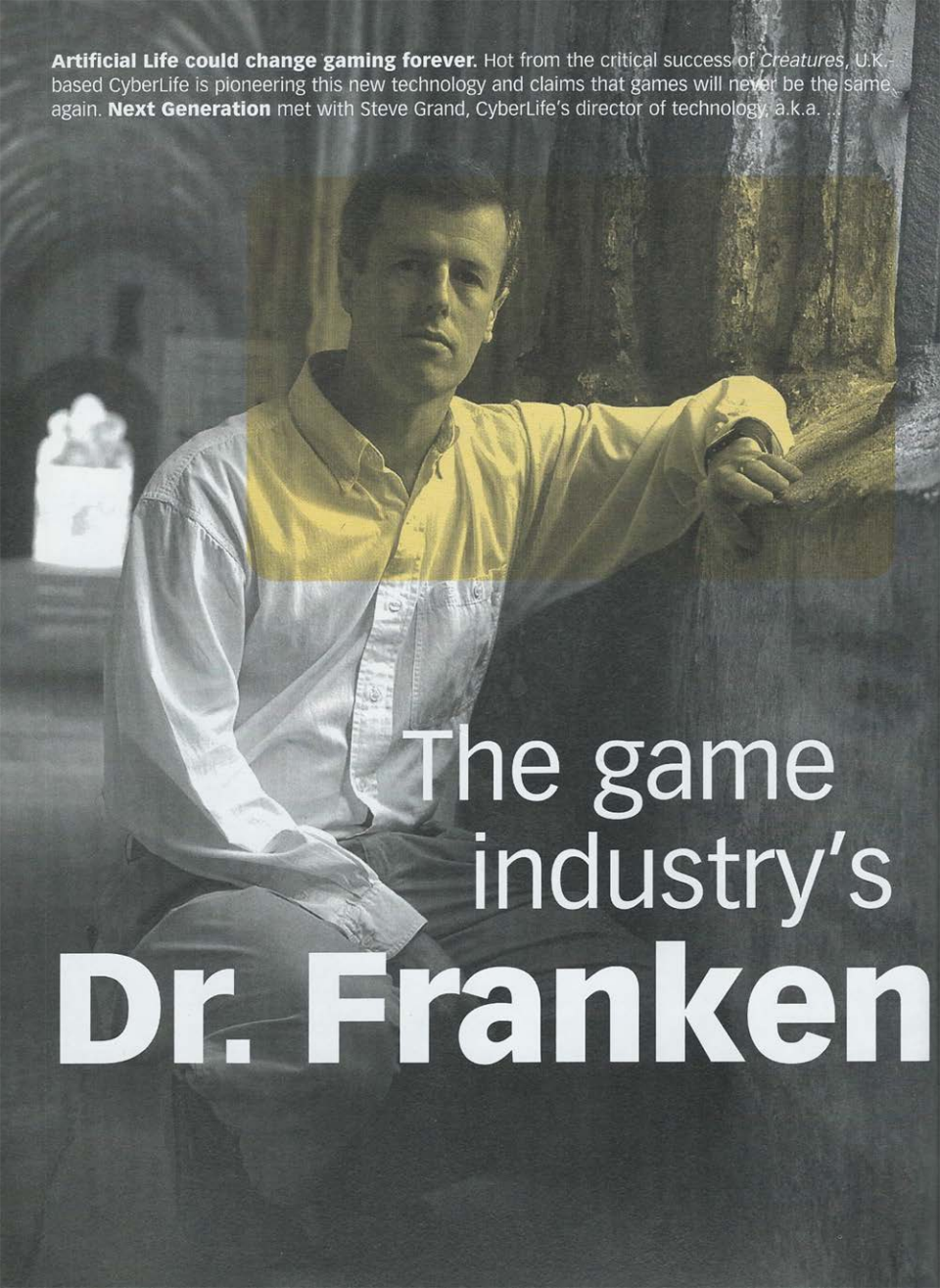
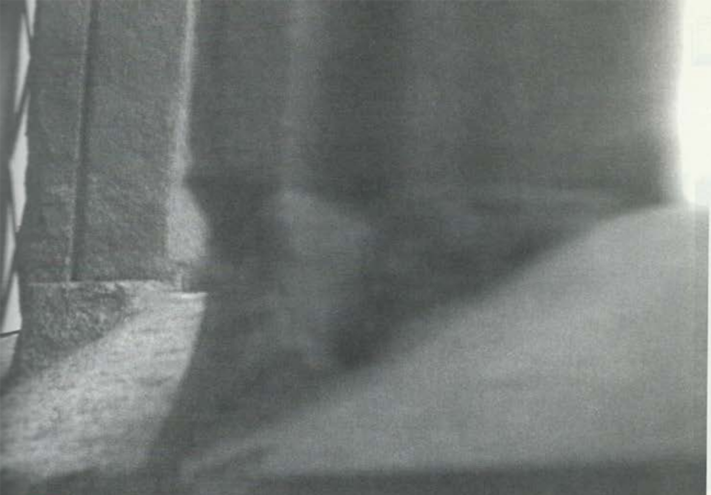
Artificial Life could change gaming forever. Hot from the critical success of *Creatures*, U.K.-based CyberLife is pioneering this new technology and claims that games will never be the same again. **Next Generation** met with Steve Grand, CyberLife's director of technology, a.k.a. ...



