Incomplete Nature: How Mind Emerged from Matter

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How the Mind Uses Natural Constraints to Further Its Goals

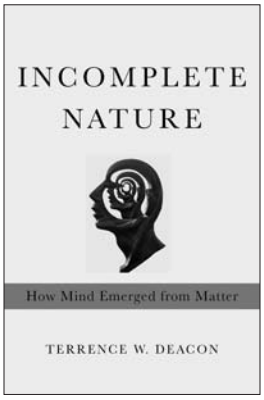
Incomplete Nature: How Mind Emerged from Matter. Terrence W. Deacon. W. W. Norton, 2011. 602 pages, 26 figures, $29.95 (978-0393049916).

The purpose of this book is nothing less than an investigation of how purpose (the ancient Greek philosophical notion of a *telos*) enters the universe. Purpose is coemergent with life itself, the author argues. It is not a product of natural selection but appears at the origin of life and mind. The mind, even the protomind of lower organisms, is the locus of information about constraints on natural processes that an organism exploits to achieve its ends of maintenance and reproduction. Integrating the mind into nature reconciles the physical and the meaningful and solves the mind–body problem.

Terrence Deacon is an evolutionary biologist specializing in neuroscience. He is a professor of biological anthropology and neuroscience and chair of the Department of Anthropology at the University of California, Berkeley. In his 1997 book, *The Symbolic Species: The Co-evolution of Language and the Brain*, he argued that language coevolved by natural selection with the brain, although he now argues that the major source of language acquisition is social transmission, with a trial-and-error process analogous to natural selection occurring while the brain develops.

Deacon's ambitious new work has a strong triadic structure, inspired perhaps by an important influence from semiotics—the philosopher Charles Sanders Peirce's triad of icon, index, and symbol. Deacon's triad levels represent the material, the ideal, and the pragmatic. The first two levels reflect the ancient philosophical dualism of materialism and idealism, or body and mind, respectively. The major transition from the nonliving to the living (the problem of *abiogenesis*) happens in the third level.

Teleodynamics is Deacon's name for the third level in his dynamics hierarchy. It is built on and incorporates the lower levels—the first physical and material, the second adding an informational and immaterial aspect. At the bottom level is the natural world, which Deacon characterizes by its subjection to the second law of thermodynamics. When entropy (the Boltzmann kind) reaches its maximum, the equilibrium condition is pure formless disorder. Although there is matter in motion, it is the motion we call *heat* and nothing



interesting is happening. Equilibrium has no meaningful differences. Deacon calls this the *homeodynamics* level, using the root *homeo-*, meaning "the same."

At the second level, form emerges. Deacon identifies a number of processes that are negentropic, reducing the entropy locally by doing work against and despite the first level's thermodynamics. This requires constraints, says Deacon, like the piston in a heat engine that constrains the expansion of a hot gas to a single direction, allowing the formless heat to produce directed motion. Atomic constraints such as the quantum-mechanical bonding of water molecules allow snow crystals to self-organize into spectacular forms, producing order from disorder. Deacon dubs this level *morphodynamics*. He sees the emerging forms as differences against the background of unformed sameness. His morphodynamic examples include, besides crystals, whirlpools, Bénard convection cells, basalt columns, and soil polygons, all of which apparently violate the first-level tendency toward disorder in the universe.

The quantum physicist Erwin Schrödinger saw the secret of life in an aperiodic crystal, and this is the basis for Deacon's third level, where "a difference that makes a difference" emerges as purposeful. Deacon ponders the role of ATP (adenosine triphosphate) monomers in energy transfer and their role in polymers like RNA and DNA, where the nucleotide arrangements can store information about constraints. He asks whether the order of nucleotides might create adjacent sites that enhance the closeness of certain molecules and thus increase their rate of interaction. This would constitute information in an organism that makes a difference in the external environment, an autocatalytic capability to recruit needed resources. Such a capability might have been a precursor to the genetic code.

Deacon crafts an ingenious model for a minimal "autogenic" system that has a teleonomic (purposeful) character, with properties that might be discovered some day to have existed in forms of protolife. His simplest "autogen" combines an autocatalytic capability with a self-assembly property like that in lipid membranes, which could act to conserve the catalyzed resources inside a protocell.

