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## Chaos, Complexity, and Coevolution: The Web of Law, Management Theory, and Law Related Services at the Millennium

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# CHAOS, COMPLEXITY, AND COEVOLUTION: THE WEB OF LAW, MANAGEMENT THEORY, AND LAW RELATED SERVICES AT THE MILLENNIUM\*

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### III. LAW AND BUSINESS TOGETHER BUT SEPARATELY: AN ANALOGY OF COMPLEXITY AND EVOLUTION IN FOUR PARTS

#### *A. Punctuated Equilibrium and Complex Adaptive Systems*

Lester Thurow uses the idea of "punctuated equilibrium" in evolutionary biology as an analogy to help describe and understand what is happening in the world economy today:

To understand what those forces are doing and what must be done to adjust to them it is necessary to borrow the concept of "punctuated equilibrium" from evolutionary biology. Normally evolution proceeds at a pace so slow that it is not noticeable on a human time scale. . . . But occasionally something occurs that biologists know as "punctuated equilibrium." The environment suddenly changes and what has been the dominant species . . . takes a quantum leap. Natural selection, which normally works on the margins, suddenly alters the core of the system.<sup>289</sup>

Thurow's quote introduces the science of biological evolution as a comparison with, or metaphor for, current world economic events. Therefore it is necessary in this part of the article to examine and detail the science of biological punctuated equilibrium in order to later plumb the metaphor to law at greater depth. In addition, punctuated equilibrium will be the gateway to complexity, chaos, and complex adaptive systems (CAS) theory, which will also be discussed in this part. Again, like the methodology required of a paleontological monograph, this discussion requires detailed examination of several scientific models. The next part of the article will discuss the application of CAS theory to business.

One biological example of punctuated equilibrium (which is still a hotly debated theory in scientific circles) is described in the book *Wonderful Life* by Stephen Jay Gould.<sup>290</sup> Therein Professor Gould recounts the discovery of the Burgess Shale in British Columbia.<sup>291</sup> The paleontological record in the Burgess Shale is evidence of what is called the "Cambrian Explosion."<sup>292</sup> In other words, the Burgess Shale is a geological record of the "body types" in existence immediately after that explosion of life.<sup>293</sup> Although technical,

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289. LESTER C. THUROW, *THE FUTURE OF CAPITALISM: HOW TODAY'S ECONOMIC FORCES SHAPE TOMORROW'S WORLD* 7 (1996).

290. STEPHEN JAY GOULD, *WONDERFUL LIFE: THE BURGESS SHALE AND THE NATURE OF HISTORY* (1989).

291. *Id.*

292. *Id.* at 55.

293. *Id.*

the following quote is helpful to fix the Cambrian Explosion in science as well as to illustrate punctuated equilibrium:

Thus, instead of Darwin's gradual rise to mounting complexity, the 100 million years from Ediacara to Burgess may have witnessed three radically different faunas . . . culminating in the maximal anatomical range of the Burgess. Nearly 2.5 billion years of prokaryotic cells and nothing else—two-thirds of life's history in stasis at the lowest level of recorded complexity. Another 700 million years of the larger and much more intricate eukaryotic cells, but no aggregation to multicellular animal life. Then, in the 100-million-year wink of a geological eye, three outstanding different faunas . . . . Since then, more than 500 million years of wonderful stories, triumphs and tragedies, but not a single new phylum, or basic anatomical design, added to the Burgess complement.<sup>294</sup>

Stated less technically, there was an explosion of basic body-types (phenotypes; basic platform structures) during the Cambrian period on which slower, more marginal, traditional Darwinian evolution could later shape. As the previous quote indicates, some scientists therefore argue that the basic structural morphology (body-types) of the modern world were established during the Cambrian Explosion. If correct, this means that the traditional tree-like graph model of evolution (starting with a single trunk and branching like a tree) needs be redrawn as a bush (a short "trunk" that diversifies broadly, *e.g.*, quickly and low to the ground).<sup>295</sup>

In the Cambrian period, then, the number of body-types exploded quickly, and traditional Darwinian evolution selectively pruned these body-types through extinction until there was "stereotypy." "Stereotypy[, a related term is convergence], or the cramming of most species into a few anatomical plans, is a cardinal feature of modern life—and its greatest difference from the world of Burgess times."<sup>296</sup> There are, of course, other possible examples of punctuated equilibrium.<sup>297</sup>

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294. *Id.* at 59-60.

295. *Id.* at 45-47.

296. *Id.* at 49.

297. Thurow uses the extinction of the dinosaur as an illustration:

The best-known example is, of course, the dinosaurs. They dominated the surface of the earth for 130 million years, but then suddenly all of them became extinct (or birds?). Recent theories point to a comet hitting the surface of the earth near the Yucatán Peninsula with such force that it caused sulfuric volcanoes to erupt on the other side of the earth. A persistent cloud of sulfuric dust destroyed the environment that made the dinosaurs possible. For reasons that are still not clear, mammals could cope with this new environment and they became the earth's dominant species. But whatever happened, it happened quickly, and profoundly changed who would dominate—and who would become extinct.



The discovery and study of the *mechanisms* that allowed body-types to develop rapidly in response to a changed environment immediately preceding the Cambrian explosion is in its hypothetical stage and is, therefore, speculative. In fact, Murray Gell-Mann, a Nobel Prize winner in physics, has commented about the possible causes of punctuated equilibrium dividing the “mechanisms thought to be responsible . . . into various categories.”<sup>298</sup> He describes one such mechanism as an “alteration” in “the physicochemical environment.”<sup>299</sup> For example, in his opinion:

At the end the Cretaceous Period about sixty-five million years ago, at least one heavy object collided with the Earth, the one that formed the huge crater of Chicxulub on the edge of the Yucatán peninsula. The resulting atmospheric changes helped to produce the Cretaceous extinction, which did away with the large dinosaurs and very many other forms of life.<sup>300</sup>

“Another kind of rapid change that may punctuate apparent evolutionary equilibrium”<sup>301</sup> is of the most interest herein because it even better implicates self-organization and complexity theory:

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THUROW, *supra* note 289, at 7 (footnotes omitted).

The idea of punctuated equilibrium is itself “revolutionary” in the scientific sense because slow, steady, marginal evolution has been an article of faith of evolutionary biologists since Darwin:

Remember how the paleontologist Robert Broom put it in his 1933 book, *The Coming of Man: Was It Accident or Design?*: “Much of evolution looks as if it had been planned to result in man, and in other animals and plants to make the world a suitable place for him to dwell in.” Broom’s was an extreme statement, but it captures the essence of a mode of thinking that pervaded all scholarly endeavor.

We now have to face the fact that this is wrong. . . . When complexity eventually arose 530 million years ago, in the form of multicellular organisms, it did so explosively; within five million years (an instant in geologic time), evolutionary innovation produced a myriad of multicellular forms of life. Life’s flow is therefore not smooth, but extremely erratic.”

RICHARD LEAKEY & ROGER LEWIN, *THE SIXTH EXTINCTION: PATTERNS OF LIFE AND THE FUTURE OF HUMANKIND* 226 (1995) (footnote omitted).

298. MURRAY GELL-MANN, *THE QUARK AND THE JAGUAR: ADVENTURES IN THE SIMPLE AND THE COMPLEX* 239 (1994). For a good general explanation of punctuated equilibrium, see JACK COHEN & IAN STEWART, *THE COLLAPSE OF CHAOS: DISCOVERING SIMPLICITY IN A COMPLEX WORLD* 308-40 (1994).

299. GELL-MANN, *supra* note 298, at 239.

300. *Id.*

301. *Id.*

[This kind of change] does not require dramatic sudden changes in the physical environment. Instead, it results from the tendency of genomes [(genotype, genetic pattern)] to change gradually with time in ways that do not profoundly affect the viability of the phenotype [or individual's actual features]. As a result of that process of "drift," a cluster of genotypes constituting a species may move toward an unstable situation in which fairly small genetic changes can radically alter the phenotype. [Thus, the label "genetic drift."] It may happen at a certain time that a number of species in an ecological community are approaching that kind of instability, creating a situation that is ripe for the occurrence of mutations that do lead to important phenotypic changes in one or more organisms. Those changes can initiate a series of linked events, in which some organisms become more successful, others die out, the whole community is altered, and new ecological niches open up.<sup>302</sup>

Thus, there are at least two independent kinds of changes that may result in punctuated equilibrium, neither of which are necessarily mutually exclusive.

A third possible "cause" of punctuated equilibrium, either independent or in conjunction with the other two, could be related to the evolution of the regulatory genes themselves. For example:

Erwin and the others believe [that] some worm-like creature expanded its *Hox* [(gene)] cluster, bringing the number of genes up to six. Then, 'Boom!' shouts Jablonski. 'At that point, perhaps, life crossed some sort of critical threshold.' Result: the Cambrian explosion[, a change in genotype as opposed to phenotype].<sup>303</sup>

However:

Carroll suspects that the Cambrian explosion was powered by more than a simple question of expansion in the number of *Hox* genes. Far more important, he believes, were changes in the vast regulatory networks that link each *Hox* gene to hundreds of other genes. Think of these genes, suggests Carroll, as the chips that run a computer. The Cambrian explosion, then, may mark not the invention of new hardware, but rather the elaboration of new software that allowed existing genes to perform new tricks. Unusual-looking arthropods for example, might be cobbled together through variations of the genetic software that codes legs.<sup>304</sup>

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302. *Id.*

303. J. Madeline Nash, *When Life Exploded*, TIME, Dec. 4, 1995, at 73.

304. *Id.* Even though technically phrased, the following quote is important evidence from mainstream science that "networks" are legitimate and currently popular areas of study whether or not these connections themselves *cause* punctuated equilibria:

In sum, at least a few scientists hypothesize that evolution in the ordering mechanism for gene networks may have played a key role in the Cambrian explosion.

The foregoing brief description of evolutionary “punctuated equilibrium” is the gravamen for the analogy of economics to evolutionary biology as well as any punctuated equilibrium hypothesis relating economics and law herein. Recall that, in explaining the Cambrian explosion, the quoted scientists used the terms “regulatory networks”<sup>305</sup> and “critical threshold.”<sup>306</sup> It is the network idea, according to Fritjof Capra and others, that may be the linchpin in any theory that realistically encompasses living systems. For example:

During the last few decades the network perspective has become more and more central to ecology. As the ecologist Bernard Patten put it in his concluding remarks to a recent conference on ecological networks: “Ecology is networks. . . . To understand ecosystems ultimately will be to understand networks.” Indeed, during the second half of the century the network concept has been the key to the recent advances in the scientific understanding not only of ecosystems but of the very nature of life.<sup>307</sup>

Networks at least imply interdependence. This interdependence, as Capra recently observed, is consistent with the philosophy of Immanuel Kant, whom Capra summarizes as follows:

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The interactions of biological macromolecules and the flow of regulatory information that controls development, behavior, and homeostasis can be considered a genetic network. The nodes in such networks are genes or their RNA and protein products. The connections are regulatory and physical interactions among the RNAs, proteins, and . . . DNA sequences of each gene. Modern molecular genetic techniques have greatly increased the rate at which genes are being recognized and their primary sequences determined. The challenge is to link the genes and their products into functional pathways, circuits, and networks. Analyses of regulatory networks (such as those involving signal transduction and transcriptional regulation cascades) illustrate combinatorial action that implements, for example, digital logic, analog-digital conversions, cross-talk and insulation, and signal integration. . . . Much of current molecular biology focuses on identifying new components, defining the regulatory inputs and outputs of each node, and delineating the physiologically relevant pathways.

William F. Loomis & Paul W. Sternberg, *Genetic Networks*, 269 SCI. 649, 649 (1995).

305. See *id.*

306. See *supra* note 303 and accompanying text.

307. FRITJOF CAPRA, *THE WEB OF LIFE: A NEW SCIENTIFIC UNDERSTANDING OF LIVING SYSTEMS* 35 (1996) (quoting B.C. Patten, *Network Ecology*, in *THEORETICAL STUDIES OF ECOSYSTEMS: THE NETWORK PERSPECTIVE* (1991)) (footnote omitted).

In his *Critique of Judgment* Kant discussed the nature of living organisms. He argued that organisms, in contrast with machines, are self-reproducing, self-organizing wholes. In a machine, according to Kant, the parts only exist *for* each other, in the sense of supporting each other within a functional whole. In an organism the parts also exist *by means of* each other, in the sense of producing one another. "We must think of each part as an organ," wrote Kant, "that produces the other parts (so that each reciprocally produces the other). . . . Because of this, [the organism] will be both an organized and self-organizing being."<sup>308</sup>

This reciprocity (or interdependence) exists in theory across biological disciplines; for example, reciprocal networks in biological systems exist at the levels (scales) of organisms, parts of organisms, and communities of organisms, "all of which are integrated wholes whose essential properties arise from the interactions and interdependence of their parts."<sup>309</sup> In evolutionary biology one manifestation of this interaction is the word "coevolution." Stuart Kauffman provides one rather poetic description of coevolution:

Species live in the niches afforded by other species. They always have and presumably always will. Once initial life arose and began to diversify, exchanging molecules that might poison or feed one another, organisms joined into a coevolutionary dance, jockeying for places next to one another as mutualists, competitors, predators and prey, or hosts and parasites.<sup>310</sup>

The idea expressed by the word "coevolution" provides the reciprocity or interdependence characteristic of evolution that, in part, helps establish evolution as a type of network. Thus, this discussion has logically come full circle from genetic regulatory networks (focusing on genetic material, genotypes) through living ecosystem networks, and back to coevolution on the phenotypic level (focusing on individual or individual species' actual physical characteristics) because of the operation of the "living" ecosystem. This certainly seems to establish that the theoretical study of networks may inform our study of both evolution and biology.

On the other hand, perhaps this somewhat poetic inter-species illustration of the coevolutionary dance ending with my logical circle is too easy to accept. That is, it seems easy to understand that the characteristics of one

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308. *Id.* at 21-22 (quoting IMMANUEL KANT, *CRITIQUE OF JUDGMENT* 253 (Werer S. Pluhar trans., 1987)) (footnote omitted) (alteration in original).

309. *Id.* at 34.

310. STUART KAUFFMAN, *AT HOME IN THE UNIVERSE: THE SEARCH FOR LAWS OF SELF-ORGANIZATION AND COMPLEXITY* 215 (1995).

species (or of an individual within one species) might help form the evolutionary environment for another. From there, it is tempting to extrapolate that fitness in the evolutionary sense includes such traits as altruism and cooperation and that evolutionary principles extend to selection of the fittest *group* as well as the fittest *individual* (without regard to group formation attributes). Such an extrapolation, even if seemingly logical, would miss one of the great evolutionary debates of this century between the “ultra-Darwinists” and the “naturalists.”<sup>311</sup>

So far, the ultra-Darwinian view that evolution is never anything more than a race between individuals to leave more of their DNA on earth “has become the prevailing wisdom in the field of animal (and plant) behavior.”<sup>312</sup>

In this perspective, it's the genetic instructions that are being selected and that are evolving [the genotype]. Or you might with nearly equal justice say it's the individual organisms, under the tight control of the genetic instructions, that are being selected and that are evolving. There is no room here for group selection—the natural and attractive idea that species are in competition with one another . . . . Acts of apparent altruism are instead attributed chiefly to kin selection. The mother bird slowly flutters from the fox, one wing bent as if broken, in order to lead the predator away from her brood. She may lose her life, but multiple copies of very similar genetic instructions will survive in the DNA of her chicks. A cost-benefit analysis has been made. The genes dictate to the outer world of flesh and blood with wholly selfish motives, and real altruism—self-sacrifice for a non-relative—is deemed a sentimental illusion.<sup>313</sup>

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311. See ERNST MAYR, TOWARD A NEW PHILOSOPHY OF BIOLOGY: OBSERVATIONS OF AN EVOLUTIONIST 119 (1988); see also NILES ELDREDGE, REINVENTING DARWIN: THE GREAT DEBATE AT THE HIGH TABLE OF EVOLUTIONARY THEORY 201-19 (1995); CARL SAGAN & ANN DRUYAN, SHADOWS OF FORGOTTEN ANCESTORS: A SEARCH FOR WHO WE ARE 111-18 (1992).

According to Niles Eldredge, there is a “second paradox,” in addition to altruism, that has confronted ultra-Darwinians during the past three decades:

[It] is the very existence of sex. If the very name of the game of life is to leave as many copies of your genes behind, why on earth do so many organisms reproduce sexually, thereby limiting themselves to contributing only half of the genes that go to each descendant? Here, ultra-Darwinians rather candidly admit, they haven't quite got it all figured out. Despite a number of good books . . . and multiauthored symposia, the paradox of sex has not yet been resolved. Nor will it just go away.

ELDREDGE, *supra*, at 311; see also RICHARD DAWKINS, THE BLIND WATCHMAKER: WHY THE EVIDENCE OF EVOLUTION REVEALS A UNIVERSE WITHOUT DESIGN 268 (1987).

312. SAGAN & DRUYAN, *supra* note 311, at 112

313. *Id.* (footnotes omitted). Note that “[a]t the human level it [individual genetic selection] helps to explain such varied matters as nepotism and the fact that foster children are much more likely (in America, for example, about a hundred times more likely) to be fatally abused than children living with their natural parents.” *Id.* (footnote omitted).

Indeed evolutionary biologist Richard Dawkins, an ultra-Darwinian,<sup>314</sup> largely refuses to acknowledge or recognize species selection except that “[a] form of species selection, then, could favour, not individual self-sacrifice, but those species in which individuals are not asked to sacrifice their own welfare.”<sup>315</sup> The surviving species would then *appear* to favor altruism because in those species individual self-interest is more closely aligned with the altruism asked of them. In sum, then, “to an ultra-Darwinian, the apparently altruistic cooperation underlying social behavior is really a form of selfishness in disguise.”<sup>316</sup>

Ernst Mayr adds analytical method to this discourse and furthers the discussion by “distinguish[ing] clearly among four different meanings of the

314. ELDREDGE, *supra* note 311, at 5 and accompanying text.

315. DAWKINS, *supra* note 311, at 268. Dawkins suggests that his biggest problem with punctuated equilibrium is not the theory itself as long as it is seen as “rapid gradualism” and not confused with “macro-mutation” (he alleges Gould has a “soft-spot for” macro-mutations of a certain type):

[B]ecause the theory is heavily promoted and widely misunderstood, I must just stress that the theory of punctuated equilibrium does not have—or should not be represented as having—any legitimate connection with macro-mutation. . . . [R]apid though these bursts [in punctuated equilibrium] may be, they are still spread over large numbers of generations, and they are still *gradual*. It is just that the intermediates usually pass too quickly to be recorded as fossils. This ‘punctuation as rapid gradualism’ is very different from macro-mutation, which is instantaneous change in a single generation.

RICHARD DAWKINS, CLIMBING MOUNT IMPROBABLE 105 (1996) [hereinafter CLIMBING MOUNT IMPROBABLE].

Moreover, in his 1996 book Dawkins addresses the possible existence of “magnets” or “attractors” in evolutionary multi-dimensional animal space. He leaves his theory open just a crack for its existence by saying: “I will stand up and assert that natural selection is responsible for the goodness of apparent design. ‘Magnets’ or ‘attractors’ in Animal Space cannot, unaided by selection, achieve good functional design. But now, let me soften my position just a little by introducing the idea of ‘kaleidoscopic’ embryologies.” *Id.* at 223.

Dawkins “kaleidoscopic embryologies” limit the vast space of possible evolution by placing certain symmetrical design limits on the actual wandering of evolution therein. In this narrow sense, Dawkins agrees that there has been an “evolution of improved evolvability.” *Id.* at 255.

316. ELDREDGE, *supra* note 311, at 205-06. For a good general discussion of “altruism” in evolution, see William H. Rodgers, *Where Environmental Law and Biology Meet: Of Pandas’ Thumbs, Statutory Sleepers, and Effective Law*, 65 COLO. L. REV. 25, 38-46 (1993). Rodgers identifies five types of altruism: (1) kinship; (2) reciprocal altruism (a tit-for-tat concept over an extended period of time); (3) indirect (reputational) reciprocity (perhaps a third party will reward the altruistic actor); (4) commitment and passion (important for establishing core relationships with others, e.g., mates); and (5) pure (capital “A”) Altruism (personal sacrifice with no expectation of, or realistic prospect for, reward). *Id.*

term group, each of which has a different relation to natural selection."<sup>317</sup> Of these groups, Mayr opines, human cultural groups are "the only well-established cases of group selection."<sup>318</sup> New research seems to support, at least in part, Mayr's opinion that human cultural groups are subject to the group selection level of survival of the fittest. According to an anthropologist at the Jane Goodall Research Center at the University of Southern California:

[V]irtually all hunter-gatherer societies have an egalitarian ethic that makes it difficult for individuals to increase their fitness at the expense of other individuals in the same group. The [individual] impulse to dominate and surpass one's neighbors is not absent, but . . . [t]he egalitarian ethic causes meat and other important resources to be shared among the entire group, circumscribes the power of leaders, punishes freeriders, and causes virtually all important decisions to be made by a consensus process.<sup>319</sup>

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317. MAYR, *supra* note 311, at 119.

318. *Id.* at 122 (citation omitted).

319. David Sloan Wilson, *Human Groups as Units of Selection*, 276 SCI. 1816, 1816 (1997) (summarizing Christopher Boehm, *Impact of the Human Egalitarian Syndrome on Darwinian Selection Mechanics*, 150 AM. NATURALIST S100 (Supp. 1997)). As a harbinger of topics discussed later in this article, group formation is also addressed in an anthology about chaos theory in the social sciences. Therein the author of a chapter concludes as follows:

The purpose of this chapter was to reraise the question of the "black box" of the individual-group connection. We know that this connection is not the simple additive relation that early theorists once assumed. We know it is "strange," as evidenced by complex outcomes, instability, and sensitivity. In this chapter I sought to demonstrate that this black box of aggregation from individual to group is in the realm of chaos theory. . . . I showed this with the example of multidimensional spatial voting: the voting context with the most pervasive presence of instability. However, I suspect this applies to most aggregations, as I suggested by pointing to similar findings by Saari on voting and by economists in terms of aggregation through price mechanisms.

Diana Richards, *From Individuals to Groups: The Aggregation of Votes and Chaotic Dynamics*, in CHAOS THEORY IN THE SOCIAL SCIENCES: FOUNDATIONS AND APPLICATIONS 115 (L. Douglas Kiel & Euel Elliott eds., 1996). See generally MATT RIDLEY, *THE ORIGINS OF VIRTUE: HUMAN INSTINCTS AND THE EVOLUTION OF COOPERATION* (1996); *THE SENSE OF JUSTICE: BIOLOGICAL FOUNDATIONS OF LAW* (Robert Masters & Margaret Gruter eds., 1992); ROBERT C. SOLOMON, *A PASSION FOR JUSTICE: EMOTIONS AND THE ORIGINS OF THE SOCIAL CONTRACT* (1990). For a description of strange attractors, see Appendix, pt. A, *infra*.

Further and consistently, social science research now seems to support the idea that "social and organizational characteristics of neighborhoods and that some measure of civil mindedness (for lack of a more descriptive term) in a community correlates to reduced violence." This conclusion is not surprising and barely noteworthy given anecdotal observation. What *is* significant, however, is that research methodology using mathematics now seems to support that anecdotal common wisdom. In other words, the relationship between a social survey concerning "community" and "violence" can now be expressed,

This ethic is a set of society-enforced cultural norms (resembling laws) that defines acceptable behavior for individual group members. Indeed, "the egalitarian ethic accomplishes a degree of behavioral uniformity within groups, and differences between groups, *that could never be predicted from their genetic structure.*"<sup>320</sup> Finally, the article describing the research

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tentatively, by a mathematical formula. "Fraternity" in reporting the results of this research is expressed as "collective efficacy":

Together, three dimensions of neighborhood stratification—concentrated disadvantage, immigration concentration, and residential stability—explained 70% of the neighborhood variation in collective efficacy. Collective efficacy in turn mediated a substantial portion of the association of residential stability and disadvantage with multiple measures of violence, which is consistent with a major theme in neighborhood theories of social organization. After adjustment for measurement error, individual differences in neighborhood composition, prior violence, and other potentially confounding social processes, the combined measure of informal social control and cohesion and trust remained a robust predictor of lower rates of violence.

Robert J. Sampson et al., *Neighborhoods and Violent Crime: A Multilevel Study of Collective Efficacy*, 277 SCI. 918, 923 (1997) (citation omitted).

320. Wilson, *supra* note 319, at 1816 (emphasis added). Others use different terminology in their research, but ultimately the basic themes seem similar. Professor McAdams, for example, suggests using an "eastern model" to help understand the development of norms (group forming conditions?), explaining that:

[T]he initial force behind norm creation is the desire individuals have for *respect* or *prestige*, that is, for the relative *esteem* of others. Withholding esteem is, under certain conditions, a costless means of inflicting costs on others. These costs are often extremely small; their insignificance compared to material incentives is probably what explains the tendency of economic theories to ignore them altogether. But Part II demonstrates that dynamic forces can cause the weak desire for esteem to produce powerful norms, sometimes because individuals struggle to avoid deviance, sometimes because they compete to be heroic.

Richard H. McAdams, *The Origin, Development, and Regulation of Norms*, 96 MICH. L. REV. 338, 342 (1997).

McAdams uses the term "feedback effect"—a term that the current article generally identifies with CAS theory to categorize the process in which "behavioral regularity" becomes a norm through "competition to avoid deviance":

Because esteem is relative, the intensity of disesteem directed at those who engage in a disapproved behavior is partly a function of the total number of people who are thought to engage in that behavior. If twenty percent of the population is thought to violate the initial [and earlier proposed] norm against smoking or fur, then violating that norm will place one in the bottom quintile of the group with respect to that criterion of esteem. But if only two percent are believed to be smokers or fur wearers, then one falls to the bottom two percent for that criteria. Other things being equal, the latter represents a greater esteem cost than the former; the more deviant the violation, the more it appalls group sentiment.

*Id.* at 366 (footnotes omitted).

Interestingly, for purposes of the current article, McAdams cites a business related article as an illustration that "law and society scholars discussed informal social sanctions and their



suggests that "human social groups have been guided by an egalitarian ethic for many millennia, long enough to have influenced *both genetic and cultural evolution*."<sup>321</sup> Basically, that means that individuals with a genetic predisposition toward the acceptance of cultural norms were favored as mates over time and, in turn, eventually this biological evolution reinforced the existence and extension of those norms.

Even before the most recent research, however, Mayr said that "[t]here is a great deal of evidence that human cultural groups, as wholes, can serve as the target of selection[, and] [r]ather severe selection among such cultural groups has been going on throughout hominid history."<sup>322</sup> Further, "[a]s history repeatedly illustrates, those behaviors will be preserved and those norms will have the longest survival that contribute the most to the well-being of a cultural group as a whole."<sup>323</sup>

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relationship to legal rules" before ever using the concept or term "norms." *Id.* at 343 n.20 (citing Stewart Macaulay, *Non-Contractual Relations in Business: A Preliminary Study*, 28 AM. SOC. REV. 55 (1963)). Indeed, "norms" in law and economics was used by Professors Black and Kraakman in advising and consulting with Russia on its business and corporate codes. Bernard Black & Reinier Kraakman, *A Self-Enforcing Model of Corporate Law*, 109 HARV. L. REV. 1911, 1912 (1996). The self-enforcing model leverages business and cultural norms; the prohibitive model, as its name suggests, prohibits "a wide variety of suspect corporate behavior in considerable detail." *Id.* at 1929.

321. Wilson, *supra* note 319, at 1817 (emphasis added). See, e.g., ELDREDGE, *supra* note 311, at 207 (discussing class stratification in species of wasps).

322. MAYR, *supra* note 311, at 79; cf. JOHN KEEGAN, A HISTORY OF WARFARE 24-60 (1993) (providing an anthropological history of war and its methods and providing a vast array of inductive evidence about impact of cultural groups on war); DAVID S. LANDES, THE WEALTH AND POVERTY OF NATIONS (1998).

323. MAYR, *supra* note 311, at 80. A comprehensive but readable scholarly treatment of both social and biological evolution given by William H. Durham outlines what he believes to be system requirements for evolution and "propose[s] a theory of cultural evolution—that is, of descent with modification in the shared conceptual systems we call 'cultures'—that is parallel in many ways to Darwin's theory of organic evolution." WILLIAM H. DURHAM, COEVOLUTION: GENES, CULTURE, AND HUMAN DIVERSITY 419 (1991). Further, the "basic premise of the theory . . . is that genes and culture constitute two distinct but interacting systems of information inheritance within human populations." *Id.* at 419-20.

Durham summarized what "the new consensus in anthropology" regards as "culture": "systems of symbolically encoded conceptual phenomena that are socially and historically transmitted within and between populations." *Id.* at 8-9. Importantly, this consensus "leads us back to the heart of the problem of relating genes and culture—not away from it." *Id.* at 9. It also allows for a distinction analogous to the genotype (genetic network recipe) and the phenotype (the flesh and blood expression of that genetic recipe). *Id.* Durham lists the following as "'system requirements' for evolutionary change": (1) that the system "can be divided into recognizable subunits of transmission"; (2) that "there are sources of variation"; (3) "that there exist one or more mechanisms of transmission"; and (4) that "Darwin was right in suggesting natural selection as the main but not exclusive means of modification in organic evolution." *Id.* at 420-21.

The primary reason Mayr believes that group selection is a uniquely human phenomenon is because "[t]he ability to apply group norms . . . is intimately correlated with the evolving reasoning capacity of the human brain,"<sup>324</sup> which itself seems to have undergone the explosive growth that characterizes punctuated equilibrium.<sup>325</sup> Stated rhetorically, if the choice of the optimal mix between strict selfishness and strict altruism for "each novel circumstance" is "too difficult for the genes to figure out on their own" through selection, "might it not be advantageous for [the genes] to delegate authority [to the brain]?"<sup>326</sup>

It is not just the mental capacity to judge but also the mental capacity to learn that is important for the transmission of cultural and ethical information necessary in any theory of group selection:

Man is distinguished from all other animals by the openness of its behavioral program. By this I mean that many of the objects of behavior and the reactions to these objects are not instinctive, that is, not part of a

324. MAYR, *supra* note 311, at 80.

325. See, e.g., RICHARD M. RESTAK, M.D., *THE BRAIN: THE LAST FRONTIER* 71 (1979). A relatively new idea is that "politics" actually helped drive the evolution in human brain size. Not long ago most anthropologists believed that tool-making or hunting was the driving evolutionary force. RICHARD LEAKEY & ROGER LEWIN, *ORIGINS RECONSIDERED: IN SEARCH OF WHAT MAKES US HUMAN* 285 (1992). The tool-making theory, however, is now being contested by what some call the "theory of social chess." *Id.* at 181. This latter theory posits that group politics, not tool-making, drove the evolutionary development of the brain and is, in large part, based on the study of primates. *Id.* at 298-99. Self-awareness allows primates to form alliances. *Id.* It also allows an individual to use deception.

One author has posited further that the explosion of human brain capacity now continues through the invention and use of computers:

I hope I have convinced you that the evolution of the mind has not yet stopped for the human species. We are now, of course, using technology to extend the capabilities of our brains in ways that were unimaginable just a few years ago. This is in itself not biological evolution, but it may give a biological advantage to those individuals who are best able to utilize these new capabilities.

CHRISTOPHER WILLS, *THE RUNAWAY BRAIN: THE EVOLUTION OF HUMAN UNIQUENESS* 310 (1993).

Indeed, the capacity of the human brain is breathtakingly explained by brain science researcher Paul M. Churchland. By way of summary that is far less breathtaking than his original description, he first invites the reader to imagine one tower (all four sides) of the World Trade Center to be tiled by about 500,000 TV screens (consisting of about 100 billion television pixels). PAUL M. CHURCHLAND, *THE ENGINE OF REASON, THE SEAT OF THE SOUL: A PHILOSOPHICAL JOURNEY INTO THE BRAIN* 6-7 (1995). Next, he translates the television screens into having the physical quality of aluminum foil and then simply says that if one were to peel the foil from the building and crumple it tightly into a wrinkled ball about the size of a large grapefruit the result would be close to the representational capacity of the human brain. *Id.* at 7-9.

