The Lure of Complexity (Part 2)

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(This is the second part of a two-part essay. The first part appeared in our Fall, 2001 issue and is also available on the web: http://www.netfuture.org/ni/ic/ic6/complexity.html.)

Anyone who lives in an earthquake zone knows that mild earthquakes are much more common than powerful, devastating ones. What you might not expect, however, is that a simple, straight-line mathematical relationship known as a "power law" tells you what percentage of earthquakes will exceed any given energy. Even more surprisingly, you can derive the same sort of law showing what percentage of cities will be larger than a given size. Or what percentage of fjords in Norway will exceed a given length. Other power laws occur when you look at word-usage patterns in texts, global temperature variations, the occurrence of traffic jams, stock market performance, and (as discussed in part 1) avalanches in artificially constructed sand piles.

In each of these domains any attempt at causal analysis leads you to the complex, nearly unanalyzable interplay of countless factors. (Try to tabulate all the reasons why individuals migrate to and from any particular city!) And yet, in every case this interplay yields an elegant, straight-line power law. This is the kind of thing that appeals to so many complexity theorists, convincing them that they are on the track of a grand, unified theory of nearly everything.

Seeking Universality

A planet in motion, obeying Newton's laws, does not present a picture of complexity. By contrast, the geological, biological, and evolutionary realities of a landscape (such as a fjord or region of earthquake faults) *are* complex. This, at least, is the thought Per Bak expresses when he says, "we do not live in a simple, boring world consisting only of planets orbiting other planets, regular infinite crystals, and simple gases or liquids." He goes on: "Crystals and gases and orbiting planets are not complex, but landscapes are" (Bak 1996, pp. 4–5).

Bak, who is a pioneer of complexity theory, rejoices in the challenges of the landscape. But note the slight oddity here. A planet is, after all, the bearer of its landscapes, so it must be at least as complex as any one of those landscapes. Only when we think away all the planet's rich detail, reconceiving it abstractly as little more than a mathematical point in Newtonian motion, does its complexity fall from view. We should keep in mind that "boring" simplicity characterizes a way of theorizing about phenomena, not the phenomena themselves.

And the irony is that, in embracing landscapes and other complex phenomena, complexity theorists such as Bak rely on their own abstract simplifications, along with a fierce resolve to "shear away detail." So they end up merely repeating, on this new front, the astronomer's sacrifice of the world's fullness. Where celestial mechanics reduces the planet to a locus for interaction of a few simple mathematical laws, these researchers now reduce the landscape to a locus for interaction of a few — rather different and more statistical — mathematical laws. The landscapes that, in their qualitative and particular reality, are so invisible to the astronomer plotting a planet's Newtonian trajectory in space seem to be nearly as invisible to the complexity theorist looking for deep, context-free truths. All too often the study of complexity begins to look like an abandonment of the phenomena the researchers originally set out to investigate.

Bak wants a general theory of life so profound that it "cannot have any specific reference to actual species" — a theory that doesn't get sidetracked by "utterly accidental details ... such as the emergence of humans" (Bak 1996, p. 10). Likewise, speaking of the various power laws, he observes that "since these phenomena [that is, statistical patterns] appear everywhere, they cannot depend on any specific detail whatever." And again: theorists who are going after fundamental principles must "avoid the specific details, such as the next earthquake in California." Rather,

> Our strategy is to strip the problem of all the flesh until we are left with the naked backbone and no further reduction is possible. We try to discard variables that we deem irrelevant. In this process we are guided by intuition. In the final analysis, the quality of the model relies on its ability to reproduce the behavior of what it is modeling. (Bak 1996, p. 42)

But, just as Bak refers to "phenomena" when he is really speaking only of statistical patterns, so, too, the "behavior" he alludes to here is hardly the behavior of any particular thing. The particulars — such as the individual character of the fault line that will produce California's next earthquake — have been ruled out of the picture in advance. So the behavior at issue is, again, a matter of highly abstract, statistical generalities.

What seems never to occur to Bak and many of his fellow researchers is that the grand unifying theory they are stalking may be grand in scale, and may be unifying, but for this very reason promises to be more or less trivial. Don't get me wrong, however. There are doubtless interesting ways to elucidate the power laws we can abstract from diverse phenomena. It's just that the act of abstraction here has been so severe — so many aspects of the phenomena we were looking at have been left out — that our discoveries, while interesting in their own right, will tell us almost nothing about these particular phenomena. The scholar who is seeking to understand the population growth of Cairo is much better advised to explore the relevant cultural, social, political, economic, geographic, and ecological realities bearing on this one place than to dwell on the elegance of a straight-line graph showing the frequency of occurrence of cities with different population levels. It's not clear who among students of particular phenomena *will* find much use, or much revelation, in that graph.