Autocatalysis and self-assembly are examples of morphodynamic processes that combine to produce the third-level, teleodynamics. Note that Deacon's simplest autogen need not replicate immediately. Like the near-life of a virus, it lacks a metabolic cycle and does not maintain its

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"species" with regular reproduction. But insofar as it stores information, it has a primitive ability to break into parts that could later produce similar wholes in the right environment. And the teleonomic information might suffer accidental changes that produce a kind of natural selection.

Deacon introduces a second triad he calls *Shannon–Boltzmann–Darwin* (Claude, Ludwig, and Charles). He describes it on his Web site *www.teleodynamics.com*. I would rearrange it with Boltzmann first (matter and energy in motion, but both conserved, merely transformed by morphodynamics). The Shannon stage then adds information (it is neither matter nor energy, says Deacon); for example, knowledge in an organism's "mind" about the external constraints that its actions can influence. This enables the organism to act in the world as an agent that can do useful work, that can evaluate its options, and that can be pragmatic (more shades of Peirce) and normative. Thus Deacon's model introduces value into the universe—good and bad (from the organism's perspective). It also achieves his goal of explaining the emergence of perhaps the most significant aspect of the mind: that it is normative and has goals.

Appreciating Deacon's argument is easier with a little history. Claude Shannon's information theory produced an expression for the potential information that can be carried in a communication channel. It is the mathematical negative of Boltzmann's formula for entropy. Confusingly, John von Neumann suggested that Shannon use the word *entropy* for his measure of information. Then Leon Brillouin coined the term *negentropy* to describe far-from-equilibrium conditions in the world epitomized by information.

Shannon entropy (which is negentropy) describes the large number of possible messages that could be encoded in a string of characters. Shannon's *actual information* reduces the uncertainty in the entropy of potential messages. Deacon notes correctly that new information can be transmitted only if these alternative possibilities exist. "No possibilities = no uncertainty = no information," he says. Without something new, the amount of information in the universe would be fixed.

Organisms are not machines, and minds are not computers, says Deacon, criticizing cognitive scientists who seek a one-to-one correspondence between conscious thoughts or actions and neuronal events. Machines are assembled from parts, whereas organisms self-assemble, he insightfully observes. Computers are designed to be totally predictable logical devices that are noise-free, but organisms and the mind could not survive if they worked that way, because the universe continually generates new information that would degrade them. The mind supervenes on astronomical numbers of neuronal events, which likely transmit far more stochastic noise than they do meaningful signals. Deacon thinks that meaningful mental events are probably only statistical regularities, averages over neuronal events, just as macroscopic classical properties are averages over quantum-level events.

I find Deacon's interest in the etymology of words fascinating, but his love of symbols leads him to use neologisms that make his sentences too dense, often obscuring his excellent ideas. For example, he uses *homeodynamic* for his first level instead of the standard term *thermodynamic*, which he does use occasionally and which would have been more clear. Then, instead of *morphodynamic* for the second level, he might have used *negentropic* (implying Shannon entropy). For his third level, *teleodynamic* is fine, but I'd have chosen the well-known term *teleonomic* used by Ernst Mayr and by Jacques Monod, whose Nobel colaureate François Jacob said that the goal of every cell is to become two cells. Deacon has now given us a specific model for the locus of the *telos*.

Since Schrödinger, we have known that life is impossible without the negative-entropy flow of far-from-equilibrium available energy from the sun. Deacon says that the first particles, the first atoms forming molecules, the first stars, and so on, can be explained without reference to anything nonphysical. But since these are formed by what he calls *morphodynamic processes*, I maintain that they also involve nonphysical information generation. In my own work, I attempt to show that without the expansion of the universe and ontological chance arising from quantum uncertainty, no new information could have come into existence from the assumed original state of thermodynamic equilibrium. There would be no galaxies, no stars, no planets, no life, no minds, no creative new thoughts, and in particular, no *telos*.

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Why does Deacon describe nature as incomplete? Because information seems nonphysical, he says, we lack a scientific understanding of how words and sentences refer to atoms of meaning. The meanings of words and thoughts, the contents of the mind—especially goals and purposes—are "not present," he says. He reifies this absence and finds that "a causal role for absence seems to be absent from the natural sciences." He calls this a "figure/ground reversal" in which he focuses on what is absent rather than present, likening it to the concept of zero, the holes in the "(w)hole." I agree with Deacon that ideas and information are immaterial, neither matter nor energy, but they need matter to be

embodied and energy to be communicated. And when they are embodied, they are obviously present (to my mind)—in particular, as those alternative possibilities (potential information) in a Shannon communication.

