MEETING BRIEFS

Artificial-Life Researchers Try to Create Social Reality

Some scientists, among them cosmologist Stephen Hawking, argue that computer viruses are alive. A better case might be made for many of the self-replicating silicon-based creatures featured at the fourth Conference on Artificial Life, held on 5 to 8 July in Boston. Researchers from computer science, biology, and other disciplines presented computer programs that, among other things, evolved cooperative strategies in a selfish world and recreated themselves in ever more complex forms.

The Artifice of Cooperation

Altruism is a difficult fact of life to explain. After all, selfishness, from an evolutionary point of view, seems to have so much going for it: The animal that grabs the most resources—food, for instance—would appear to stand a better chance of surviving and passing on its genes than does a less selfish neighbor. "In a world based on survival of the fittest," says University of Oxford biologist Martin Nowak, "you would expect to see animals just competing."

But as Nowak has seen, cooperation often rears its mysterious head. Observations of unrelated chimpanzees feeding one another and other instances have spawned a vast body of research by zoologists, anthropologists, and the like. But among the artificial-life crowd, computer models offer a way to speed up evolution enough to see cooperation emerge before researchers' eyes. For 20 years, computer modelers have been devising ever more sophisticated simulations. And at the Artificial Life conference, researchers reported on the digital evolution of cooperation seen by pitting scores of artificial players against one another in a game called "prisoners' dilemma." One group showed how cooperation stands a better chance of arising spontaneously when some players can choose not to play the game at all.

The game allows "players" to reproduce and their strategies to evolve over many generations. As long ago as the 1970s, political scientist Robert Axelrod of the University of Michigan began to pit populations of players with different strategies (never cooperate, always cooperate, and other variants) against one another in repeated rounds of a computer tournament. The life analog was to prisoners: You and a partner in crime are sitting in separate prison cells, and someone offers each of you a reduced sentence if you inform on the other. You don't know your ex-partner's intentions, so you have to decide by yourself. Cooperating by staying silent offers the best deal for the pair, but ratting if your partner stays silent will get you off nearly scot-free and send your partner up the river. Of course, the reverse is also true.

On screen, Axelrod set this up as follows: In a single encounter, if both players cooperated, they got a medium-sized reward of, say, 3 points. If one defected and the other cooperated, the defector got a bonus of 5 points, and the cooperator got zero. If both defected, they each got the smallest reward: 1 point. The best players—those with the most points after one round—reproduced themselves so more of them would play in the next round.

Although cooperators could sometimes gain the upper hand in these tournaments, the players that did the best offered a more guarded strategy, known as "Tit for Tat." Players would cooperate until someone else defected on them, and then they would retaliate by defecting on the next move.

But researchers began to realize that real life offered yet another option in encounters: refusing to play with undesirable partners. This notion was first introduced to the prisoners' dilemma last year by mathematician Ann Stanley of Iowa State University. Allowing players to refuse certain partners, she found, encouraged more cooperation than people had seen in the more restrictive form of the game.

Philosopher Philip Kitcher and computer scientist John Batali of the University of California at San Diego added an "opt out" move to a simpler version of the game to solve another problem. They noticed that cooperation could only come about if, by chance, a large enough number of players started out cooperating early in the game. If too many players started out playing a selfish strategy—always defecting on one another—then cooperation would never evolve. Trouble was, in offspring, any new player trusting enough to offer cooperation was trounced by the defectors.

Enter Kitcher and Batali's "optional prisoners' dilemma." They started with a group of players employing completely random strategies. Sometimes the defectors did better than nearly anyone else did and took over the population. But the new option—opting out—won a player more points against a defector than defecting back. If a few individuals decided to opt out, they began to win points and proliferate. "If you live in a nasty world, go off and live in the woods," says Batali. After 100 generations, Batali noted, "the defectors get driven out not by being beaten but just by the fact that no one will play with them." Eventually, the field becomes dominated by players who continually opt out—Batali calls them soloists. Once this happens, cooperators start to come back. Of course, that left room for a resurgence by the defectors, and a cycle began.

