

A World Beyond Physics

The aim of this chapter, indeed the driving purpose behind this book, is to show that life, though rooted in physics, surges beyond it into the myriad unprestatable ways of making a living in the world. Thanks to the three closures—constraint, work cycle, and catalytic—living systems literally construct themselves, and construct themselves upward into the unending openness of complexity in the nonergodic universe above the level of atoms. No laws describe or entail this miracle.

Entropy and Evolution

The famous second law of thermodynamics states that disorder, or entropy, increases in closed systems. Evolution is a story of increasing vast complexity and organization of organisms and ecosystems comprising the biosphere. Does the second law preclude the complex becoming of the biosphere? The answer is no. First, given open systems, the input of high-quality energy—for example, blue photons—allows thermodynamic work to be done, for

example, in photosynthesis, with the release of red-shifted photons of lower energy. In this process, of course, entropy is produced.

But more than that, the union of the three closures—constraint closure and work cycle closure, plus catalytic closure—means that protocells and later cells literally do thermodynamic work to construct themselves, harnessing free energy available to them in doing so and producing entropy in doing so. Given heritable variation and natural selection of protocells and beyond, the creatures of the burgeoning biosphere build themselves upward into the complexity that they mutually create. They do so faster than the increase of entropy would degrade them. Order wins.

Niche Creation Is Self-Amplifying

We saw in chapter 10 that jury-rigging is easier the more tools there are in the tool kit. And we saw that much of evolution is due to Darwinian preadaptations, the unprestatable co-opting of organs and features for “this and that,” like Patrick’s peptide.

The increasing diversity of proto-organisms and organisms—Patrick, Rupert, Sly—creates ever more niches, which increases the diversity of “contexts,” which increases the diversity of adjacent possible “uses,” which in turn increases the ease of finding new ways to make a living in a biosphere exploding with possibility.

The filling of these niches by ever new, unprestatable organisms, creates yet further new contexts and opportunities. The total system “explodes” in a self-amplifying way into the very adjacent possible it itself creates. And, as noted, selection does not accomplish this magic of emergent becoming.

The same claims are true for the global economy, which has exploded in diversity from perhaps 1,000 goods and

services—stone tools, for example, some 50,000 years ago—to billions today. Like species in a biosphere, goods and services afford niches for ever new goods and services, enabled to come into existence by what exists now. The mainframe computer of IBM did not cause, but, through the market it created, enabled the personal computers of Apple, along with the invention of the chip, and other makers; which did not cause but enabled word processing, spreadsheets, and companies like Microsoft; which did not cause but enabled modems and file sharing; which did not cause but enabled the World Wide Web; which did not cause but enabled selling on the Web with eBay and Amazon; which did not cause but enabled search engines such as Google. Each new good, starting with the personal computer, is a component enabled by the former. Strikingly, economic growth theory seems to ignore these facts.

In short, for the biosphere, and “econosphere,” niche creation is self-amplifying. In both cases, the current system enables an unprestatable adjacent possible into which the system is “sucked.” We become what it is next possible to become, and we ourselves create those very possibilities. The swim bladder creates the possibility that a worm could evolve to live in swim bladders.

This *is* life, explosively rich in its emergent complex, surging, unprestatable, and diversifying becoming—a myriad miracle of which we are part.

Beyond Law: Biology Cannot Be Reduced to Physics

As we saw in chapter 2, biology cannot be reduced to physics because physics cannot discriminate functions as subsets of causal

consequences. The function of the heart is to pump blood, not make heart sounds. Further, the *only reason* in biology that such functions *exist* in the universe, hearts, for example, is that they abet the propagation and selection of the living forms of which they are parts. Hearts *only get to exist* in the nonergodic universe above the level of atoms because they are selected for the function of pumping blood sustaining the organisms of which they are parts. But we cannot deduce *ab initio*, 3.7 billion years ago, that hearts and swim bladders will emerge.

But there is more. We cannot even prestate the phase space of biological evolution.

In physics, one always prestates the phase space of a system. For Newton, given his three laws of motion, the phase space is defined by the boundary conditions, for example, the boundaries provided by a billiard table. Given these, we can define what we call the phase space of all possible positions and momenta—every way the balls can move on the table. Then we write Newton's laws in the form of differential equations; and from the initial and boundary conditions, we solve for the trajectories of the balls by integrating the equations.

Integrating Newton's equation is precisely to *deduce* the consequence of the differential equations for the trajectories of the balls, given the initial conditions and the boundary conditions. But deduction is logical entailment: all men are mortal, Socrates is a man, therefore Socrates is a mortal. Feel the logical force of the deduction.

What is true for the billiard table is true in general in classical physics. As Rosen (1991) said, Newton mathematized Aristotle's efficient cause as such deduction. The becoming of the Newtonian world machine is logically entailed by the initial conditions of the universe and Newton's laws.

But biology is different. Biological functions are part of the phase space of biological evolution: the trunks of elephants

reaching for water, ears and middle ear bones and hearing, hearts pumping blood, swim bladders enabling sensing of neutral buoyancy in water columns.

But we cannot *prestate* the ever-changing phase space of ever new functionalities that arise! Therefore, we can write no laws or equations of motion for this emergence. And therefore, we cannot integrate the equations of motion that we do not have to yield entailing laws.

No Laws Entail the Becoming of the Biosphere

We can write no laws of motion, from the time of Patrick and Rupert, for the emergence of the eukaryotic cell, sex, multicelled organisms, the Cambrian explosion with its specific marvels of the explosion of diversity of early flora and fauna, promissory of us, fish, amphibians, reptiles, mammals, and primates, let alone the specific proteins that have emerged. We live in an unprestatable, literally unimaginable, myriad of emergent becoming. Because we can write no laws for the specific emergence we live, we are based on physics, but beyond physics.

The living world is not a machine, deducible by Laplace's demon for whom the world was deducible given Newton's laws and the current positions and momenta of all the particles.

Reductionism Fails

The biosphere is part of the universe. Reductionism, Weinberg's superb dream of a final theory, is of one that would allow us to deduce all that becomes in the universe—that would entail all. But no laws entail the becoming of the biosphere, and the

biosphere is part of the universe, so reductionism fails. There is no final theory.

Thanks to the three closures—constraint, work, and catalytic—life literally constructs itself upward, the tree lunging for the sun. Life tweaks itself into the very cracks in Darwin's floor of nature that life itself creates for itself in its untellable fusillade of creativity. We have gotten from Patrick to a microbial world, a eukaryotic world, to a world of plants and animals, to Darwin's "forms most beautiful."

This vast emergent becoming is beyond physics, yet based on it. This is life co-constructing itself and enabling its own vast evolutionary diversification here, and on any biosphere, in the universe.

If among the 10^{22} solar systems estimated to exist, life is common, this self-constructing diversifying becoming is rife in the universe, is beyond physics, and may be as huge as physics in the emerging and growing complexity of the evolving universe as a whole.

This is a world beyond physics.