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Gnarled Defined

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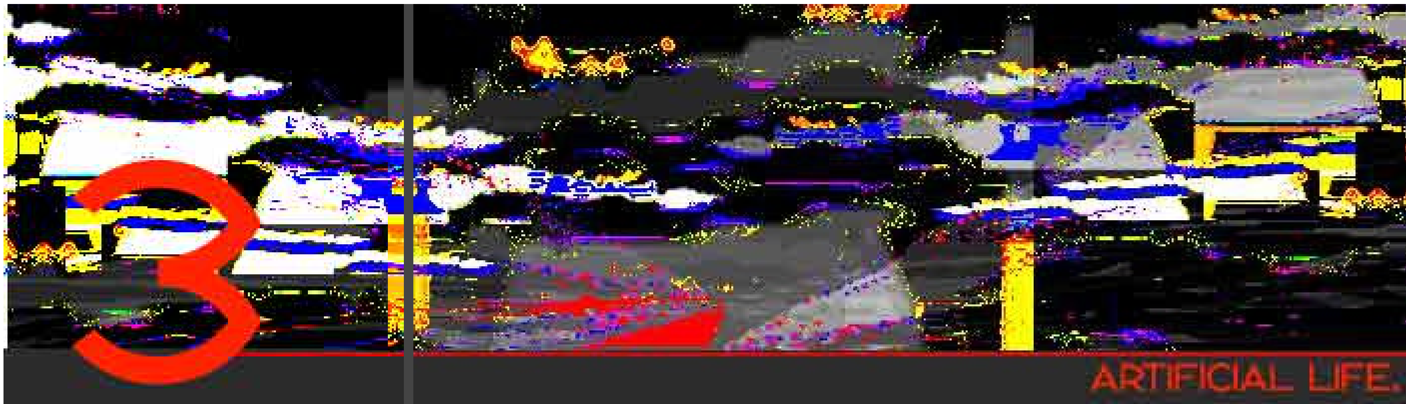

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Rudy Rucker on May 1 1996 **issue 03**

Gnarly artificial life created by the computer

Gnarl Defined

[This is based on material in Rudy Rucker, ***ARTIFICIAL LIFE LAB***, Waite Group Press, 1993.]

The original meaning of "gnarl" was simply "a knot in the wood of a tree." In California surfer slang, "gnarly" came to be used to describe complicated, rapidly changing surf conditions. And then, by extension, "gnarly" came to mean anything that included a lot of surprisingly intricate detail. Living things are gnarly in that they inevitably do things that are much more complex than one might have expected. The grain of an oak burl is of course gnarly in the traditional sense of the word, but the life cycle of a jellyfish, say, is gnarly in the modern sense. The wild three-dimensional paths that a humming-bird sweeps out are kind of gnarly, and, if the truth be told, your ears are gnarly as well. A simple rule of thumb for creating artificial life on the computer is that the program should produce output which looks gnarly.