326. SAGAN & DRUYAN, *supra* note 311, at 116.

"closed program," but are [learned] in the course of life. . . . As Waddington proposed it, "The human infant is born with probably a certain innate capacity to acquire ethical beliefs, but without any specific beliefs in particular."<sup>327</sup>

Some difference in moral norms is probably the result of random chance coupled with natural selection on the group level.<sup>328</sup> Other aspects of moral or ethical codes are probably the product of applied reasoning and judgment which, in another context, will be described as artificial selection.<sup>329</sup> Even so,

when we compare the major religions and philosophies, . . . we discover ethical codes that are remarkably similar, despite their largely independent histories. This suggests that the philosophers, prophets, or law-givers responsible for these codes must have carefully studied their societies and, using their ability to reason on the basis of these observations, must have decided which norms were beneficial and which others were not [and must have reached similar general conclusions].<sup>330</sup>

Eldredge and Grene observe that one common governmental conclusion seems to be based upon

our apparent need for the coercive structure of the state; at least in many cultures, we have to devise complicated and arbitrary sanctions in order to control our own violence toward one another. We are indeed social animals, but each of us also retains an asocial, even antisocial, tendency that demands arbitrary control. Thus we are not only social but also *political* animals.<sup>331</sup>

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327. MAYR, *supra* note 311, at 84 (citation omitted).

328. *Id.* at 81.

329. For a discussion of Dawkins's computer simulation of evolution called "Biomorph Land," see *infra* notes 342-50 and accompanying text.

330. MAYR, *supra* note 311, at 81.

331. NILES ELDRIDGE & MARJORIE GRENE, *INTERACTIONS: THE BIOLOGICAL CONTEXT OF SOCIAL SYSTEMS* 173 (1992).

It is also worth noting that certain characteristics of political organizations have been described in the terms of catastrophe theory and energy flows, both of which are related to biological punctuated equilibrium. For a discussion of open and closed systems, see *infra* note 536. For a discussion of energy flows, see *infra* notes 352, 378, and 423.

John Casti uses the fall of the Berlin Wall as an example of catastrophe theory where the network dimensions are "two conflicting pairs of social goals: an economic conflict between equality and opportunity, a political conflict between liberty and fraternity." JOHN L. CASTI, *COMPLEXIFICATION: EXPLAINING A PARADOXICAL WORLD THROUGH THE SCIENCE*

OF SURPRISE 48 (1994). Relatedly,

Human societies and political organizations, like all living systems, are maintained by a continuous flow of energy. . . . The simplest familial unit to the most . . . patterned interactions that comprise a human society are dependent on energy. At the same time, the mechanisms by which human groups acquire and distribute basic resources are conditioned by, and integrated within, sociopolitical institutions. Energy flow and sociopolitical organization are opposite sides of an equation. Neither can exist . . . without the other, nor can either undergo substantial change without altering both the opposite member and the balance of the equation. Energy flow and sociopolitical organization must evolve in harmony.

JOSEPH A. TAINTER, *THE COLLAPSE OF COMPLEX SOCIETIES* 91 (1988).

Writing about the possible application of evolution (as informed by complexity theory) to history, Robert Artigiani states:

While requiring that certain distinctive features of human behavior be recognized, applying the theory of evolution to history produces important opportunities. On the one hand, if human history follows the laws governing the evolution of nature then the events of history become meaningful, for they can be subsumed under the aegis of "covering laws." History would no longer be, at best, a litany of "one damn thing after another" or, at worst Henry Ford's immortal "Bunk!"

Robert Artigiani, *Cultural Evolution*, 23 *WORLD FUTURES: THE JOURNAL OF GENERAL EVOLUTION* 93, 95-96 (1987) [hereinafter *Cultural Evolution*] (citations omitted).

According to Artigiani, the genetic materials of social evolution are cognitive maps which "are sets of symbols representing physical phenomena, people, and procedures that group sequences of facts and ideas governing particular behavior sets around values with each behavior set playing the role of a cultural gene." *Id.* at 98. Said another way, "[v]alues are the medium through which behavior is structured. They are symbols that trigger emotional responses encouraging or discouraging specific actions, specified by 'norms.'" Robert Artigiani, *Post-Modernism and Social Evolution: An Inquiry*, 30 *WORLD FUTURES: THE JOURNAL OF GENERAL EVOLUTION* 149, 149 (1991) [hereinafter *Post-Modernism*].

These cultural genes (memes) are transmitted from generation to generation through such media "as language, myth, tools, art, ritual, and simple imitation." *Cultural Evolution, supra*, 98-100. Any mutation (change in either the gene as given by giver or the gene as reinterpreted creatively when received by receiver) that is favored by the environment will, in turn, reproduce more rapidly, eventually changing the society. Interestingly, Artigiani suggests that the first reaction to an environmental change will "more frequently be in the form of reactions against destabilization." *Id.* at 104. For example, it will take the form of a vociferous defense of the status quo. In the same article, Artigiani explains revolutions in terms of catastrophe theory and, without using the term, emergence. *Id.* at 105-06.

Recall that the ability to change and mutate is arguably itself an evolved trait in the context of evolutionary biology. See *supra* note 302 and accompanying text. Artigiani and others have hypothesized that post-modernism may be a change or adaptive accelerator in social evolution. Artigiani does an excellent job, in my opinion, of describing post-modernism. To summarize what he says, post-modernism is a world-view that is internally contextual with the observer. That is, meaning emerges from the observer "deconstructing" the text or work into separate component parts that have personal significance to her and then reconstructing the meaningful tent in her own mind:

The process of deconstruction and reconstituting is unavoidable, and when critics review a work their recorded reactions themselves become the sources for new texts. Thus, the

Needless to say, for purposes of this article, there seems to be enough scientific evidence to assert that some group selection of human culture takes place and, therefore, that culture is an operational part of the evolutionary environment that affects biological evolution.<sup>332</sup> Moreover, the

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original "work" is not accessible, for what the artist intended cannot control the reactions of the audience. Consequently, as David Lodge puts it, "every decoding is a new encoding," and the literary world lies trapped within an interpretive circle from which there is no apparent escape.

*Post-Modernism, supra*, at 153 (citation omitted).

From there, some post-modernists "argue that, even if there is an independent external reality, as prisoners of linguistic conventions we cannot know it and ought to abandon the search for it." *Id.*; see also RICHARD A. POSNER, LAW AND LITERATURE: A MISUNDERSTOOD RELATION 211-37 (1988) (discussing deconstruction and post-modernism and their relationship to law in a way generally consistent with the views of Artigiani, except expressly concerning legal texts). For purposes of this article, I believe the previous statement, if taken to its logical extreme, goes too far.

Nonetheless, post-modernism helps "demythologize" much of what might otherwise be seen as factual reality or inveterate values:

[I]t may . . . be a liberation, an opportunity for free creation. Symbolic mutations—literary metaphors, scientific paradigms, or new technologies—exploit this opportunity. They play with words or ideas, combining symbols to search through linguistic possibilities. Some combinations enrich the information flow within a social structure. A social structure with an enriched information flow, of course, can model an expanded environment. Modeling an expanded environment makes a society more complex.

*Post-Modernism, supra*, at 154-55 (citation omitted).

More to the point of social evolution, Stuart Kauffman says:

"So maybe we have the starts of models of historical, unfolding processes for such things as the Industrial Revolution, for example, or the Renaissance as a cultural transformation, and why it is that an isolated society, or ethos, can't stay isolated when you start plugging some new ideas into it." You can ask the same thing about the Cambrian explosion: the period some 570 million years ago when a world full of algae and pond scum suddenly burst forth with complex, multicellular creatures in immense profusion.

M. MITCHELL WALDROP, COMPLEXITY: THE EMERGING SCIENCE AT THE EDGE OF ORDER AND CHAOS 127 (1992) (quoting Stuart Kauffman).

332. Interestingly law, for narrow purposes, judges science. This judging draws post-modernism, science, and law into juxtaposition. What does post-modernism add to the mix? According to entomologist Edward O. Wilson:

As today's celebrants of unrestrained Romanticism, the postmodernists enrich culture. They say to the rest of us, Maybe, just maybe, you are wrong. Their ideas are like sparks from fireworks explosions that travel away in all directions, devoid of following energy, soon to wink out in the dimensionless dark. Yet a few will endure long enough to cast light in unexpected places. That is the one reason to think well of postmodernism, even as it menaces rational thought. . . . We will always need postmodernists or their rebellious equivalents. For what better way to strengthen organized knowledge than continually to defend it from hostile forces? John Stuart Mill correctly observed that teacher and learner alike fall asleep at their posts when there is no enemy in the

field.

Edward O. Wilson, *Back From Chaos*, ATLANTIC MONTHLY, March 1998, at 41, 59-62.

To appreciate the function of the post-modernist, however, it is not necessary to believe in an absence of external truth, nor is it necessary to give equal value to different representations of truth. In that regard, Carl Sagan rather poignantly asks: "How can you tell when someone is only imagining?" CARL SAGAN, *THE DEMON-HAUNTED WORLD: SCIENCE AS A CANDLE IN THE DARK* at xii (1995).

Rather chillingly, Sagan reports the legal consequences of answering his question incorrectly when he quotes an early edition of *The Courage to Heal: A Guide for Women Survivors of Child Sexual Abuse* by Ellen Bass and Laura Davis, a book which he describes as influential in the therapy literature. He quotes:

"*Believe the survivor.* You must believe your client was sexually abused, even if she doubts it herself. . . . Your client needs you to stay steady in the belief that she was abused. Joining a client in doubt would be like joining a suicidal client in her belief that suicide is the best way out. If a client is unsure that she was abused but thinks she might have been, work as though she was. So far, among the hundreds of women we've talked to and the hundreds more we've heard about, not one has suspected that [sic] she might have been abused, explored it, and determined that she wasn't."

SAGAN, *supra*, at 158 (quoting ELLEN BASS & LAURA DAVIS, *THE COURAGE TO HEAL: A GUIDE FOR WOMEN SURVIVORS OF CHILD SEXUAL ABUSE* 347 (1988)) (alteration in original).

Courts have been forced to grapple with both imagination and science in the trial context. To some degree then, while the "tenets of skepticism do not require an advanced degree to master, as most successful used car buyers demonstrate," *id.* at 76, an almost incredible amount of legal material and debate has been generated about the use of scientific evidence and the judge's role of "gatekeeper." Under the FEDERAL RULES OF EVIDENCE: "If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise." FED. R. EVID. 702.

In *Judging Science*, Kenneth Foster and Peter Huber acknowledge both the difficulty of, and the limitations on, using scientific evidence in trials (*e.g.*, those where the defendant is accused of sexual abuse) stating that

"Validity" in science is not a binary attribute . . . . Grossly invalid data or theories can usually be identified for what they are. But often decisions about validity depend on the needs one has for the data. This is not to say that "truth" is relative, as a pernicious kind of postmodernism maintains. Rather, it is to say that science has limited ability to answer questions of great social importance.

KENNETH R. FOSTER & PETER W. HUBER, *JUDGING SCIENCE: SCIENTIFIC KNOWLEDGE AND THE FEDERAL COURTS* 16-17 (1997).

On the other hand, science is particularly good at answering some questions, as Sagan suggests by delineating a few examples:

Not every branch of science can foretell the future[, or the past in the trial context,] . . . but many can and with stunning accuracy. If you want to know when the next eclipse of the Sun will be, you might try magicians or mystics, but you'll do much better with scientists. . . . They can routinely predict a solar eclipse, to the minute, a millennium in advance. You can go to the witch doctor to lift the spell that causes your pernicious anemia, or you can take vitamin B12. . . . Try science.

authorities quoted also seem to imply (rather directly) that law is a part of that culture.

Although Mayr might be straying a bit outside his area of expertise when he expresses his opinion about whether the traditional ethical norms of the Western world are adequate for future evolution, "an understanding of evolution gives us a world view that can serve as a sound basis for the development of an ethical system that is appropriate for the maintenance of a healthy human society."<sup>333</sup> He further opines that the traditional Western ethical norms are no longer adequate for two reasons: (1) they are too rigid, and (2) mankind has "experienced a drastic and accelerating change of conditions" since their inception.<sup>334</sup> Mayr also asserts that one of the problems not adequately addressed by Western ethics is the inability of groups to develop a regulatory ethic that allows for both equality and diversity without "excessive egocentricity and exclusive attention to the rights of the individual."<sup>335</sup>

The study of networks, even after noting the importance of the *Hox* regulatory gene in genetic networks, may seem to the uninitiated to be a rather dull pursuit. To those individuals actually involved, however, it is not dull, as evidenced by a computer game from the 1970s called the "Game of Life," which helped inspire further network study. The computer program for the game was developed by John Conway, an English mathematician, in the early 1970s.<sup>336</sup> The program is a set of simple rules that switch squares of a computer screen on or off in successive iterative runs (generations) depending on whether neighboring squares are dead (off, white) or alive (on, black) during the previous generation. One of the pioneers of complexity, Chris Langton, described the game as follows:

Each square in each generation would first look around at its immediate neighbors. If too many of those neighbors were already alive, then in the next generation the square would die of overcrowding. And if too few neighbors were alive, then the square would die of loneliness. But if the number of neighbors was just right, with either two living squares or three living squares, then in the next generation that central square would be alive—either by surviving if it were already alive or by being "born" if it weren't.

That was all. The rules were nothing but a kind of cartoon biology. . . . You could start up the game with a random scattering of live

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SAGAN, *supra*, at 30.

For a related discussion about the Scopes trial, which inspired a debate over science and religion, see EDWARD J. LARSON, SUMMER FOR THE GODS: THE SCOPES TRIAL AND AMERICA'S CONTINUING DEBATE OVER SCIENCE AND RELIGION (1997).

333. MAYR, *supra* note 311, at 89.

334. *Id.* at 85.

335. *Id.* at 86.

336. WALDROP, *supra* note 331, at 200-01.

squares, and watch them instantly organize themselves into all manner of coherent structures. . . . Every run was different, and no one had ever exhausted the possibilities.<sup>337</sup>

Langton described being in the presence of this program late one night in terms of a personal epiphany:

I realized that it must have been the Game of Life. There was something *alive* on that screen. And at that moment . . . I lost any distinction between the hardware and the process. . . . I remember looking out the window. . . . Across the Charles River in Cambridge you could see the Science Museum and all the cars driving around. I thought about the patterns of activity, all the things going on out there. The city was just sitting there, just *living*. And it seemed to be the same sort of thing as the Game of Life. It was certainly much more complex. But it was not necessarily different in kind.<sup>338</sup>

If the "Game of Life" illustrates the idea that simple rules might mimic something that looks alive, another computer program extended that illustration. The other program was developed by Craig Reynolds in the mid-1980s to simulate the flocking behavior of birds on a computer screen. After observing real birds for many hours, "Reynolds boiled the behavior down to three primary components: 1. A clumping force that kept the flock together[;] 2. An ability to match velocity so that the birds in the flock would move at the same speed[; and] 3. A separation force that prevented birds from getting too close to each other."<sup>339</sup> The result was that the electronic blips, called boids, "using nothing but Reynolds's simple rules, were able to flock in large configurations so convincingly that ornithologists, intuiting that real birds might be performing the same [processes] as Reynolds's creations, began calling the animator to find out his rules."<sup>340</sup>

In the world of computer simulation, it turns out, the simulation of bird flocking is just a step away from modeling evolution. Indeed, although atypical in his profession, Dawkins "viewed artificial life as 'a generator of insight in our understanding of real life.'"<sup>341</sup> He developed a program that simulated the dynamic process of evolution in conjunction with his book

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337. *Id.* at 201-02; see also STEVEN LEVY, ARTIFICIAL LIFE: THE QUEST FOR A NEW CREATION 43 (1992).

338. WALDROP, *supra* note 331, at 202-03.

339. LEVY, *supra* note 337, at 76-77.

340. *Id.* at 77.

341. *Id.* at 172.



*The Blind Watchmaker*.<sup>342</sup> Basically, Dawkins wrote a program he believed would generate, in successive generations, “a variety of tree-like shapes.”<sup>343</sup>

I can't remember exactly when in the sequence it first began to dawn on me that an evolved resemblance to something like an insect was possible. With a wild surmise, I began to breed, generation after generation, from whichever child looked most like an insect. [This is artificial selection based on Dawkins's personal aesthetic selection of insect-like patterns.] I still cannot conceal from you my feeling of exultation as I first watched these exquisite creatures emerging before my eyes. I distinctly heard the triumphal opening chords of *Also sprach Zarathustra* (the '2001 theme') in my mind. I couldn't eat, and that night my insects swarmed behind my eyelids as I tried to sleep.<sup>344</sup>

In summary, a computer program with relatively simple rules like “the Game of Life” and “Boids,” with the help of artificial selection, generated insect-like forms.

Dawkins named his computer program “Biomorph Land,” and he used it to illustrate “[a]ccumulating small change” through selection.<sup>345</sup> Did Dawkins, through artificial selection, *create* the insects? No. He *found* the insects that, “in a mathematical sense, [are] already sitting in [their] own place in the genetic space of Biomorph Land.”<sup>346</sup> Thus, for every resultant figure in the program there is an “evolutionary history [that] consists of a particular pathway, or trajectory, through genetic space.”<sup>347</sup>

Biomorph Land's creatures were the result of the interaction of nine characteristics or “genes.” Dawkins explains an important and somewhat tricky mathematical concept simply using his nine biomorph characteristics:

I wanted to try to represent this genetic space in the form of a picture [for purposes of the book]. The trouble is, pictures are two-dimensional. The genetic space in which the biomorphs sit is not two-dimensional space. . . . It is nine-dimensional space! . . . If only we could draw in nine dimensions we could make each dimension correspond to one of the nine genes. The position of a particular animal . . . is fixed in genetic space by the numerical value of its nine genes. . . . The amount of genetic difference between one animal and another, and hence the time taken to

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342. See DAWKINS, *supra* note 311.

343. *Id.* at 59.

344. *Id.* at 59-60.

345. *Id.* at 43.

346. *Id.* at 65.

347. *Id.* at 67.

evolve, and the difficulty of evolving from one to the other, is measured as the *distance* in nine-dimensional space from one to the other.<sup>348</sup>

Even though Dawkins's creatures exist to be found, "[e]ffective searching procedures become, when the search-space is *sufficiently* large, indistin-

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348. *Id.*; see also Ian R. Macneil, *The Many Futures of Contracts*, 47 S. CAL. L. REV. 691 (1974) (discussing the concept of multi-dimensional phase-space filled with "ideas" that theoretically could be mapped). The key for seeing the possibility that many futures exist is, according to Macneil's article, the idea of relational contracting:

The major premise of this essay is the prevalence of relation in the post-industrial socioeconomic world. Its dominance seems constantly to be increasing, in spite of declines over the past 50 years in certain specific relational patterns, *e.g.*, family farming, household master-servant, some aspects of family life. Outweighing declines in these particular relations are the constantly increasing service share of the GNP (services are inherently more relational than the transfer of goods); the development of franchising and other relational techniques for distributing and producing goods and services; the increasing dominance of corporate and ongoing intercorporate methods of doing business; the increase in white collar salaried employment relative to blue collar wage employment; . . . patterns such as the development among the relatively well-to-do of closed residential communities with numerous kinds of communal services and affiliations.

*Id.* at 694-95 (footnotes omitted).

Part I of that article detaches "promise" as the sole source of contract by identifying the "primal roots of contract" (specialization of labor and exchange; sense of choice; conscious awareness of past, present and future; the social matrix). *Id.* at 696-712. It then identifies the existence of non-promissory "contracts" that, together with contractual promises, are projected into the future (*e.g.*, culture, religion, habit, bureaucratic patterns, and what would now probably be called path dependent behavior for future contracts, based on the current contract). *Id.* Macneil then identifies space along a transactional axis and a relational axis and between transactional and relational poles. *Id.* at 808-09. The lesson from Macneil to be used in this current article is that visualization of a legal phase-space and the trend toward a growing importance of relational contracting was observed in 1974, when Macneil wrote his article.

Recognizing some difference between transactional and relational contracts might also be important. Macneil's article concludes: "This essay has been an attempt to free contract from the myth of pure transactionism which so dominates many current concepts, to put exchange in its real life context of relation, and to show promise as the limited tool it is." *Id.* at 805-06 (footnote omitted).

As a post-script, Macneil suggests the following:

The broad principles of contract law running through all contracts, relational and transactional, are norms growing out of the . . . primal roots of contract. They may be characterized as follows: (1) reciprocity; (2) role effectuation; (3) limited freedom of exercise of choice; (4) effectuation of planning; and (5) harmonizing of contracts with their internal and external social matrices. These are by no means watertight . . .

*Id.* at 808-09.

guishable from true creativity.”<sup>349</sup> Dawkins, therefore, was able to use a computer program to illustrate the accumulation of small change in evolution using artificial selection in nine mathematical dimensions corresponding to the nine characteristics of his biomorphs.<sup>350</sup>

Dawkins has been called the “ultimate ultra-Darwinian.”<sup>351</sup> As previously discussed, the ultra-Darwinians (as opposed to the “naturalists”) “see[] . . . competition for reproductive success as the underpinning of absolutely all biological phenomena.”<sup>352</sup>

Naturalists like paleontologist Niles Eldredge, on the other hand, “are loathe to write [large-scale systems] off simply as epiphenomena of reproductive competition—especially entities like ecosystems, which lie squarely in the realm of economics (matter-energy transfer processes) and have nothing overtly to do with reproductive biology in the first place.”<sup>353</sup> In other words, naturalists “are convinced that there are processes relevant to understanding evolution that go on within each of these levels—from

349. DAWKINS, *supra* note 311, at 66.

350. Dawkins, in a more recent book entitled *Climbing Mount Improbable*, describes a more sophisticated computer evolution program, which more closely emulates nature by simulating environmental natural selection in comparison with Biomorph Land’s artificial selection. CLIMBING MOUNT IMPROBABLE, *supra* note 315, at 62. The program is called NetSpinner and it traces the evolution of types of net building within a spider population. *Id.* “Natural” selection is based on the efficiency of the web. *See id.* Efficiency is “the web that catches the most flies *minus* a cost function computed from the length of silk.” *Id.* “And what evolves under these conditions? It is really rather gratifying how lifelike are the webs that emerge in an overnight run of forty generations.” *Id.* (citation omitted). A later generation of the program, “NetSpinner III incorporates sexual reproduction.” *Id.* Note that Dawkins uses an economic concept of efficiency for purposes of stimulating biological evolution. It is probably worth noting, however, that selected mating of domesticated animals to emphasize a trait (like milk production) is really a form of *artificial* selection as represented by Dawkins’s earlier Biomorph Land program.

351. ELDREDGE, *supra* note 311, at 5.

352. *Id.* “Even ecosystems,” according to ultra-Darwinians, “are ultimately to be understood as products of competition within and among populations for reproductive success.” *Id.* at 5-6. Eldredge, on the other hand, sees the ecosystem community differently. Eldredge describes his view as follows:

I join other naturalists in seeing such complex systems as existing in their own right. For example, I agree with systems ecologists who understand ecosystems as complex entities. They believe ecosystems are formed of populations of many distinct species, held together by the complex flow of energy between different populations and the nonbiological environment. Ecosystems exist and can be studied in their own right, and it is mere empty rhetoric to claim that ecosystems ultimately are epiphenomena of competition for reproductive success.

*Id.* at 6.

353. *Id.* at 6.

genes, right on up through populations, species, and ecosystems,” in addition to the ultra-Darwinians’ “reproductive imperative.”<sup>354</sup>

The distinction between the ultra-Darwinian and the naturalist schools of evolutionary biology is important, in part, because ultra-Darwinians are sometimes seen as being biased toward the “gradualist” theory of evolution, as opposed to the punctuated equilibrium hypothesis of evolution.<sup>355</sup> Dawkins, however, suggests that “gradualist” evolutionary theory is, or at least could be, consistent with variable speed evolution where evolution occurs in relatively short bursts. Variable speed evolution would also account for periods of little change (stasis) in the geologic record.<sup>356</sup> “[T]he one respect in which punctuationists do differ from other schools of Darwinism,” according to Dawkins, “is in their strong emphasis on stasis as something positive: as an active resistance to evolutionary change rather than as, simply, absence of evolutionary change.”<sup>357</sup> Stated differently: “The differences between the classical theory of evolution and the emerging new theory [of punctuated equilibrium] center around the question of the *dynamics* of evolution—the mechanisms through which evolutionary changes take place.”<sup>358</sup> Enter, for our purposes, Kauffman, who “has used binary networks as mathematical models of the genetic networks of living organisms and [who has been] able to derive several known features of . . . evolution from these models.”<sup>359</sup>

While still in medical school, Kauffman became obsessed with embryology, “particularly how embryonic cells differentiate, forming muscle cells, nerve cells, cells of connective tissue, and so on; [and] how the one hundred thousand genes in the human genetic package might produce this bewildering assembly of different cell types.”<sup>360</sup> Similar to the “Game of Life,” but by using a “networked” triangular assembly of only three lights, Kauffman starts to explain *regulated networks* as follows:

[T]he system can be in a finite number of states, here eight. If started in one state, over time the system will flow through some sequence of states. This sequence is called a trajectory [, and] [s]ince there is a finite number of states, the system must eventually hit a state it has previously encountered. Then the trajectory will repeat. Since the system is deterministic [(it follows certain rules concerning when a given light is on or off)], it will cycle forever around a recurrent loop of states called a state cycle. . . .

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354. *Id.*

355. DAWKINS, *supra* note 311, at 307.

356. *Id.* at 244.

357. *Id.* at 248.

358. CAPRA, *supra* note 307, at 223.

359. *Id.* at 227.

360. ROGER LEWIN, COMPLEXITY: LIFE AT THE EDGE OF CHAOS 26 (1992).

Depending on the initial state in which we start our network[,] . . . it will follow various trajectories. . . .<sup>361</sup>

These “state cycles” can form various patterns; from quickly getting “stuck” in a steady state (a single non-varying pattern), to a pattern that repeats through all eight state cycles and, thus, makes the three lights appear to “twinkle.”<sup>362</sup> Adding additional lights begins to make Kauffman’s network look and act like the computer “Game of Life” or “Boids.”<sup>363</sup> Of course, rather than a flat computer screen, a more complicated version could be graphically arranged in three dimensions or, like the space in Dawkins’s *Biomorph Land*, in as many mathematical dimensions as there are characteristics or traits to be measured.<sup>364</sup>

Kauffman told another researcher, Per Bak, about the concept of evolutionary punctuated equilibrium.<sup>365</sup> In turn, they collaborated in an attempt to adopt Per Bak’s physical catastrophe theory to evolution through a computer network program that Kauffman was using to model multidimensional ecological “fitness landscapes.”<sup>366</sup> Fitness landscapes<sup>367</sup> are multidimensional graphic representations of different traits of individuals or species measured on a survivability or “fitness” scale.<sup>368</sup> They are “a concept that the University of Chicago geneticist Sewell Wright developed in the 1930s.”<sup>369</sup> One of the most easily understood descriptions of these landscapes is as follows:

You have to think about the “fitness” of an individual in terms of different combinations of gene variants[, genotypes or, another way, as traits known as phenotypes,] it might have. Now think of a landscape[, for ease of visualization either like a “real” three-dimensional landscape or like a two-dimensional picture of a mountain range on an horizon,] in which each different point on the landscape represents slightly different packages of these variants. Lastly, if you imagine some of the packages as being fitter than others, raise them up as peaks. The fittest of the packages has the highest peak. The landscape overall will be rugged, with peaks of different height, separated by valleys. Remember, this landscape represents fitness probabilities, places where individuals of a species [or, if you so

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361. KAUFFMAN, *supra* note 310, at 77.

362. *Id.*

363. *See supra* notes 336-44 and accompanying text.

364. *See supra* notes 345-50 and accompanying text.

365. PER BAK, *HOW NATURE WORKS: THE SCIENCE OF SELF-ORGANIZED CRITICALITY* 117 (1996).

366. *Id.* at 122-23.

367. *Id.*

368. *Id.* at 118.

369. LEWIN, *supra* note 360, at 57.

choose, an entire species,] might be. . . . If an individual happens to be in a fitness valley, then mutation and selection might push it up a local peak, representing a rise in fitness. Once on the local peak it may, metaphorically, gaze enviously at a nearby peak, but be unable to reach it because that would require crossing a valley of lower fitness.<sup>370</sup>

Next, catastrophe theory is sometimes identified as a component area of complexity science, which includes, *inter alia*, chaos theory.<sup>371</sup> The essence or basic idea of catastrophe theory, as it is now formulated, is probably most easily described by avalanches (catastrophes) on a sandpile. Imagine, therefore, repeatedly dropping single grains of sand on a flat table:

Soon [the sand grains] rest on top of one another, creating a pile. . . . Now and then, when the slope becomes too steep somewhere on the pile, the grains slide down, causing a small avalanche [a type of chain reaction]. As more sand is added and the slope of the pile steepens, the average size of the avalanches increases. Some grains begin to fall off the [table]. The pile stops growing when the amount of sand added is balanced, on average, by the amount of sand falling off the edge. At that point, the system has reached a *critical state*.

When a grain of sand is added to a pile in the critical state, it can start an avalanche of any size, including a "catastrophic" event. But most of the time, the grain will fall so that no avalanche occurs.<sup>372</sup>

Thus, the "addition of grains of sand . . . transformed the system from a state in which the individual grains follow their local dynamics"<sup>373</sup>—at a subcritical level the additional grains might cause a small local shift somewhere on the pile that does not "affect sand grains in more distant parts

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370. *Id.*

371. Terminology in this field is at best amorphous. "Complexity" is a term often used and confused for "chaos" or, perhaps more formally, as the transitional region in phase-space between ordered systems and chaotic systems. See *supra* note 331 and accompanying text.

Some scientists and writers seem to believe that all systems previously thought to be random are actually chaotic, and therefore, use the term "chaos" instead of "randomness." Further, according to a *Scientific American* article, there are at least thirty-one definitions of the word "complexity" when used as a label for this new scientific field. John Horgan, *From Complexity to Perplexity*, SCI. AM., June 1995, at 104, 106. In many respects it seems, therefore, that the field of complexity is held together only by the common methodology of computer modeling—"complexity" for our purposes is largely defined by John Casti, author and executive editor of *Complexification*, *supra* note 331.

372. Per Bak & Kan Chen, *Self-Organized Criticality*, SCI. AM., Jan. 1991, at 46, 46.

373. BAK, *supra* note 365, at 51.

of the pile"<sup>374</sup>—to a "critical state where the emergent dynamics are global"<sup>375</sup> in which any given additional grain of sand might set off a chain reaction affecting other grains of sand in a far distant location on the pile. It is important to recognize that in the critical state there are not "local" disturbances (though there could be local effects) because the pile has become "one complex system . . . with its own emergent dynamics . . . [and which] could not have been anticipated from the properties of individual grains."<sup>376</sup>

It is also important to understand that the sandpile organizes itself to this critical state without external ordering. The pile organized the dropped sand grains naturally to achieve the critical state. Unlike Dawkins's artificial selection of outcomes in Biomorph Land, the sandpile represents what is called a self-organized critical state, shaped in part by a flow of energy started by dropping a grain of sand, with the flow then continuing through the system (sometimes the energy manifests itself in kinetic form, and sometimes in the form of frictional heat).<sup>377</sup> That critical point where the dynamics of the pile shift from local to global is sometimes said to be "the edge of chaos."<sup>378</sup> According to Kauffman, the self-organized criticality

374. *Id.* at 50-51.

375. *Id.* at 51.

376. *Id.*

377. *Id.*

The most widely touted definition [of complexity] involves the "edge of chaos." The basic idea is that nothing novel can emerge from systems with high degrees of order and stability, such as crystals. On the other hand, completely chaotic systems, such as turbulent fluids or heated gases, are *too* formless. Truly complex things—amoebae, bond traders and the like—appear at the border between rigid order and randomness.

