Everything Is Alive

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Consciousness and Life

Panpsychism is the philosophical doctrine that every physical entity is conscious. By a "physical entity" I will mean any physical object or naturally occurring process.

Note that panpsychism is different from (although consistent with) the pantheistic doctrine that the universe as a whole has a conscious mind. Panpsychism allows that the universe may be conscious, but its primary statement is that each object and each process has a little consciousness of its own. Galaxies, rocks, planets, atoms, electrons, air currents, fires, rivers—each of them has a mind.

Panpsychism is related but not equivalent to *hylozoism*, which says that every object is alive. That curious word comes from the Greek words *hyle*, matter + *zoe*, life.

To clarify the distinction between the two doctrines, we can divide entities into four distinct categories, listed in the left-hand column of Table 1. And the right-hand column of the table lists some possible candidates for each category.

Category	**Possible Examples**
Conscious but not alive.	Brittle chip-based ultracomputers. Ghosts.
Conscious and alive.	Humans, higher animals. "Self-reproducing" robots who build more robots.
Alive but not conscious.	Bacteria. Biological viruses. Group organisms such as anthills or human societies. Self-modifying computer viruses.
Not alive and not conscious.	Stones. Atoms. Planets. Fires. Waterfalls. Air currents. Fluttering flags.

Table 1: Consciousness and Life

Despite these seeming distinctions, I'm going to argue that everything really belongs to the "conscious and alive" category, for I am both a panpsychic and a hylozoist. Certainly I realize this is not a common point of view! To some extent, I am only adopting these ideas on to see how they feel, that is, I practice *ein philosophie als ob*—a philosophy as if.

I currently work as a science fiction novelist as well as a philosopher of computer science. I find it useful to adopt extreme philosophical positions so that I can dramatize them as novels. One might regard my novels as extended thought experiments. Some of the ideas I discuss in this paper are finding their way into my most recent two novels, *Postsingular*, [Rucker 2007], and *Hylozoic,* [Rucker 2009].

Part of the attraction of panpsychism and hylozoism is emotional. It feels pleasant to imagine oneself to be surrounded by living minds. The nineteenth century philosopher Gustav Fechner was an eloquent advocate for the satisfactions of panpsychism: "Humans are surrounded at all levels of being, by varying degrees of soul. This is Fechner's 'daylight view'—the human soul at home in an ensouled cosmos. This he contrasted to the materialist 'night view': humans alone, isolated points of light in a universe of utter blackness." —Quoted in [Skrbina 2005], p. 122.

In the long, run, I believe there will be quite practical reasons for believing in panpsychism. Firstly, it begins to seem possible that we can build computers which are conscious. And secondly, in the longer run, our computers will consist of ordinary objects. For the history of technology tells us that digital chip-based computers are likely to disappear from the scene, like any other technology. We don't use clockwork gears in our watches anymore, and we don't make radios out of vacuum tubes. The age of digital computer chips is going to be over and done, if not in a hundred years, then certainly in a thousand. By then we will be working with the quantum computations of ordinary objects.

In this paper, I'll present a logical argument for panpsychism and hylozoism My argument hinges on the concept of "gnarly computation," which is a term I apply to chaotic processes that are somewhat orderly. My argument will proceed through the following nine steps.

(1): *Universal Automatism.* Every physical entity is a computation.

(2): Moreover, every physical entity is a *gnarly* computation.

(3): *Wolfram's Principle of Computational Equivalence.* Every naturally occurring gnarly computation is a universal computation.

(4): Consciousness = Universal Computation + Self-Reflection.

(5): Any complex system can be regarded as having self-reflection.

(6): *Panpsychism*. Every physical entity is conscious.

(7): *Walker's Thesis.* Life = Universal Computation + Memory.

(8): Every physical entity has memory via its interactions with the universe.

(9): *Hylozoism*. Every physical object is alive.

Everything is a Gnarly Computation

I enjoy using a dialectic approach to develop ideas, as I am Georg Hegel's great-great-great grandson. Usually we think of dialectic in terms of thesis, antithesis, and synthesis—the synthesis represents an escape from the contradiction found between the thesis and antithesis. This pattern is called a dialectic triad.