Oxford's Nowak believes further work with the prisoners' dilemma, though it's still simpler than the natural world, does have the potential to reveal the development of social cooperation. And Axelrod notes that opting out is a step in this direction, a strategy that can apply "anywhere you have choice over who to interact with or where you choose your territory." In other words, it's truly artificial life with a dose of reality.

Art Imitates Life

At the end of his talk to the Boston audience, biologist and graphic artist Karl Sims of Thinking Machines Corp. showed one of his animated cartoons. It wasn't exactly Rocky and Bullwinkle, but the 10-minute video did raise a few laughs as robotlike creatures wobbled around and fought awkward battles over a stationary cube. If the creatures didn't look very lifelike, their behavior as time passed was another matter. Each creature began as two or three simple shapes drawn by a computer program. But with a little nudge from the computer's version of natural selection, they evolved into more physically and behaviorally complex beasts.

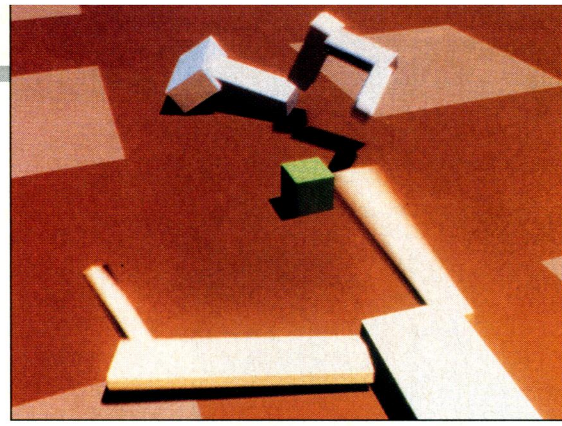
Yes, others have made life-evolving computer programs, but Chris Langton of the Santa Fe Institute in New Mexico, who coined the term "artificial life," says that Sims' progeny are the first that illustrate possible paths by which evolution can give rise to sophisticated forms and actions. Like living things, they can reproduce. And each time they do, random "mutations" in the code introduce novel offspring and, over time, more complex entities evolve from simpler ones. Langton calls it "a whole rich biology; a world that would allow us to study all aspects of life." In particular, the program allows researchers to examine the evolution of behavior, something that is very difficult to tease out of the fossil record.

Of course, you can't have evolution without a means of natural selection. Sims' program favors creatures that are able to approach a cube. Reproduction privileges are granted to the winners of a series of one-on-one battles over this prize. Sims starts by programming a parallel supercomputer to randomly animate simple forms made from two or three connected blocks. By chance, one proto-creature gets a mutation that makes it twitch a little bit toward the cube. That individual would then reproduce itself, and thus any mutation that gets a creature closer proliferates.

After 100 generations, some creatures developed long "bodies" that could fall on the cube, "arms" that could bat away competitors, and any number of types of "pincers" or "claws" that could grab hold. They also started creeping, crawling, and hopping around the screen.

Sims realized at the outset that he would have to give the creatures environmental constraints and programmed into the simulation some relevant laws of physics—gravity and friction, for instance. But he made a mistake with the law of the conservation of momentum and soon found some of his creatures were moving by kicking themselves. Sims, kicking himself, corrected the error, and evolution proceeded apace.

–Faye Flam



K. SIMS/THINKING MACHINES CORP.

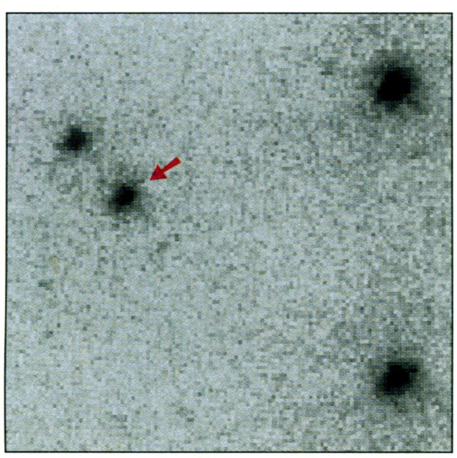
Give my creatures life! These animated entities evolved complex form and function on their own.

ASTRONOMY

Do Tides Power Black Widow's Mate?

