She could then observe what patterns emerge from the interactions and how simple changes can affect the entire ecosystem. At home, she and her friends might simulate how people gather into groups at a party. By working on projects like these, Rachel could come to understand the importance of decentralized ideas in explaining the world around her.

By the time Rachel was four, she had developed a new theory about the rain. "The clouds get together at night, and they decide whether it should rain the next day," she explained. This new theory still involves some centralized planning, but there was no longer a central actor, the thunder, in charge of the whole process. If Rachel is surrounded by new types of computational tools and ideas as she grows, one can only wonder what new theories she'll develop to explain the rain. ■



Traffic congestion can occur without obvious impediments, as this simulation illustrates. Each car (white dot)—shown as it travels from left to right—follows two rules: If it sees a car close ahead, it slows down. If not, it speeds up. As time elapses, jams appear (and move right to left) because whenever a few cars happen to converge, they slow down, causing the cars behind them to slow down as well. A jam would not occur if all cars were evenly spaced and traveling at exactly the same speed.