The game industry's Dr. Franken



During the final stages of the development of *Creatures*, strange things started happening. The game (published by Mindscape) is kind of a complex Tamagotchi, in which the player has to guide little critters called Norns around the game world, helping them learn about their habitat, survive, and evolve (see review page 206). One day, a play tester went to lunch, leaving the game running on his PC with just one solitary Norn wondering about. He came back from lunch to find the game world full of Norns squabbling with each other. Where the hell had they come from?

It turns out the solitary Norn had worked out — all by itself — that if it picked up Norn eggs and threw them in the incubator, out would pop a friend. This made it happy. It then spent all its subsequent time scouring the world for eggs and placing them in the incubator.

The salient point of this story being that no one at CyberLife knew that this would happen. No one programmed this behavior. It was a complete surprise. Except, of course, that it wasn't. Because when you're dealing with Artificial Life, you have to expect the unexpected ...

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What is Artificial Life?

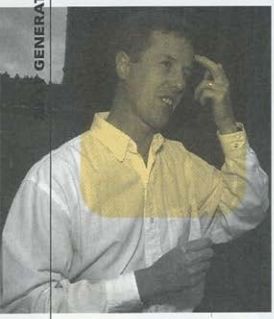
NG: Most gamers are already familiar with Artificial Intelligence (AI). In a common gaming context, artificial intelligence is "given" to a game world or a computer character in an attempt to make it appear lifelike or human. So what is Artificial Life (AL), and how does it differ from AI?

Steve: To an Artificial Intelligence person, the pinnacle of success would be to create a machine that plays chess. They think that because human beings find it hard to play chess, playing chess must be a very intelligent thing to do, and so that's what they try to achieve. However, if you drop a chess computer in the bathtub, it isn't smart enough to call out for help or find a way out. So, if you ask me, it's not very intelligent.

NG: So what's the AL approach?

Steve: Artificial Intelligence and Artificial Life take two completely different approaches to the problem of recreating lifelike intelligence and behavior. On the one hand, AI attempts to model and replicate specific areas of behavior of very complex systems (such as human beings) without regard to the underlying structure that makes them what they are. On the other hand, AL people would consider the intelligence of a rat to be an ambitious goal and set about trying to model the underlying structures that make up rats — almost like trying to replicate a rat from the ground up — in the belief that genuine ratlike intelligence will eventually emerge from the system.

NG: [illegible]



prepares for a holiday in France by learning a few French phrases, parrot fashion, and someone who actually sits down and learns the language from scratch. The first person may appear to achieve the more immediately impressive results, but in the long term, the second person will prevail. In theory, at least.

Steve: AI is a top-down approach to the problem — it tries to control the system and mimic effects. Whereas Artificial Life is a bottom-up approach — it tries to recreate the cause of the behavior, the underlying structures of whatever life-form is being simulated, and let the behavior occur naturally as a result.

NG: And in this way, you will achieve superior results to a solution based on AI?

Steve: It is the only way to create truly lifelike behavior, yes. If you approach the problem in the normal AI way and try and mimic behavior without considering or replicating the processes that determine this behavior, you end up fudging all the time. You end up bolting on rule after rule to try and explain all the little quirks. In this way, most attempts to create lifelike behavior using AI suffer from immense complexity problems and eventually programmers just give up.