The female black widow spider has achieved notoriety for devouring her mate, and such conjugal homicide inspired astronomers to name a star discovered in 1988 the Black Widow pulsar—because they believe the star is boiling away its nearby companion. In a paper to be published in November, two investigators from Columbia University now suggest that the Black Widow's unfortunate mate derives its energy from tides—the irregular flow of stellar gases caused by the neighboring pulsar's strong gravity.

That would be a first, since all other known stars are thought to be powered by nuclear fusion. As the companion has aged and lost mass, contends Columbia theoretical astrophysicist James Applegate, "it slowly switched from nuclear power to tidal power." If true—the jury is still out—this unusual energy source could then help explain some puzzling steps seen in the orbital dance between these two stars.



A. FRUCHTER/STSCI

Holding on to life. While the Black Widow pulsar *(not shown)* is destroying its companion star *(arrow)*, the pulsar's gravity may create the companion's energy.

Objects like the Black Widow pulsar are spinning neutron stars from which astronomers detect regular pulses of radio waves. When it was discovered in 1988, astronomers noticed that the signals from this pulsar, located some 5000 light-years away, disappeared for 50 minutes every 9 hours. They concluded that the pulsar's fierce radiation was gradually evaporating gaseous layers of the companion star, creating a stellar wind that trailed behind the companion and periodically blocked the Black Widow's radio pulses. Eventually, it is thought, this process will destroy the companion completely, a fate that not only gave the system its morbid name but also explained why some similar pulsars had no companions: They had already finished their meals.

In recent years, attention has partly shifted from the death of the companion to its orbit around the pulsar. To the puzzlement of everyone, says Princeton University radioastronomer Zaven Arzoumanian, the companion "went from spiraling in to spiraling out to spiraling back in now." He, Princeton colleague Joseph Taylor, and Andrew Fruchter of the Space Telescope Science Institute gave the latest report on these orbital changes in the 10 May *Astrophysical Journal Letters* and suggested that a theory used to explain similar variations in other star duos might also explain these unexpected motions.

The theory, first put forth by Applegate in the late 1980s, argues that magnetic fields within a star can distort its shape, producing changes in its gravitational fields and, in turn, affecting how it orbits around another star. But applying this notion to the pulsar's companion was problematic, because magnetic fields are generated by convection, an internal flow of energy within a star. Convection requires a strong energy source, and the standard energy source in a star—nuclear fusion—requires a lot of mass. The Black Widow's companion was much too small: It is only 25 times the mass of Jupiter and was thought to be white dwarf, a star that no longer generates new energy.

In the upcoming November issue of the *Astrophysical Journal*, Applegate and his colleague Jacob Shaham come to the theoretical rescue. They claim there is an alternative energy source available to the companion. The much more massive Black Widow has a huge gravitational pull, which should exert changing tidal forces on the companion as that star rotates. Those forces could slosh gaseous material around within the star, producing internal friction that becomes heat. This heat would then drive convection, producing the magnetic fields necessary for Applegate's theory of orbital variations.

Over time, the neutron star's immense gravity would normally "lock" the rate of the companion's rotation, so that the companion always offers the same face to the pulsar—as the moon offers but one side to Earth. The tidal forces on the companion would then be unchanging, material within the star would stop moving, and the energy source would stop. But Applegate and Shaham argue that the companion's stellar wind interacts with the star's magnetic field, producing a torque that jiggles the star's rotation and prevents it from ever locking in.

This is an awful lot of theorizing, and other astronomers, though intrigued, say facts may still get in the way. Some suggest it is still impossible for a star the size of the pulsar's companion to produce a large enough magnetic field for Applegate's complex orbital mechanism to work. "How you excite a very big field in a low-mass companion is not clear," says Princeton theorist Marco Tavani, who has an alternative theory in which the varying direction of the companion's eclipsing solar wind causes orbital swings.

Astronomers are trying to provide one check of the new theory. In addition to the bright glow caused by the pulsar heating part of its surface, the companion should have an intrinsic luminosity about one-thousandth that of the sun, if tides do provide it with energy. Recent pictures from the Hubble Space Telescope haven't resolved that issue, however. Fortunately, this celestial Black Widow should take eons to finish off her mate, allowing plenty of time for further study.

–John Travis