This is, of course, not the word which most research scientists use. Instead, they speak of life as being chaotic or complex. Chaos as a scientific concept became popular in the 1980s. Chaos can be defined to mean complicated but not random. The surf at the shore of an ocean beach is chaotic. The patterns of the water are clearly very complicated. But, and this is the key point, they are not random. The patterns that the waves move in are, from moment to moment, predictable by the laws of fluid motion. Waves don't just pop in and out of existence. Water moves according to well understood physical laws. The reason people might think waves are random is because the computation which the water performs is many orders of magnitude larger than anything which our computers can simulate. For practical purposes, the waves are unpredictable, but they are really chaotic rather than random. As it turns out, you don't need a system as complicated as the ocean to generate unpredictable chaos. Over the last couple of decades, scientist have discovered that sometimes a very simple rule can produce output which looks, at least superficially, as complicated as physical chaos. Computer simulations of chaos can be obtained either by running one algorithm many many times (as with the famous Mandelbrot set, or with the closely associated Julia sets,) setting up an arena in which multiple instances of a single algorithm can interact (as with computer a-life). Some chaotic systems explode into a full-blown random-looking grunge, while others settle into the gnarly, warped patterns that are known as chaotic attractors. A computer screen filled with what looks like a seething flea circus can be a chaotic system, but the chaotic images that you see on T-shirts and calendars are pictures of chaos as well. Like all other kinds of systems, chaotic systems can range from having a lesser or a greater amount of disorder. The less disorderly kinds of chaos are often called chaotic attractors. To return to the surf example, you might notice that the waves near a rock tend every so often to fall into a certain kind of surge pattern. This recurrent surge pattern would be a chaotic attractor. In the same way, chaotic computer simulations will occasionally tighten in on characteristic rhythms and clusters that act as chaotic attractors. But if there is a storm, the waves may be just completely out of control and choppy and patternless. This is full-blown chaos. As disorderliness is increased, a chaotic system can range from being nearly periodic, up through the fractal region of the strange attractors, on up into impenetrable messiness. Some scientists use the word complexity to stand for a certain type of chaos. system is complex if it is a chaotic system that is not too disorderly. I prefer using the word gnarly for this concept. The notions of chaos and complexity come from looking at a wide range of systems---mathematical, physical, chemical, biological, sociological, and economic. In each domain, the systems that arise can be classified into a spectrum of disorderliness. At the ordered end we have constancy and a complete lack of surprise. One step up from that is periodic behavior in which the same sequence repeats itself over and over again---as in the structure of a crystal. At the disordered end of the spectrum is full randomness. One notch down from full randomness is the zone of the gnarl. As an example of the disorderliness spectrum in mathematics, let's look at some different kinds of mathematical functions, where a function is rule or a method that takes input numbers and gives back other numbers as output. The most orderly kind of mathematical function is a constant function, such as a function which always gives the value seven. The graph of such a function is nothing but a horizontal line. At the next level of disorder, we might look at a function which varies periodically like a sine wave. At the next step up lies chaos.Chaotic mathematical functions have finitely complicated definitions, but unpredictable patterns. There are different degrees of chaos: a chaotic function may range from being nearly periodic to being a smeared out mess. The most disorderly function would be a randomizer that is based on something like flipping coins or counting cosmic rays. It is an old question in the philosophy of science whether anything in the universe truly is random in the sense of not having a finite explanation. It may be the whole universe itself is simply a chaotic system whose finite underlying explanation happens to lie beyond our ability to understand. Before going on to talk about the disorder spectrums of Matter, Pattern, and Flow, let's pause to zoom in on the appearance of the mathematical field's disorderliness spectrum within the zone of chaos. The most orderly kind of chaos is "quasiperiodic," or nearly periodic. Something like this might be a periodic function that has a slight, unpredictable drift. Next comes the "attractor" zone in which chaotic systems generate easily visible structures. Next comes a "critical" zone of transition that is the home of the gnarl. A process in the gnarly zone may seem to jump from one strange attractor to another. And at the high end of disorder is "pseudorandom" chaotic systems, whose output is empirically indistinguishable from true randomness---unless you happen to be told the algorithm which is generating the chaos. Now let's get back to Matter, Pattern, and Flow. In classical (pre-quantum) physics, a vacuum is the simplest, most orderly kind of matter: nothing is going on. A crystalline solid is orderly in a predictable, periodic way. In a liquid the particles are still loosely linked together, but in a gas, the particles break free and bounce around in a seemingly random way. In classical physics, I should point out, the trajectories of a gas's particles can in principle be predicted from their starting positions---much like the bouncing balls of an idealized billiard table---so a classical gas is really a pseudorandom chaotic system rather than a truly random system. Here, again, chaotic means "very complicated but having a finite underlying algorithm". In any case, the gnarly zone of matter would be identified with the liquid phase, rather than the pseudorandom or perhaps truly random gas phase. The critical point where a heated liquid turns into steam would be a zone of particular gnarliness and interest. In terms of patterns, the most orderly kind of pattern is a blank one, with the next step up being something like a checkerboard. Fractals are famous for being patterns that are regular yet irregular. The most simply defined fractals (such as the famous Mandelbrot set) are complex and chaotic patterns that are obtained by carrying out many iterations of some simple formula. The most disorderly kind of pattern is a random dusting of pixels, such as is sometimes used in the random dither effects that are used to create color shadings and gray-scale textures. Fractals exemplify gnarl in a very clear form. The flow of water is a rich source of examples of degrees of disorder. The most orderly state of water is, of course, for it to be standing still. If one lets water run rather slowly down a channel, the water moves smoothly, with perhaps a regular pattern of ripples in it. As more water is put into a channel, eddies and whirlpools appear---this is what is known as turbulence. If a massive amount of water is poured down a steep channel, smaller and smaller eddies cascade off the larger ones, ultimately leading to an essentially random state in which the water is seething. Here the gnarly region is where the flow has begun to break up into eddies with a few smaller eddies, without yet having turned into random churning. In every case, the gnarly zone is to be found somewhere at the transition between order and disorder. Simply looking around at the world makes it seem reasonable to believe that this is the level of orderliness to be expected from living things. Living things are orderly but not too orderly; chaotic but not too chaotic. Life is gnarly, and artificial life should be gnarly as well.