*Id.*

378. See *supra* note 372. The concept of energy organizing matter is a central tenet of complexity, including catastrophe theory. It also, as an aside, leads to some of the more poetic descriptions and metaphors in the field. For example, "rising column[s] of cigarette smoke break[ing] into wild swirls," and turbulent flows "[n]o matter what the medium." JAMES GLEICK, CHAOS: MAKING A NEW SCIENCE 5 (1987). One of the most inclusive and speculative authors in the area uses what he calls the "grok circle" of discovery:

[T]he *grok circle* is similar to the dialectical process of thesis, antithesis and synthesis, and it constitutes the basic process in hermeneutical thought, called the *hermeneutical circle*. Some think of it as a spiral—the turning of this circle or spiral being the motor for the growth of our understanding. The evolution of science, of Old Testament scholarship, or of Cretan archaeology, for example, may be regarded as a hermeneutical spiral. Understanding this spiral may be crucial for our own evolution, as we struggle with the challenges of postmodern planetary society.

RALPH ABRAHAM, CHAOS, GEIA, EROS: A CHAOS PIONEER UNCOVERS THE THREE GREAT STREAMS OF HISTORY 14 (1994).

The behavior of smoke, rivers, and streams, to some extent, conjures notions of spirals. Economist Brian Arthur uses river imagery this way:

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Actually, you're just the captain of a paper boat drifting down the river. If you try to resist, you're not going to get anywhere. On the other hand, if you quietly observe the flow, realizing that you're part of it, realizing that the flow is ever-changing and always leading to new complexities, then every so often you can stick an oar into the river and punt yourself from one eddy to another.

WALDROP, *supra* note 331, at 330-31 (quoting W. Brian Arthur).

Obviously, popular culture also uses this imagery in a way not directly related to scientific chaos or complexity. For example, the lyrics of a country song entitled "The River" performed by Garth Brooks includes the following verse:

You know a dream is like a river/Ever changin' as it flows/And a dreamer's just a vessel/That must follow where it goes/Trying to learn from what's behind you/And never knowing what's in store/Makes each day a constant battle/Just to stay between the shores.

GARTH BROOKS & VICTORIA SHAW, *The River*, on ROPIN' THE WIND (Capitol Records 1991).

Similarly, the soundtrack from the Disney movie *Pocahontas* contains the following lyrics: "What I love most about rivers is: You can't step in the same river twice/The water's always changing, always flowing . . ." STEPHEN SCHWARTZ, *Just Around the Riverbend*, on POCAHONTAS (Walt Disney Records 1995). Another song in the same soundtrack completes the paradox: "Though the river's proud and strong/He will choose the smoothest course/That's why rivers live so long/They're steady . . . /As the steady beating drum." STEPHEN SCHWARTZ, *Steady as the Beating Drum (Reprise)*, on POCAHONTAS (Walt Disney Records 1995).

The idea of energy organizing matter goes beyond "physics." Margaret Wheatley, a business consultant who uses chaos and complexity theory in her practice writes:

Although we experience ourselves as a stable form, our body changes frequently. As physician Deepak Chopra likes to explain, our skin is new every month, our liver every six weeks; and even our brain, with all those valuable cells storing acquired knowledge, changes its content of carbon, nitrogen, and oxygen about every twelve months. Day after day, as we inhale and exhale, we give off what were our cells, and take in elements from other organisms to create new cells. "All of us," observes Chopra, "are much more like a river than anything frozen in time and space."

MARGARET J. WHEATLEY, LEADERSHIP AND THE NEW SCIENCE: LEARNING ABOUT ORGANIZATION FROM AN ORDERLY UNIVERSE 7, 103 (1992); *see also* David Van Biema, *Emperor of the Soul*, TIME, June 24, 1996, at 64 (concerning Chopra and other "alternative healers").

The concept of energy organizing matter also creates very difficult physics and engineering problems. In fact, mathematician John von Neumann used two examples of fluid dynamic problems (atomic bomb shock waves and the weather): "to stir up enthusiasm for electronic computing in the late 1940s." Barry Cipra, *Mathematicians Open the Black Box of Turbulence*, 269 SCI. 1361, 1361 (1995).

Like chaos, to which it is closely related, turbulence defies easy understanding because it amplifies infinitesimal fluctuations into major effects. Indeed, [two] decades after von Neumann's prediction, Richard Feynman remarked that scientists had yet to understand what goes on in one of the easiest of such problems, that of turbulent fluid flow in a simple, cylindrical pipe.

*Id.*



exhibited by Per Bak's sandpile model is a "close cousin" to the "edge of chaos" idea, but it is not technically the same.<sup>379</sup> Nonetheless, Kauffman further speculates:

Sandpiles, self-organized criticality, and the edge of chaos. If I am right, the very nature of coevolution is to attain this edge of chaos, a web of compromises where each species prospers as well as possible but where none can be sure if its best next step will set off a trickle or a landslide. In this precarious world, avalanches, small and large, sweep the system relentlessly. One's own footsteps shed small and large avalanches, which sweep up or by the other hikers on the slopes below. One may even be carried off in the avalanche started by his or her own footsteps. This image may capture the essential features of the new theory of emergence we seek. *At this poised state between order and chaos, the players cannot foretell the unfolding consequences of their actions.* While there is law in the distribution of avalanche sizes that arise in the poised state, there is unpredictability in each individual case. If one can never know if the next footprint is the one that will unleash the landslide of the century, then it pays to tread carefully.<sup>380</sup>

In order to understand the concept represented by the phrase "the edge of chaos," it is necessary to have only a basic conceptual knowledge of chaos and complexity. Chaos is not the same as complexity,<sup>381</sup> but chaotic systems may exhibit complex behavior.<sup>382</sup> At its core, chaos is "a simple dynamical system" which if continually dialed, tweaked, or tuned correctly, may exhibit "complex dynamical system" behavior.<sup>383</sup> Both the chaotic and

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Finally, Solzhenitsyn also uses the idea of fluid dynamics and mathematics to make the following analogy to those in exile:

Who were these people? Above all the families of men condemned to the camps. But families were by no means always drawn in, and it was by no means only the families of prisoners who poured into exile. Just as it requires extensive knowledge of hydrodynamics to explain the currents in a fluid, without which you can only observe in despair the chaotically swirling and howling element, so here: we lack the information to study all the differential impulses which in various years, for no apparent reason, sent various people not to camps but to exile. We can only observe the bewildering mixture of resettlers . . . .

3 ALEKSANDR I. SOLZHENITSYN, *THE GULAG ARCHIPELAGO 1918-1956: AN EXPERIMENT IN LITERARY INVESTIGATION* 371 (Harry Willets trans., Harper & Row 1978) (1976).

379. KAUFFMAN, *supra* note 310, at 28-29.

380. *Id.* at 29 (emphasis added).

381. Relatively detailed and more technical descriptions of chaos theory and complexity theory are provided in the Appendix at the end of this article.

382. See Appendix, pt. A, *infra*.

383. BAK, *supra* note 365, at 29.

complex system share several common attributes.<sup>384</sup> First, their underlying mathematical equations, which in some sense determine their behavior, are nonlinear. "A system is nonlinear when actions can have more than one outcome and when actions generate nonproportional outcomes, in other words, when the system is more than the sum of its parts."<sup>385</sup> Thus, while these systems are determinative in the sense that they may be explained by mathematical equations, they are largely unpredictable. This has led one researcher to say that nonlinear equations "usually [have] multiple—and perhaps infinite—solutions. As in real life, there are many possibilities."<sup>386</sup>

The second common attribute shared by chaotic and complex systems is that both systems are extremely sensitive to initial conditions. This is described by the nonproportionality of nonlinear mathematics. In fact, it was this feature that led Edward Lorenz, a Massachusetts Institute of Technology scientist studying computer-modeled weather on his new computer in 1961, to rediscover and notice "chaos":

[This new run] should have exactly duplicated the old. Lorenz had copied the numbers into the machine himself. The program had not changed. Yet as he stared at the new printout, Lorenz saw his weather diverging so rapidly from the pattern of the last run that, within just a few

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384. N. KATHERINE HAYLES, *CHAOS BOUND: ORDERLY DISORDER IN CONTEMPORARY LITERATURE AND SCIENCE* 11-14 (1990); cf. H. RICHARD PRIESMEYER, *ORGANIZATIONS AND CHAOS: DEFINING THE METHODS OF NONLINEAR MANAGEMENT* 7-19 (1992).

385. RALPH D. STACEY, *COMPLEXITY AND CREATIVITY IN ORGANIZATIONS* 288 (1996).

386. EDGAR E. PETERS, *CHAOS AND ORDER IN THE CAPITAL MARKETS: A NEW VIEW OF CYCLES, PRICES, AND MARKET VOLATILITY* 136 (1991). For an analysis of "determinism" and complexity theory in the context of sociology, which foreshadows further discussion later in this essay, see Robert Huckfeldt, *Structure, Indeterminacy and Chaos: A Case for Sociological Law*, 2 J. THEORETICAL POL'Y 413 (1990). As explained therein, the "debate" about whether there exists sociological law is largely one of the role of determinism in human behavior. In turn:

The often torturous debate over determinism within the social sciences frequently transcends the practice of empirical social science and addresses instead a theological dichotomy between Calvin's determinism (predestination) and Luther's free will. Some free will advocates have perceived a social scientific threat, particularly in early sociological efforts to specify [scientific] laws governing social relations and social behavior.

*Id.* at 414.

The article then argues "on the basis of a simple mathematical model, [chaos theory,] that the logic of a wholly determinate structure is capable of generating a seemingly stochastic process with an apparently indeterminate outcome." *Id.* at 413. Thus, Huckfeldt argues, not only may the "displacement of determinism by probabilism . . . be the wrong lesson," *id.*, but concludes that by "reacting too violently against the supposed naïvety of the 'determinists' we may be losing sight of a primary purpose for the social sciences—an identification of the structure and logic underlying human behavior," *id.* at 431.

months [of the simulated weather, not in real time], all resemblance had disappeared. . . . His first thought was that another vacuum tube [in the analogue computer] had gone bad.

Suddenly he realized the truth. . . . The problem lay in the numbers he had typed. In the computer's memory, six decimal places were stored: .506127. On the printout, to save space, just three appeared: .506. Lorenz had entered the shorter, rounded-off numbers, assuming that the difference—one part in a thousand—was inconsequential.

. . . A small numerical error was like a small puff of wind—surely the small puffs faded or canceled each other out . . . . Yet in Lorenz's particular system of equations [simulating the weather], *small errors proved catastrophic*.<sup>387</sup>

Simply summarized, systems exhibiting chaotic or complex behavior, therefore, are extremely sensitive to initial conditions.

The third common attribute is the existence of feedback mechanisms that “create loops in which output feeds back into the system as input.”<sup>388</sup> In computer network modeling, it means using the result of the last run as the starting point for the next run (the mathematical manipulation process). Each run also could be termed an experience. In other words, the last run caused the system to experience a change.

The fourth and final common attribute is methodological in that both systems are “mapped” and often studied using those resultant graphs. This methodological feature is actually more important than it might seem because it implicates the following statement by physicist Richard P. Feynman:

The next great awakening of human intellect may well produce a method of understanding the qualitative content of equations. Today we cannot. Today we cannot see that the water-flow equations contain such things as the barber pole structure of turbulence that one sees between rotating cylinders. Today we cannot see whether Schrödinger's equation contains frogs, musical composers or morality—or whether it does not.<sup>389</sup>

However, the importance of the visual representation of results, the “geometric” attribute, as a unifying or common characteristic is a bit

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387. GLEICK, *supra* note 378, at 16-17 (emphasis added).

388. HAYLES, *supra* note 384, at 14.

389. Richard P. Feynman, *quoted in* JACK COHEN & IAN STEWART, *THE COLLAPSE OF CHAOS: DISCOVERING SIMPLICITY IN A COMPLEX WORLD* at iv (1994). There has been a heightened interest in the life and work of Richard Feynman since his death. For a very good biography, see JAMES GLEICK, *GENIUS: THE LIFE AND SCIENCE OF RICHARD FEYNMAN* (1992).

paradoxical because the actual patterns that are mapped provide one of the differences between chaotic systems and complex systems.<sup>390</sup> Generally speaking, complex systems have more identifiable "maps" than the near-random maps produced by chaotic systems. Indeed, it is this essence of complexity that is often equated with the phrase "the edge of chaos."<sup>391</sup> Christopher Langton, a computer scientist formerly of the Los Alamos National Laboratory, is credited with the "edge of chaos" analogy by relating network behavior to the phases of matter: ordered networks related to solids, chaotic networks related to gases, and intermediate-state networks related to liquids.<sup>392</sup> He introduced the analogy to help "one think about the change between order and disorder in different ensembles of networks."<sup>393</sup>

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390. See BAK, *supra* note 365, at 31.

[S]imple chaotic systems cannot produce a spatial fractal structure like the coast of Norway. In the popular literature, one finds the subjects of chaos and fractal geometry linked together again and again, despite the fact that they have little to do with each other. The confusion arises from the fact that [some] chaotic motion can be described in terms of mathematical objects known as *strange attractors* embedded in an abstract phase space. These strange attractors have fractal properties, but they do not represent geometrical fractals in real space like those we see in nature.

*Id.* See also Appendix, pt. A, *infra* (providing a more detailed description of fractals, strange attractors, and chaos).

391. See *supra* note 377; see, e.g., LEWIN, *supra* note 360. See generally WALDROP, *supra* note 331.

392. Stuart A. Kauffman, *Antichaos and Adaptation*, SCI. AM., Aug. 1991, at 78, 82. Langton adds that "[t]he analogy should not be interpreted too literally, of course: true liquids are a distinct phase of matter and not just a transitional regime between gases and solids." *Id.*

393. *Id.* The term "fractal geometry" also implicates "trees" or "bushes" or "fitness landscapes," which are closely associated with complexity theory (actually chaotic systems at the edge of chaos or "complex" systems, whether or not self-organized). See *supra* notes 367-71 and accompanying text. For an explanation of chaos, see Appendix, pt. A, *infra*. One explanation of fractals follows:

In nature, a complex nonlinear ('fractal') structure such as an *individual* coastline, cloud formation, or rugged mountain peak involves comparably complex irregularities repeated on all scales simultaneously. In 1975, Benoit Mandelbrot coined the word 'fractal' from the Latin *fractus*, which describes a broken stone—broken up and irregular. As Mandelbrot defines them:

Fractals are geometrical shapes that, contrary to those of Euclid, are not regular at all. First, they are irregular all over. Secondly, they have the same degree of irregularity on all scales . . . . Nature provides many examples of fractals, for example, ferns, cauliflowers and broccoli, and many other plants, because each branch and twig is very like the whole. The rules governing growth ensure that small-scale features become translated into large-scale ones.

HARRIETT HAWKINS, *STRANGE ATTRACTORS: LITERATURE, CULTURE AND CHAOS THEORY* 79 (1995) (alteration in original).

Fractals, as natural occurring geometric patterns, may be described mathematically. That may be one reason why nature and art, to some extent, seem to intuitively support the

Perhaps even more surprising than Langton's analogy, however, is his prognostication that science may become less *linear* and, as a result, more *poetic* in the future. "Poetry is a very nonlinear use of language, where the meaning is more than just the sum of the parts," Langton explains. "I just have the feeling that culturally there's going to be more of something like poetry in the future of science."<sup>394</sup>

If the mathematical constraints (biases) in an ordered network are lowered and maintained near a critical value, it is possible to slightly "melt" the frozen components. That is, the system at that point becomes a complex system (according to the physical phase transition metaphor), and interesting dynamic behaviors emerge at the edge of chaos. "At that *phase transition*, both small and large unfrozen islands would exist,"<sup>395</sup> and, borrowing from

validity of mathematics:

The world around us is full of patterns: of light, of sound, and of behaviour. As a result, the world finds itself well described by mathematics, because mathematics is the study of all possible patterns. Some of those patterns have concrete expressions in the world around us—where we see spirals, circles, and squares. Others are abstract extensions of these worldly examples; yet others seem to reside purely in the fertile minds of their conceivers. Viewed like this, we see why there has to be something akin to "mathematics" in the Universe in which we live.

JOHN D. BARROW, *THE ARTFUL UNIVERSE* 230 (1995).

At least conceptually, the idea of fractals also has seeped into literary criticism; however, the analogy often goes the other way as follows:

Their shared conceptual and structural concern with the complex interaction between order and chaos in nature, as in our lives—which is the traditional stuff that fictions are made of—clearly explains why so many scientists so often refer to comparable portrayals of this dynamic in literary classics as well as in painting, music and architecture. For instance, Benoit Mandelbrot aptly described, as "The Merchant of Venice syndrome", the "fractal" structure nature devised for the circulation of blood . . . [where] no cell is ever more than three or four cells away from a blood vessel: "Not only can't you take a pound of flesh without spilling blood, you can't take a milligram." Thus Mandelbrot pointedly paraphrases Shylock: "If you prick us, do we not bleed?"

HAWKINS, *supra*, at 12 (footnote omitted).

The "poets" have invaded management consultancy as well. According to the book *The Witch Doctors*:

The second group (which really ought to know better) is the original "unacknowledged legislators of mankind": poets. A few modern bards have felt the calling of the corporate check book. David Whyte, a Yorkshireman now based in Seattle, has written *The Heart Aroused: Poetry and the Preservation of the Soul in Corporate America*. . . . Poets have been joined by novelists. One of the best-selling management books of the last few years is Elie Goldratt's, *The Goal* (1989), which tells of how a production manager grapples with the complexities of total-quality management.

JOHN MICKLETHWAIT & ADRIAN WOOLDRIDGE, *THE WITCH DOCTORS: MAKING SENSE OF THE MANAGEMENT GURUS* 316 (1996). For another brief foray into law and literature, see *supra* notes 331-32 (discussing post-modernism and deconstruction).

394. Horgan, *supra* note 371, at 107.

395. Kauffman, *supra* note 392, at 82 (emphasis added).

the sandpile illustration, minimal perturbations would cause numerous small avalanches and a few large avalanches. Thus, "sites within a network can *communicate* with one another—that is, affect one another's behavior . . . : nearby sites communicate frequently via many small avalanches of damage; distant sites communicate less often through rare large avalanches."<sup>396</sup> Thus, both fractals and behavior explained by catastrophe theory may occur at this phase transition.

Said another way, a dynamical system "at the edge of chaos" is, like the sandpile on the table, constantly critical; it lies in the transitional region between frozen order and unmanageable chaos. Too much chaos in the system, and perturbances will either "propagate hectically" or not at all because there is little structured communication in the system.<sup>397</sup> On the other hand, too much order in the system, and perturbances are quickly muted and absorbed.<sup>398</sup> That is, in "the *ordered* regime, many elements in the system freeze in fixed states of activity."<sup>399</sup> Somewhere between order and chaos is the edge of chaos, where complexity occurs (*i.e.*, paradoxes, catastrophes, chaos, incomputability, irreducibility, and emergence).<sup>400</sup>

Most of the sandpile research was based on computer modeling where numbers were assigned to grains of sand in a two-dimensional grid.<sup>401</sup> Thus, the sandpile was stylized as a computer *network* and the software, the simple regulatory rules (expressed mathematically in phrases known as algorithms<sup>402</sup>), was designed and tuned until it modeled real experimental sandpile behavior. Recall that Kauffman worked with the same kind of multidimensional networks in his study of evolutionary fitness landscapes. The hypothesis was, therefore, that punctuated equilibrium in the evolutionary computer models could be described by the same "rules" (mathematical algorithms) as Per Bak and Kan Chen were using to simulate "catastrophic"

396. *Id.* (emphasis added).

397. LEWIN, *supra* note 360, at 62.

398. *Id.*

399. STUART A. KAUFFMAN, *THE ORIGINS OF ORDER: SELF-ORGANIZATION AND SELECTION IN EVOLUTION* 174 (1993). See generally COHEN & STEWART, *supra* note 389, at 29.

400. KAUFFMAN, *supra* note 399, at 174. Although this transitional region sounds small, it is not. For example, Waldrop explained:

In the space of all possible dynamical behaviors, the edge of chaos is like an infinitesimally thin membrane, a region of special, complex behaviors separating chaos from order. But then, the surface of the ocean is only one molecule thick, too; it's just a boundary separating water from air. And the edge of chaos region, like the surface of the ocean, is still vast beyond all imagining.

WALDROP, *supra* note 331, at 295; see also Appendix, pt. B, *infra*.

401. See BAK, *supra* note 365, at 52-69.

402. "Algorithm" simply means a "step-by-step procedure for . . . accomplishing some end." WEBSTER'S NINTH NEW COLLEGIATE DICTIONARY 70 (1990).

avalanche events in their sandpile models.<sup>403</sup> The sandpile models were most important because, unlike Boids and the "Game of Life," the sandpile models were self-organized critical states, not human-programmed, artificially created "interesting patterns." Indeed, self-organization is probably another hallmark of the science of complexity.<sup>404</sup>

The collaborative process concerning biological evolution and punctuated equilibrium was, at the very least, frustratingly slow, and then, according to Per Bak, a breakthrough came during a sub-collaboration between Bak and Kim Sneppen, a graduate student from the Niels Bohr Institute in Denmark.<sup>405</sup> The breakthrough occurred by changing the model expressly to take into account relative fitness values between species.<sup>406</sup> That is, they changed the way the model accounted for "fitness" by designing a more dynamic view of coevolution.<sup>407</sup> Indeed, a species is "'fit' only as long as the network exists in its current form."<sup>408</sup> The new model made the evolution of one species part of the fitness landscape of another. As stated by Kauffman:

The idealization we have used that fitness landscapes are fixed and unchanging is false. Fitness landscapes change because the environment changes. And the fitness landscape of one species changes because the other species that form its niche themselves adapt on their own fitness landscapes. Bat and frog, predator [sic] and prey, coevolve. Each adaptive move by the bats deforms the landscape of the frogs. Species coevolve on coupled dancing landscapes.<sup>409</sup>

This kind of thinking has spawned serious study exploring naturally occurring systems that seem to "move" to, or remain at, the edge of chaos (their poised critical "complex" states) without external intervention. Such naturally poised systems would explain the commonly observed feature of "punctuated equilibrium" (avalanches) across substantive disciplines.

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403. Per Bak describes the inquiry as follows:

Our approach is to explore, by suitable mathematical modeling, the consequences of Darwin's theory. Perhaps then we can judge if some other principles are needed. If the theory of self-organized criticality is applicable, then the dynamics of avalanches represent the link between Darwin's view of continuous evolution and the punctuations representing sudden quantitative and qualitative changes. Sandpiles are driven by small changes but they nevertheless exhibit large catastrophic events.

BAK, *supra* note 365, at 131.

404. See generally *id.* at 29-32.

405. *Id.* at 132.

406. *Id.* at 135.

407. *Id.*

408. *Id.* at 142.

409. KAUFFMAN, *supra* note 310, at 208.

Professor John H. Holland, a computer scientist, helped launch the study of these kinds of systems, named complex adaptive systems (CAS), in February 1987 when he delivered a paper at the Santa Fe Institute entitled *The Global Economy as an Adaptive Process*.<sup>410</sup>

Holland started by pointing out that the economy is an example par excellence of what the Santa Fe Institute had come to call "complex adaptive systems." In the natural world such systems included brains, immune systems, ecologies, cells, developing embryos, and ant colonies. In the human world they included cultural and social systems such as

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410. WALDROP, *supra* note 331, at 144.

The Santa Fe Institute in New Mexico is a lively center for exchange and debate on complex systems. In the words of the economist Brian Arthur of Stanford University, now the Citibank Professor at the institute, "It is the only place where a biologist can come and hear an economist explain how a jet engine works." . . .

The institute is the brain-child of George A. Cowan, former head of research at Los Alamos National Laboratory near Santa Fe. It soon received the backing of top scientists in a number of fields, including Philip W. Anderson, Nobel Prize winner for his work on condensed matter physics, Murray Gell-Man, Nobel Prize winner for the discovery of quarks, which are among the most fundamental of all particles, and Kenneth Arrow, economist and Nobel Prize winner for the general equilibrium theory of economics.

BAK, *supra* note 365, at 114.

For a general tour of how chaos and complexity are being studied by computer scientists under one of several terms, including "Artificial intelligence," see Thomas Earl Geu, *The Tao of Jurisprudence: Chaos, Brain Science, Synchronicity, and the Law*, 61 TENN. L. REV. 933, 942-55 (1994) (including a basic discussion of "genetic algorithms"). In addition to the works cited therein, serious or technically inclined readers might consult DOUGLAS HOFSTADTER & THE FLUID ANALOGIES RESEARCH GROUP, *FLUID CONCEPTS & CREATIVE ANALOGIES: COMPUTER MODELS OF THE FUNDAMENTAL MECHANISMS OF THOUGHT* (1995), and BARBARA VON ECKARDT, *WHAT IS COGNITIVE SCIENCE?* (1993). For an enjoyable and informative read in this area, see DAVID FREEDMAN, *BRAINMAKERS: HOW SCIENTISTS ARE MOVING BEYOND COMPUTERS TO CREATE A RIVAL TO THE HUMAN BRAIN* (1994).

A practical application of CAS theory can be seen at a Deere & Company plant where custom scheduling is now done by a computer program using genetic algorithms based on a precursor of CAS theory. The program engineered a solution to the plant's scheduling problems caused by re-engineering:

Deere had re-engineered itself into a corner. "It became obvious we had an ongoing problem," says engineer Dick McKinnon. "I made some phone calls." One of the calls went to Bill Fulkerson.

Purely by chance a short time earlier, a Deere executive had stopped by Mr. Fulkerson's cubicle. Looking at the mathematician's notoriously messy desk, the boss made a comment about a book on the emerging science of chaos theory, then wished him a Merry Christmas and walked away. That was in December 1992.

Thomas Petzinger Jr., *At Deere They Know a Mad Scientist May Be a Firm's Biggest Asset*, WALL ST. J., July 14, 1995, at B1. Of course, this is a success story: "Planters now flow smoothly through the assembly line, with monthly output up sharply. Overtime has nearly vanished." *Id.*



political parties or scientific communities. Once you learned how to recognize them, in fact, these systems were everywhere.<sup>411</sup>

In that paper, Holland posited that complex adaptive systems share the following “crucial properties”: (1) “each of these systems is a network of many ‘agents’ acting in parallel”;<sup>412</sup> (2) “a complex adaptive system has many levels of organization, with agents at any one level serving as the building blocks for agents at a higher level”;<sup>413</sup> (3) “all complex adaptive systems anticipate the future”<sup>414</sup> by “constantly making predictions based on its various internal models of the world—its implicit or explicit assumptions about the way things are out there[, either by conscious choice or through instinct]”;<sup>415</sup> and (4) “complex adaptive systems typically have many *niches*, each one of which can be exploited by an agent adapted to fill that niche.”<sup>416</sup>

Other physical scientists studying this special kind of complexity previously observed that at least some of these kinds of yet unnamed systems also exhibited other properties like “emergence, collective behavior, and spontaneous organization.”<sup>417</sup>

In a subsequent book, Holland revised and expanded his four crucial properties of complex adaptive systems into seven basic elements consisting of four properties and three mechanisms.<sup>418</sup> His four properties are diversity;<sup>419</sup> aggregation;<sup>420</sup> nonlinearity;<sup>421</sup> and flow.<sup>422</sup> He then moved internal models into his mechanism category.<sup>423</sup> These labels, with one or

411. WALDROP, *supra* note 331, at 145.

412. *Id.*

413. *Id.*

414. *Id.* at 146.

415. *Id.*

416. *Id.* at 145.

417. *Id.* at 149.

418. JOHN H. HOLLAND, *HIDDEN ORDER: HOW ADAPTATION BUILDS COMPLEXITY* 11-40 (1995).

419. *Id.* at 27.

420. *Id.* at 10.

421. *Id.* at 15.

422. *See id.* at 23.

423. The other mechanisms are “building blocks” (a prior crucial property) and “tagging.” Tagging “facilitates the forming of aggregates.” *Id.* at 12. Thus, tags are important in boundary formation between aggregates. *Id.* at 13-15. Examples of tags include a banner or flag under which armies congregate and rally and “headers” in Internet addresses. *Id.* “Building blocks” help generate internal models. At bottom, they are component subcategories of a larger category. For example, Holland uses “faces” as the larger (meta) category and eyes as one of the component subcategories. *Id.* at 36. Now, imagine your mother with the eyes of a tiger. Can you do it? The set including different kinds of eyes is a building block. Of course, our categories are nothing more than abstraction, and somehow this seems to be related to creativity, as suggested by the following:

two exceptions, are descriptive enough for the purposes of this essay without further discussion. A couple of the labels, however, probably benefit from additional comment.

First, *aggregation* is used in two senses: (1) the sorting sense, that is, the “standard way of simplifying complex systems . . . [b]y aggregat[ing] similar things into categories—trees, cars, banks—and then treat[ing] them as equivalent. Humans analyze familiar scenes in this way with the greatest of ease”<sup>424</sup>; and (2) the sense that “concerns the emergence of complex large-scale behaviors from the aggregate interactions of less complex agents”.<sup>425</sup>

An ant nest serves as a familiar example. The individual ant has a highly stereotyped behavior, and it almost always dies when circumstances do not fit the stereotype. On the other hand, the ant aggregate—the ant nest—is highly adaptive, surviving over long periods in the face of a wide range of

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Arthur Koestler: “Einstein’s space is no closer to reality than Van Gogh’s sky. The glory of science is not in a truth more absolute than the truth of Bach or Tolstoy, but in the act of creation itself. The scientist’s discoveries impose his own order on chaos, as the composer or painter impose his—an order that always refers to limited aspects of reality, and is biased by the observer’s frame of reference, which differs from period to period, as a Rembrandt nude differs from a nude by Monet.”

RICHARD M. RESTAK, M.D., *THE MODULAR BRAIN* 135 (1994). According to the book’s back cover, Restak is a neurologist “and serves on the advisory councils of the National Brain Tumor Foundation, the National Foundations for Brain Research, and the United States Congress-sponsored New Developments in Neuroscience Project. He is author of *The Brain* and *The Mind*, which accompanied the PBS series of the same names” as well as other books. *Id.*

In fact, it seems that the root of modeling is in mathematics, science, and art:

Imagination—the making of images—lies at the root of all human creativity, and directs our conscious experience of the world. From early childhood, we are constantly making pictures of things, of people, and of places. As we grow older, we learn new ways of doing it. Photography, painting, descriptive writing, sculpture, poetry: all are means of capturing images in permanent form, so we can savour and re-experience the fruits of our imagination. Science is another quest to make images of the world. It has different goals and often requires different skills, but its beginnings had much in common with those of art: the accurate observation and representation of the world. Yet, there is more to the world than meets the eye. The accuracy of our perceptions of the world is not something that we can take for granted. Illusion is the dark side of imagination, and illusion tempts with self-delusion, under whose command we cannot long survive. The use of imagination to enlarge our picture of reality without, at the same time, subverting it is a delicate enterprise.

BARROW, *supra* note 393, at 5.

424. HOLLAND, *supra* note 418, at 10.

425. *Id.* at 11.

hazards. It is much like an intelligent organism constructed of relatively unintelligent parts.<sup>426</sup>

Relatedly, therefore, Holland undergirds the importance of aggregation by suggesting that emergence hints of "intelligence of large numbers of interconnected neurons [in the brain] . . . or even the coherence and persistence of a large city."<sup>427</sup>

Second, Holland's *diversity* property deserves discussion because it illustrates a fundamental tension in a CAS between the necessity of group formation (aggregation) and diversity (to provide system novelty at the individual level).<sup>428</sup>

426. *Id.*

427. *Id.* For a more detailed introduction to the brain as an emergent system, see Geu, *supra* note 410, at 963-71. In addition to the sources cited therein, see BAK, *supra* note 365, at 175-82. For an interesting book on the brain, which is largely consistent with the emergence theory of consciousness, see RESTAK, *supra* note 423. Restak writes:

Put another way, consciousness must be understood as a very special *emergent* property of the human brain. It is not an indispensable quality, since we have seen the vast majority of the brain's activities do not involve consciousness. It is not always a desirable property, at least in its more self-reflected forms (conscious of myself as consciously thinking about conscious, and so on in an infinite regress, as with some of the characters depicted by Kafka and Dostoyevsky [sic]). But consciousness is a unique property of the brain made possible by a sufficient number of parallel interacting modules.

*Id.* at 135 (emphasis added).

428. In the realm of society, perhaps,

Since "the more uncertain an environment potentially could be, the more would biological systems have diversified to dissipate that information," it follows that where there is no uncertainty there is no need for diversification. Diversity, versatility, variability, and variety all "represent (or, as reflected in object system behavior, measure) environmental uncertainties" and correlate positively with resilience. Thus, social diversity is not something to be lamented; on the contrary, spatial and temporal heterogeneity should be encouraged so as to ensure metastability—the system's ability to process increasingly complex environmental information. In other words, the meta-utopian ideal is a stew rather than a melting pot.