If you drop a chess computer in the bathtub, it isn't smart enough to call for help

NG: As more and more AI routines are added in an attempt to get more and more sophisticated behavior, programmers find themselves constantly having to wallpaper over cracks ...

Steve: Exactly. And the user is not fooled. It's obvious that the people you shoot in *Doom*, for example, are not real people, and no matter how hard you try with the AI approach, you will never be able to fool people.

NG: So AL is the best long-term way to mimic lifelike behavior, even though — at this stage — it is still in its infancy?

Steve: Obviously, at this stage you can't expect AL to achieve everything you want. Your Artificial Life won't immediately be able to play chess, for example. But the belief is that eventually and way down the line, it may learn how to play for itself.

A core philosophy is that only by following the same evolutionary route that real life took will we ever be able to achieve intelligent systems at a human level. And because AL is still such a new science, it is a necessary step to start off with something like rats and then work upwards.

Building the beast

NG: So implementing this theory, how do you start work on creating AL?

Steve: If you're attempting to create some kind of artificial animal life — say a rat or a monkey — you would try and recreate the way its brain works. An animal brain is a neural network — a network of neurons, which are relatively simple processing structures, wired together in very complicated ways. The behavior of the brain is the result of the wiring and not some smart, central neuron somewhere that understands things. It's a parallel system, as opposed to, say, a computer that is a serial machine handling one task at a time.

NG: So it's the way these individual neurons interact and are wired together — the structure of this neural network — that results in an animal's behavior?

Steve: Right. Compare it to an ants' nest. Individual ants are very stupid, but a colony of ants can make extremely complex mounds with tunnels and so on, even though there are no little architect ants who know the plans and are telling the others what to do. The mound is simply the result of a lot of little ants doing their own thing, guided by very simple rules.

If you look at human beings, we are made up of about one trillion little cells. Each cell is very simple, relatively speaking — it just does a few things. So you have a trillion little cells in your body doing very simple jobs. Not one of them's in charge. Not one of them even knows what all the other cells are there for or what they do. And yet the whole thing fits together and works as an extremely complicated single machine.

Brains based on neural networks work in a very similar way.

NG: And if you can model that neural network on a computer, you can effectively recreate the processes that result in complex animal behavior?

Steve: And at that point you have Artificial Life, yes.

Origins of Artificial Life

NG: How did Artificial Life first begin?

Steve: Artificial Life really started in 1987 when Dr. Christopher Langton organized a conference in Los Alamos. He'd discovered that there were a lot of scientists and researchers working with common goals in different areas, but that up until this conference, these people weren't even aware of each other's existence. They certainly weren't talking together.

NG: So what kinds of things were all these people working on?

Steve: For example, there were people working on self-replicating systems, people working on complexity theory, and people working in various fields that were more akin to massively parallel biological systems than the traditional serial computer fields. Fundamentally, all these people were working on complex adaptive systems — such as economic systems, in which thousands of individuals acting autonomously create trends — and he realized that all these projects shared a common fundamental premise, and this was the start of Artificial Life.

NG: Was Artificial Life given an official definition?

Steve: Yes, Dr. Langton offered that "Artificial Life is the study of man-made systems that exhibit behaviors characteristic of natural living systems. It compliments the traditional biological sciences concerned with the analysis of living organisms by attempting to synthesize lifelike behaviors within computers and other artificial media. By extending the empirical foundation upon which biology is based beyond the carbon-chained life that has evolved on earth, Artificial Life can contribute to theoretical biology by locating life as we know it within the larger picture of life as it could be."

NG: "Life as it could be"? That's an interesting suggestion ...

Steve: The assumption has always been made that life is what we see. If you asked a biologist 50 years ago — or even now, sometimes — how to define life, he or she would come up with a definition in which a lot of the criteria were only applicable to carbon-based life because this is the only type of life we know. Life-forms on earth — plants, animals, fish — all happen to be made of carbon, and so far we haven't seen any little green men who were made out of silicon.

But life doesn't have to be regarded in this narrow way. The concept of life itself can be extended, and by trying to extract the central principles of life and ignoring the carbon — ignoring the detailed chemistry of life as we happen to know it on earth — we can establish what it is about life in general that makes life so much more interesting than nonlife.

NG: So you're arguing that life isn't necessarily restricted to carbon-based plants and animals, and may in fact exist in all manner of other forms. That's a revolutionary idea ...