Explanations that do not depend on specific details will fail to elucidate those details. If, at the outset of our investigations, we strip away every concrete particular we can, then we will hardly arrive at any profound understanding of concrete, particular phenomena. But what else is there to understand? It was the whole concern of the key figures of the Scientific Revolution to shun the abstract cerebrations of the medieval schoolmen and open their eyes to the world around them. Should science reject this stance now, preferring (in Bak's words) "to free ourselves from seeing things the way they are"?

The problem with a scientific method based on maximum generalization and abstraction is that the more it succeeds — that is, the more general and abstract its results become — the shallower they tend to be. They tell us less and less about the particular contexts we wish to understand.

Look at it this way. If you let X represent anything at all and let 1 stand for "exists" and 0 for "does not exist," then it is true to say of every existent thing (every X) in the universe: "X = 1". By the standard of generality, abstraction, and precision, this must be just about the deepest truth of all. And, perhaps in some sense worthy of meditation, it really is. But as a scientific statement it is vacuous. Its vacuity is directly related to its generality. Precisely because it tries to tell us something about everything, it doesn't tell us much about anything in particular.

In our drive toward generality and abstraction, we end up with what we ask for. If, for example, we are determined to reckon only with what is generally true of both living organisms and systems of inanimate, mineral objects, we will end up seeing only the inanimate, mineral aspects of living organisms. We will get a theory that "connects" diverse things, but in the process loses the things we are connecting.

Flight from Phenomena

The abandonment of detail by complexity theorists sometimes begins to look like an outright abandonment of phenomena. In the first part of this article I mentioned Stuart Kauffman's pot of symbol strings. A symbol string is just an ordered group of zeroes and ones — for example:

011
101011
11100

Kauffman asks us to imagine these strings floating around rather like molecules in a pot of liquid, interacting with each other according to a set of "grammar rules." That is, when strings "collide," zeroes and ones may be appended to a string, or deleted, or changed (drawing as necessary upon a reservoir of available digits). As the grammar rules are applied to the colliding strings, the latter may "evolve" in interesting ways.

Now, you may well wonder just what sort of pot this is. How do numbers interact in a pot? Kauffman describes the process almost as if it were a matter of physics — a matter of real materials obeying real laws. He speaks (albeit in quotation marks) of "enzymes" and "substrates" and "strings" that "collide." And he considers his strings to be *models:*

> Bear in mind that we can consider our strings as models of molecules, models of goods and services in an economy, perhaps even models of cultural memes such as fashions, roles, and ideas. (Kauffman 1995, p. 287)

Yet Kauffman shows no sign of reckoning with the stubborn realities of an actual model that works. What excites him is an abstract set of purely logical relations. Yes, his excitement quite evidently arises because he imagines these relations to be applicable to real phenomena; but he is not so much engaged in the study of the phenomena as in the elaboration of his logical scheme.

Among complexity theorists there is often a strange disregard of the distinction between abstract thought structures and real-world phenomena, including real models. But there is, after all, a radical difference between a purely notional pot of symbol strings, conceived as a set of logical relations, and any actual embodiment of these relations. You can see this difference even if the embodiment takes form only as a computer simulation, where the zeroes and ones are translated into electrical patterns in silicon and light patterns on a screen.

Once you have such embodiment, your thought experiment comes under constraints that were absent from the purely abstract logical relations. The abstract relations just are what they are — eternally, you might say — but the embodiment is an entirely different matter. To begin with, a computer simulation of the symbol pot can be sustained only because a massive technical infrastructure is in place and because engineers have carefully designed the simulation hardware and software. And even once it is up and running, the simulation might take an unexpected turn due to an electrical power failure, or I might spill coffee into the computer's circuitry, or a bug in the supporting software might supervene, or a giant meteor might strike the earth, or the hardware might (and over time certainly will) succumb to normal wear and tear. Contingencies of this sort are exactly what make the difference between the purity of logic and the reality of the world.

This is the kind of reflection that seems wholly irrelevant to a person enamoured of disembodied abstractions. But it is exactly what should matter to anyone who, like Kauffman, takes the abstractions as key to understanding the evolution of real (embodied) life forms.

This point is worth pressing further.

Physics or Fancy?