I'll start with a dialectic triad whose synthetic component is my statement (2): Every naturally occurring phenomenon can be regarded as a gnarly computation. My first version of this triad appears in a book whose title summarizes the argument: *The Lifebox, the Seashell and the Soul,* [Rucker 2005]. This title is a pattern of the form thesis, synthesis, and antithesis. (If I wanted to closely match the usual order of

ideas, I might have called my book *The Lifebox, the Soul and the Seashell*. But that phrase doesn't roll off the tongue so well.)

My *thesis* in this case is statement (1): Every object or process is a computation. My name for this thesis *Universal Automatism*. Universal Automatism says the world is made of computations. A particularly contentious case of Universal Automatism is the statement that a human mind is a computation. In my book's title, I represented this case of the Universal Automatism thesis by the word "lifebox," which is a (still science-fictional) device that holds enough data and algorithms to fully emulate a person's behavior. I feel that we will see lifeboxes on sale within a century or two.

In order to make Universal Automatism more believable, I have to use a very inclusive notion of computation. So I say that a *computation* is any process that obeys finitely describable rules.

Do note that, rather than saying the world is one single computation, I prefer to say that the world consists of *many* computations—at high and low levels. There need not be any single underlying master computation—no robot voice reciting numbers in the dark. Instead we are a seething swarm of little computations made of yet smaller computations.

My *antithesis* in the book's dialectic triad, expressed by the word "soul," is the existential observation that consciousness doesn't *feel* like a computation. We have an innate sense of awareness that we express by the phrase, "I am." One has a feeling that being conscious involves merging into the world, which doesn't seem like something a computation would easily do. Our experiences with sensual qualia give us a sense that consciousness has a texture not captured by computation. Dreams and religious visions also give us a feeling of having a higher consciousness that's not captured by computations.

My *synthesis* in this dialectic triad is to claim that naturally occurring computations can in fact have the richness of consciousness, for the reason that they are *gnarly computations*. Furthermore, I argue that all naturally occurring processes are in fact complex enough to be gnarly computations.

I'll say more about gnarly computations in the next section, but for now suffice it to say they are complex and unpredictable. In my book's title, I use the word "seashell" to represent the notion of gnarly computations because certain seashell patterns are believed to be naturally occurring computations of this complex sort. (See Figure 1.)

[Insert rucker_figure1.eps]

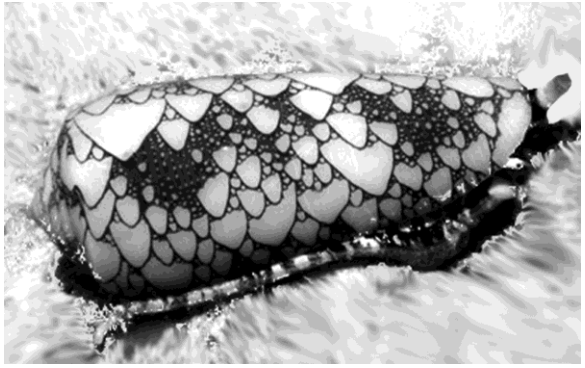

Figure 1: A Cone Shell Bearing a Gnarly Cellular Automata Pattern

To summarize, my original dialectic argument says:

- *Thesis:* Everything is a computation.
- *Antithesis:* Human consciousness doesn't feel like a computation.
- *Synthesis:* Everything is a gnarly computation.

So this argument takes us from my statement (1) to my statement (2).

What is Gnarl?

By way of explaining more precisely what I meant by a gnarly computation, I'll point out that computations lie on a spectrum of complexity. My analysis follows that of Stephen Wolfram in his book, *A New Kind of Science*, [Wolfram 2002].

[Insert rucker_figure2.eps]

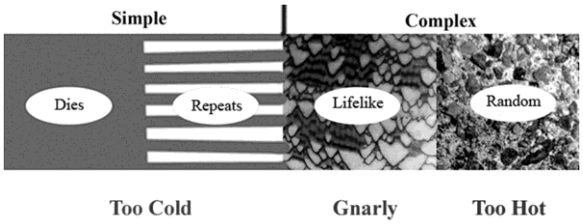

Figure 2: The Spectrum of Computational Complexity

Suppose that we focus on some particular category of computations such as Turing machines or cellular automata rules. No matter what the category, we always find four basic kinds of behaviors: comes to a halt; goes into a repeating loop; produces unpredictable but somewhat orderly output, produces random-looking output.