Steve: You have to come to terms with a view of life that is not absolute. I believe that there is no such thing as "being alive" or "not being alive," but certainly some things are more alive than others. Maybe a thunderstorm is more alive than a brick, for example. And not only are some things more alive than others, but they can be alive in different ways — so life is not just a one-dimensional continuum.

NG: So what things that most people would consider "dead" — or at least "without life" — might in fact be alive?

Steve: When you start looking at the world in this way, all sorts of phenomena — such as economies or weather systems — show some characteristics of living systems. What's more, there doesn't appear to be any kind of particularly important cutoff point where you can say that "these things are really alive" and "these other things really aren't alive."

NG: So are the life-forms in *Creatures* really alive?

Steve: I would argue that my creatures lie somewhere where you would put that cutoff point if you were determined to put one. Certainly, I think it's a very interesting — and valid — question whether or not the creatures are really alive. [Smiles].

I believe that there is no such thing as "being alive" or "not being alive"

Creatures, creatures, everywhere

NG: So how did the *Creatures* project get started?

Steve: About five years ago I had an idea for a game involving a whole artificial world in which you looked after a computer pet. This was before there were any other computer pets and before I'd thought much about Artificial Life. I saw this game as a small, six-month project. As I said, this was five years ago. [Smiles].

But then I realized that people wouldn't care about these computer pets unless they believed in them — unless they believed that they were alive. This, then, became my goal. I realized that no one would react with emotions to what they knew was just a sprite walking around on screen according to an algorithm, so it soon became obvious that a standard kind of rule-based system was never going to come up behavior-rich enough.

NG: So where did this lead you?

Steve: Once I'd committed myself to creating believable, rich behavior, I thought I'd start out with the idea of a neural network. It just so happened that I'd been studying neural networks and so I kind of knew where to start. I thought it would be fairly easy, and as

it turned out, it wasn't too hard. I went and sat on top of a hill for a week and figured out how to get it up and running and came up with a mechanism that I thought would work. I programmed it, it worked, and I got the rich dynamics from it that I wanted.

NG: So you're saying that the *Creatures* project was easy?
Steve: No, not at all. [Laughs]. As it turned out, the initial neural network was just the start of a very slippery slope, and as I decided to add yet more and more realism to the game world, things got very, very complicated. Over the course of development I added to the creatures much, much more detail, including a digestive system, an immune system, and a drive-based punishment/reward system. All of these were based on accurate biochemistry models — so, once again, I'm not trying to mimic behavior but recreate the systems and biochemical makeup of real living things. I also added bacteria into the game world (bacteria that were capable of mutating into different strains) and even a reproductive system.

Computer games as we know them will be a relatively short-lived phenomenon

NG: At what point did you say, "enough is enough" and wrap up the project?
Steve: The company had given up all hope of ever publishing the game, but I went back to the drawing board for the third time and finally added genetics. So instead of programming in all of the biochemical and neural structures that made up the creatures, instead I programmed a model of genetics in which genes cope with these things — I took it yet another step further down the ladder.

In other words, there is nothing in the program that knows about being a creature. The program only knows about being a neuron or being a biochemical, and then it is the genetics that tells the program how to be a creature.

NG: And that is the stage at which the project was completed?
Steve: There was just one more thing. Because I had a reproductive system, it was a fairly simple matter for these creatures to breed. Now, because the game was based on genetics, the creatures could pass their genes from parents to offspring and cross over, and mutation could happen. And that's how a million or so creatures got released into the world and are now capable of evolution and potentially much better brain models than I was smart enough to think of.

NG: And all without any further input or programming? They can simply evolve themselves?
Steve: Yes, and they will continue to do so.

Life, but not as we know it

NG: So just how complicated are these creatures? If you were to compare them to "real" life, what animals would you compare them to?
Steve: They are different ... it's difficult to answer. For example, they can speak, not in a sophisticated way like we do, but then no other animal can speak, so in that sense they are very sophisticated. The psychological model that I used to design their brains is taken from the kind of behaviors of rats, so we're kind of at the rodent level.

NG: But surely a rat — compared to, say, an ant or a slug — is a very complicated animal?
Steve: Oh, absolutely. But of course in the virtual world you can cheat. In real life a large proportion of a rat's complexity is devoted to moving it around in physical space. To move a rat around involves hundreds of coordinated muscles, but we didn't have to bother about any of them. To move one of my creatures around a TV screen is a lot easier.