Alicia Juarrero-Roqué, *Fail-Safe Versus Safe-Fail: Suggestions Toward an Evolutionary Model of Justice*, 69 TEX. L. REV. 1745, 1763 (1991) (citations omitted).

In one way or another, "evolution" usually includes the major conceptual elements of CAS theory. Other authors who have used evolutionary models for legal rules, for example, include E. Donald Elliott, *The Evolutionary Tradition in Jurisprudence*, 85 COLUM. L. REV. 38 (1985); Herbert Hovenkamp, *Evolutionary Models in Jurisprudence*, 64 TEX. L. REV. 645 (1985); M.B.W. Sinclair, *The Use of Evolution Theory in Law*, 64 U. DET. L. REV. 451 (1987).

Indeed, the failure of futurist Jacques Ellul to account for diversity, in this author's opinion, may be the reason his ultimate predictions miss their marks (even though many of his interim predictions ring true). Ellul, a French law professor, is a well-known futurist and

Third, Holland's *internal model* mechanism for CAS is a necessary mechanism for the system to "learn." The most "critical characteristic of a model," according to Holland, is that it "allows us to infer something about the thing modeled."<sup>429</sup> Thus, it seems that the model is something like an analogy.

Holland then illustrates and identifies a tacit model as one that "simply prescribes a current action, under an implicit prediction of some desired future state," like a bacterium moving "in the direction of a chemical gradient, implicitly predicting that food lies in that direction."<sup>430</sup> Holland also identifies an overt model: "An overt internal model is used as a basis for *explicit*, but internal, explorations of alternatives, a process often called *lookahead*. The quintessential example of lookahead is the mental exploration of possible move sequences in chess prior to moving a piece."<sup>431</sup>

Importantly, if "predictions" based on either tacit or overt models are wrong, there are negative consequences to the agent. In the bacteria example, it gets no food and will die, and natural selection will favor a mutant bacteria or a different species of the same that has a better internal model. In the chess example, the player may lose the game and, if she was paying attention, change the model that resulted in the negative outcome. The agents (or the system as an aggregate of the agents), therefore, learn (at least in some sense) from experience. Thus, Holland's CAS explicitly accounts for feedback.<sup>432</sup> Holland's system also creates diversity as a

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his *The Technological Society* is considered a classic in the area. See Robert M. Merton, *Forward* to JACQUES ELLUL, *THE TECHNOLOGICAL SOCIETY* at vi (John Wilkinson trans., 1964).

429. HOLLAND, *supra* note 418, at 33.

430. *Id.* at 32.

431. *Id.* at 33.

432. Moreover, since the bacteria's current fitness or the current state of our chess player's move reflects learning through experience, we also can say that the "system" has a memory or that history is embedded in the system's current state of affairs. It also allows me to say, in some sense, that the position of a baseball between pitcher and catcher has a "memory" even though the baseball itself is not an adaptive agent. How can I say the baseball's position has a memory? Its position in the photograph was "determined" by a number of factors including the position of the pitcher's fingers on the ball when it was delivered. Therefore, the pitcher's finger placement is part of history "embedded" in the ball's current position.

Fritjof Capra, furthermore, emphasizes the idea that mental models are not reality and also suggests why learning can be difficult:

Buddhist philosophy contains some of the most lucid expositions of the human condition and its roots in language and consciousness. Existential human suffering arises, in the Buddhist view, when we cling to fixed forms and categories created by the mind instead of accepting the impermanent and transitory nature of all things. The Buddha taught that all fixed forms—things, events, people, or ideas—are nothing but *maya*. Like the Vedic seers and sages, he used this ancient Indian concept but brought it down from the cosmic level it occupies in Hinduism, connecting it with the process

product of progressive adaptations, and “each new adaptation opens the possibility for further interactions and new niches”:<sup>433</sup>

Roughly, each kind of agent fills a niche that is defined by the interactions centering on that agent. If we remove one kind of agent from a system, creating a “hole,” the system typically responds with a cascade of adaptations resulting in a new agent that “fills the hole.” The new agent[, assuming the entire environment has not changed and that the niche still exists on the fitness landscape,] typically occupies the same niche as the deleted agent and provides most of the missing interactions. This process is akin to the phenomenon called *convergence* in biology.<sup>434</sup>

In sum, it appears that Holland’s complex adaptive systems evolve to the edge of chaos.<sup>435</sup>

As the *Scientific American* reported in 1993:

By selecting an appropriate strategy, organisms tune their coupling to their environment to whatever value suits them best, Kauffman asserts. And if they adjust their coupling to their own advantage, he believes, they will reach the boundary between order and randomness—the regime of peak average fitness. “The bold hypothesis is that complex adaptive systems adapt to and on the edge of chaos,” Kauffman declares. “It now begins to appear that systems in the complex regime can carry out and coordinate the most complex behavior, can adapt most readily and can build the most useful models of their environments.”<sup>436</sup>

Armed with the foregoing basic discussion and understanding of punctuated equilibrium and complex adaptive systems, this article can turn to the direct application of complexity theory to business theory.

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of human cognition and thus giving it a fresh, almost psychotherapeutic interpretation. Out of ignorance (*avidya*), we divide the perceived world into separate objects that we see as firm and permanent, but which are really transient and ever-changing. Trying to cling to our rigid categories instead of realizing the fluidity of life, we are bound to experience frustration after frustration.

CAPRA, *supra* note 307, at 294-95 (citations omitted).

433. HOLLAND, *supra* note 418, at 29.

434. *Id.* at 27.

435. See *supra* notes 393-400 and accompanying text.

436. Russell Ruthen, *Adapting to Complexity*, SCI. AM., Jan. 1993, at 130, 140.

*B. Complexity Theory and Business*

There has been an increasing amount of management literature directly applying chaos and complexity theory to management and business without any mediation afforded by biological evolution. There is enough literature, in fact, to have John Micklethwait and Adrian Wooldridge include an explicit (albeit rather unflattering) discussion in their book-length survey of management consultancy.<sup>437</sup> Even established management consultants like

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437. They include chaos theorists in a larger classification of "management interlopers" in a chapter entitled "A Walk on the Wild Side":

The fourth group of management interlopers might be described as intellectual traders—people who import ideas wholesale from other disciplines. For instance, chaos theory (which has already migrated from physics to financial economics—with mixed success) pops up from time to time in management theory too: some people argue that companies should no longer try to form strategies, because strategies are an artifact of linear thinking, and we now live in a non-linear world, where tiny events can cause gigantic triumphs or disasters. Recently, however, biology rather than physics seems to be the ascendant.

MICKLETHWAIT & WOOLDRIDGE, *supra* note 393, at 316-17.

Obviously, "The Witch Doctors" have a rather limited understanding of chaos or they would not narrowly fix its application to physics and exclude biologically complex adaptive systems. Nonetheless, there exists responsible scientific criticism of complexity theory, some of which is described in this note but none of which really casts doubt on the historical record of the phenomena that the mathematics of the theory attempt to describe and prove. In other words, the record of the observed natural phenomena that complexity seeks to explain is largely settled. The reasons, and the mathematical proof, for the observed phenomena, however, are not yet so settled and, like the efficient market hypothesis relied upon by neoclassical economists, should be best understood as being hypothetical.

The difference in perspective on "complexity" could hardly be better illustrated than by juxtaposing John Horgan's article in the *Scientific American* with Fritjof Capra's book entitled *The Web of Life*. Compare Horgan, *supra* note 371, with CAPRA, *supra* note 307. Horgan acknowledged that the *Scientific American*, in which his article appears, had published numerous articles on complexity. Nonetheless, he implied that the bloom was off the rose and that it might be time to throw complexity into the ash bin of science along with the former fallen angels of cybernetics, catastrophe theory, chaos, and information theory. Horgan points out that each were searching for "a mathematical theory of, well, everything." Horgan, *supra* note 371, at 108. He also observes that, at least in some areas, complexologists "keep changing their definition." *Id.* at 106. "It's a moving target . . . ." *Id.*

Capra, on the other hand, integrates Horgan's failed individual "unification theories" into an historical crescendo of systems thinking, which science has combined, evolved, and culminated in what appears to be a self-organizing-system theory of life. Capra labels this result of the "deep ecology paradigm." See CAPRA, *supra* note 307, at 3-13, 227. From all these theories, Capra suggests that we must reconnect with the web of life if we, as a planet, are to survive. Thus he implicitly recognizes the essence of complexity. See *id.* at 296.

A more specific criticism is leveled at the idea that "complex behavior" exists "in 'critical regimes' between order and deterministic chaos." PETER COVENEY & ROGER HIGHFIELD,

Charles Handy have made mention of it:

Intriguingly, science, too, has moved away from the search for total certainty and predictability to a concern with Chaos, Creativity, and Complexity. There is, it seems, space and randomness at the heart of things. If I had studied more science I might have known this earlier, but you have to work such things out for yourself if they are to have any real meaning.<sup>438</sup>

It should not be surprising that chaos and complexity theory have seeped into management theory because, after all, observing years of market data

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FRONTIERS OF COMPLEXITY: THE SEARCH FOR ORDER IN A CHAOTIC WORLD 272 (1995). Indeed, the mathematical proof of one of the core phenomena used herein to illustrate complex adaptive systems (the Game of Life illustration) has been severely criticized. *Id.* at 275-77. The criticism is largely based, however, on how complex behavior is defined. In fact, another scientist is credited with finding complexity "at the edge of chaos" using a different definition and research methodology. *Id.* That latter methodology, however, erodes the power of the role of evolution toward "the edge." *Id.* Nonetheless, more recent books by equally credentialed scientists continue to express confidence in the original work.

Regardless of the foregoing, this article relegates most of the criticisms of the science used as a template for this article to the margin because: (1) there exists a body of accepted science, which was produced and is professed by scientists with impeccable credentials, which supports even a "strong form" of the science of complexity; and (2) this article, and my research, use these theories primarily as a common denominator (a common point of reference) by which to understand and explain features of separate (and some would say disparate) societal systems. Thus, any flaws in the underlying theory are at least applied consistently for a comparative understanding of those separate systems.

438. CHARLES HANDY, BEYOND CERTAINTY: THE CHANGING WORLDS OF ORGANIZATIONS 18 (1996). Complexity theory is being aggressively marketed and applied to business. For example, an advertising flier from The Ernst & Young Center for Business Innovation proclaims on the front cover (over the backdrop of a spiderweb graphic), "We invite you to join in what promises to be a rich, stimulating, and relevant conversation about the business applications of complexity science." The title of the conference was "Embracing Complexity: A Colloquium on the Application of Complex Adaptive Systems to Business," and it was to be held on August 3-5, 1997 in Cambridge, Massachusetts. Authors mentioned in this current article that were scheduled to give presentations were Stephen Jay Gould, Ralph Stacey, Roger Lewin, John Casti, and Stuart Kauffman. The Ernst & Young Center for Business Innovation is at One Cambridge Center, Cambridge, Massachusetts 02142, and its internet address is: [www.businessinnovation.ey.com](http://www.businessinnovation.ey.com). The conference was to be cosponsored by Ernst & Young LLP, one of the largest international accounting and business consulting firms.

Other authors previously cited also conduct or have announced seminars. Margaret Wheatley, her co-author Myron Kellner-Rogers, and Fritjof Capra were to be featured in a seminar sponsored by Kellner-Rogers & Wheatley, Inc. at Robert Redford's Sundance Resort in Utah. The seminar was entitled "Self-Organizing Systems: A Simpler Way."

for the cotton commodity market in 1960 helped launch both chaos theory and the idea of complexity at the edge of chaos.<sup>439</sup> Indeed, fractal geometric patterns (exhibiting recursive symmetries—self-similarity across scale),<sup>440</sup> which are associated with complexity, were shadows on Mandelbrot's IBM computers and helped spur his further research by helping him formulate a hunch:

The [cotton-price data] . . . produced symmetry from the point of view of scaling. Each particular price change was random and unpredictable. But the sequence of changes was independent of scale: curves for daily price changes and monthly price changes matched perfectly. Incredibly, analyzed Mandelbrot's way, the degree of variation had remained constant over a tumultuous sixty-year period.<sup>441</sup>

Chaos and complexity research, however, goes beyond the analysis of historical price trends. One example of such research is Brian Arthur's research about "increasing returns," which are diametrically opposed to the classical economic notion that generally assumes diminishing returns.<sup>442</sup> As I wrote in an earlier article, "The idea of diminishing returns is that as supply is increased the equilibrium price must go down. Thus, as total production of a good is increased, the price of each additional good will go down and, *a fortiori*, so will the profit."<sup>443</sup> Arthur argues that, unlike resource-based economic sectors like mining, the knowledge-based economic sectors "are largely subject to increasing returns."<sup>444</sup> Increasing returns, according to Arthur, are a result of multiple interactions of *positive*

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439. GLEICK, *supra* note 378, at 53-54.

440. For a description of fractal geometry, see Appendix, pt. A, *infra*.

441. GLEICK, *supra* note 378, at 86. Mandelbrot's "new" geometry gave not only advanced the early study of chaos and complexity, it also created a new intuition:

When I came in this game, there was a total absence of intuition. One had to create an intuition from scratch. Intuition as it was trained by the usual tools—the hand, the pencil, and the ruler—found these shapes quite monstrous and pathological. The old intuition was misleading. The first pictures were to me quite a surprise; then I would recognize some pictures from previous pictures, and so on.

Intuition is not something that is given. I've trained my intuition to accept as obvious shapes which were initially rejected as absurd, and I find everyone else can do the same. *Id.* at 102.

442. W. Brian Arthur, *Positive Feedbacks in the Economy*, SCI. AM., Feb. 1990, at 92, 92-93.

443. Geu, *supra* note 410, at 980.

444. Arthur, *supra* note 442, at 92-93. For a narrative about personal aspects of Arthur's work, see WALDROP, *supra* note 331, at 136.



*feedbacks.*<sup>445</sup> As an example of positive feedback in the economy, Arthur cited the competition between Beta and VHS video formats:

As it happened, VHS recorders got . . . [a] small incremental edge in market share, which consequently, caused VHS tape rentals to increase. In turn, this slight advantage led to video outlets stocking more VHS tapes, which encouraged even more individuals to choose to buy VHS recorders instead of BETA recorders. Thus, a small increase in market share portended huge increasing returns for the VHS format, and the market for recorders entered a phase lock which finds "parallels in modern nonlinear physics."<sup>446</sup>

On a more macroeconomic scale, economists and complexity theorists are studying economic "take-off" through international trade. In other words, the hypothesis is that "if a country ever managed to diversify and increase its complexity above the critical point, then you would expect it to undergo an explosive increase in growth and innovation."<sup>447</sup> Moreover, it

445. Arthur, *supra* note 442, at 92.

446. *Id.* at 99. Another example of the application of the CAS model in a different industry is reported in the *New Yorker*.

In a recent *Economic Journal* article, [Art] DeVany and a coauthor, David Walls, developed a mathematical model of how filmgoers behave which finally provides a rigorous intellectual basis for the old Hollywood adage "Nobody knows anything." The reason the movie business seems so chaotic, DeVany and Walls declared, is that, scientifically speaking, it *is* chaotic—or borderline chaotic, at least. "The film industry is a complex adaptive system poised between order and chaos," DeVany, a muscular fifty-nine-year-old, with spiky blond hair and a deep tan, said . . .

John Cassidy, *Chaos in Hollywood: Can Science Explain Why a Movie is a Hit or a Flop?*, NEW YORKER, Mar. 31, 1997, at 36, 36.

The researchers concluded that "[t]he only reliable predictor of a film's box office take was its performance the week before." *Id.* at 37. The *New Yorker* article explains the phenomena in terms of informational cascades:

According to DeVany, the chaos of the film industry has to do with the way millions of filmgoers exchange information. Since people don't know whether they will like a movie until they see it, they have to rely on what others tell them. If they hear good things—from friends, critics, or whomever—they will probably go and see the film; if they hear bad things, they won't. Economists call this process an information cascade, and informational cascades, like droughts, are impossible to forecast. . . . Even small differences in what moviegoers prefer can grow into large differences in eventual box-office revenues.

*Id.* at 36.

447. WALDROP, *supra* note 331, at 126. Others also are working on modeling economics using CAS Theory. For example, Holland writes:

Ours is not the only computer-based model using adaptive agents to emerge from the Santa Fe Institute workshops in economics. Another model, every bit as interesting as

is theoretically possible that trade might substitute for the necessary injection of capital to otherwise build internal diversity. To illustrate:

Suppose you have two different countries, each one of which is subcritical by itself. . . . [N]ow suppose they start trading, so that their economies become interlinked into one large economy with a higher complexity. "I expect that trade between such systems will allow the joint system to become supercritical and explode outward."<sup>448</sup>

Kauffman is careful to "[c]aveat [that he] . . . [is] not an economist."<sup>449</sup> Further, he expressly warns that his economic computer models are new and "should at most" be taken "as metaphors at present."<sup>450</sup> Nonetheless:

[T]hese . . . models afford us new tools to study technological coevolution. In particular, once one sees one of these models, the idea that the web itself drives the ways the web transforms becomes obvious. We know this intuitively, I think. We just have never had a toy world that exhibited to us what we have always known. Once one sees one of these models, once it becomes obvious that the economic web we live in largely governs its own directions of transformations, one begins to think it would be very important . . . to understand these patterns. . . .

These . . . models also suggest a possible new factor in economic takeoff: *diversity probably begets diversity; hence diversity may help beget growth.*<sup>451</sup>

In words one would expect from Per Bak (the sandpile researcher) rather than Kauffman, Kauffman writes:

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the stock market model, was designed by Ranon Marimon and Thomas Sargent. This model is built on Wicksell's Triangle, a classic model in economics. Wicksell's Triangle consists of three "countries," each of which produces a single product. A problem arises because the product a country produces is not the product it wants to consume; the product it desires is produced by one of the other countries. What is an efficient trading pattern for these countries? Among other things, Wicksell's Triangle concerns the emergence of "money," the use of one of the products as a medium of exchange.

HOLLAND, *supra* note 418, at 86-87 (citations omitted).

448. WALDROP, *supra* note 331, at 126 (quoting KAUFFMAN, *supra* note 310, at 289-98).

449. KAUFFMAN, *supra* note 310, at 294.

450. *Id.*

451. *Id.* at 292.

New goods and services create niches that call forth the innovations of further new goods and services. . . . Some of these are truly triggers of Schumpeterian "gales of creative destruction," ushering out many old technologies, ushering in many new ones in vast avalanches. . . . [L]arge avalanches drive significant capital formation and growth. Other new technologies come and go with hardly a ripple. These differences presumably reflect . . . how central . . . the new technology . . . is in the current web and in its future evolution.<sup>452</sup>

In short, there seems to be ample evidence to suggest that chaos, complexity, and CAS theory applies at some level to the organization and operation of business through economics and the management arts.

Turning to management, a recent article in *Complexity*<sup>453</sup> analyzes the

452. *Id.* at 296. Per Bak writes that "[t]raditional equilibrium interpretations of economics resemble the description of water flowing between reservoirs." BAK, *supra* note 365, at 183-84. However, Bak later suggests:

[E]conomics is like sand, not like water. Decisions are discrete, like the grains of sand, not continuous, like the level of the water. There is friction in economics, just like in sand. We don't bother to advertize and take our apples to the market when the expected payoff of exchanging a few apples and oranges is too small. We sell and buy stocks only when some threshold price is reached, and remain passive in between, just as the crust of the earth is stable until the force on some asperity exceeds a threshold. We don't continually adjust our holdings to fluctuations in the market. In computer trading, this threshold dynamics has been explicitly programmed into our decision pattern. Our decisions are sticky. This friction prevents equilibrium from being reached, just like the friction of sand prevents the pile from collapsing to the flat state.

*Id.* at 185-86.

One of the most interesting descriptions of how chaos and complexity theory may change some of the static neo-classical economic assumptions is written by H. Richard Priesmeyer, a professor of management. Priesmeyer draws from the concepts of diminishing returns and equilibrium economy:

We left economics class the first day knowing one thing for sure: If we raise the price, people will demand less of our product. But what we should have remembered was the concept of that equilibrium point. And when our instructors started shifting those lines around, we should have paid close attention because that's when the dynamics of the price-quantity relation emerged. . . . [T]here is another entire dimension that unfolds when you draw layer after layer of shifting supply-and-demand curves. Each chart is like a frame in a movie, and the equilibrium points on each chart are connected to one another. . . . [S]ee the movie [and the dynamical pattern that it shows]?

PRIESMEYER, *supra* note 384, at 70.

453. Ted Lumley, *Complexity and the "Learning Organization,"* COMPLEXITY, May-June 1997, at 14.

Since [Lumley] retir[ed] in 1996 from his job as Chief Technical Computing Scientist for Mobil, he has been working with a network of associates in the field of knowledge management (KM) to foster open knowledge exchange and KM investment insights. Physics and mathematics have provided the central "ordering principle" for his

learning organization popularized by Peter Senge in his book *The Fifth Discipline*.<sup>454</sup> Basically, the article suggests that organizational value generated in a given time period is the sum of “fabricative tangible results”<sup>455</sup> (what we can measure in financial terms) plus “the [unrealized and largely unrecognizable] value of creative interference.”<sup>456</sup> It is then suggested that the fabricative and the creative values (addends) in the equation represent bipolar ways of thinking. “Fabricating” requires local rule-based assembly processes emphasizing efficiency and lack of “overlap” or duplication of efforts.<sup>457</sup> “Creating,” on the other hand, is based on “ad hoc ‘spatial’ collaboration.”<sup>458</sup>

Further, according to the author, *fabricating* is a linear process while *creating* is a nonlinear process.<sup>459</sup> And a business cannot emphasize both processes at the same time without compromise.<sup>460</sup> Moreover, organizations often “flip” modes from fabricative to creative in response to an emergency and have a tendency to flip back once the emergency is resolved. All this seems to echo Kuttner’s identification of different kinds of efficiency, thus tying management theory with economic theory.<sup>461</sup>

Part of the reason that latent emergent creativity (like team problem solving) is often ignored is because “we can’t speak directly about it, we

explorations. His website URL is <http://rampages.onramp.net/~emlumley>.

*Id.*

454. See PETER M. SENGE, *THE FIFTH DISCIPLINE: THE ART AND PRACTICE OF THE LEARNING ORGANIZATION* (1990); see also Thomas Earl Geu, *Chaos, Complexity, and Coevolution: The Web of Law, Management Theory, and Law Related Services at the Millennium*, 65 TENN. L. REV. 925, 971 & nn.217-223 (1998) (discussing Senge). Although in difficult jargon, the following quote should by now be decipherable:

In particular, this essay looks at dual ‘ordering principles’ as being responsible for value creation in teams, a fabricative ordering principle giving rise to value in a tangible-causal sense (the dominant traditional view of value creation in teams), and a creative interference ordering principle giving rise to value in a latent-emergent sense.

Lumley, *supra* note 453, at 15.

455. Lumley, *supra* note 453, at 16.

456. *Id.*

457. *Id.*

458. *Id.*

459. *Id.*

460. *Id.* Thus,

[f]or example, the efficiency-motivated pursuit of nonoverlapping contributions from organizational subcomponents, by clearly defining local roles, responsibilities, and quantitative measures, runs directly counter to the stimulation of creative interference which derives from ad hoc knowledge sharing. A by-product of viewing overlap and interference as “waste” is the loss or disregard of latent value accruing through creative interference in the interstitial space between fabricative cells.

*Id.* at 17-18.

461. See Geu, *supra* note 454, at 971.

can't remember it, and we can't quantitatively measure it . . . ."<sup>462</sup> It is difficult to talk about or remember "because it is higher dimensional and intrinsically geometrical."<sup>463</sup> To illustrate, riding a bicycle involves ten variables, and, therefore, it is a ten-dimensional learning experience that is capable of "knowing" but not capable of "explicit" memory or description (other "phenomena can involve far more [dimensions]").<sup>464</sup> The memory of riding a bicycle is, in fact, a spatial memory of a trajectory in ten-dimensional phase space.<sup>465</sup>

The other reason such creativity is often ignored is because it is difficult to measure, predict, or appropriately reward different team contributors:

Short term rewards[, most often based on fabricated output or completed ideas,] effectively foster longer term goals only where linear processes are involved. The enlightenment in learning arrives more like the avalanche in a sandpile at critical angle of repose to which one is adding grains of sand. There is no output proportional to input which can be fostered along the way to the avalanche, just an aperiodic insight triggered, unpredictably, by a single input "grain."<sup>466</sup>

If short-term reward is "out of context of the learning cycle . . . [it] foster[s] internal competition and distrust, creating an environment inherently disadvantageous to the evolution of 'learning organizations.'"<sup>467</sup> Avoiding this contextual disharmony between long-term learning and short-term rewards requires measuring "knowable," but not describable, contributions over the long term and rewarding "wastage" by consulting globally across the group. "The message is that management cannot ask for higher personal or departmental performance *and* for increasing levels of organizational coherency and adaptability . . . . To insist on improving both simultaneously is a recipe for organizational confusion and internal strife."<sup>468</sup>

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462. Lumley, *supra* note 453, at 18.

463. *Id.*

464. *Id.*

465. *Id.*

466. *Id.* at 19.

467. *Id.* at 20-21.

468. *Id.* at 20. Lumley uses the movie *Apollo 13* as an example of a team going through a "polarity reversal," caused by a technological emergency, from fabrication to creativity. Lumley explains that "[i]nterviews with members of high-performing teams in the upstream petroleum industry suggest that a similar phenomenon occurs as is often encountered in sports or ballet—that is, a transitioning from a piecewise mechanical assembly of thoughts to a seamless creative mental synthesis." *Id.* at 17. This is the very same kind of phenomenon in the context of organizational behavior that is described in the book, *Organizing Genius*. See WARREN BENNIS & PATRICIA WARD BIEDERMAN, *ORGANIZING GENIUS: THE SECRETS OF CREATIVE COLLABORATION* (1997).

Therefore, the article in *Complexity* is about designing inappropriate reward systems and, it seems, the importance of knowing the organization's stage of development as well. Thus, for example, Motorola has adopted "behavioral oriented awards" and "a multi billion dollar investment has been made, through Motorola University, to develop 'behavioral leadership' or 'role model' leaders who are differentially rewarded . . . on their ability to catalyze synergies in the workplace . . . ."<sup>469</sup> The analysis explicitly recognizes "[t]he importance of honesty, trust, and humility[, maximizing team results rather than individual statistics through recognition of the nonlinear nature of production,] in dipolar value generation."<sup>470</sup> Interestingly, the author posits that,

[i]n the creative domain, management must sit patiently on many "eggs" in order to hatch the valuable few. An observed general "impatience" in some business sectors, manifest in the decline of mentoring (a self-organizing, teaching-learning culture which accommodates multi-generational learning cycles) and the rise of a quick-fix mentality, is suggestive [of the adoption of the fabricating mode rather than the creative mode].<sup>471</sup>

The observations and management prescriptions made in the *Complexity* article generally just reinforce those made by the more traditional "management theorists" surveyed in Part II of this article. Their import, therefore, is that they arise out of a theoretical framework provided by "the new science." Moreover, these sciences have been used in the context of war and combat which, as also noted in Part II, are themselves sometimes used as an analogy for business.<sup>472</sup>

Margaret Wheatley, another management author who has adopted "the science of surprise" as her analytical framework, introduces her first book this way:

This is not a book of conclusions, cases, or exemplary practices of excellent companies. It is deliberately *not* that kind of book, for two reasons. First, I no longer believe that organizations can be changed by imposing a model developed elsewhere. So little transfers to, or even inspires, those trying to work at change in their own organizations.

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469. Lumley, *supra* note 453, at 20.

470. *Id.* at 22.

471. *Id.*

472. See, e.g., JOSHUA M. EPSTEIN, NONLINEAR DYNAMICS, MATHEMATICAL BIOLOGY, AND SOCIAL SCIENCE 7, 19, 41 (1997) (including the following lectures: "The Mathematical Biology of Arms Races, Wars, and Revolutions"; "An Adaptive Dynamic Model of Combat"; and "Imperfect Collective Security and Arms Race Dynamics: Why a Little Cooperation Can Make a Big Difference").

Second, and much more important, the new physics cogently explains that there is no objective reality out there waiting to reveal its secrets. There are no recipes or formulae, no checklists or advice that describe "reality." There is only what we create through our engagement with others and with events.<sup>473</sup>

In summary, Wheatley suggests that people trust not only in self-organization, but also that the forms of the organizations "originate from dynamic processes set in motion by information, relationships, and identity."<sup>474</sup> She cites ideas such as "adaptive [learning] organizations" and structuring organizations through "core competencies" as examples of tapping into "the property of self-organizing."<sup>475</sup> She further asserts that these ideas "bring us back to the importance of simple governing principles; guiding visions, strong values, organizational beliefs—the few rules individuals can use to shape their own behavior."<sup>476</sup>

A more recent book by Ralph D. Stacey seems to build on the same foundations as Wheatley, which include blocks of information, relationships, and identity. He then expressly prescribes organizational processes that will help self-organize the building blocks into a creative organization.<sup>477</sup> These processes include self-reflection and management of anxiety created by more freedom, as well as the maintenance of redundancy, excess resources, and play.<sup>478</sup> Interestingly, Stacey also expressly writes that a "complex adaptive system approach to understanding organizations offers, not a guarantee of success—there is no such thing—but a more useful framework for making sense of experience, reflecting, and thus potentially designing more effective actions."<sup>479</sup>

473. WHEATLEY, *supra* note 378, at 7.

474. MARGARET J. WHEATLEY & MYRON KELLNER-ROGERS, A SIMPLER WAY 87 (1996).

475. *Id.* at 88.

476. *Id.* at 133.

477. STACEY, *supra* note 385.

478. *Id.* at 277-81. In the preface to this book, Professor Stacey, Professor of Management and Director of the Complexity and Management Center at the Business School of the University of Hertfordshire, recounts the story of Nick Leeson as an illustration of complexity. He describes Leeson as "an overconfident young man, brought up in a public sector housing project," and how he brought down "the Queen's banker, Barings." *Id.* at ix-x. Succinctly, Stacey describes how this event illustrates complexity: "What started as a small change that was, at least initially, undetected by the hierarchically most powerful led to the extinction of the organization." *Id.* at x. What makes this so surprising is "that Barings survived for so long, well over two centuries, without changing all that much in fundamental, radical ways." *Id.* at ix.

479. *Id.* at 1. Self reflection is obviously not a new technique. See, e.g., STEPHEN R. COVY, THE SEVEN HABITS OF HIGHLY EFFECTIVE PEOPLE 70-71 (1989). Again, the importance of Stacey's work is that it is a result of the application of complexity theory.

Of the authors applying complexity to business, Priesmeyer gives the most detailed advice. His book's advice consists of thirty-four propositions.<sup>480</sup> One that is particularly appropriate for this article deals with organizational purpose, forecasting, and leadership. It expressly acknowledges the ideas from chaos and complexity that the "future performance of the system emerges incrementally from its current state."<sup>481</sup> Thus, it is possible to effect the end-state of the system at many decision points, both large and small, over time.<sup>482</sup> As a result, Priesmeyer suggests that "[r]ather than trying to estimate all the forces that act on a system in order to forecast the future behavior of that system, we can vision the future and then act on the forces to create the visioned condition."<sup>483</sup> Visions are not mission statements, nor are they goals: "Visioning, which identifies a specific future state of a system, can be integrated into the strategic planning process to quantify a broad mission statement. Visions differ from goals or objectives because they are multidimensional."<sup>484</sup> To illustrate:

A Mission: To provide quality medical care to the population in the district

A Vision: To attain a bed capacity of 300 and a budgeting surplus of \$100,000 by June 30, 1996

Goals: To remodel the East Wing within eighteen months[;] To reduce utility costs by 15 percent this year<sup>485</sup>

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480. PRIESMEYER, *supra* note 384, at 241-45. The propositions, which "are offered as a set of contentions for others to ponder" and "as a framework for practitioners hoping to exploit nonlinearity in business," consist of groups entitled "marketing management," "financial management," "production management," "human resource issues," "forecasting and visioning," "strategic management," and "the center of chaos." *Id.* at 241-42. To illustrate, the grouping of human resource issues contains five propositions, two of which are as follows:

*Proposition 21:* Organizational theory concepts such as centralization-decentralization and span of management trace trajectories in phase space reflecting forces in the external environment and within the organization.