In Deacon's cryptic and counterintuitive "absentialist" view, the "efficacy of absence" is constituted by the constraints responsible for unactualized potentials that do the work. So natural selection for, say, greater running speed does not actually select, he would say; rather, biological function is "the evolutionary remainder" that results from "correlations that have not been eliminated." Slowness is an absence with an effect. It seems to me, in contrast, that when I select chocolate, I think about that flavor and not the other flavors, only a few of which even come to mind.

Just because, in the minds of many, "science has no place for purpose, meaning, and value," Deacon should not, I would argue, infer from these absences that "we are what we are not, continually, intrinsically, necessarily incomplete in our very nature." Indeed, his book gives us a more-complete physical understanding of *telos*. For me, the book succeeds in making life and the mind more natural and whole, not less so. Deacon's three-level model shows us very plausibly how ideas can move mountains.

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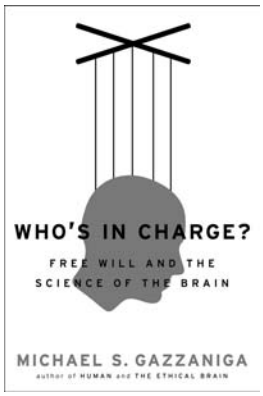
RESPONSIBILITY WITHOUT FREE WILL

Who's in Charge: Free Will and the Science of the Brain. Michael S. Gazzaniga. Harper Collins, 2011. 272 pp., illus. $27.99 (ISBN 9780061906107 cloth).

Michael S. Gazzaniga, who serves on the President's Council on Bioethics, is director of the SAGE Center for the Study of the Mind at the University of California, Santa Barbara, and Director of the Summer Institute in Cognitive Neuroscience at Dartmouth. Readers who expect to learn from his book *Who's in Charge: Free Will and the Science of the Brain* about brains and phenomena like consciousness, delusions, and confabulation will not be disappointed. They may be surprised, however, to find that they are also learning about quantum mechanics, chaos theory, law, punishment, and evolution. Based on the author's 2009 Gifford Lectures titled "The science of



mind constraining matter," this volume is impressive in its wide range of material, yet its thesis is simple: We are personally responsible and accountable agents, and scientific findings do not undermine this contention.

This is a highly readable, entertaining, and informative book. In a chapter on law, Gazzaniga makes it clear that the kind of responsibility he has in mind is directly relevant to legal judgments of guilt. But what about *free will*? The term appears in the book's subtitle, after all. His answer involves a ghostly or nonphysical element and "some secret stuff that is YOU" (p. 108). Here, of course, he is not reporting on a scientific discovery about free will; he is conveying how he understands the expression.

Given what the term means to Gazzaniga, it is no surprise that, in his view, "free will is a miscast concept, based on social and psychological beliefs... that have not been borne out and/or are at odds with modern scientific knowledge about the nature of our universe" (p. 219). If he were to believe that personal responsibility depends on free will, he would, of course, take a similarly dim view of responsibility. But Gazzaniga sees personal responsibility very differently: Free will is magical; responsibility is not. "The issue isn't whether or not we are 'free.' The issue is that there is no scientific reason not to hold people accountable and responsible" (p. 106).

Why might some people think that scientific findings undermine Gazzaniga's contention that we are accountable for some of our actions? Some might believe both that personal responsibility depends on our having *conscious* control, and recent experiments have shown that, in fact, unconscious brain processes call all the shots. In the book, Gazzaniga positions himself to take on this challenge: He reviews some of what is known about how human brains work and how they evolved, and he makes an engaging effort to explain how the brain fits into the rest of the universe.

We learn about differences between human and nonhuman brains, split-brain studies, the left-brain interpreter, and what gives individuals a feeling of psychological unity and control. Gazzaniga contends that while the brain enables and generates the mind, "the mind constrains the brain" and "responsibility arises out of social interaction" (p. 144). We become acquainted with the idea of personal responsibility through social interaction, and in the process we gain an ability that is important to our survival—our ability to know what other people intend and how they feel about things. Intentions and feelings are *mental* phenomena, and our mental grasp of these phenomena affects *unconscious* brain processes.

This is not to say that we have nonphysical minds (or souls). Rather, one thing human brains do is enable and generate very useful conscious

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