NG: One of the things that most people find hard to accept about *Creatures* is that some of the Norns' behavior can't be explained. But because they have no preset behavior rules, and everything they do is a natural consequence of their genetic makeup, unpredictable behavior has to be expected, right?
Steve: Right, and it's quite a scary thing. It's a very complicated thing, and I had no idea that my model would result in the kind of behavior that we see. Occasionally, people ask me to explain why Norns do certain things and I have no idea. I try to work it out, but I can't explain all the steps as to how it actually happened.

You have to learn to let go, and again, this is one of the big differences between Artificial Intelligence (in which you attempt to have complete control over everything) and Artificial Life (in which you just have to sit back and see what happens).

Playing with Artificial Life

NG: So is *Creatures* state of the art as far as Artificial Life is concerned?
Steve: So I've been told. I've spoken about it at various universities and scientific conferences now —

usually to wild applause. And everyone's very impressed.

NG: So what are the implications for games? Do we really need AI? Can't AI provide enough different options and fake behavior to the extent that we can't tell they're not real?

Steve: No, humans will always be able to tell the difference, and already computer games have reached the limits of what can be done with AI. Already game programs are too complex and no one is making any real progress. Currently, the robustness of programs is weak, project schedules always slip, and bugs are untraceable — traditional, serial computer science is reaching its limits.

Artificial Life is truly the way forward to achieve "realism." Take a soccer game, for example. They're great fun, but the players don't behave realistically. In theory, there's no reason why we shouldn't model Artificial Life forms of soccer players and have realistic behavior on a soccer field be the consequence.

NG: So will game programmers be able to plug in Artificial Life solutions to their existing programs?

Steve: Yes, it's possible, but it would be better in the long term to start completely from scratch and base all virtual worlds (and games based on such worlds) on this kind of Artificial Life technology. Again, it's working from the bottom up as opposed to the top down.

NG: So what's next for CyberLife after *Creatures*?

Steve: Our long-term goal is based on the assumption that computer games as we know them will be a relatively short-lived phenomenon. As all media tend towards integration online, entertainment will move into being virtual worlds that people want to go and play in. So the future of the entertainment industry is in creating virtual worlds online. Now, the existing game and graphics industry is very good at creating 3D models of what these virtual worlds look like, but the better the graphics get, the more embarrassing the lack of richness in the world's behavior becomes. And I am interested in providing that richness. I am interested in making it a real world.

NG: And Artificial Life will provide this richness?

Steve: Absolutely, but that's not all it can do. The other problem with virtual worlds is that in them everyone wants to be the hero. And yet there has to be people to do the dirty work. Someone has to be the barkeeper, the streetcleaner, and yes the cannon fodder for humans to command. No human will want to play these roles, and yet without these characters, the world will appear sterile and unlifelike. The only way to solve this problem satisfactorily is with Artificial Life.

NG: So what's the next step?

Steve: A long way down the line, we've got to be looking at Artificial Life that is as intelligent as humans. I see no theoretical obstruction to simulations of sentient life-forms that think and know of their own existence.

NG: According to science fiction writers everywhere, this business of knowing of their own existence — being "self-aware" — is a big deal, right?

Steve: Well, no one really knows what being "self-aware" means. My creatures are self-aware in that their brains know that they are bored, or know that they are hungry, or know that they have been hit on the head and it hurts — so they are aware both of the external world and the internal world, so they are self-aware in this sense. But this isn't what we usually mean when we talk of being self-aware. We are always thinking of the little person inside our head who is looking out. But there so clearly isn't one! So it's a big philosophical problem to try and figure out what that means and whether such a structure can emerge.

NG: Are you saying that there is no "self" and that human beings are nothing more than very complicated biochemical machines?

Steve: A human being is just a machine, and so it can be modeled. Certainly I have no doubt that a computer can model any other machine. Whether or not we can ever figure out how to create a model as complex as a human is another question, but technically, there's no reason why it can't be done.

NG: And how long will it take until you are creating Artificial Life that is as sophisticated as a human being?

Steve: Our goal is twenty years. There's a good chance we won't make it, but the road along the way should be very, very interesting. We already have new brain models that are far more sophisticated than the ones used in *Creatures* — it's just a matter of following the steps of evolution.