*Proposition 22:* Management can be viewed as an evolving form of behavior that is part of the system being managed. Management style can be expected to change in response to perceived effectiveness, previous experiences, and changes in the system; the evolving style will trace a trajectory in phase space.

*Id.* at 244.

481. *Id.* at 187.

482. *Id.*

483. *Id.* at 177.

484. *Id.* at 196.

485. *Id.* This vision seems to be very similar to the "Commander's Intent" in Army doctrine, which is a "concise expression of how you visualize the operation, and it is always written by the commander personally. In the absence of specific orders, it could be used as operating guidelines." TOM CLANCY WITH GEN. FRED FRANKS, JR. (RET.), INTO THE STORM: A STUDY IN COMMAND 14 (1997). The Commander's Intent is one of the key components of an operational plan, and, in Army doctrine, it is imperative that the entire command



"Meaning," is related to mission (or purpose) and is something that echoes with Maslow and others previously discussed.<sup>486</sup> There is, according to one management consultant, a role to be played by "meaning" in management principles consistent with complexity: "We instinctively reach out to leaders who work with us on creating meaning. Those who give voice and form to our search for meaning, and who help us make our work purposeful, are leaders we cherish and to whom we return gift for gift."<sup>487</sup> Moreover:

When I think about meaning as a strange attractor, I see links to these sciences. Meaning or purpose serves as a point of reference. As long as we keep purpose in focus in both our organizational and private lives, we are able to wander through the realms of chaos, make decisions about what actions will be consistent with our purpose, and emerge with a discernable pattern or shape to our lives.

When a meaning attractor is in place in an organization, employees can be trusted to move freely, drawn in many directions by their energy and creativity.<sup>488</sup>

But note:

[W]e take this vital passion [for purpose and meaning] and institutionalize it. We create an organization. The people who loved the purpose grow to disdain the institution that was created to fulfill it. Passion initiates into procedures, into rules and roles. Instead of purpose, we focus on policies. Instead of being free to create, we impose constraints that squeeze the life out. . . . We see its bloated form and resent it for what it stops us from doing.<sup>489</sup>

Finally, lest we forget, "[b]ehaviors are rooted in agreements."<sup>490</sup>

All this is less than satisfying. What it seems to indicate is that there are no answers. Handy, who is a former CEO of Royal/Shell, says that:

I was, for a while, euphoric about the openings [the end of certainty] offered to all, . . . [but] I came to realize that the end of certainty is not

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structure understand it. *See id.* It is, therefore, somewhat like purpose, except far more detailed.

486. WHEATLEY, *supra* note 378, at 135.

487. *Id.*

488. *Id.* at 136.

489. WHEATLEY & KELLNER-ROGERS, *supra* note 474, at 57.

490. *Id.* at 63.

welcome news to most. [M]ost people are not prepared for it; most would rather have chains than empty spaces, railroad tracks than prairies, even if the tracks do not lead to heaven. For many of us, the world is a confusing place once certainty is gone.<sup>491</sup>

In summary, then, Handy's book observes, "[t]hat hidden message from my school[ing], I eventually realized, was not only crippling, it was wrong. The world is not an unsolved puzzle, waiting for the occasional genius to unlock its secrets. . . . I was free to try out my ideas, invent my own scenarios, create my own futures."<sup>492</sup>

A previous section of this article discussed the direct application of chaos and complexity to biological evolution on a paleontological time scale. This section of the article has identified and described the application of chaos and complexity (some of which is direct) to business theory. Both sections are important building blocks in order to understand the coevolution of management theory and law at the millennium; that is, after all, the

491. HANDY, *supra* note 438, at 18. Such freedom, especially if coupled with lack of familiarity with the environment can seem daunting as evidenced by the following two quotes from *The Gulag Archipelago*:

N.V. Surovtseva, for instance, was unlucky enough to reach the end of her sentence. Only yesterday she had worked in the children's settlement, where she was warm and well fed, but now she was turned out to work in the fields, because there was nothing else. Only yesterday she was assured of her bed and her rations, and now she had neither rations nor a roof over her head. . . . "The oppressive burden of freedom"—that is how she described her new experiences.

3 SOLZHENITSYN, *supra* note 378, at 449. In addition:

Humanity probably invented exile first and prison later. Expulsion from the tribe was of course exile. We were quick to realize how difficult it is for a man to exist, divorced from his own place, his familiar environment. Everything is wrong and awkward, everything is temporary and unreal, even if there are green woods around, not permafrost.

*Id.* at 335.

492. HANDY, *supra* note 438, at 17. There is an unmistakable similarity between Dawkins's artificial selection within evolutionary phase space, *see supra* notes 342-50 and accompanying text (discussing Dawkin's "biomorph land"), and Handy's proposition that is quoted herein. The new uncertainty explained by complexity and CAS theory is, therefore, a new way of thinking that changes even training and teaching:

Recently, I advised a group of students who were taking on an ambitious study of a new subject area, and I noticed a different direction to my advice. They were eager to create a model or framework into which they could slot information. I was intent on letting information do its thing. They wanted to get organized at the start; I wanted them to move into confusion. I urged them to create more information than they could possibly handle. I guaranteed them that at some point the information would self-organize in them, crystallizing into interesting forms and ideas.

WHEATLEY, *supra* note 378, at 149-50.

express purpose of this article. The next section of this article discusses existing literature applying chaos and complexity to law. It also begins to discuss evolution and its possible application to law. Thus the next section will also serve as the bridge to applying evolution to business, completing this part's purpose of discussing law and business together but separately through the mediation of chaos, complexity, and CAS theory. The last parts of this article will then turn to discovering a deeper understanding of the interrelationship between law and business theory and, finally, to illustrate the possible use of that understanding through its application.

### *C. Complexity, Evolution, and Law*

This section of the article discusses the separate application of complexity to law. It also introduces, for the first time in this article, an application of evolution. There are a number of articles comparing or applying different components of complexity to aspects of law. Of course, there also have been numerous non-complexity based articles using biological evolution, or more broadly, science, as a paradigm for law. The purpose of this part of the essay is not to regurgitate in detail the existing work applying science, biological evolution, or complexity to law.<sup>493</sup>

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493. There is, of course, a grand distinction between law as a scientific discipline and using "other" science as an analogy for, or to explain, law. Compare Marcia Speziale, *Langdell's Concept of Law as Science: The Beginning of Anti-Formalism in American Legal Theory*, 5 VT. L. REV. 1 (1980), with Laurence H. Tribe, *The Curvature of Constitutional Space: What Lawyers Can Learn from Modern Physics*, 103 HARV. L. REV. 1 (1989).

One article suggesting law is a scientific discipline is John Veilleux, Note, *The Scientific Model in Law*, 75 GEO. L.J. 1967 (1987) (the citations therein could be used as an initial bibliography for law as a scientific discipline). Law as a scientific discipline "reduces" law to something different from, say, political science. Its major thrust, for our purposes, is the use of the scientific method. Following, Veilleux describes law as scientific study:

Consistent with its internal values, the scientific analogy is process, not result, oriented. That is, it prescribes an approach to analyzing and addressing legal questions that produces an answer as an end result rather than as a starting premise. It seeks "scientific solutions" in the sense that they are based on accurate facts, identified rules and principles, and would be reproduced by other scientific judges if the essential circumstances were recreated. . . . [T]hese ideas can be condensed into three elements generally found in the scientific model of judicial lawmaking: (1) an objective inquirer, (2) a process of hypothesis formulation and empirical testing, and (3) a belief in some underlying coherent system that assures that the first two principles will produce accurate and reproducible answers.

*Id.* at 1970-71 (citations omitted).

Veilleux, importantly for those of us in law that have ever attempted to win grants from multi-disciplinary review committees, notes that there are "significant differences among scientific disciplines" in how they approach their subject: "Geology, for example, uses observation as its primary empirical technique, but cannot isolate variables for experimenta-

Rather, its purpose is to briefly survey selected literature in an attempt to justify the hypothesis that law is itself a complex adaptive system and, therefore, that law may be involved in a coevolutionary dance with other such systems in society specifically including the business and economic systems.

A number of published law review articles have applied chaos or complexity to specific areas of law and, more generally, to jurisprudence.<sup>494</sup> Each of these articles has its own unique contribution; nonetheless, there are four articles that warrant special attention, not necessarily because they are the best, nor most complete, but rather because they are most germane to the purposes of this article. These articles are Professor J.B. Ruhl's *The Fitness of Law*,<sup>495</sup> Professor Mark Roe's *Chaos and Evolution in Law and Economics*,<sup>496</sup> Professor William Rodgers's *Where Environmental Law and*

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tion in the way that physics or chemistry does. Mathematics, on the other hand, relies largely on the use of logic, rather than on empirical evidence of any sort, to carry out its proofs." *Id.* at 1967-68 n.2; *see also id.* at 1970 n.16.

Although these are exceptions, it is fair to say that most of the literature concerning using "other" science in law does so analogically or metaphorically. One such exception may be the "strong" form ("first generation") of the law and economics movement, which "reduced" law to "just" another branch of economics by directly applying economic analysis to legal issues: "[t]he first generation tended to view its work as a continuation of progressive realism, and it advanced a strong thesis that law is, and ought to be like a social science—that is economics." GARY MINDA, *POSTMODERN LEGAL MOVEMENTS: LAW AND JURISPRUDENCE AT CENTURY'S END* 87 (1995). Succinctly, these "progressive legal realists . . . claimed that the answers to law's problems can be discovered in another discipline such as economics." *Id.*

The "second generation" of the law and economics movement is more like what I consider to be most of the use of science in law: "The shift from abstract theory to concrete institutional analysis has been nurtured by a new understanding of economic theory—an understanding that views 'theory' merely as a tool for investigating what may 'work' as a solution to some problem. . . . [T]he second generation views economics as an *applied* science." *Id.* at 87-88.

A good example of the use of science in law that falls somewhere between analogy and direct application is represented in Bernard Cohen's book, *Science and the Founding Fathers*. Therein, Cohen investigates whether the Constitution was directly shaped by the then-current state of scientific knowledge. I. BERNARD COHEN, *SCIENCE AND THE FOUNDING FATHERS* (1995). His conclusion therein, *see id.* at 280, is consistent in *approach* with that of Woodrow Wilson, who in 1908 wrote: "The government of the United States was constructed upon the Whig theory of political dynamics, which was a sort of unconscious copy of the Newtonian theory of the universe." WOODROW WILSON, *CONSTITUTIONAL GOVERNMENT IN THE UNITED STATES* 54-55 (1908).

494. *See supra* note 428.

495. J.B. Ruhl, *The Fitness of Law: Using Complexity Theory to Describe the Evolution of Law and Society and Its Practical Meaning for Democracy*, 49 VAND. L. REV. 1407 (1996).

496. Mark J. Roe, *Chaos and Evolution in Law and Economics*, 109 HARV. L. REV.

*Biology Meet*,<sup>497</sup> and Professor Robert Artigiani's *Chaos and Constitutionalism*.<sup>498</sup> Each need to be discussed and contrasted.

The most accessible of the articles is Roe's. Simply stated, Roe matter-of-factly acknowledges the "classical evolutionary paradigm" (neo-Darwinian) as follows: "The classical evolutionary paradigm has a strong grip on law and economics scholarship. What survives is presumptively efficient: if it were inefficient, the practice, the law, or the custom would be challenged by its more efficient competitors."<sup>499</sup> He then cogently explains the classic economic<sup>500</sup> application of neo-Darwinian evolutionary biology:

Entrepreneurs without a clear understanding of what they are doing can stumble on an efficient practice. They make money and their firms grow at the expense of firms that failed through bad luck or poor skill to adopt the efficient practice. States compete by producing efficient law. States that fail to provide efficient law get less of the regulated activity. Inefficient rules are challenged because the challengers find it profitable to do so.<sup>501</sup>

He suggests that the classical theory "works best" when applied to competing businesses; conversely, he also suggests "it works less well in explaining the survival . . . of the . . . politically and legally determined business institutions or of the national systems themselves."<sup>502</sup>

Roe's essay specifically explores adding the "overlapping paradigms" of (1) "the science of chaos" (limited in his discussion to mean sensitivity to initial conditions and nonlinearity); (2) "modern thought on evolution" (the idea of being trapped in a local equilibrium on a fitness landscape and, later in the essay, the idea of punctuated equilibrium); and (3) "path dependence" (implicitly described as habit; this is similar to the idea of "attractors" from chaos).<sup>503</sup> Roe suggests that these three paradigms should be applied "[i]f we want a finer approximation to explain resultant

641 (1996). Roe's work is only an essay which is not meant to be a compendium for research. It cites the classic evolutionary literature, but it does not cite legal literature concerning chaos and law. That literature, however, was at best scant.

497. Rodgers, *supra* note 316.

498. Robert Artigiani, *Chaos and Constitutionalism: Toward a Post-Modern Theory of Social Evolution*, 34 *WORLD FUTURES: THE JOURNAL OF GENERAL EVOLUTION* 131 (1991).

499. Roe, *supra* note 496, at 641.

500. For a brief explanation of neo-classical economic theory, see *supra* note 452 and accompanying text.

501. Roe, *supra* note 496, at 641-42 (footnote omitted).

502. *Id.* at 642.

503. *Id.* at 642-43.

reality.”<sup>504</sup> He then applies his path dependency paradigm to examples from corporate and bankruptcy law as an illustration of the analogical use of the three paradigms he discussed.<sup>505</sup>

As an introductory matter, three other points concerning chaos and evolution need be made, to which I will return later. First, while Roe briefly acknowledges the interrelationship between chaos theory and path dependence, he does not attempt to develop that interrelationship (nor does he develop the relationship between those two paradigms and that of punctuated equilibria). That is, he generally chooses to treat each of his three paradigms as separate, unrelated addends which may be applied

504. *Id.* at 642. This view would make Roe’s article an example of “second-generation law and economics scholarship” under Minda’s taxonomy. See MINDA, *supra* note 493, at 87.

505. Here, Roe’s article is at its best for his examples of path dependency alone. One of his examples is near the core of this article: *corporate governance*. See Roe, *supra* note 496, at 653-60. (As an aside, Roe seems to draw heavily from his 1994 book entitled *Strong Managers, Weak Owners*). He contrasts the corporate governance structure from several developed economies, all of which he recognized must have been efficient for their economies to thrive. Thus he writes,

There were thus at least two models for corporate governance in economically advanced economies. While the American system invested authority disproportionately in the CEO . . . , the German and Japanese structures were more bank-centered and their CEOs lacked the central authority of their American counterparts. American CEOs were confined by hostile takeovers; German and Japanese CEOs were confined, it was said by their banks. Neither the American nor the foreign system was perfect, each had lapses and limitations, but what is important for path dependence is that they differed from one another.

Roe, *supra* note 496, at 653-54.

After a very good analysis, Roe internally concludes:

How would one fit rough equivalence in basic tasks into the path-dependent paradigm? In stark form, I believe that although America started with comparatively weak financial intermediaries, it eventually developed comparatively strong boards. In contrast, although Germany and Japan started with relatively strong intermediaries, they developed [comparatively] weak boards.

*Id.* at 655-56.

Another of Roe’s examples of path dependency concerns “bankruptcy.” Roe uses path dependency to explain the counterintuitive regulation that bars “bondholder votes to approve certain types of recapitalizations of the bonds—those that would extend the maturity date or change the principal amount.” *Id.* at 660. The path dependent reason for this rule, he suggests, has to do with the “original condition” of the law of negotiability under the New York Negotiable Instruments Law in force in 1928: “Negotiability was valuable for all bonds, failed or not, as they could change hands more easily if negotiable. But recapitalization ease is important only for failed bond issues, so corporations and their bankers simply reacted by deleting the offensive recapitalization-by-vote clauses, thereby making the bonds [surely adaptable].” *Id.* at 661. This example is also consistent with the idea of evolution and the peacock’s tail as discussed later in this article. See *infra* note 520 and accompanying text. It is also consistent with “sensitivity to initial conditions,” which is a tenant of chaos theory.

linearly, somewhat like separate transparencies can be superimposed on an overhead projector.

Second, Roe generally concludes that the “evolution-toward-efficiency paradigm”<sup>506</sup> does not alone “determine the institutions we observe”<sup>507</sup>; but, rather, evolution toward efficiency “only applies within broad parameters.”<sup>508</sup> This, of course, is consistent with what other economic and management authors have asserted. One piece of evidence that Roe uses to support the need for supplementing the classic evolutionary paradigm in economics is that in comparing business structures across nations the evolution of foreign business structures “sometimes did not produce the same institutions we had . . . [, and] [i]f foreign systems did not replicate our institutions and if their economies were at roughly the same level as ours, we needed further explanation.”<sup>509</sup>

Third, Roe suggests that:

Thinking about path dependence tempts us toward greater government direction. For many law and economics advocates (and I include myself here), it would be most satisfying to believe in evolution-toward-efficiency if we could believe that no important path could be inefficient, a belief the modern biological analogy does not support. If we could believe that what survives is efficient, then we would not need to consider the possibility that a centralized administrator might get the needed information fastest and make a correct decision to change the path. A mistrust of governmental action is more persuasive (and more satisfying in constructing a coherent belief system) if we can convincingly presume the efficiency of most key economic institutions. If we cannot, because too much depends on chaotic original conditions or path dependence, then the verbal space would widen in which to debate government action and directives for change.<sup>510</sup>

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506. Roe, *supra* note 496, at 667.

507. *Id.* at 668.

508. *Id.*

509. *Id.*

510. *Id.* at 666 (footnote omitted). Professor Roe also suggests that chaos theory is of somewhat limited usefulness because of its indeterminacy and difficulty extrapolating policy prescriptions. *Id.* at 666-67. Because of the acknowledgment of the existence of indeterminacy, academics (of all persuasions but certainly lawyers and economists), politicians, business people, and other policy makers or influencers should be just a little more humble in our prognostications. This is particularly important to understand now because the new indeterminacy is not “just” confined to pure “chaos theory” but to all the disciplines to which it applies:

The indeterminacy of most strictly biological processes no longer stands in sharp contrast to a strict determinacy in physical processes. The study of the effects of turbulence in galaxies and nebulae, as well as in the oceans and weather systems, has shown how frequent and powerful are stochastic processes in inanimate nature . . . . Only absolute predictions are impossible owing to the complexity of the hierarchical systems, the high number of possible options at each step, and the numerous interactions

I respectfully agree with what Roe says in the quote. However, I would disagree with at least any strong form of the lesson apparently derived. Before returning to my agreement or disagreement with Roe's conclusion, however, it seems to me that Rodgers's discussion of evolutionary maladaptation is consistent with Roe's observations about path dependency and chaos because he states quite unambiguously that "adaptive perfection is not to be expected from a functioning Darwinian system."<sup>511</sup> He then implicitly presages Roe by noting that chaos theory plays a role in biological evolution and, further, that maladaptation is a symptom of a complex system. Rodgers's synthesizing explanation is illuminating when placed in juxtaposition with Roe's "separate" and more static paradigms. Rodgers's synthesis includes the statement that

evolutionary biology is an historical science focusing on the study of complex systems, not unlike investigations of the weather patterns, the movements of the earth, the oceans, and the drift of galaxies. The study of evolutionary biology is the study of systems that: (1) move in a fashion constrained by the past yet informed by the generation of information from within; (2) demonstrate ambiguous features of gradualism and episodic response; and (3) display chaotic, nonlinear and unpredictable characteristics.<sup>512</sup>

The three features of Rodgers's complex system are roughly equivalent to Roe's three separate paradigms. More specifically: (1) path dependence correlates roughly to "systems . . . constrained by the past" (although Roe might also say this feature is derived from chaos's sensitivity to initial conditions),<sup>513</sup> (2) Roe's punctuated equilibria (which, perhaps, may be explained by Catastrophe Theory) correlates to Rodgers's "ambiguous features of gradualism and episodic response";<sup>514</sup> and (3) Roe's Chaos seems roughly equivalent to Rodgers's Chaos (although Rodgers's concept of chaos

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of simultaneously occurring processes. Weather systems and cosmic nebulae are, in that respect, not in principle different from living systems.

Rodgers, *supra* note 316, at 47 (quoting ERNST MAYR, *THE GROWTH OF BIOLOGICAL THOUGHT: DIVERSITY, EVOLUTION, AND INHERITANCE* 42 (1982)) (omission in original).

For a marvelous historical and philosophical look at "luck" outside the world of science, see NICHOLAS RESCHER, *LUCK: THE BRILLIANT RANDOMNESS OF EVERYDAY LIFE* (1995) (distinguishing between luck, fortune, and fate; also suggesting that luck cannot be controlled but may sometimes be managed).

511. See Rodgers, *supra* note 316, at 46.

512. *Id.* at 47 (footnotes omitted).

513. *Id.*

514. *Id.*



arguably has a richer texture by expressly including nonlinearity).<sup>515</sup> As a result, Rodgers's complexity may provide a coherent theory for Roe's three separate but related paradigms.

Rodgers's article documents five specific biological evolutionary maladaptations and derives lessons or applications to law directly from those maladaptations. The first lesson is "that the good and the bad, the adaptive and the maladaptive, can be packaged in a single unit . . . that must be taken as a whole."<sup>516</sup> And Rodgers's article matter-of-factly correlates the biological to the "legal" by stating: "Negotiators across all walks of legal life, from bargaining over the content of administrative rules to international treaty-making, are well aware of the tactical implications of linkage and severance."<sup>517</sup> In addition, Rodgers looks "to the lessons of the pandas' thumbs, which instruct us in the art of the possible by resort to the means available."<sup>518</sup> Quoting Stephen Jay Gould:

An engineer's best solution is debarred by history. The panda's true thumb is committed to another role [as a running and clawing digit], too specialized for a different function to become an opposable, manipulating digit. So the panda must use parts on hand and settle for an enlarged wrist bone[, the radial sesamoid,] and a somewhat clumsy, but quite workable, solution. [This adaptation] wins no prize in an engineer's derby. It is, to use Michael Ghiselin's phrase, a contraption, not a lively contrivance. But it does its job and excites our imagination all the more because it builds on such improbable foundations.<sup>519</sup>

Another of Rodgers's biological evolutionary illustrations involves peacocks' tails; the longer the male's tail, the more attractive it is to the female for purposes of sexual selection. Unfortunately, the longer tails make the "best" males more vulnerable to predators because the tails impede efficient flight: "The simultaneous pursuit of multiple goals is hardly a novel phenomenon in law. However, the peacock's experience underscores again that doing two things at once precludes optimization of either goal."<sup>520</sup>

The last of Rodgers's illustrations that I want to reiterate is the "bat wing" example of "preadaptation":

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515. *Id.* at 48.

516. *Id.*

517. *Id.* (footnote omitted).

518. *Id.* at 52.

519. *Id.* at 50-51 (quoting STEPHEN JAY GOULD, THE PANDA'S THUMB: MORE REFLECTING IN NATURAL HISTORY 24 (1980)) (citations omitted).

520. *Id.* at 50 (footnote omitted).

There are obvious parallels between the relentless opportunism that drives natural selection and that which scours the landscape for legal advantage. Preadaptation is certainly an observable phenomenon in law, if it is understood to mean application of a legal rule in a context not contemplated by the designers.<sup>521</sup>

"Preadaptation" is the concept that allows for much creative legal work and for the evolution of law to fit new contexts. It helps explain the flexibility of law, and in that regard it can be seen as a legal virtue. Taken to its logical extreme, however, it may also become a legal vice. Examples of maladaptation of law through the use of preadaptation is given by Solzhenitsyn, who painstakingly went through all fourteen sections of Article 58 of the Soviet Criminal Code of 1926 and chronicled their interpretation. The chronic maladaptation of one such section follows:

Section 8 covered terror (not that terror from above for which the Soviet Criminal Code was supposed to "provide a foundation and basis in legality," but terrorism from below).

Terror was construed in a very broad sense, not simply a matter of putting bombs under governors' carriages . . . . The *murder* of an activist, especially, was always treated more seriously than the murder of an ordinary person . . . . If a husband killed his wife's lover, it was very fortunate for him if the victim turned out not to be a Party member . . . .

An even more important extension of the concept was attained by interpreting [terrorism to include] intent in the sense of *preparation*, to include not only a direct threat against an activist uttered near a beer hall ("Just you wait!") but also the quick-tempered retort of a peasant woman at the market ("Oh, drop dead!").<sup>522</sup>

The Solzhenitsyn example of maladaptation is the result of judicial or quasi-judicial administrative decision-making interpreting existing law. Rodgers, on the other hand, continues his article by finding and discussing several models of statutory (as opposed to judicial) rule-making, including the administrative rediscovery of the Refuse Act of 1899 in the campaign against water pollution,<sup>523</sup> and Professor Vincent Di Lorenzo has written two

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521. *Id.* at 55-56 (footnote omitted).

522. 1 SOLZHENITSYN, *supra* note 378, at 65.

523. The first model he discusses is one of his own which he championed in a prior article:

The model obviously is a gross simplification of how laws are made. Yet, it rests upon behavioral assumptions widely observed in nature, including *Homo sapiens sapiens*—namely, a predilection to cooperate when the repeated transactions necessary for establishment of reciprocal altruism are present, and a disposition towards selfish

articles on complexity and the legislative process. In his most recent article, Di Lorenzo suggests that law-givers' reliance on linear analogies, like one-to-one causation, may be misguided based on what is now known about the nonlinear world of complexity:

The more we learn of causal relationships, the more we are struck by the law's refusal to recognize and embrace complexity, in both physical effects and human decisions. The failure is in the continuing assumption that causes can be individually identified as responsible for specific effects on a consistent basis. Curiously, juries seem more willing to impose liability despite possible shortcomings in proof of causation. Perhaps they recognize the unrealistic burden it imposes in particular circumstances. However, the law has not been willing to be similarly cognizant.<sup>524</sup>

Thus, legal adaptation can come at least from either legislative or judicial sources. Di Lorenzo, however, concludes by petitioning the legislature to recognize

the existence of complexity . . . [and that it] embrace[s] . . . a targeted purposes approach as a type of legislative signature useful in complex, nonlinear contexts . . . . This need not be the exclusive legislative approach. It might exist side by side with a prohibitory enactment—to prevent blatant but individual, undesirable actions. However, as we approach the new century, it is urged that the law put aside its past reliance on prohibitory enactments.<sup>525</sup>

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behavior when they are not.

Rodgers, *supra* note 316, at 57 (footnotes omitted). Further, the model suggests that provisions like those "calling for more study" are "useful tools for maintaining reciprocal civility" and are "products of 'consensus,'" while provisions such as "sleepers" are products of betrayal. *Id.* "Sleepers" include provisions "that result from the gaming at the moment of creation," like slipping in a word that has more than one meaning or changing a provision when a timing opportunity presents itself. *Id.* at 58. See generally William H. Rodgers, Jr., *The Lesson of the Red Squirrel: Consensus and Betrayal in the Environmental Statutes*, 5 J. CONTEMP. HEALTH L. & POL'Y 161 (1989).

The second and third models are the Elliot-Ackerman-Millian model of statutory evolution. The model "borrows, and gives content to, several concepts familiar to . . . evolutionary biology, including historical constraint, selection, coevolution, adaptation, . . . and even predation" and the "Krier-Ursin book-length study of the evolution of thirty-five years of air pollution control policy in the Los Angeles basin," which is in a form of "historical narrative." Rodgers, *supra* note 316, at 59 & 60 (footnotes omitted).

524. Vincent Di Lorenzo, *Complexity and Legislative Signatures: Lending Discrimination Laws as a Test Case*, 12 J.L. & POL. 637, 651 (1996) (footnotes omitted).

525. *Id.* at 663-64.

Implicitly, targeted purposes, as opposed to prohibitions, unleash individual creativity in finding ways to meet the goals.

Another of the centerpiece articles, this one by J.B. Ruhl, hearkens the biological evolutionary concept of random drift, the slow genotype change, which does not necessarily manifest previously discussed phenotype (body) change.<sup>526</sup> Random drift echoes preadaptation, except on the genotype level, setting the stage for further evolution. Evolution by random drift is consistent with punctuated equilibrium (which is one of Roe's separate paradigms). In other words, because this random drift of the genotype does not affect the phenotype, natural selection does not favor or disfavor the change; therefore, it may be the genetic equivalent of evolution toward the edge of chaos (criticality). In Ruhl's words, "through such random drift the genotypes defining a species may reach an unstable situation in which small genetic changes can lead to large phenotype changes for better or worse."<sup>527</sup> The genetic drift sets the stage for the operation of catastrophe theory, and, in that regard, the drift itself is preadaptive.

I find it initially easier to analogize "genetic drift" toward the edge of chaos to the common law rather than to legislation. The cast of my analogous characters are: (1) the litigants are the parents; (2) the event leading to the litigation is mate selection (or possibly the sex act); (3) the legal arguments (perhaps easier to see if thought of as written briefs) are the egg and the sperm, each containing genetic material (diploid genotype) from their respective parent; (4) the written judicial opinion is the genotype of the resultant "legal" individual; and (5) in this analogy the phenotype of "the legal individual" is the judgment itself as docketed by the court (as opposed to the genotypic written opinion).

The judge, at the first instance, performs the equivalent of "natural selection." Of course one may argue, as some members of the Critical Legal Studies Movement surely would argue, that the judge is performing artificial selection in the style of Dawkins's aesthetic choice of insect-like patterns for Biomorph Land.<sup>528</sup> At some point, however, the distinction between natural and artificial selection may merge, or at least it should be the subject of greater research. As Rodgers points out:

Sexual selection is a process in evolutionary biology by which "an individual gains reproductive advantage by being more attractive to individuals of the other sex." Darwin himself took a particular interest in this "aesthetic" side of nature's work, and invoked "female choice" as the explanatory agent for a wide variety of male adornment and song. . . . Studies by ethologists and others have shown that males and females in a number of animal populations engage in a protracted process of salesmanship/sales-resistance preparatory to mating. Often, the females really do

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526. Ruhl, *supra* note 495, at 1431.

527. *Id.*

528. See *supra* notes 342-50 and accompanying text.

decide, and the interesting question is whether they are moved by good taste, good sense, or some combination of the two.

Not surprisingly . . . evidence is accumulating that females choose mates on the basis of utilitarian factors such as resistance to parasites, stamina, size, and strength.<sup>529</sup>

Although the length of the peacocks' tail is a maladaptive exception to natural selection, tail length may be "an excellent marker of overall fitness even though it represents [the paradox of] a particularized liability."<sup>530</sup> Similarly, the rules of evidence (fact), *stare decisis*, and other legal procedural rules (law) provide selection criteria or norms for judges that may be maladapted like long tails in some cases. These norms are enforced by appellate courts. Thus, at least some of the maladapted decisions should die by appellate reversal.

Further, and generally speaking, it seems that the genotype for any given appellate jurisdiction is largely made up of the opinions of the highest appellate court of that jurisdiction because of the precedential value of those opinions. The precedential value of such opinions would seem to assure that lawyers representing litigants at the trial level select and cite those case opinions in their legal arguments. Thus, the common law system seems to be a self-referential case-law network which replicates itself largely through citation to the "strongest authority." Because the strongest authority is from multi-judge and geographically diverse appellate courts, perhaps it is less likely that the most maladaptive cases will replicate through the system.

A question remains, however, about the sources of novelty that may drive legal change toward that edge of chaos. There are at least five such sources of change. First, competitive litigants themselves may be creative by finding and building upon preadaptation (with novel combinations of legal principles or otherwise) within existing case law. Second, there may rarely occur random mutations caused by replication error, for example, not finding the controlling authority or misquoting it, resulting in a "novel" or new legal principle or position.

Third, judges may simply change their minds for whatever reason (constrained by legal norms, of course). Two different reasons for change could be overwhelming public opinion (fear of publicity) or, more literally, "mind replacement" through judicial appointment or the election process. This third source of change seems to be largely external to the technical process of decision-making and might be properly subject to combination with the last category of change which I later label politics. As to judges simply changing their minds, Solzhenitsyn again suggests that the power of public opinion on government should not be underestimated:

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529. Rodgers, *supra* note 316, at 49 (footnotes omitted).