We view the first two types of behavior as simple, and the second two types as complex. In chaos theory, both of the complex classes are regarded as chaotic. The reason I have introduced the word "gnarly" for the third class is so as to have a more convenient phrase than "somewhat orderly chaos." Christopher Langton refers to this zone as the *edge of chaos*.

In this context, we aren't very interested in the distinction between the terminating and repeating computations, so we lump those two simple classes together. Thus we arrive at three general classes: simple, gnarly, and random-looking. And just as in the fairy tale about Goldilocks and the Three Bears, we can view the behaviors as too cold, just right, and too hot.

- Simple (Too Cold): Dies Out or Repeats.
- Gnarly (Just Right): Complex, moving, unpredictable. Life. Natural processes.
- Random-looking (Too Hot): Seething.

Most of my own taxonomic research on computations has centered on two-dimensional cellular automata. We can think of these computations as taking place on a computer screen. Each pixel acts as

a tiny independent computer, each pixel updates its state on the basis of the states of its neighboring pixels, and the states are depicted as colors.

At the end of his life, the computer science pioneer Alan Turing was beginning to use these kinds of rules to show how the patterns on animal coats and butterfly wings might emerge from cellular automata rules based on two competing chemicals, an activator and an inhibitor. The "Turing patterns" that emerge from these rules can look like spots or filigrees.

[Insert rucker_figure3.eps]

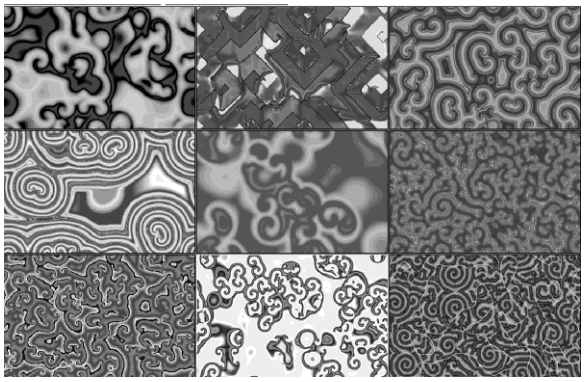

Figure 3: Gnarly Two-Dimensional Cellular Automata

We can create computer simulations of these rules by supposing that the state of each pixel includes two real numbers representing the intensities of activator and inhibitor. Figure 3 shows some of the patterns generated by these rules. In these images we see the spontaneously generated scrolls that biochemists call Belousov-Zhabotinsky scrolls. The dynamics of these patterns are lovely. The spirals are constantly turning, and the scrolls expand, swallow each other, and spawn off new scrolls—almost like living creatures.

Getting back to my main line of argument, let me say a bit more in my support of my statement (2): Every object or process is a gnarly computation. In many cases it's intuitively clear that nature is performing a gnarly computation: think of swaying trees, a flickering fire, the cracks in drying mud, flowing water, or even a rock. A rock? To the human eye, a rock appears not to be doing much. But viewed as a quantum computation, the rock is as lively and seething as, say, a small star. At the atomic level, a rock is like a zillion balls connected by force springs, and we know this kind of compound oscillatory system behaves chaotically.

Panpsychism

For the next stage of my argument, I want to argue for a form of what Wolfram calls the *Principle of Computational Equivalence*. This is my statement (3): Every naturally occurring gnarly computation is a universal computation.

Computer scientists define universal computers as systems capable of emulating the behavior of every other computing system. The complexity threshold for universal computation is in fact very low. Any desktop computer is a universal computer. A cell phone is a universal computer. A Tinkertoy set or a

billiard table can be a universal computer. And very many gnarly computations such as Conway's Game of Life have been proved to be universal computations as well.

One difficulty here is that in 1956, Richard Friedberg and Albert Muchnik, working independently, showed that one can in construct computations which are gnarly but not computation universal. This is why in my version of the Principle of Computational Equivalence, I restrict the focus to "naturally occurring computations"—the supposition being that the Friedberg and Muchnik computations are in fact so artificial as not to occur in the wild.

Now we come to the question of consciousness. On the surface, being a universal computation seems like very nearly a sufficiently strong condition for being conscious. But there is a sense that one's consciousness has something more, and one might well suppose this additional ingredient to be self-reflection, where the self-reflection aspect of a system stems from having a feedback process whereby the system has two levels of self-awareness: first, an image of itself reacting to its environment, and second, an image of itself watching its own reactions. (See [Damasio 1999].) Thus we arrive at statement (4): Consciousness = Universal Computation + Self-Reflection.