You may have heard of the Game of Life. It divides your computer screen into a fine-meshed rectangular grid wherein each tiny cell can be either bright or dark, on or off, "alive" or "dead." The idea is to start with an initial configuration of bright or live cells and then, with each tick of the clock, see how the configuration changes as the software applies these simple rules:

** If exactly two of a cell's eight immediate neighbors are alive at the clock tick ending one interval, the cell will remain in its current state (alive or dead) during the next interval.

** If exactly three of a cell's immediate neighbors are alive, the cell will be alive during the next interval regardless of its current state.

** And in all other cases — that is, if less than two or more than three of the neighbors are alive — the cell will be dead during the next interval.

You can, then, think of a cell as dying from loneliness if too few of its neighbors are alive, and dying from overcrowding if too many of them are alive.

Now, what interested the early students of this game in the 1960s was the fact that, given well-selected initial configurations, remarkable patterns are produced. A "glider" composed of lit cells might sail serenely across the screen. A "glider gun" might produce an endless series of gliders. Another entity might swallow up any glider that makes contact with it, while itself remaining intact. There are static patterns, blinking patterns, rotating patterns, and forms that can evolve and even reproduce themselves in endlessly fascinating ways.

What is still more remarkable is the conclusion some researchers eventually drew from all this. Full of excitement as they watched their enchanted screens, they began to suspect that they were being initiated into the deepest secrets of biological evolution, of reproduction, and of life itself. (The complexity discipline known as Artificial Life grew out of this work.)

Referring to the Game of Life and the three-part law governing its performance, philosopher Daniel Dennett has remarked that "the entire physics of the Life world is captured in that single, unexceptionable law" (Dennett 1995, p. 167). Moreover, "our powers of prediction [regarding the Life world] are perfect: there is no noise, no uncertainty, no probability less than one" (Dennett 1991, p. 38).

But, as we have seen, the "unexceptionable law" is hardly a law of physics, and it is a little odd to talk about our "powers of prediction" where only thought relations are in view. If, on the other hand, we really are talking about a physical machine equipped to represent the thought relations in some embodied form — a machine whose activity we might now venture to predict — then the problems of a sustainable power supply, spilled coffee, and all the rest cannot be avoided. What we have, contrary to Dennett, is noise, no certainty, and no probability equal to one.

It is not that brilliant thinkers such as Dennett would fail to recognize this obvious truth. It's just that the truth doesn't seem to count for much in their thinking. The "something else" that enables us to talk about the phenomenal world instead of the pure thought relations of an assemblage of abstractions draws no particular attention from them.

What's happening here is that the world has been reconceived as a machine, the machine has been reconceived as a pure abstraction (for example, as software — see Talbott 2000), and the theorists, taking up their stance within this realm of abstraction, merrily spin out new thought relations to "explain" the world. But since their method has instructed them to avoid the real world as far as possible by shearing away detail, they remain mostly in a kind of abstract never-neverland. The rules of the Game of Life do not explain what I see on my computer screen even when I am running the Game of Life. Any such explanation would have to reckon with power supplies, programmers, and a great deal else.

The Consequences of Abandoning the World

I have restricted myself here largely to the problem of generality and abstraction. However, I should offer at least these exceedingly brief remarks about some of the other complexity themes I alluded to in Part 1.

Reductionism. The claim by some complexity researchers to have moved "beyond reductionism" is not justified by the facts. The decisive and damaging act of reduction within conventional science has always been the reduction, in thought, of the qualitative world of phenomena to abstract, machine-like models devoid of qualities. Complexity theorists seem at least as committed to this reduction as any other scientists. It is true that many of these theorists want to grant "irreducible" status to higher-level orders of reality such as economics, animal behavior, and human thinking. But this hardly makes much difference if the concepts available for dealing with these realities are as machine-like and as qualitatively emptied as the concepts previously applied to atoms and photons.

Holism. There can be no holism without the qualities that complexity researchers strip from the world. It is the nature of qualities to interpenetrate one another, and only through such mutual interpenetration can a whole express itself through each of its parts. Without qualities, there are featureless "particles" side by side in changing arrangements, but nothing to make an integral unity of them — nothing to give the assemblage the sort of distinctive, expressive character enabling us to recognize a whole. Where theorists do speak of wholes, you will find that either their terms do not justify such speaking, or else they have surreptitiously imported qualitative considerations without acknowledging them and without giving them a proper place in their method.

The literature of complexity presents us with countless references to wholes that are "more than the sum of their parts." But those who speak this way don't seem to take their own words seriously. If they did, they would be forced to grant that the whole — the "something more than the sum" — remains even after all the parts have been removed. They would, for example, strive to grasp the generative idea, the productive unity, of the rose — the unity that expresses itself through root, leaf, and flower but is by no means a mere collection (sum) of roots, leaves, and flowers. (See "Of Ideas and Essences" in this issue.)