530. *Id.* at 50 (footnotes omitted).

It turned out that the strength which the previous regime had uneasily acknowledged in political prisoners was imaginary. What had created and maintained that strength was only *public opinion* in the country. Once public opinion was supplanted by *organized opinion*, the exiles with their protests and their rights were helplessly subjected to the tyranny of stupid, flustered GPU men and inhuman secret instructions.<sup>531</sup>

The fourth source of change is regular systematic adaptation to the “edge of chaos,” created by the endless stream of new fact patterns to which existing law applies. It is the novel facts of any case that expose judicial decisional “space” in precedential cases (or statutory law) or which create niches for existing law to exploit. The essence of this kind of niche discovery is taught to every first-year law student. One first-year legal analysis and writing text incants its essence in describing legal reasoning:

By comparing and contrasting your problem with the [existing law], you will be able to show how well the rules of those cases fit your case. This in turn should enable you to predict the probable outcome of your own case. When you reason by analogy, though, you can only offer probable proof for your conclusions, not certainty. Your task is to assess all the possible applications of the relevant rules and to offer the best prediction of the outcome.

Although analogizing and distinguishing may sound like mechanical exercises, legal analysis is rarely analysis by rote. Comparing the similarities and contrasting the differences between cases is often a creative process and the ability to do this is one of the hallmarks of a skillful lawyer. You will become more sophisticated in this process as you gain experience.<sup>532</sup>

Illustratively, assume that the foregoing analysis is undertaken by a plaintiff’s lawyer (or prosecutor). If the lawyer believes there is a reasonable chance of success, the lawyer will “take the case.” If the facts are “too good,” the parties probably settle the case, and it does not get tried. Further along in the process, if one or both sides’ lawyers have misanalyzed the chances of success, the judge may grant some sort of pretrial disposition. Again, the result is no trial. The usual result is that only relatively “close” cases even make it to trial and only the “closest” legal issues (or the grossest trial errors) get appealed. It seems reasonable to assume, therefore, that most appellate cases are close cases. Thus, the common law may be seen as evolving to the edge of chaos where a slight change in fact or in the

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531. 3 SOLZHENITSYN, *supra* note 378, at 344.

532. HELENE S. SHAPO ET AL., WRITING AND ANALYSIS IN THE LAW 31 (1989).

law may determine the outcome (phenotype *and* genotype) of a given appellate case. Moreover, because judicial “networks” include diverse appellate jurisdiction within a hierarchical organization, any such case outcome might cascade throughout the system in future cases consistent with criticality and emergence observed in the “Game of Life.”<sup>533</sup>

Thus, it appears that the common law exhibits the characteristics of a CAS, including sensitivity to initial conditions. It also appears that the common law and CAS both respect history and Roe’s path dependency, but also provide a mechanism by which to break free from such dependency.<sup>534</sup>

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533. For a discussion of catastrophe theory and emergence, see *supra* notes 372-80 and accompanying text. Dawkins, in describing insect species that have two types of males, suggests there are two theories for the existence of a two-male system in a species, which may assist in understanding the role of judicial minority opinions. The two theories are the “‘best of a bad job’ theory” and the “stable balance theory.” CLIMBING MOUNT IMPROBABLE, *supra* note 315, at 314.

[T]he “best of a bad job theory” . . . probably applies to a species of solitary bee called *Centris pallida*. The two kinds of male bee are called “patrollers” and “hoverers.” . . . Evidence suggests that the patrollers do better than the hoverers but, given that you are a small male with little chance of succeeding as a patroller, you can make the best of a bad job by hovering instead. As always, this is genetic, not conscious choice.

*Id.*

In an appellate opinion, the application is that if I (as a judge) disagree with the majority and know that I am to be outvoted, then to preserve my rationale, I write a separate opinion. The separate opinion may be, to other courts not bound by this decision, a more persuasive argument; it may memorialize my opinion for my own later use in a different case; or it may tweak the majority opinion enough to make the decision apply only to the *exact* facts of that case, which will give the judge a chance to fight the issue again.

The other theory about how two kinds of males can co-exist in a species is the stable balance theory. It seems that this may apply in the case of the fig freeloaders. The idea here is that both kinds of male succeed equally well when they exist in a special, balanced proportion in the population. What keeps the proportion balanced is this. When a male is a member of the rarer type he does well, specifically because he is rare. Therefore more of his kind are born, and they consequently cease to be rare. If they succeed so well that they become common, the other kind now have the advantage by virtue of being relatively rare and they accordingly become commoner again. So the proportion is regulated rather in the manner of a thermostat. I’ve told the story as if it gave rise to wild oscillation but this there need not be, any more than a thermostatically controlled room oscillates wildly in temperature. Nor does the stable equilibrium proportion have to be 50-50. Whatever the equilibrium proportion may be, natural selection keeps pushing the population back towards it. The equilibrium proportion is that proportion at which the two types of male do equally well.

*Id.*

This theory, it seems to me, would better explain the cyclical nature, if any, of court decisions. Both theories seem to have metaphorical value for comparison with the “minority” of jurisdictions or, more closely, to ideas and concepts expressed in dissents.

534. See *supra* notes 418-29 and accompanying text.

Ruhl generally agrees with this assertion.<sup>535</sup> He strengthens the argument, however, by offering an explanation of Professor Kauffman's insightful assertion that the British common law system is an example of a CAS. Accounting for multiple jurisdictions and using Kauffman's own imagery, Ruhl says:

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535. Ruhl writes:

These qualities have led some legal commentators to posit an "analogy between pure Chaos Theory and the common law." For example, case outcomes are generated by the application of relatively simple legal principles to a given set of facts and yet are unpredictable. The importance of facts to this process of deterministic randomness, therefore, "can be analogized to initial conditions to which chaotic systems have extreme sensitivity." Hence, through its system of patched jurisdictions and various loose and strong couplings, the common law offers reasonable expectations of evolving towards the region of complexity—to the edge of chaos.

Ruhl, *supra* note 495, at 1472 (quoting Geu, *supra* note 410, at 941-42) (footnotes omitted).

The way appellate courts in different circuits develop law seems very close to how Richard Dawkins describes the evolution of spider groups (local populations called demes) into different species (with the highest court, I suppose, providing for the ultimate "natural" selection, which, of course, is "artificial" selection):

The process continues and the population evolves, generation after generation, but with one further refinement. There is not just one deme of six spiders[—appellate court—]but (say) three semi-separate demes[—three circuits—] . . . Each of the three demes evolves in isolation except that, from time to time, an individual "migrates" to another deme, carrying its genes with it . . . For the moment we can briefly say that all three demes evolve towards improved webs: webs that are better at catching flies economically. Some demes may run up evolutionary blind alleys. Migrating spider genes can be thought of as an injection of fresh "ideas" from another population. It is almost as though a successful sub-population[—an individual appellate court—]sends out genes that "suggest" to a less successful population a better way to solve the problem of building a web.

CLIMBING MOUNT IMPROBABLE, *supra* note 315, at 64.

In *Fail-Safe Versus Safe-Fail: Suggestions Toward an Evolutionary Model of Justice*, Professor of Philosophy Alicia Juarrero-Roqué, by taking a *slightly* different path, reaches the same conclusion:

During quiescent periods legal precedent fulfills the function of "stabilizing contexts." For a society to evolve and survive, however, it must also be capable of reinterpreting sedimented meaning, thereby creating new meaning which better maps a [new] environment. It has been my claim that the procedural redundancy of the United States' judicial system provides the context-sensitive information that in turn gives the system the resilience which this newly reinterpreted meaning allows.

Juarrero-Roqué, *supra* note 428, at 1777.

I suggest that Juarrero-Roqué takes a slightly different path to reach the same conclusions as have I anew herein because she emphasizes the law and literature approach to law for her analogies much as this article will be perceived as emphasizing the law and economics approach herein. *See id.* at 1764-77.



As for the common law, it would be difficult to conceive of a system for making law that more closely corresponds to Professor Kauffman's "coupled patches" model of adaptive organizations. The common law inherently is a patchwork of nonoverlapping [states] and overlapping jurisdictions. Couplings between the patches—such as through the hierarchy of courts, the principle of stare decisis, and sensitivity to persuasive authority from other courts—are diffuse but present in sufficient quantity to prevent rigidity. Through this design, as Professor Lon Fuller put it, the common law "mirrors the variety of human experience; it offers an honest reflection of the complexities and perplexities of life itself."<sup>536</sup>

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536. Ruhl, *supra* note 495, at 1471-72 (footnote omitted). For an article both explaining and championing the efficiency of the common law, see Robert D. Cooter, *Decentralized Law for a Complex Economy: The Structural Approach to Adjudicating the New Law Merchant*, 144 U. PA. L. REV. 1643, 1690-94 (1996).

Recall that the idea of energy organizing matter is an important feature in all physical complexity theory (which includes complex adaptive systems and biological evolution). See *supra* note 378. That is, complex adaptive systems are not closed systems but they do have boundaries. Researchers have coined the term *autopoiesis* as a label for special kinds of systems somewhere between open and closed, and the term has already attracted attention by legal scholars. Before turning to law, however, let us first figure the scientific definition of the term. *Autopoiesis* is a new word coined by Chilean neuroscientist Humberto Maturana and one of his former students, Francisco Varela: "*A* *uto*, of course, means 'self' and refers to the autonomy of self-organizing systems; and *poieses*—which shares the same Greek root as the word 'poetry'—means 'making.' So autopoiesis means 'self-making.'" CAPRA, *supra* note 307, at 97. It represents "the distinctive organization of living systems." *Id.* Indeed, Maturana and Varela "assume that autopoiesis is a general pattern of organization, common to all living systems, whichever the nature of their components." *Id.* at 98. Thus, there is a difference between *organization* and *structure* and autopoiesis is a matter of organization. They then define autopoiesis as follows:

[A] network of production processes, in which the function of each component is to participate in the production or transformation of other components in the network. In this way the entire network continually "makes itself." It is produced by its components and in turn produces those components. . . .

An important characteristic of living systems is that their autopoietic organization includes the creation of a boundary that specifies the domain of the network's operations and defines the system as a unit. The authors point out that catalytic cycles, in particular, do not constitute living systems, because their boundary is determined by factors (such as a physical container) that are independent of the catalytic processes. *Id.* at 98-99; see also BRIAN GOODWIN, *HOW THE LEOPARD CHANGED ITS SPOTS: THE EVOLUTION OF COMPLEXITY* 175-76 (1994) (citing and paraphrasing the Maturana and Varela definition of autopoiesis as "the capacity of active self-maintenance and self-generation that underlies regeneration, reproduction, and healing, which are all ways organisms become coherent wholes").

In the realm of law, the *Cardozo Law Review* devoted a symposium issue to autopoiesis and the law, focusing on the work in the area by Niklas Luhmann, a European sociolegal theorist. See Symposium, *Closed Systems and Open Justice: The Legal Sociology of Niklas Luhmann*, 13 CARDOZO L. REV. 1419 (1992). The two key autopoietic concepts stressed and argued in law seem to be structural coupling and operational closure, but "[a]ll subsystems

The fifth source of change in the common law returns to the more purely political realm primarily begotten of the legislative branch of government. As previously suggested, one way politics may be injected into the common law is through the selection of judges. More importantly, the political branches of government are also directly engaged in the statutory law-making process. New statutes bind courts (absent constitutional infirmity). Thus, statutory law is a major source of change in the law as applied to factual settings by the courts. The ideas of complexity-informed and evolutionary-derived legislation have already been briefly mentioned and noted.<sup>537</sup> Indeed, Professor Glenn Harlan Reynolds expressly analogizes one feature of democracy and political fitness to biological sex. In his essay *Is Democracy Like Sex?*,<sup>538</sup> Reynolds analogizes special interest groups to parasites of the body politic (the political branches of government), suggesting that public opinion between elections serves the same "randomizing" function on the body politic for protection from special interest groups as does sex on the biological genotype against parasites.<sup>539</sup>

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use the same domain, 'communication.'" Niklas Luhmann, *Operational Closure and Structural Coupling: The Differentiation of the Legal System*, 13 CARDOZO L. REV. 1419, 1434 (1992). "For Luhmann, then, law is a specialized system of information processing." Drucilla Cornell, *The Relevance of Time to the Relationship Between the Philosophy of the Limit and Systems Theory*, 13 CARDOZO L. REV. 1579, 1584 (1992).

Obviously, this article could, to some extent, be seen as within the category of "autopoietic law." Unfortunately, in my opinion, much of the literature concerning the autopoietic features of law loses its "scientific grounding" and follow other paths (e.g., lamenting lack of empirical opportunity in its study, following post-modernism and deconstructive literary critique to their logical extremes) and, as a result, do not fulfill all their *practical* analytical and descriptive potential. Nonetheless, structural coupling and operational closure, together with communication primacy, are common component interests in Luhmann's style of autopoietism and complexity theory. Professor Ruhl provides one of the best discussions of the relationship between autopoietic legal theory and complexity theory in J.B. Ruhl, *Complexity Theory as a Paradigm for the Dynamical Law-and-Society System: A Wake-Up Call for Legal Reductionism and the Modern Administrative State*, 45 DUKE L.J. 849, 901-06 (1996). See also WHEATLEY, *supra* note 378, at 18-19 (discussing autopoiesis and management theory).

537. See *supra* notes 523-25 and accompanying text.

538. See Glenn Harlan Reynolds, *Is Democracy Like Sex?*, 48 VAND. L. REV. 1635 (1995).

539. See *id.* at 1646.

Because democratic politicians have to answer to the changing mood of the voters, their actions are not always predictable. Furthermore, because politicians are frequently replaced by the voters, even the coziest relationships are liable to disruption. Just as the randomizing factor of sex creates a "moving target" for parasites, preventing them from becoming too well adapted to their hosts, so the randomizing factor of democratic politics creates a "moving target" for special interests, keeping their relationships with lawmakers from becoming too comfortable or mutually beneficial.

Ruhl's extrapolation "[t]hat democracy might lead to political parasite resistance suggests that an analogous coevolutionary process unfolds in the sociolegal system, a process in which parasite resistance is just one component of fitness."<sup>540</sup> Before taking such a leap, however, it is helpful, if not necessary, to further analyze the legislature as a separate and distinct CAS apart from the judiciary.

There are several ways to account for statutory law-making as a CAS. For example, one could say that the legislators are in the same position in a legislative network as individual judges are in the judicial network. That is, based on norms provided in part by public opinion, the individual legislator makes a judgment on an issue and then argues her underlying rationale in order to convince other legislators to vote consistently. In this way, the individual legislator sells her position through reasoned argument just as a judge explains her judgment in a written opinion. Individual legislator votes, then, could be seen as flickering across the "Game of Life" screen, and, if poised at criticality, patterns could emerge just as judicial trends cascade across jurisdictions.

There are, however, degrees of difference between the judicial process and the legislative process which make the sexual combination analogy used for the common law less satisfying for the statutory law network. One such difference is time scale. Votes may be taken and legislation passed relatively quickly (of course, the statute may be repetitively amended in following years, which seems to evidence the existence of path dependence on the approach taken in the original legislation).

Another reason the sex analogy does not work as well for legislation as it does for the common law is because there are always more than two legislative "sex" partners sharing ideas. In that limited regard, the legislature might seem to be less hierarchical than the judiciary because its "decisions" lack appealability and, as opposed to judicial decisions and not judicial opinions, are less binary (yes-no, right-wrong, 0-1). At the very least, legislators are neither disciplined nor constrained by the necessity of providing a written rationale to the public for each of their actions.

A better analogy than sex to the legislature, therefore, might be that Congress, as a category, is more like a species than an individual and that its legislative offspring (statutory law) reflects the idea of group selection (species evolution). In other words, Congress might be better situated to experience collaborative emergence than the judiciary.<sup>541</sup> Wheatley, for example, describes this emergence as follows:

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*Id.*

540. Ruhl, *supra* note 495, at 1468.

541. For a discussion of collaborative emergence, see *supra* notes 425-27 and accompanying text.

We witness emergence any time we are surprised by a group's accomplishments or by our own achievements within a group. We expected a certain level of behavior, and instead we discovered unknown abilities. We also see emergence vividly in the first hours after a disaster. Before official agencies can arrive, people join together and respond. Without training or direction, coordinated behaviors emerge that rescue and save. People speak about these experiences with awe and humility. They call them miracles. They remember forever those moments of extraordinary capacity that took them by surprise.<sup>542</sup>

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542. WHEATLEY & KELLNER-ROGERS, *supra* note 474, at 67. Complexity and chaos theory are being applied directly to political science. For example, a 1996 anthology edited by Elliott and Kiel contains a part entitled *Chaos Theory and Political Science*. Included in that part are three papers: Michael McBurnett, *Complexity in the Evolution of Public Opinion*; J. Barkley Rosser, Jr., *Chaos Theory and Rationality in Economics*; Alvin M. Saperstein, *The Prediction of Unpredictability: Applications of the New Paradigm of Chaos in Dynamical Systems to the Old Problem of the Stability of a System of Hostile Nations*. See CHAOS THEORY IN THE SOCIAL SCIENCES, *supra* note 319, at 165, 199, 139.

As further circumstantial evidence of the coevolution of the topics in this essay, politics, business, and family are at least metaphorically linked by John L. Ward in his book *Keeping the Family Business Healthy*. Therein, in a very *applied* way, Ward advises:

The eight models described below are all constructs of what a family could become five to twenty years from now. Each has its pros and cons, and each has particular implications for the family's business. A list of these models should be passed around the family prior to the meeting at which they will be discussed. Family members should select the one that most closely matches what they would like the family, and the business, to become. The ensuing discussion should reveal each family member's personal hopes for his or her future, as well as his or her hopes for the business.

JOHN L. WARD, *KEEPING THE FAMILY BUSINESS HEALTHY: HOW TO PLAN FOR CONTINUING GROWTH, PROFITABILITY, AND FAMILY LEADERSHIP* 145 (1987). The eight models are labeled "royal families," "anarchical families," "laissez-faire families," "social democratic families," "democratic capitalist families," "representative democracy families," "pure capitalist or entrepreneurial families," and "utopian families." *Id.* at 145-49. By way of example, "representative democracy families" are described as follows:

Families holding this philosophy appoint a trustee of some sort to represent the extended family in the business. This trustee may be a bank officer, a family lawyer, an outside board of directors, or even an individual from the family. The trustee, who is sometimes elected, represents all shareholders in voting matters. Equity value is shared among all of them as shareholders or as investors. Such a model helps keep the business in the family, since it prevents any one member from selling his or her shares. Its centralized leadership also helps preserve family harmony. This structure is especially useful to families that seek equal distribution of ownership because the value of the business has greatly increased or because nonbusiness resources are insufficient to spread among family members not in the business.

Representative democracy concentrates leadership in the hands of a few capable people who are experienced at running a business. But the leaders of the business tend to be governed by rules of their own making. Therefore, they might not work for the best interests of the family as a whole.

*Id.* at 148.

The same underlying analogical process of complex adaptation may be taking place in both the common and statutory law-making arenas. On the wing, however, no single legislative mechanism (like the facts leading to litigation) seems to be present that regularly pushes the legislative system to the edge of chaos.<sup>543</sup> Nonetheless, it is the potential of emergence from the synergistic, collaborative legislative process that seems to best evidence the existence of CAS in the legislative setting. This synergism (or emergence) is not available in the same way in other non-CAS organizational forms. This observation makes me disagree with the implication of Reynolds's tongue-in-cheek emphasis (for somewhat different purposes) on the flaws of democracy:

Similarly, most criticisms of democracy have to do with its efficacy as a means of making decisions. Because intelligence is not additive (as anyone who has ever served on a committee can attest), groups of people do not *necessarily* make better decisions than do individuals. Democracy is messy, which is why diplomats notoriously prefer to deal with autocracies than with democracies.<sup>544</sup>

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543. See Geu, *supra* note 454, at 986. Maybe one way of looking at complexity in legislation is close to the "garbage can model of organizational choice," which is described as follows:

Under this conceptualization, Congress is like an "organized anarchy," in which there is *no linear process* for identifying a problem, defining alternative solutions, and reaching a decision. Rather, salient problems, possible solutions, and choice opportunities will coexist as separate "streams" in the "garbage can" (the system). Sometimes problems are resolved, sometimes they go away, sometimes the system despairs of solving them. The outcome is dependent upon the "coupling of the streams": A problem becomes salient at the same time a solution becomes well-regarded and participants favoring the solution can seize the legislative process for that end. The outcome, in other words, is dependent upon fortuity.

WILLIAM N. ESKRIDGE, JR. & PHILIP P. FRICKEY, *CASES AND MATERIALS ON LEGISLATION: STATUTES AND THE CREATION OF PUBLIC POLICY* 60 (2d ed. 1995) (quoting Michael D. Cohen et al., *A Garbage Can Model of Organizational Choice*, 17 ADMIN. L.Q. 1, 1-3 (1972)).

Nationally syndicated columnist George Will, probably unwittingly, uses the same imagery of organized anarchy when describing the courts. In sharply criticizing the judiciary about "a case that should have been laughed out of court before battalions of lawyers filed the first cubic foot of briefs," he asserts "that the nation is still *slouching toward government by judiciary*, which will just be anarchy in a stately setting." George F. Will, *Judges Taking Over the Subway*, WASH. POST, Jan. 7, 1996, at C7.

544. Reynolds, *supra* note 538, at 1646 (emphasis added). Perhaps this group collaborative effort is more analogous to the "informational cross-fertilization" of bacteria: [B]acteria have developed a second avenue of evolutionary creativity that is vastly more effective than random mutation [and less limiting than sharing by sex]. They freely pass hereditary traits from one to another in a global exchange network of incredible power and efficiency. Here is how Lynn Margulis and Dorion Sagan describe it:

While Reynolds's "necessarily" statement is correct, it is democracy's very messiness that *allows* emergence.

As previously suggested, statutory law is one source of change in the common law. Of course, the converse is also true. In other words, except as constitutionally prohibited, the political branches may react to judicial decisions by passing inconsistent, but trumping, legislation. This interrelationship between branches of government suggests not only a different level of organization but also a different category: "Congress, the White House, and the Supreme Court are things—at least each of them can be physically located in space and time. The government, in contrast, is quite another thing altogether. It is, in fact, a super category *which describes the interactions of the other three*."<sup>545</sup> And that description applies beyond the federal government to include state and local governments and their various interrelationships under federalism.

Federalism leads us to the last of the four articles to be discussed: Professor Artigiani's *Chaos and Constitutionalism: Toward a Post-Modern Theory of Social Evolution*.<sup>546</sup> Therein Artigiani asserts that the Constitution

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Over the past fifty years or so, scientists have observed that [bacteria] routinely and rapidly transfer different bits of genetic material to other individuals. Each bacterium at any given time has the use of accessory genes, visiting from sometimes very different strains, which perform functions that its own DNA may not cover. Some of the genetic bits are recombined with the cells native genes . . . . As a result of this ability, all the world's bacteria essentially have access to a single gene pool and hence to the adaptive mechanisms of the entire bacterial kingdom.

. . . .

. . . Thus microbiology teaches us the sobering lesson that technologies like genetic engineering and global communications network, which we consider to be advanced achievements of our modern civilization, have been used by the planetary web of bacteria for billions of years to regulate life on Earth.

CAPRA, *supra* note 307, at 228-29 (footnote omitted) (quoting LYNN MARGULIS & DORION SAGAN, *MICROCOSMOS: FOUR BILLION YEARS OF EVOLUTION FROM OUR MICROBIAL ANCESTORS* 16 (1986)).

545. RESTAK, *supra* note 325, at 19 (paraphrasing philosopher Gilbert Ryle) (emphasis added).

546. Artigiani, *supra* note 498. By trade, Artigiani is an historian, and he has applied chaos theory to history as well as to the Constitution. David L. Harvey and Michael Reed go so far as to suggest that Artigiani's historical work is how chaos research in the study of history "should look":

Artigiani's . . . work on modern revolutionary movements was an early landmark and still exemplifies what deterministic chaos research should look like when taken up by historians. Working in the demanding medium of historical detail, Artigiani identifies chaotic elements in his narrative treatment of revolutionary movements. He treats them as compact "modules," so to speak, constellations that illuminate portions of the larger unfolding narrative. . . . Yielding at time to comparative asides, Artigiani nonetheless

is like the genes in the gene network; nonetheless, he also implies that “we the people” regulate which genes or nodes “light up at any given time”.<sup>547</sup>

The “meaning” of the U.S. Constitution is not, therefore, in the document itself, any more than the explicit form of an organism is its DNA. The Constitution’s meaning depends upon how a particular environment—its historical “context”—decodes it in a structured societal form. Different environments will decode the Constitution in different ways by their system-level behaviors. But the identity derived from the U.S. Constitution provides a society embedded in a dynamic environment with the built-in capacity for evolution. The Constitution is “in the first instance a set of ways of living and doing” that “generates *attitudes* not only of general and specific approval . . . but also . . . built-up predispositions in the participants, to deal with situations those participants have previously never met or thought of, *along the lines* of the ways they know. . . .” Thus, when altered environmental conditions provide a new context in which to evaluate social behavior, the self-referential relationship between a people and fair procedures for societal self-correction periodical-

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allows the singular substance of his subject matter to dictate the form his chaos analysis will take. His method, in short, embodies the methodological pluralism this paper has advocated by letting the ontology of the subject matter dictate the range of methods employed, and not vice versa. He has followed a path consistent with the ontological turn advocated by Bhaskars critical realism, and exemplifies the direction deterministic chaos theory must take in the cultural sciences if they are not to succumb to scientism when adapting the perspective of deterministic chaos to the study of history.

David L. Harvey & Michael Reed, *Social Science as the Study of Complex Systems*, in CHAOS THEORY IN THE SOCIAL SCIENCES, *supra* note 319, at 321-22 (citation omitted); *cf.* James N. Gardner, *Mastering Chaos at History’s Frontier*, COMPLEXITY, Dec. 1997, at 28.

Another example of an historian using these theories is Michael Shermer, co-author of a soon to be released book on the Holocaust entitled *Denying History*, who uses complexity and chaos theory to explain (not justify) the occurrence of the Holocaust in an article in *Complexity* magazine. Michael Shermer, *The Crooked Timber of History*, COMPLEXITY, July-Aug. 1997, at 23. Therein he comments on the confounding variable of history, which he identifies as “human purpose and freedom”:

All historical events are the product of deterministic laws in stable regions and unpredictable events in unstable regions. Our lives are pushed, pulled, guided, and influenced by gravity, the weather, supply and demand, demographic changes, political events, wars and revolutions, etc. But the sensitive dependence on our personal initial conditions, and the countless unstable regions in which we may choose alternative futures means we can act as if we are free, even if we really are determined. Human behavior is no less caused than other physical or biological phenomena, just more difficult to understand and predict. . . . Since no cause or set of causes we select to examine as the determiners of human action can be complete, they may be pragmatically considered as conditioning causes, not determining ones. Human freedom arises out of this ignorance of causes, and chaos and complexity theory explain why.

*Id.* at 29.

547. Artigiani, *supra* note 498, at 145-48.

ly folds the society back on the Constitution. Then the standards of fairness incarnated in the rules of procedure serve as the established criteria of judgment, and the subtle relationship between co-evolving system levels becomes apparent.<sup>548</sup>

In sum, the Constitution allows the luxury of legal reaction to changed circumstances.<sup>549</sup> This reaction is a learning (feedback) loop. The stakes in learning, however, are high: "In environments as dynamic as those selecting for or against contemporary societies, the only choice is 'learn' or perish."<sup>550</sup>

This "experience of the continuous feedback between self and society[, however,] creates great tensions,"<sup>551</sup> and, as in all critical systems, the criticality maintained by the tension between individual self-interest (randomness, chaos) and collective activity (structure, rigidity) is delicate.<sup>552</sup> Artigiani fears that the "public space" created by valuing the system as a whole (and respecting the individual rights of others) is in danger of collapse because of self-interest (the unfettered exercise of an individual's own rights).<sup>553</sup> Thus, Artigiani sees in the status quo reason to fear that individualism is randomizing society to the point of too little cultural glue, resulting in the loss of the necessary modicum of stability for systems to remain poised at the edge of chaos.<sup>554</sup>

548. *Id.* at 147-48 (quoting Karl Llewellyn) (citations omitted) (alterations in original).

549. *Id.* at 150.

550. *Id.*

551. *Id.* at 154. I do not necessarily believe that learning and teaching are different sides of the same coin; nonetheless, they probably have enough in common to make the following statement by Anthony D'Amato relevant to help identify a resistance to *learning*: Teaching is an attempt to change the student's mind. As I will argue below, the best teaching challenges and alters the mental pathways, connections, and "censors" within the student's brain. But there is no doubt that teaching, totally unlike advertising[, which feeds into and strokes consumer preferences no matter how arbitrary or ridiculous,] is a deliberate form of interference with how the student thinks. The student is likely to resist.

Anthony D'Amato, *The Decline and Fall of Law Teaching in the Age of Student Consumerism*, 37 J. LEGAL EDUC. 461, 462 (1987).

552. Artigiani, *supra* note 498, at 153.

553. *See id.*

The reluctance to sacrifice for a common good that is not externally ordained measures the individual American's ambiguity about society. In the absence of a unifying cultural commitment, which concentrating on procedural rules makes problematical, even when there is respect for the process individuals need not feel bound to societal goals. The society tends to fragment, and, without the comforting assurance of enduring cultural values, individuals may turn to religious fundamentalism, rabid nationalism, or single issue politics to define themselves.

*Id.*

554. Arguably, some of E.D. Hirsch's writings would fit here in the taxonomy. *See*,



Ruhl, on the other hand, sees a federal government suffocating the freedom of individual action necessary for experimentation and adaptive behavior. He concludes:

The difficulty in fulfilling that vision is that it will take more than just a wave of the wand—there is more to it than, say, having the Supreme Court overturn the decisions that led to the bloated commerce power[, in effect weakening the state patches,] and the puny nondelegation doctrine [establishing the administrative state]. Those measures are necessary, but not sufficient. . . . Congress has decayed to a shell of its constitutional potential because it has fallen deeply into the reductionist trap of lawmaking and thus has devised rules of politics that perpetuate that structure. . . . Reform measures dealing with campaign financing, committee structure, term limits, third party access, and the like need to be given serious consideration if we expect Congress to take back some of the responsibilities it has frittered away to agencies and exercise them adaptively.<sup>555</sup>

In the end, therefore, Ruhl sees harbingers of disaster based on too much rigidity, and Artigiani sees harbingers of disaster based on too much atomization. Such a conclusion could evidence that tension exists between chaos and order necessary for criticality. While that conclusion may be partially correct (and, therefore, comforting because it indicates that the politico-legal structure is at appropriate criticality to be a CAS), it is only partially correct because the opinions of Artigiani and Ruhl are not mutually exclusive. Indeed, they seem to agree on some categorical level that society (for Artigiani, aggregate society; for Ruhl, Congress) is in danger of atomizing into random chaos, and they imply that a cultural (value) change is necessary to encourage behavior for the common good.

One alternative to encourage individuals to act for the common good would be through the force of more statutory and regulatory law. In another article, however, Ruhl suggests that simply more law would be a mistake because it creates a positive feedback loop that ever increases the “investment” and “intensification” of the legal structure.<sup>556</sup> At some point, the “resulting structure[, the structure of the statutes and regulations rather than that of the institutions,] ultimately reaches levels of . . . increasing vulnerability to collapse [like large sandpile avalanches].”<sup>557</sup> In other words, the complexity of the law itself causes a collapse into an ineffective random

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e.g., E.D. HIRSCH, JR. ET AL., *CULTURAL LITERACY: WHAT EVERY AMERICAN NEEDS TO KNOW* (1987).

555. Ruhl, *supra* note 495, at 1487.

556. J.B. Ruhl & Harold J. Ruhl, Jr., *The Arrow of the Law in Modern Administrative States: Using Complexity Theory to Reveal the Diminishing Returns and Increasing Risks the Burgeoning of Law Poses to Society*, 30 U.C. DAVIS L. REV. 405 (1997).