I have come to believe however that the requirement of self-reflection is otiose. That is, my experience as a computer scientist suggests that one can in fact used fixed-point methods to give any universally computing system this kind of self-reflectivity. This leads to my statement (5): Any complex system can be regarded as having self-reflection.

And thus we can deduce (6): *Panpsychism*. Every physical entity is conscious.

One problem which remains to be solved is whether we can learn to converse with the conscious objects surrounding us. Possibly we will develop some quantum computational technique so that one can sufficiently entangle oneself with an object so as to able to talk with it.

Hylozoism

My fellow philosopher of computer science, John Walker, makes the point that living beings seem to have memory as well as universal computation. (See [Walker 2004].) Walker points out that humans, for instance, have physical memories at three different levels.

- *Genetic memory*: DNA.
- *Organic memory*: Immune system.
- *Behavioral memory*: Neural patterns.

Even if we don't expect living entities to have a biological component, one can make a case that memory plays an essential role in such characteristically life-like processes as reproduction, morphogenesis, and homeostasis.

Thus we arrive at (7): *Walker's Thesis.* Life = Universal computation + Memory.

So now in order to extend my line of thought to reach hylozoism, I need some way of asserting that every physical object already has some kind of memory.

While preparing this paper to present in Kyoto, I started thinking of the Zen koan of the flag. Two monks are looking at a flag fluttering in the wind, and this system is performing a gnarly and therefore universal computation. But what *is* the system? The first monk says, "The flag is moving." The second monk says, "The wind is moving." The third says, "Mind is moving."

The flag koan is, in its own way, a dialectic triad, and the flag/wind system is a conscious mind.

That is my panpsychic interpretation of the koan; probably the more common interpretation is a pantheistic one, under which the flag/wind motion is viewed as an aspect of a single, overarching mind that imbues all things.

Now suppose we want to say the flag/wind system is alive as well. Does the fluttering flag have a memory so as to satisfy Walker's thesis? At first it seems the answer must be no. An isolated natural system is dissipative, that is, different past histories can lead to identical present states.

In my novel *Hylozoic*, I suppose that we might get around this problem by changing the topology of space at scales below the Planck length—that is, below the size scale at which our current notions of physics break down.

The current notion of space at very small scales, taken from string theory, is that we have a lot of extra dimensions down there, and that most of them are curled into tiny circles. But what if we could find a way to change the intrinsic topology of space, uncurling one of these stingily rolled-up dimensions? Of course we'd be careful to pick a dimension that's not absolutely essential for the string-theoretic Calabi-Yau manifolds that are supporting the existence of matter and spacetime. Just for the sake of discussion, let's suppose that it's the eighth dimension that we uncurl.

I see our eighth-dimensional coils as springing loose and unrolling to form infinite eighth-dimensional lines. This unfurling will happen at every point of space. Think of a plane with hog-bristles growing out of it. That's our enhanced space after the eighth dimension unfurls. And the bristles stretch to infinity.

And now we'll use this handy extra dimension for our universal memory upgrade! We'll suppose that atoms can make tick marks on their eighth dimension, as can people, clouds, or stones. In other words, you can store information as bumps upon the eighth-dimensional hog bristles growing out of your body . The ubiquitous hog bristles provide endless memory at every location, thereby giving people endless perfect memories, and giving objects enough memory to make them alive as well.

Is there any less science-fictional way to achieve the same result? One approach might be to say that there are in fact no isolated natural systems. The effects of the flag/wind system's state ten minutes ago are still present in the state functions of the myriads of particles that are quantum-entangled with the particles of the air and the flag. Put more simply, the system's memory is part of the universal state function. In this once again pantheistic view, each limited system can draw upon the entire memory of the universe as a whole.

This notion is anticipated by the Zen koan in which a monk asks the sage, "Does a stone have Buddha-nature?" The sage answers, "The universal rain moistens all creatures."

Thus we arrive at (8): Every physical entity has memory via its interactions with the universe. And now we have reached our goal of (9): *Hylozoism*. Every physical object or process is alive.

In closing, I should mention that in an earlier paper [Rucker 2008] I combined statements (4) and (7) to have this statement: Consciousness = universal computation + memory + self-reflection. And moving from there, I argued that to be a conscious physical object of this kind is essentially to be alive—so that in the end, I arrived at the same position as in the present paper: Everything is conscious and alive.

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