Disciplinary convergence. The loss of any foundation for holism within complexity studies suggests that the hope for meaningful disciplinary convergence is probably misplaced. Confusion on this point results from a failure to see the double aspect of abstract generality. It is true, on the one hand, that we can homogenize many disciplines by seeing only their projections upon the same abstract grid. In this way, chemistry, biochemistry, genetics, botany, zoology, evolutionary theory, and cosmology have increasingly come to be dominated by the same sort of remote, non-experiencable "entities" — particles, atoms, molecules, genes — that first colonized the physicists' imagination.

But the interdisciplinary unity being sought here, as I have been arguing, is an emptied unity — the unity that comes from the one-sided urge to strip away differences and refuse to consider them. The study of cities and of earthquakes—or the study of plants and of minerals—become the "same" studies.

By contrast, a true unity arises when we recognize differences while at the same time bringing *those very differences* into meaningful relationship — an essentially qualitative undertaking. We would not see the expressive unity of *Hamlet* if we turned away from the uniqueness of each character, looking only for what they had in common. There would be nothing significant left to bring into unity.

So the other tendency of abstract generality — and this is what has driven the fragmentation of science from the beginning — is to rob the various disciplines of the distinctive elements through which they might have entered into muscular relationship. An increasingly featureless commonality replaces mutual illumination and complementation. One is left with no scientific tools for relating the world's different phenomena to each other (as opposed to obscuring their differences), so compartmentalism remains a major affliction. How meaningfully can Artificial Life investigators, on the one hand, and naturalists observing living frogs and trees, on the other, relate their separate undertakings?

Emergence. When your scientific work repeatedly brings you up against vaguely conceived "emergent" phenomena — phenomena that seem to arise from out of nowhere — you might reasonably wonder whether your models and explanatory mechanisms have omitted something important. While most complexity theorists seem undisturbed by this thought, I have been suggesting above that the omission has in fact been as radical as it could possibly be: what the models tend to leave out is the phenomenal world as such, with all its contingencies and with all its causal, or generative, powers. To these investigators, therefore, *all* actual phenomena are likely to appear emergent simply because all phenomena present a qualitative fullness that has intentionally been stripped from the theoretical apparatus employed to explain them.

What the situation requires is a fundamental reconsideration of method. Most importantly, this means a reconsideration of the founding decision within science to ignore qualities, since it turns out that to ignore qualities is to ignore the world. There is no way to get from the sheer abstractions of complexity theory back to the world of phenomena, except by re-introducing qualities "through the back door" when no one is looking — and then exclaiming about the "emergent" wonders that arise. It would be much more sound scientifically to face qualities up front, wrestling through to an understanding of their proper place in the scientific enterprise.

Looking for the Positive

I have left a huge amount out of my cursory survey, and this is the place to acknowledge the fact. I have said nothing, for example, about the promise of chaos theory (about which I hope to write in the future). And I have not noted that some investigators, such as the Nobel prize-winning chemist, Ilya Prigogine, avoid at least some of the excesses dominating the field. (See Grégoire and Prigogine 1989; Prigogine and Stengers 1984.)

Let me conclude, then, on a somewhat more balanced note. It is certainly arguable — as I have indeed argued — that the tools complexity researchers bring to their work are even more severely constrained, more one-sidedly abstract and quantitative, less tolerant of qualities, less relevant to the richness of the world given through observation, than was the case with much of the science they are trying to reform.

But it is also true that the students of complexity really are seeking a better science. Their desire to overcome narrow compartmentalization is genuine, and this means they are acknowledging broader contexts — they are actually *seeing* nature's diversity — at least long enough to wheel out the heavy artillery of abstraction with which they proceed to level the newly acknowledged landscape. Moreover, the hunger for "emergent" realities surely reflects a sense that we need to reckon scientifically with a larger reality than the traditional "hard" sciences have addressed. Researchers looking at earthquake faults or economic transactions or the population growth of cities no longer accept the charge that they are on secondary scientific ground whenever they speak, not of particles, but of the phenomena they can actually observe.

This willingness to observe, for purposes of explanation, a much fuller world is the main hope of complexity work. The problem, as we have seen, is that the kinds of explanation employed immediately obscure the fuller world the researchers are straining toward. This, of course, is where Goethean scientists can play a helpful role by demonstrating the possibilities of a qualitative science that honors the phenomena in all their richness.

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