557. *Id.* at 467.

state rather than pushing the system toward criticality required for adaptability. The book *The Death of Common Sense* (which is subtitled *How Law is Suffocating America*), by Philip K. Howard may provide illustrations of the kinds of feedback loops addressed by Ruhl:

The safety of every worker "to the maximum extent feasible" was the goal of Congress when it passed the Occupational Health and Safety Act in 1970 [OSHA]. . . . For twenty-five years OSHA has been hard at work. The agency has over 4,000 detailed regulations, dictating everything from the height of railings (42 inches) to how much a plank can stick out from a temporary scaffold (no more than 12 inches). . . . Several hundred billion dollars have been spent by industry to comply with OSHA's rules. Intuitively, all this expense must have done some good.

It hasn't. Safety in the American workplace is about the same as it was in 1970. A tour of the Glen-Gery brick factory, near Reading, Pennsylvania, gives an indication why.<sup>558</sup>

It seems that OSHA inspectors "are especially interested in railings. Glen-Gery has been cited for having railings 39 and 40 inches high, not the regulation 42 inches, in older parts of the factory."<sup>559</sup> Indeed:

Bob Hrasok, Glen-Gery's full-time manager in charge of compliance, considers each inspection a kind of negative lottery: "Every inspector knows different rules" and will always find a violation, even though "we have done basically everything they asked for the last twenty years." "Everything they say is not wrong," says Ron Smeal, the plant manager, "but most of the requirements miss the point." . . .

The one thing of no interest to the inspectors is Glen-Gery's safety record. In the inevitable discussion after each inspection, they are unwilling even to discuss whether a violation actually has anything to do with safety.<sup>560</sup>

One-hundred and fifty pages later in the book, Howard suggests:

Our hatred of government is not caused mainly by government's goals, whatever their wisdom, but by government's techniques. How law works, not what it aims to do, is what is driving us crazy.

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558. PHILIP K. HOWARD, *THE DEATH OF COMMON SENSE: HOW LAW IS SUFFOCATING AMERICA* 12 (1994).

559. *Id.* at 13.

560. *Id.* at 14.

. . . Thousands of rigid rules are not needed to satisfy the important goal of worker safety; people could come up with their own plan, as Glen-Gery Brick did, and do a much better job. . . .

Law is hailed as the instrument of freedom because without law, there would be anarchy, and we would eventually come under the thumb of whoever gets power. Too much law, we are learning, can have a comparable effect: Millions of tiny legal cubicles give humans virtually no leeway. Unlike any legal system we ever admired, it tells us what to do and exactly how to do it.<sup>561</sup>

Therefore, Howard prefers the common law system, in part, because “[c]ontext is vital in law”<sup>562</sup> and because the common law gives judges the latitude to consider context.

Howard’s prescriptive suggestion is “[r]elaxing a little and letting regulators use their judgment,”<sup>563</sup> which is consistent both with Ruhl’s general fear of the administrative state and also with Di Lorenzo’s prescription concerning goal-targeting legislation<sup>564</sup> (which applies equally well to administratively generated regulatory law). Note that Howard is not against government, just its coercion (of the phase-state of the system beyond criticality into frozen rigidity, which prohibits individual adaptation and evolution): “We seem to have achieved the worst of both worlds: a system of regulation that goes too far while it also does too little. . . . This paradox is explained by the absence of the one indispensable ingredient of

561. *Id.* at 173. Howard gives the following example that is opposite to universal requirements:

Britain’s Inspectorate of Pollution, considered highly effective, works in the opposite way. It enforces pollution control against a legal principle to reduce pollution “by the best means practicable.” Its “relationship to the manufacturer is more like that of a doctor getting the patient’s cooperation in treating a disease than that of a policeman apprehending a culprit.” Britain has “presumptive standards;” but they are not binding on anybody who has a better idea or can show a special problem. There are almost no absolutes.

*Id.* at 176.

562. *Id.* at 17.

563. *Id.* at 180.

564. See *supra* note 524 and accompanying text. Howard continues:

We can think for ourselves. As the head of a large company said recently: “The majority of people will do right if they’re given goals and left to get the job done. . . . Regulations telling us how long our ladders should be are not useful.”

I can almost hear a swelling chorus of lawyers and bureaucrats chanting, “A government of laws, not of men.” We don’t trust bureaucrats. Who elected them? But we don’t have an alternative; if there is no flexibility for the regulator, there is no flexibility for us. Creating rules without flexibility is just a version of central planning. HOWARD, *supra* note 558, at 180.

any successful human endeavor: use of judgment.”<sup>565</sup> Moreover, giving regulators more discretion may, counterintuitively, require them to take individual responsibility because, like the normative constraints on judicial discretion, “[a]n official’s discretion,” legal philosopher Ronald Dworkin reminds us, does not mean ‘that he is free to decide without recourse to standards of sense and fairness.’”<sup>566</sup> In addition, according to Howard, “[r]esponsibility requires the attributes we used to value the most: effort and courage and leadership.”<sup>567</sup> Quoting Justice Cardozo, Howard reiterates: “He must gather his wits, pluck up his courage, go forward one way or the other, and pray that he may be walking not into ambush, morass, and darkness, but into safety, the open spaces, and the light.”<sup>568</sup>

Some of the foregoing CAS analysis seems inconsistent with Professor Roe’s conclusion that path dependence suggests a greater role for centralized (government) planning in order to jump to higher fitness peaks in the evolutionary fitness landscape and to avoid the lock-in caused by path dependency.<sup>569</sup> Two of the lessons from CAS do at least partially support Roe’s conclusion. First, preadaptation and past evolutionary changes are consistent with Roe’s observation that competitive evolution does not necessarily increase efficiency to higher levels. On the other hand, the institutions or businesses that survive economically must be at least minimally efficient as most of the aggregate of their adaptations.

Second, as previously discussed in the context of non-complexity management and economics theory, and as supported by complexity analysis, there may be different kinds of efficiency, and not all efficiency arguments are equally well-suited to the long and short runs. Thus, like the maladaptation of the peacocks’ tail, these efficiencies are competing rather than complementary. In fact, the free market may not be best suited to evolve an optimum aggregate mix of all those kinds of competing efficiencies.

Moreover, it seems unlikely that the centralized planner will be as sensitive to the current conditions (which, of course, is the initial condition for further action) as those closer to the more local patches. Further, there will be less aggregate experimentation and, therefore, learning by using centralized planning simply because there will be fewer decision-makers in play. As previously discussed, ten thousand gold miners (decision-makers) have a better chance of finding gold (innovating) than does one miner (in this case one centralized decision maker).<sup>570</sup> Both these observations seem inconsistent with Roe’s conclusion.

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565. *Id.* at 11.

566. *Id.* at 180.

567. *Id.* at 181.

568. *Id.* at 182.

569. See *supra* notes 503-11 and accompanying text.

570. See Geu, *supra* note 454, at 953-54 & n.141.

In addition, although free-market evolution does not guarantee the most efficient institutions, it at least seems to guarantee that the resultant institutions will not be grossly inefficient. Finally, just as the private sector is to sensitive path dependence, so too is the centralized planner. It does not appear that either pure system may escape those attractors but that because the private sector has a greater number of decision-makers, its chances appear to be better of such escape.

Obviously, I interpret Roe's conclusion to mean *greater* governmental involvement rather than *any* governmental involvement. To the extent that I am wrong in my interpretation, and he really means *any*, I must agree with him that there exists space in which *some* governmental intervention is helpful or necessary. Certainly management consultants Charles Handy and Peter Drucker believe there is some role for government even without relying upon CAS theory.<sup>571</sup> The difficulty is determining when and where that intervention is most appropriate.

Given that I conclude there is some economic planning role for government (albeit both limited and ambiguous), it seems that government must be a part of the description of the coevolution of business practices and more general societal values as well. Indeed, given the foregoing, the analytical approach provided by CAS states a single, coherent way (a model) of understanding the dynamics of law and economics.

#### *D. The Biology Analogy Applied to Business Organizations*

The final explanatory piece of the coevolution of law and business is the application of biological evolutionary principles to management theory with (or without) the mediation of CAS theory. Thus by the end of this section, this article will have completed its discussion of the coevolution of business and law as mediated by CAS theory both together and separately.

Thurow observes that "[p]eriods of punctuated equilibrium are equally visible in human history"<sup>572</sup> as they are in the paleontological record, and, like Fukuyama,<sup>573</sup> he argues that these periods at least correlate to advances in technology:

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571. See generally *supra* notes 428-36 and accompanying text. Furthermore, and on a bit more technical economic point, Roe uses a roadway example to illustrate path dependence. It is a great illustration, but a road is generally seen as a *public good*, and as such, probably is not the best case in which to think about the relative appropriateness of legislative direction over the private sector. Finally, of course, Roe is attempting to apply neo-classical economic analysis upon which, I believe, complexity theory has cast doubt "about its universality." See, e.g., Geu, *supra* note 454, at 953-55 (discussing economist Paul Romer's work).

572. THUROW, *supra* note 289, at 7.

573. See FRANCIS FUKUYAMA, *THE END OF HISTORY AND THE LAST MAN* at xiv (1992); see also Geu, *supra* note 454, at 942 & n.56 (discussing Fukuyama).

Although they came almost two thousand years later, Napoleon's armies could move no faster than those of Julius Caesar—both depended upon horses and carts. But seventy years after Napoleon's death, steam trains could reach speeds of over 112 miles per hour. The industrial revolution was well under way and the economic era of agriculture, thousands of years old, was in less than a century replaced by the industrial age. A survival-of-the-fittest social system, feudalism, that had lasted for hundreds of years was quickly replaced by capitalism.<sup>574</sup>

"Today," Thurow flatly states, "the world is in a period of [economic] punctuated equilibrium."<sup>575</sup> Moreover:

Biological, social, or economic systems enter periods of punctuated equilibrium with slowly evolving but firmly established structures. They emerge from periods of punctuated equilibrium with radically different structures that once again begin slowly evolving. The characteristics needed to be a winner on one side of a period of punctuated equilibrium are very different from the characteristics needed to be a winner on the other side. During periods of punctuated equilibrium everything is in flux, disequilibrium becomes the norm, and uncertainty reigns!<sup>576</sup>

Although the advancement of technology is widely perceived as a condition precedent for the punctuated equilibrium (or revolution) that the global economy and businesses are currently undergoing, it is not sufficient alone. "Organization," for example, remains important on a macro scale, and restructuring organizations, as we have seen, is imperative for business success.<sup>577</sup>

A recent business book, *The Death of Competition*, by James F. Moore has expressly adopted the business-biology analogy as its thesis.<sup>578</sup> Rather than adopting evolutionary biology as a base of comparison, Moore uses ecology and eco-systems as his model. Recall that Professor Holland inclusively listed ecology as an example of an "adaptive complex system."<sup>579</sup>

Moore explains both the title of his book and the metaphoric use of ecology as follows:

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574. THUROW, *supra* note 289, at 7.

575. *Id.* at 8.

576. *Id.* at 7-8.

577. See Geu, *supra* note 454, Part II.B.

578. JAMES F. MOORE, *THE DEATH OF COMPETITION: LEADERSHIP AND STRATEGY IN THE AGE OF BUSINESS ECOSYSTEMS* (1996).

579. See *supra* note 432-35 and accompanying text.

Not that competition is vanishing. In fact it is intensifying. But competition as most of us have routinely thought of it is dead—and any business manager who doesn't recognize this is threatened. . . .

The problem [with the traditional competition model] . . . is that it ignores the context—the environment—within which the business lies, and it ignores the need for coevolution with others in that environment, a process that involves cooperation as well as conflict.<sup>580</sup>

To illustrate the ecosystem analogy, Moore says “[a] good restaurant in a failing neighborhood is likely to die.”<sup>581</sup>

Moore goes further by suggesting that the best way for a business to survive and prosper is to create a market, that is, to make itself a key player in a new business ecosystem: “Market creation is actually a form of applied economic development. It requires intensive cooperation among diverse contributors to realize a workable economic future. It takes generating shared visions, forming alliances, negotiating deals, and managing complex relationships.”<sup>582</sup>

580. MOORE, *supra* note 578, at 3.

581. *Id.*

582. *Id.* at 5. The following quote by an evolutionary biologist illustrates what appears to be a connection deeper than mere analogy between ecology and business:

Flowers have no role in the life of their plant except to exchange genes with another plant that has a different hand of genes. Some, like grasses, do it by wind. . . . This method of pollination is haphazard and, from some points of view, wasteful. It is often more efficient to exploit the wings and muscles of insects . . . . This technique aims the pollen much more directly at its target, and consequently far less pollen is needed. On the other hand there has to be some expenditure . . . [of the] insects. Part of the budget goes on advertising—bright-coloured petals and powerful scents. Part goes in bribes of nectar [or simply compensation for services rendered].

Nectar is high-quality aviation-fuel for an insect and it is costly for a plant to manufacture. Some plants duck out of the expense and employ deceptive advertising instead. Most famous are those orchids whose flowers look and smell like female insects.

CLIMBING MOUNT IMPROBABLE, *supra* note 315, at 260-61.

The above can make one empathetic with William Jennings Bryan's arguments concerning the teaching of evolution in the public schools:

At the time, most Americans simply understood the theory of human evolution to mean that people came from apes. Bryan played on this common understanding in his public addresses, often repeating the popular applause line, “How can teachers tell students that they came from monkeys and not expect them to act like monkeys?”

LARSON, *supra* note 332, at 116.

According to Dawkins, on the other hand, “natural selection will always favour short-term benefit” because most of nature does not have “human foresight.” CLIMBING MOUNT IMPROBABLE, *supra* note 315, at 309 (discussing the evolutionary issue of altruism). This at least leaves a crack in Dawkins's evolutionary theory for the salvation of long-term survival

What Moore's book suggests is a form of packaging. It packages the same kinds of business advice given by others in more traditional jargon into an ecosystem model which Moore hopes is successful in presenting the advice from a different perspective and in a more coherent story or pattern.

It is beyond the scope of this article to detail Moore's book much further. In fact, to do so would largely be redundant of some of the more general consultancy advice already discussed. The primary purposes of its discussion herein are simply to (1) illustrate another application of the biology analogy, and (2) introduce the analogy as an idea-generating device. Nonetheless, one more example from the book is helpful in drawing the analogy between business and the biological world and casting in network terminology. Moore identifies business ecosystems as having five stages of development that are roughly analogous to ecological "assembly rules" . . . [that] tell which species can coexist in a community, as well as the sequences in which species are likely to colonize an ecosystem."<sup>583</sup> Simplistically, for example, grass must establish itself in an ecosystem before a grasshopper can survive within it and, according to Moore "[t]he parallel to business ecosystems is strong. In both cases, a system and a sequence of symbiotic relationships are established."<sup>584</sup> The five stages he identifies for business ecosystems are "pioneering," "expansion," "authority," and "renewal" or "death."<sup>585</sup>

Pioneering "is a brainstorming stage . . . focus[ing] on identifying the particular seed innovations, whether technologies or concepts, that will create radically better products and services."<sup>586</sup> Pioneering businesses "attempt to establish 'proof of concept,'"<sup>587</sup> that is, to establish the basis of a food chain. It is like the grasshopper in the above example deciding to move to a patch of bare soil. To live, the grasshopper would be forced to seed grass. That may mean that the grasshopper must first attract birds to drop grass seed in the soil.

An example of a "pioneer" is Netscape Communications. Netscape, in effect, saw a patch of bare soil in underdeveloped Internet software:

Netscape chairman Jim Clark . . . found a recent college graduate . . . who understood the technology and the subculture of the Net. He added . . . a seasoned . . . operating manager to whom Wall Street investors would relate. . . . [He] then invested heavily in product development, gave away free entry-level desktop 'browser' software, and allied . . . with dozens of other software companies to bring combined offerings to market.

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through human foresight.

583. MOORE, *supra* note 578, at 65.

584. *Id.*

585. *Id.* at 69.

586. *Id.* at 69-70.

587. *Id.*



Finally, Netscape went to the public financial markets with such a strong story—and such a tiny quantity of available shares—that its price rose meteorically. . . . Only time will tell whether Netscape can grow the core business and turn its initial position into a sustainable, profitable business ecosystem.<sup>588</sup>

In essence, pioneering species in biological ecosystems, or pioneering businesses in business ecosystems, develop a patch of bare soil; that is, they create a niche not already filled with competitors. The same could be stated for pioneers in the realm of law.

Here there may be a common underlying principle for biological evolution and ecosystem assemblage under the rubric of complex adaptive systems. At the very least, it is a point at which the Cambrian explosion in evolution may provide an analogy for ecology. The common idea is that space or room to grow is necessary for creative endeavors. Thus, for example, one scientific hypothesis for why the Cambrian Explosion occurred so quickly is “the so-called empty barrel, or open spaces, hypothesis”.<sup>589</sup>

Here scientists delicately slide across data-thin ice, suggesting scenarios that are based on intuition rather than solid evidence. One favorite is the so-called empty barrel, or open spaces, hypothesis, which compares the Cambrian organisms to homesteaders on the prairies. The biosphere in which the Cambrian explosion occurred, in other words, was like the American West, a huge tract of vacant property that suddenly opened up for settlement. After the initial land rush subsided, it became more difficult for naive newcomers to establish footholds.<sup>590</sup>

In summary, this section has cited business consultants analogizing to biological ecosystems, and in turn, has come full circle back to punctuated

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588. *Id.* at 34; see also *A Survey of the Software Industry*, ECONOMIST (special section), May 1996. Professor Heifetz also uses biological evolution and ecosystem assembly in his more general study of leadership, which includes the business context:

When people walk outdoors on a hot summer day, they sweat and move slowly to maintain a constant internal temperature of 98.6 degrees Fahrenheit. When a fire burns down a forest, the seeds that routinely blow in from a distance now take root in the ash. Knocked out of equilibrium, living systems summon a set of restorative responses.

These responses to disequilibrium are the product of evolutionary adaptations that transformed into routine problems that were once nearly overwhelming threats. RONALD A. HEIFETZ, *LEADERSHIP WITHOUT EASY ANSWERS* 28 (1994). Heifetz also uses jargon from chaos theory like “disequilibrium dynamics” later in the same chapter. *Id.* at 35-40.

589. Nash, *supra* note 303, at 73.

590. *Id.* Note the “reverse” analogy to a social historical event in the quote.

equilibrium which introduced this part of the article as an application of CAS theory to biological evolution. As a result, this section completes this part of the article. It has described evidence that indicates (1) that biological evolution may be an example of a CAS; (2) that businesses may be a CAS; (3) that CAS theory has been independently applied to better understand law and that biological evolution has been a metaphor for law without CAS theory; and (4) that business and management literature have also used ecology and evolution (with and without the use of CAS) metaphorically to help understand business. Thus the stage is now set to discuss the ultimate analysis of this article: the coevolution of business and law and speculation on the lessons that may be drawn as a result of this deeper understanding.

#### IV. GROPING TOWARD UNDERSTANDING ORGANIZATIONAL LAW, ECONOMICS, BIOLOGY, AND PUNCTUATED EQUILIBRIUM: A MODEL REVISITED AND APPLIED

A system of law at any time is the resultant of present needs and present notions of what is wise and right on the one hand, and, on the other, of rules handed down from earlier states of society and embodying needs and notions which more or less have passed away.

- Oliver Wendell Holmes<sup>591</sup>

On the macro scale, Thurow, in recounting the crumbling of the Roman Empire and the subsequent Dark Ages, illustrated the importance of organization: "Romans knew about technologies such as fertilization. What later Europeans lost was the organizational ability to produce and distribute fertilizer."<sup>592</sup> As a contemporary of the Roman military observed:

The Romans were less prolific than the Gauls, shorter than the Germans, weaker than the Spanish, not as rich or astute as the Africans, inferior to the Greeks in technology and in reason applied to human affairs. What they had was the ability to get organized.<sup>593</sup>

On the micro scale, business management authors have stressed the importance of an organization's ability to evolve innovation and speed.<sup>594</sup> Thus, the "reengineering" of existing organizations and the "virtual

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591. OLIVER WENDELL HOLMES, *The Bar as a Profession*, in COLLECTED LEGAL PAPERS 153, 156 (1920).

592. THUROW, *supra* note 289, at 262 (footnote omitted).

593. *Id.* at 13 (footnote omitted).

594. See Geu, *supra* note 454, Parts II.B.2, II.B.4.

corporation" remain in vogue.<sup>595</sup> Moreover, bringing the necessary resources and knowledge to bear on a project basis requires networking, just-in-time employees, outsourcing, and bringing customers and suppliers into the design and manufacturing process.<sup>596</sup> Organizational ability, therefore, is key to success at both the business and macroeconomic levels. In the pathological sense this development is remarkable because management science and organizational theory have developed only since World War II.<sup>597</sup> Despite the shift toward a global economy and rapid advances in information technology, knowledge, and management science, however, the basic structures of business organizations are anachronistic, having remained unchanged since the 1800s:

The railroads of the late nineteenth and early twentieth centuries often functioned with towering hierarchies of management. . . . Management hierarchies made it possible to operate the railroads effectively, just as scientific management made it possible to run the factories efficiently. Combining the two created a management system that was ideal for controlling static, inflexible, mass production systems.<sup>598</sup>

Furthermore:

Inflexibility, unresponsiveness, the absence of customer focus, an obsession with activity rather than results, bureaucratic paralysis, lack of innovation, high overhead—are the legacies of one hundred years of American industrial leadership. . . .

. . . America's business problem is that it is entering the twenty-first century with companies designed during the nineteenth century to work well in the twentieth.<sup>599</sup>

At least in part, the problem is that organizations have lost their ability to adapt and have done so with a certain level of hubris born of the same linear miscalculations as some of the well-known doomsayers.<sup>600</sup>

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595. See *id.* Part II.B.3.

596. See *id.* Part II.B.4.

597. See *id.* Part II.A.2.b.

598. WILLIAM H. DAVIDOW & MICHAEL S. MALONE, *THE VIRTUAL CORPORATION: STRUCTURING AND REVITALIZING THE CORPORATION FOR THE 21ST CENTURY* 165-66 (1992).

599. MICHAEL HAMMER & JAMES CHAMPY, *REENGINEERING THE CORPORATION: A MANIFESTO FOR BUSINESS REVOLUTION* 30 (1993).

600. See *Geu*, *supra* note 454, at Part II.A.2.a.

These management techniques [i.e., hierarchies and scientific management] were so effective that within a [relatively] short time the United States was populated with the world's greatest industrial corporations. So dominant was the industrial might of our country that Jean-Jacques Servan-Schreiber, in his 1968 book *The American Challenge*, presented a vision of the industrialized world totally dominated by giant American corporations that would crush at will the industrial midgets of Europe.<sup>601</sup>

This part of the article will first discuss examples of what might be termed "neo-classical" or "Darwinian" evolution of business organization law and then will take a critical look at a few current proposals for change from a CAS perspective. This part will end by suggesting a networked approach to drafting business organizational statutes that might be closer attuned to providing a different mix of rigidity and flexibility in order to move to the edge of chaos.

The dominant legal model for the large American companies that in turn dominated the industrial ecosystem was the corporation. It developed during the American Industrial Revolution and was an important innovation. Its importance is illustrated by a quote that has been attributed to at least two individuals, one of whom was Nicholas Murray Butler, president of Columbia University in 1911: "*the limited liability corporation is the greatest single discovery of modern times. . . . Even steam and electricity are far less important than the limited liability corporation.*"<sup>602</sup> Obviously, limited liability is a legal attribute. Law, therefore, arguably played a role in facilitating the Industrial Revolution.

The current pace of the legal innovation of both statutory and nonstatutory organizations is fast and seems to be accelerating and coevolving with today's business needs and business ecosystems. "Coevolution" has been discussed,<sup>603</sup> but by way of emphasis it has been defined as

a process in which interdependent species evolve in an endless reciprocal cycle—"changes in species A set the stage for the natural selection of changes in species B," and vice versa. Take the caribou and the wolf. The wolf culls the weaker caribou, which strengthens the herd. But with a stronger herd, it is imperative for wolves to evolve and become stronger themselves to succeed. And so the pattern is not simply competition or

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601. DAVIDOW & MALONE, *supra* note 598, at 166 (footnote omitted).

602. Roger E. Meiners et al., *Piercing the Veil of Limited Liability*, 4 DEL. J. CORP. L. 351, 351 (1979) (quoting Nicholas Murray Butler, in W. FLETCHER, 1 CYCLOPEDIA OF THE LAW OF PRIVATE CORPORATIONS § 21 (1917)) (emphasis added).

603. See, e.g., Edward O. Wilson, *Resuming the Enlightenment Quest*, WILSON Q., Winter 1998, at 16, 24.

[symbiotic] cooperation, but coevolution. Over time, as coevolution proceeds, the whole system becomes more hardy.<sup>604</sup>

Darwinian evolution, as opposed to punctuated equilibrium, seems to work on the margin where changes happen by slow and steady random mutation and natural selection works to select the survivors.<sup>605</sup> An example of this kind of steady evolution in the business ecosystem is the evolution of such combination organizations as limited partnerships that have corporate general partners, and general partnerships that have corporate partners. While these organizations exhibit unique combined characteristics, they are at base simply aggregations of entirely separate legal structures and not merely the blending of individual characteristics of different legal structures.<sup>606</sup>

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604. MOORE, *supra* note 578, at 11-12 (1996) (quoting anthropologist Gregory Bateson).

605. See generally DAWKINS, *supra* note 311 (explaining the process of random mutation and its effect on natural selection).

606. The word "blending" is used to provide a point of departure to make sure readers understand a basic tenet of modern genetics. One of the keys to understanding how evolution works is to go beyond the understanding of it that was possessed by its founder Darwin. Going beyond Darwin is necessary scientific advancement but still sounds rather heady for those of us who are not evolutionary biologists. One of the real weaknesses in Darwin's theory of evolution was that Darwin, "[l]ike most naturalists working before the acceptance of Mendelian genetics, . . . believed that the inherited traits of an offspring consisted of a blending of those possessed by its parents." LARSON, *supra* note 332, at 17-18. Thus, rather than trait by trait or gene by gene, *blended* transmission would produce [s]light, random variation in an individual—no matter how much it helped that animal or plant survive—[that] quickly would be swamped as that individual bred with others of its species, so that gradually each succeeding generation would lose its distinctiveness. Even if individuals with a particularly beneficial trait mated solely with those possessing the same trait—such as happens in the breeding of domesticated animals—their offspring then simply would tend to preserve that trait, not exceed it. If organic evolution occurred (and by 1880 most naturalists believed that it did), then some mechanism must accelerate and direct variation; for some devout Christians, this left a role for God.

*Id.*

As is obvious to present Mendelian geneticists, gene-governed traits are not blended but rather one or the other is chosen (note the possibility of inchoate recessive traits, *e.g.*, blue eyes, that might suddenly manifest themselves). Mendelian genetics, therefore, allows for trait-specific selection leading to greater individual diversity rather than to a gradual accession into trapped homogeneity without the inability to adapt further. It seems to me, that the competing issues in the Scopes trial, as reflected in the above-quoted book, in many interesting ways reflect the tension inherent between science and politics at the edge of chaos, where some researchers posit evolution takes place, and where Mendelian genetics operates. Illustratively, on appeal, "the defense [in the Scopes trial] stressed that the anti-evolution statute unreasonably restrained the individual liberty of teachers and students by establishing a preference in public education for a particular religious belief over the

Another example of this type of steady legal coevolution, in response to the complex relational needs of business as competing in the global economy, is inter-entity project-based "partnering," which has been described as follows:

The objective of partnering is to develop a team approach . . . with the overall objectives of reducing cost, reducing stress, and reducing and hopefully eliminating claims which must be resolved through litigation. Using some of the team building management techniques of TQM (total quality management) programs, procedures are implemented to (1) foster mutual trust and respect among the key players involved in the project; (2) identify and establish specific objectives and the means to reach those objectives; (3) monitor and develop an ongoing evaluation process of how the procedures are working; (4) establishing a problem escalation/resolution process that avoids "no action" bottlenecks; and (5) a commitment to the process.<sup>607</sup>

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conclusions of modern scientific thought." *Id.* at 213. The State of Tennessee, on the other hand, "countered the defense's plea for academic freedom with an unabashed appeal to majoritarianism . . . 'The public schools are created by the legislature,' the brief began in Bryanesque fashion, 'and the courts can in no manner control, limit or proscribe the legislature in the exercise of power' over them." *Id.* This is the conflict between majoritarian democracy and individual rights, which implicates the edge of chaos. See KAUFFMAN, *supra* note 310, at 28.

Alternatively, as suggested by Carl Sagan about the political sphere: "each society must decide where in the continuum between openness and rigidity safety lies." SAGAN, *supra* note 332, at 311. Stalin and Soviet Russia chose the path of rigidity and tried to manipulate science (a very post-modern view) politically:

[B]y the middle 1930s a charlatan named Trofim Lysenko had caught the notice and then the enthusiastic support of Stalin. Lysenko argued that genetics—which he called "Mendelism-Weissmanism-Morganism," after some of the founders of the field—had an unacceptable philosophical base, and that philosophically "correct" genetics, genetics that paid proper obeisance to communist dialectical materialism, would yield very different results. In particular, Lysenko's genetics would permit an additional crop of winter wheat . . . .

*Id.* at 261. The result in the Soviet Union was that "no new crop of winter wheat grew; incantations of the phrase 'dialectical materialism' went unheard by the DNA of domesticated plants . . . ." *Id.* at 263.

607. James P. Houghton, *The Quest For a Better Way: Partnering in Construction Projects—Thoughts for the Real Estate Lawyer*, in DESIGN AND CONSTRUCTION LAW CLE PROGRAM 1994, at 2 (ABA Annual Meeting—Real Property, Probate & Trust Section) (on file with author). Houghton also quoted "[t]he Associated General Contractors" approach to partnering, which it advocated in its 1991 publication, *Partnering, A Concept For Success*:

It is going back to the way people used to do business when a person's word was their bond and people accepted responsibility. Partnering is not a contract, but a recognition that every contract includes an implied covenant of good faith. While the contract establishes the legal relationship, the partnering process attempts to establish working relationships among the parties (stakeholders) through a mutually-developed, formal

The heart of "partnering" is the "initial workshop," which "requires the presence of persons from each partnered organization who can commit their groups to implementing plans developed at the workshop and who will empower personnel at each level to resolve problems in a timely manner."<sup>608</sup> Often the workshop is conducted by a mediator or facilitator, and it appears similar to mediation on a prescriptive basis. It is intended to be outside the contract documents, which creates room for conflict between the unwritten understanding and the documentation.<sup>609</sup> Moreover, those attending the initial workshop or subsequent workshops often sign documents styled as such things as "partnership agreements" or "written commitments."<sup>610</sup>

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strategy of commitment and communication. It attempts to create an environment, where trust and teamwork prevent disputes, foster a cooperative bond to everyone's benefit, and facilitate the completion of a successful project.

*Id.* at 7.

608. Robert A. Shearer et al., *Partnering: A Commitment to Common Goals*, DISP. RESOL. J., Apr.-June 1995, at 30, 30.

609. See generally J. B. Ruhl, *Thinking of Mediation as a Complex Adaptive System*, 1997 BYU L. REV. 777 (1997).

610. Houghton, *supra* note 607, at 7, 11. See generally Thomas J. Stipanowich, *Beyond Arbitration: Innovation and Evolution in the United States Construction Industry*, 31 WAKE FOREST L. REV. 65, 127-28 (1995) (analyzing the results from the 1991 ABA-sponsored survey on dispute resolution in the construction industry as well as other original empirical data).

There are other rather high profile examples of behavior similar to partnering outside the construction industry. One such example is cooperation between developers, either private or public, and the Environmental Protection Agency to redevelop "brownfields" as part of communities:

The benefits are numerous if these efforts succeed: a cleaner environment, a larger tax base for cities, more jobs, a more stable community, and a reason for companies not to relocate in outlying areas and contribute to suburban sprawl.

The idea behind brownfields redevelopment is to solve the problems that made these sites unattractive to investors in the first place—the open-ended expenses associated with liability, the too stringent standards that make cleanups more expensive than necessary . . . .

. . . For environmental lawyers, the change in regulatory environment is . . . striking.

"To say it's revolutionary is an understatement . . . ."

Stephanie B. Goldbert, *Let's Make a Deal: Cooperation, Not Litigation is the Newest Way to Clean Up Urban Wastelands*, A.B.A. J., Mar. 1997, at 42, 42-43.

Another such example is budding cooperation between two traditionally opposing special interest groups in the West: Ranchers and the Nature Conservancy. Indeed, a confluence of events in southern Arizona resulted in ranchers forming a radical center called "the Malpai Borderlands Group, a nonprofit organization of nine members . . . devoted to restoring and maintaining 'the natural processes that create and protect a healthy, unfragmented landscape to support a diverse, flourishing community of human, plant, and animal life in our Borderlands Region.'" Jake Page, *Finding Common Ground in the Range War: Ranchers Form a 'Radical Center' to Protect Wide-Open Spaces*, SMITHSONIAN, June 1997, at 50, 55.

Another kind of relational contract-based business form has appeared in which over 100 large businesses have “signed pacts agreeing to mediate almost all disputes with industry rivals.”<sup>611</sup> Such a “movement promises to alter the course of corporate litigation and . . . is a major step towards moving lawyers’ mindsets . . . towards settlement.”<sup>612</sup> In fact, between eighty-five and ninety percent of the disputes mediated so far (out of more than 100) have been resolved without going to court. In one case alone a senior executive estimated that mediation saved between \$150,000 and \$200,000 in legal fees.

More importantly, “[m]ediation has also allowed companies to preserve important business relationships. . . . [which litigation] would have destroyed.”<sup>613</sup> The mediation scheme works, the article seems to imply, because it removes “hard-charging lawyers spoiling for a fight” from the settlement mix, which is particularly interesting since the “prime movers . . . have been general counsel.”<sup>614</sup> The process under these particular agreements “require[s] that before serious money is spent on legal warfare, senior executives not directly involved in a dispute first try to negotiate a settlement. If that fails, they must bring in a mediator.”<sup>615</sup>

Additionally, the common law itself is being challenged by novel issues that are consistent with a more sophisticated palate for “relational” business environment. One general issue that has emerged, for example, is whether a partner, without any special employment arrangement with the partnership, is an employee for purposes of federal statutory law. A case analysis will illustrate both the legal evolutionary process and the new kinds of relational issues that result from a deeper relational understanding. The case of *Simpson v. Ernst & Young* concerned the discharge of a certified public accountant who was managing partner of the Cincinnati office of Ernst &

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Even given the group’s initial success, however, it remains in the “radical center”:

Not all the neighbors in this million-acre borderlands area are convinced that the Malpai group and its cozy relationship with conservationists is a good thing. . . .

. . . Keeler, a [local] third-generation rancher . . . voiced deep-rooted suspicions about the Conservancy’s “hidden agenda” . . . although this agenda “has yet to be disclosed.”

. . . [T]he Malpai group has also had to face the scrutiny of environmentalists . . . .

And many hard-liners . . . “have a tough time seeing any form of ranching as an environmentally sustainable activity.”

*Id.* at 60. Thus, the Malpai group remains in the interesting borderlands area between ranchers and non-ranching conservationists.

611. Margaret A. Jacobs, *Industry Giants Join Movement to Mediate*, WALL ST. J., July 21, 1997, at B1. Companies listed in the article as having signed the pact include PepsiCo Inc., Kellogg Co., Chase Manhattan Corp., BankAmerica Corp., NationsBank Corp., DuPont Co., W.R. Grace & Co., McDonald’s Corp., and the Holiday Inn unit of Bass PLC.

612. *Id.*

613. *Id.*

614. *Id.*

615. *Id.*



Young.<sup>616</sup> The accountant, Peyton Larue Simpson, was “requested to resign” shortly after the 1989 merger of Arthur Young & Co. and Ernst & Whinney that resulted in what the court called a “mega-firm known as Ernst & Young.”<sup>617</sup> Simpson sued, alleging that his discharge violated the Age Discrimination in Employment Act (ADEA) and the Employee Retirement Income Security Act (ERISA).<sup>618</sup> Ernst & Young argued that Simpson was a partner of the firm rather than an employee and that, consequently, neither federal statute would apply to Simpson.<sup>619</sup>

The relational issue in the case was whether Simpson was an employee of Ernst & Young for purposes of the ADEA and ERISA. Both the trial court and the Sixth Circuit Court of Appeals determined that Simpson was an employee despite the fact that he had signed a document that purported to be a partnership agreement.<sup>620</sup> The trial court and the appellate court used two separate but related analytical paradigms to determine whether Simpson was an employee for purposes of the ADEA and ERISA. The paradigm or model used by the appellate court was the “common-law test” that applied “agency law principles” and was mandated by the Supreme Court in ERISA cases.<sup>621</sup>

The common-law test is based on the master-servant legal dichotomy and is at least ostensibly under the umbrella of broader agency law.<sup>622</sup> The Sixth Circuit Court of Appeals explained that test as follows:

Applying the *Darden* analysis of the master/servant relationship to the instant case, as particularized by the traditional common-law agency doctrine, this appellate consideration reviews numerous factors impacting the employment relationship to be judged in arriving at a decision with no one decisive factor. Among the elements to be debated in determining the independent contractor/employee question are: the hiring party’s right to control the manner and means by which the product is accomplished; the skill required by the hired party; the duration of the relationship between the parties; the hiring party’s right to assign additional projects; the hired party’s discretion over when and how to work; the method of payment; the hired party’s role in hiring and paying assistants; whether the work is part of the hiring party’s regular business; the hired party’s employee benefits; and tax treatment of the hired party’s compensation.<sup>623</sup>

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616. Simpson v. Ernst & Young, 100 F.3d 436 (6th Cir. 1996) (Daughtrey, J., concurring).

617. *Id.* at 440.

618. *Id.* at 439.

619. *Id.*

620. *See id.* at 439-41.

621. *Id.* at 442-43 (quoting Nationwide Mut. Ins. Co. v. Darden, 503 U.S. 318 (1992)).

622. *Id.* at 443.

623. *Id.* (citation omitted).

The Sixth Circuit declared that this master-servant test subsumed the “economic realities’ test,” which the trial court arguably used, because the two tests were so closely attuned.<sup>624</sup>

The Sixth Circuit then pointed out that the common-law test was used to determine independent contractor/employee status rather than partner/employee status.<sup>625</sup> Next, the Sixth Circuit used the Uniform Partnership Act as a template to determine whether Simpson was a partner or an employee.<sup>626</sup> The Sixth Circuit’s transition between the agency test and the partnership test interestingly analogized partners and independent contractors to employers, and apparently assumed that employer status was mutually exclusive from employee status. By doing so, the Sixth Circuit implicitly equated independent contractor status with partner status:

Although the conventional agency test is directed to the independent contractor/employee issue, neither this circuit nor the Supreme Court have, to date, considered the partner versus employee question. In approaching the subject, it is significant to observe that bona fide independent contractors and partners are employers, not employees; and as employers, neither come within the entitlement protection or coverage of either the ADEA or ERISA.<sup>627</sup>

The reasoning that the Sixth Circuit employed in *Simpson* may leave creative or evolutionary space for substituting the independent contractor test for the partner test in the next case that comes along on the same issue. That “space” is significant because the tests that the court used are not in unity and the facts underlying the case in which the argument will be made will probably create a close legal question. Moreover, equating independent contractor with partner status also eliminates the “partner but employee” status that already exists in some courts.

In defining what constitutes a partner relationship, the Sixth Circuit looked to the Eleventh Circuit’s decision to “focus not on any label, but on the actual role played by the claimant in the operations of the involved entity and the extent to which that role dealt with traditional concepts of management, control and ownership.”<sup>628</sup> The Sixth Circuit then relied on the

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624. The “economic realities” test as formulated by this court seems a bit broader than the other test because it contemplates the legislative purpose: “In . . . [a prior case], we . . . decided that independent contractors would be covered by Title VII if, under an ‘economic realities’ test, they are susceptible to the types of discrimination Title VII meant to prohibit.” *Id.* at 442.

625. *Id.* at 443.

626. *Id.*

627. *Id.*

628. *Id.* (citation omitted).

default provisions of the state's UPA in the same way that the superseded federal income tax entity classification regulations<sup>629</sup> relied on the UPA as the model for the prototypical general partner:

This court, in addressing the distinction between partners and employees, an issue of first impression within this circuit, evaluates the undisputed facts of the instant case against the common-law principles as codified in the UPA, including, but not limited to: the right and duty to participate in management; the right and duty to act as an agent of other partners; exposure to liability; the fiduciary relationship among partners; use of the term "co-owners" to indicate each partner's "power of ultimate control;" participation in profits and losses; investment in the firm; partial ownership of firm assets; voting rights; the aggrieved individual's ability to control and operate the business; the extent to which the aggrieved individual's compensation was calculated as a percentage of the firm's profits; the extent of that individual's employment security; and other similar indicia of ownership.<sup>630</sup>

Judge Daughtrey, writing in a concurring opinion, would have gone even farther than attempting to look through labels to adjudge relationships, questioning the validity of the partner model and alluding to the existence of a partner-employee creature:

I write separately, however, to encourage the legislative branch of our federal government to recognize as well that the realities of today's global marketplace no longer justify distinguishing between "employees" and "partners" in all instances.

In an era of small, closely-operated partnerships, it may have been logical to conclude that an employer/partner could not and would not discriminate in employment decisions against himself or herself or against a close friend and business associate. In a world-wide organization like Ernst & Young that employs almost 2200 "partners," however, the nominal co-owners of the company are, by necessity, . . . removed from the seat of actual power . . . .<sup>631</sup>

The opinions in *Simpson* illustrate the coevolution of business and law because the Sixth Circuit confronted "relational" business issues based on changes that occurred, according to the concurrence, because of the growth of "global" business. Further, the majority opinion set forth two relational tests, the independent contractor/employee test and the partner/employee test,

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629. See *infra* note 652 and accompanying text.

630. *Simpson*, 100 F.3d at 443-44 (footnotes and citations omitted).

631. *Id.* at 445 (Daughtrey, J., concurring).

which themselves are relational model patterns based upon how parties interact and establish business connections. Moreover, both tests are nonlinear and extremely sensitive to initial factual conditions because no single element or factor in either test is dispositive.

The *Simpson* case also illustrates connections and relationships at the level of the judicial system's internal structure. For example, the Sixth Circuit Court of Appeals, a federal court, used the common law independent contractor test and the UPA test, both of which are based on state law, to arguably operate in coupled-fitness landscapes. Relatedly, the concurrence called for the legislature to modify existing statutory law to take into account the new business realities, which illustrated a connection between federal government branches. Finally, the Sixth Circuit's internal court rules attested to the existence of procedural switching or grammatical decisional rules, as between the trial and appellate courts.<sup>632</sup>

The Uniform Commercial Code (UCC) is another example of the coevolution of business and law that is consistent with traditional Darwinian evolutionary principles. For example, UCC Articles 2B and 4B have changed in reaction to the evolution of information and telecommunication technology. Moreover, the influence of business practices on law is also reflected in UCC Article 8 (investment securities), and at least indirectly in the revised Article 5 (letters of credit).

Article 2B focuses on licenses, and the stereotypical transaction that it will cover is computer software licensing:

A decision . . . to develop an article of the UCC dealing with licensing and other transactions in intangibles reflects the most direct recognition within the UCC of the fact that the modern economy no longer depends on sales of goods. The decision acknowledges that intangibles contracts entail far different commercial and practical considerations than a sale of goods model followed under current Article 2.<sup>633</sup>

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632. The grammatical rules are explained by the court itself as follows:

The trial court's summary judgment ruling is reviewed *de novo*. *Barnhart v. Pickrel, Schaeffer & Ebeling Co.*, 12 F.3d 1382, 1388 (6th Cir.1993). The jury verdicts returned in these proceedings are reviewed pursuant to the "sufficient evidence" rule. See *Argistor Leasing v. A.O. Smith Harvestore Prods., Inc.*, 869 F.2d 264, 269 (6th Cir.1989). The legal issues inherent to the ERISA claim are reviewed *de novo*, and its factual issues are reviewed for clear error. *Schwartz v. Gregori*, 45 F.3d 1017, 1021 (6th Cir.), *cert. denied*, — U.S. —, 116 S.Ct. 77, 133 L.Ed.2d 36 (1995). Resolutions concerning prejudgment interest and front pay are reviewed for abuse of discretion. *Shore v. Federal Express Corp.*, 42 F.3d 373, 380 (6th Cir.1994).

*Id.* at 440 (citations unaltered). For a direct application of biological evolutionary theory to an employment-related topic, see Jim Chen, *Diversity in a Different Dimension: Evolutionary Theory and Affirmative Action's Destiny*, 59 OHIO ST. L.J. 811 (1998).

633. Raymond T. Nimmer, *Contract Law in the Information Age*, in THE UNIFORM

Article 4A, which has been in existence for a few years, covers electronic funds transfers and reflects how advances in technology can affect the law.<sup>634</sup> Other UCC changes include revisions made to Article 2 to include statutory law dealing with such technology-based terms as "copy," "electronic message," "electronic transaction," "intangible intermediary," and "record." A "record," for example, is "information that is inscribed on a tangible medium or that is stored in an electronic or other medium and is retrievable in perceivable form."<sup>635</sup>

Three miscellaneous changes to Article 2 are particularly notable because they seem to emphasize the increasingly important concepts of organizational relationships or relational law. First, revised section 2-201 eliminates the statute of frauds, in apparent recognition of the fact that many "deals" are evidenced only by oral communications and course of conduct. Second, revised Article 2 expands its coverage beyond goods to include contracts "(1) relating to the quality of goods supplied under a contract in which the sale of goods does not predominate, and (2) arising under a contract obligating the seller to install, customize, service, repair, or replace the goods at or after the time of contracting."<sup>636</sup> Third, and perhaps most important for relational purposes, revised Article 2, "[a]lso proposes to redefine good faith for Article 2 purposes . . . [and] it will [most likely] expand the definition [of good faith] to include in all cases both honesty in fact and the observance of reasonable commercial standards."<sup>637</sup>

All of the foregoing coevolutionary changes seem to recognize a migration from "discrete contracting" toward "relational contracting" and seem to recognize a greater understanding or sophistication about business relationships. "In *discrete contracting*, the parties have no preexisting obligations to each other. As they approach a contemplated venture, they negotiate a contract that anticipates and provides a rule governing all contingencies."<sup>638</sup> On the other hand, "[r]elational contracting is a response to the defects of discrete contracting. In relational contracting, parties do not attempt to provide an answer to all contingencies . . . . Instead, they attempt to build a governance structure that will allow them to solve problems when, and if, they arise."<sup>639</sup>

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COMMERCIAL CODE: PAST, PRESENT, FUTURE 1996 at 3 (South Dakota State Bar continuing legal education—prepublication draft no.6) (1996) (on file with author).

634. *Id.*

635. Mark Roszkowski, *Revised Article 2 of the UCC v. 1990 Official Text*, in THE UNIFORM COMMERCIAL CODE: PAST, PRESENT, FUTURE 1996 at 2 n.3 (South Dakota State Bar continuing legal education—prepublication draft) (on file with author).

636. *Id.*

637. *Id.* at 2-3.

638. CHARLES R. O'KELLEY, JR. & ROBERT B. THOMPSON, CORPORATIONS AND OTHER BUSINESS ASSOCIATIONS: CASES AND MATERIALS 9-10 (1996).

639. *Id.* at 10. The franchise relationship of business and law may be the line of

Novel statutory organizational structures have recently proliferated among the states. Before attempting to put this explosion into context, however, it is helpful to recall that current organizational statutes provide "off-the-rack organizational forms" that include both "default" and "immutable rules."<sup>640</sup> In fact, the statutes are "'enabling' in the sense that they provide parties with default rules that govern their relationship if they do not provide otherwise."<sup>641</sup> According to a casebook, "[i]f lawmakers are efficiency minded, they will set the default rules of . . . law so as to maximize the parties' ability to adapt to changed circumstances while minimizing their exposure to opportunism. To choose the appropriate rule, lawmakers must appreciate the difference between tailored, majoritarian and penalty default rules."<sup>642</sup> The same casebook defines those rules as follows: "*Majoritarian rules* are designed to provide . . . the result that most similarly situated parties would prefer"<sup>643</sup>; "*penalty default rules* are designed to motivate one or more contracting parties to contract around the default"<sup>644</sup>; and "*tailored rules* are designed to give contracting parties the exact rule that they would themselves choose if they were able to bargain costlessly over the matter in dispute."<sup>645</sup> All of these off-the-rack kinds of rules should be designed in a way to reduce the time and money necessary to form an organization by reducing the need to draft everything into the organic document. In that way, these statutes provide efficiency in the economic sense by reducing transactional costs that specifically include information costs.

A brief history of the evolution of unincorporated business organizations focused on the new limited liability partnership (LLP) form of business organization, and reads as follows:

The law of business organizations has attempted to respond to the needs of modern business. The Revised Uniform Limited Partnership Act (RULPA) was promulgated . . . to modernize the Uniform Limited Partnership Act, then revised in 1985 . . . . The Model Business Corporation Act (MBCA) was revised in 1984. More recently, the limited liability company (LLC) was created in response to a business need for an unincor-

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demarcation between discrete and relational contracting. The growth of franchising in the past forty years, moreover, may also have been evidence of the need for new types of "organizations" that combined the economic factors of production in new ways, presaging the newer and more novel forms of business organization. See generally, e.g., Meg Whittemore, *The Adaptable Enterprise*, NATION'S BUS., Nov. 1990, at 47, 47-56 (discussing franchising).

640. O'KELLEY & THOMPSON, *supra* note 638, at 48.

641. *Id.*

642. *Id.* at 48-49 (footnote omitted).

643. *Id.* at 49.

644. *Id.* at 50.

645. *Id.* at 49.

porated business organization affording protection against vicarious liability to all of its owners. The . . . Uniform Partnership Act (UPA) [was modified] into a revised act (RUPA) [Revised Uniform Partnership Act] to provide a partnership with more definite entity characteristics. RUPA retained the joint liability of the partners for partnership obligations found in the UPA.<sup>646</sup>

The article then describes and analyzes the limited liability partnership (LLP). In doing so it notes that "the liability protection afforded by LLPs reflects the evolution of the LLP from a unique vehicle to a more conventional limited liability organization,"<sup>647</sup> and identifies three generations of LLP statutes since Texas adopted the first LLP provisions in 1992.<sup>648</sup> Of importance for present purposes are the statutory creation of the new entity, the speed of its adoption by the various states, and the fact that there have been three successive statutory generations in less than five years.<sup>649</sup>

The growth and speed of adoption of LLP legislation occurred concurrently with the maturation of the limited liability company (LLC). At least forty-two jurisdictions adopted LLC Acts within a four year period, and during that time the statute itself has also continued to mature. As Professor Larry E. Ribstein wrote:

Three years ago, *The Business Lawyer* published the first comprehensive survey of the law relating to limited liability companies (LLCs), *The Limited Liability Company: A Study of the Emerging Entity*. When that article was written, only eight states had passed LLC statutes. There was no settled model for the LLC, no settled tax treatment beyond the rudimentary partnership tax classification of some Wyoming LLCs, and no clear recognition of LLCs outside of their formation states. "Emerging" aptly described the LLC form.

As this Article was being written, all U.S. jurisdictions except Hawaii and Vermont had passed LLC statutes. There are Uniform and Prototype LLC laws, a comprehensive Internal Revenue Service (IRS) Revenue Procedure dealing with LLCs, and explicit statutory recognition of foreign LLCs in forty-eight [now fifty] states. Thousands of LLCs have been formed across the country, often at a greater rate than limited partnerships. The LLC has emerged.<sup>650</sup>

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646. Robert R. Keatinge et al., *Limited Liability Partnerships: The Next Step in the Evolution of the Unincorporated Business Organization*, 51 BUS. LAW. 147, 147-48 (1995) (footnotes omitted).

647. *Id.* at 175.

648. *Id.* at 175-80.

649. *Id.*

650. Larry E. Ribstein, *The Emergence of the Limited Liability Company*, 51 BUS. LAW. 1, 1 (1995) (footnotes omitted).

Like the LLP, the speed of the adoption of LLC statutes is important, but even more important is the fact that LLCs have been created from almost whole-cloth, as a new business form in the United States.

The explosion of new approaches to the law of organizations and the new LLP and LLC body-types (phenotype or morphology) begs for an analogy to punctuated equilibrium in evolutionary biology. One advantageous way to compare the two is to note that recent economic changes have created a space for new business organization body-types. To the extent that some of the changes are simply adaptations to, or of, existing statutes, it could be argued that the law is slowly adapting in the classical Darwinian style, perhaps through a process similar to genetic drift.<sup>651</sup> It may also be, however, that we are witnessing something more basic on the grander scale of punctuated equilibrium, not simply in reaction to Thurow's economic punctuated equilibrium of business, but as an integral feedback component thereto.

The thawing of state statutory provisions concerning limited liability allowed new body types like LLCs and LLPs to develop. Perhaps the heat that those new entities generated had a part in thawing the federal income tax entity classification regulations that previously fixed the allowable organizational-permutations around the characteristics (the "other genes") of centralized management, continuity of life, transferability of ownership interests, business purpose, and the existence of more than one associate.<sup>652</sup> Without rigid state-law constraints on limited liability, and with the advent of check-the-box federal income tax entity classification, we may be in the midst of a punctuated equilibrium in organizational law caused by a change in the control sequence of organizational genes.

To the extent that the number of kinds of new organizations increase or, further, to the extent that each of the organization statutes provide fewer immutable rules, any efficiency provided by off-the-rack organizations may be lost. In short, business planning will, as is usual with its biological counterpart, evolve to greater complexity, which allows for survival but which is not necessarily the most efficient design.

Robert R. Keatinge, a respected commentator on unincorporated entities and a practicing lawyer,<sup>653</sup> has analyzed existing empirical data from state

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651. For a description of genetic drift, see *supra* note 302 and accompanying text.

652. See *United States v. Kintner*, 216 F.2d 418, 422-24 (9th Cir. 1954); *Treas. Reg. § 301.7701-2(a)* (1995).

653. Mr. Keatinge, who is of counsel with Holland & Hart in Denver, Colorado, was the ABA advisor to the Uniform Laws Commission's drafting committee on the Uniform Limited Liability Company Act, is a member of the Joint Editorial Board on Unincorporated Business Organizations of the ABA Business Law Section and the Uniform Laws Commission, chair of the ABA Committee on Partnerships and Unincorporated Business Organizations of the ABA Business Law Section Committee on Taxation, and liaison from the ABA Business Section to the Real Property Probate and Trust Law Section. Keatinge



corporation administrators and from the *Statistical Income Bulletin* concerning federal income tax filings and other related data.<sup>654</sup> He concluded, based on this data, that "although many business organizers prefer a flexible pass-thru [sic] entity [with single-level federal income tax] that affords limited liability, corporations remain the vehicle of choice for new and existing business entities."<sup>655</sup> Keatinge suggested that:

[T]he enduring trend of corporate preference is attributable at least to the following factors: (1) inertia [path dependency], (2) greater specificity of rules in the corporate entity [*i.e.*, greater certainty], (3) in a few distinct circumstances, tax benefits of operating in corporate form, (4) rules favoring corporations over unincorporated associations [banks and insurance companies typically must be corporations], (5) the ability to avoid difficult issues at the time of formation, and (6) the perceived simplicity of formation.<sup>656</sup>

Interestingly, items (2), (5), and (6) seem interrelated. Keatinge stated, for example, that "(2) greater specificity of rules"<sup>657</sup> really means that "[i]n comparison to the laws governing unincorporated organizations, corporation statutes provide fewer rules, but greater specificity."<sup>658</sup> So, for example, corporate codes address such issues as notice, quorum, and voting in specific detail but, unlike unincorporated business statutes, contain "no default rules governing the termination of a shareholder's investment in a corporation."<sup>659</sup> In turn, concerning item (5), "the ability to avoid confronting difficult issues at the time of formation,"<sup>660</sup> he stated that:

Because the corporate organizer need not address matters such as the disposition of shareholders' shares or employment arrangements, it is possible to form a corporation without confronting difficult issues that might otherwise give rise to disputes or protracted negotiations. By contrast, if the organizer of an unincorporated organization fails to address

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et al., *supra* note 646, at 147. He is also the co-author of LARRY E. RIBSTEIN & ROBERT R. KEATINGE, *RIBSTEIN AND KEATINGE ON LIMITED LIABILITY COMPANIES* (1997), a multi-volume looseleaf publication. Mr. Keatinge also regularly speaks at numerous continuing legal education seminars and symposia.

654. See Robert R. Keatinge, *Corporations, Unincorporated Organizations, and Unincorporations: Check the Box and the Balkanization of Business Organizations*, 1 J. SMALL & EMERGING BUS. L. 201, 234 & n.178, 235 & n.182 (1997).

655. *Id.* at 237.

656. *Id.*

657. *Id.*

658. *Id.* at 238.

659. *Id.*

660. *Id.* at 237.

certain matters such as the death or withdrawal of an owner, statutory default rules will apply, often requiring the liquidation of the business.<sup>661</sup>

Finally, Keatinge suggested that the corporate structure might be selected over those of unincorporated entities because of the “[p]erceived [s]implicity of [f]ormation and [o]peration.”<sup>662</sup> He gave two examples. One example was closely related to the corporate advantage of specific rules. That example illustrated the implicit information cost savings associated with immutable or commonly applicable procedural default rules:

[T]he fact that the duties and authority of corporate officers and directors are well established in statutes and common law allows business organizers to adopt a management structure that, while not specific to the business organized, establishes predictable rules without extensive thought. By contrast, the management structure of an unincorporated organization may differ from business to business, and often must be clarified in the agreement, requiring owners to confront potentially contentious issues.<sup>663</sup>

Another example of the perceived simplicity of the corporate structure is really a reflection of unincorporated entities’ complexity:

[A]n unincorporated organization generally involves more owner-specific accounting and operation than a corporation. These owner-specific considerations often require extensive language in the organic agreement, as well as ongoing computations on an owner by owner basis. Thus, where owners agree at formation on their respective ownership percentage in an organization, the corporation (with its fungible shares) offers an easier way of dividing the operation than the unincorporated organization.<sup>664</sup>

Keatinge concluded by suggesting that the creation of an entity called “the unincorporation,” which would use some of the simplifying characteristics of corporate statutes, including “(1) fungible ownership interests [*i.e.*, the share concept], (2) separation of ownership from management and agency, and (3) elimination of provisions regarding the owners’ right to withdraw [that currently exist in some unincorporated entity statutes],” would be a popular and welcome addition to noncorporate statutory business

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661. *Id.* (footnote omitted).

662. *Id.* at 240.

663. *Id.* (footnote omitted).

664. *Id.* (footnote omitted).

organizations.<sup>665</sup> Keatinge, therefore, simply identified what the business environment presumably desires, based on the popularity of initial entity selection. In turn, he borrowed parts from different statutes (genetic materials) in order to genetically engineer new entity statutes (genotypes). For example, if the market finds it difficult to deal with withdrawal or exit rights as an initial planning matter, this perceived maladaptation in LLC and LLP statutes should, like a peacock's tail in the evolutionary context, be deemed inefficient and simply ignored in designing the new "unincorporation" form. In other words, consistent with neoclassical economics, assume the market to be efficient and give it what it demands.

It is Keatinge's logical simplifying extension concerning exit or withdrawal rights that is interesting from a CAS perspective:

The unincorporated business organization statutes permit owners to withdraw at any time. In the case of unincorporated organizations, this right is necessary to allow owners to terminate ongoing individual liability or to eliminate fiduciary duties. It is assumed that the unincorporation does not impose individual liability on owners, so the first reason for providing a right of withdrawal is not an issue. Similarly, the ability to eliminate fiduciary duties is not an issue: members without agency authority in an unincorporation would not be subject to fiduciary duties (such as the duty of loyalty or care). As a result, members would be able to resign as managers to eliminate their fiduciary obligations. Thus, as there is no need for an unincorporation to provide a right to withdraw, it may be eliminated. Finally, because interests in an unincorporation would be fungible and transferable, the argument in favor of the right to put an interest back into an organization should be no greater than it is for a closely held corporation.<sup>666</sup>

There are alternatives to the unincorporation suggested by Keatinge. One comprehensive alternative that has been discussed is simply a reorganization of all business entity statutes into a "hub-and-spokes" statutory format where: "The hub would be provisions common to all unincorporated entities covered by the statute, and the spokes would be provisions relating only to a certain type of entity."<sup>667</sup> The hub would probably consist of "matters relating to life cycle events (e.g., formation, amendments, merger, cancellation, foreign qualification, etc.)."<sup>668</sup> The

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665. *Id.* at 241.

666. *Id.* at 244 (footnote omitted).

667. George W. Coleman & Robert R. Keatinge, "UNiversal [Contractual] ORgaNI-ation," LIMITED LIABILITY COMPANIES: CHOICE OF ENTITY AT FIN DE SIÈCLE (Real Property, Probate, & Trust Law Section, A.B.A. Annual Meeting), Aug. 5, 1996, app. at 1 (documenting e-mail correspondence of Martin I. Lubaroff dated May 30, 1995) (on file with author).

668. *Id.*

spokes would “deal with all of the questions which are dealt with today in each of the separate entity statutes.”<sup>669</sup> The “hub-and-spokes” alternative is also interesting from the standpoint of CAS theory because the name itself makes it easy to visualize the statutory network pattern.

Finally, before further assessing either unincorporation or “hub-and-spokes” organizational statutes, the growing contractarian approach to organizational law within the contexts of both unincorporated and incorporated business forms should be mentioned as an ideological evolutionary force. Its theoretical roots are in the law and economics movement, and:

Following the basic precepts of welfare economics, Law and Economics scholars see atomistic contracting agents engaging in maximizing behavior that generally has no significant impact on third parties. In so doing, the parties are generally expected to reach socially optimal “contractual” arrangements with one another. . . . Each set of contracting parties has maximized its joint wealth, and hence the aggregate value of all contracts cannot be increased.<sup>670</sup>

The purest contractarian approach in corporate law assumes “no significant information imperfections,” and equates the “firm’s value” with “social wealth.”<sup>671</sup> As a result:

From these positive claims follows a normative view of corporate law: that the primary objective of corporate law should be to facilitate the drafting of corporate contracts by providing a set of default terms that firms may accept or reject at their option. Any mandatory element of corporate law must be justified by a market failure—an externality or an information imperfection—that severs the link between individuals’ maximizing behavior and social optimality.<sup>672</sup>

In other words, contractarians assert that the corporation is a network of contracts existing in the world of perfect neoclassical economics.<sup>673</sup>

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669. *Id.* at 2.

670. Michael Klausner, *Corporations, Corporate Law, and Networks of Contracts*, 81 VA. L. REV. 757, 758 (1995).

671. *Id.* at 760.

672. *Id.*

673. See generally FRANCIS FUKUYAMA, *TRUST: THE SOCIAL VIRTUES AND THE CREATION OF PROSPERITY* (1995) (discussing neoclassical economics). Fukuyama’s assessment was that “[w]e can think of neoclassical economics as being, say, eighty percent correct.” *Id.* at 13.

At base, Keatinge recognized some of the external costs of the unincorporation he described and, therefore, seemed to adopt only a portion of contractarian theory. On the other hand, like corporate law, he was willing to forego default rules that lead to pre-formation negotiating costs, thereby preserving the “[p]erceived [s]implicity of [f]ormation and [o]peration,”<sup>674</sup> presumably in order to achieve an otherwise economically (efficiently) organized firm. The foregone negotiation, however, seems to guarantee the existence of systemic external costs associated with court-determined exit strategies, none of which Keatinge attempted to identify or quantify. In other words, Keatinge seemed to implicitly decide, consistent with neoclassical economic theory, that the up-front benefits of the ease of organizing firms outweighed the possible back-end costs at the margin. Those costs include not only exit inefficiencies, but also, without fiduciary standards, the costs of the opportunistic lock-in of capital at a level which is not necessarily its highest and best use.<sup>675</sup>

The CAS perspective seems to ask whether the hub-and-spokes, unincorporation, or contractarian corporation alternatives have enough structure, or “grammatical” rules (both default and immutable) to be at the edge of chaos rather than in chaos. Keatinge’s version of the

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674. Keatinge, *supra* note 654, at 240.

675. In fact, Keatinge recognized all this richness and interrelationship, and suggested tension among multiple continuum:

Many aspects of associations are apparently contradictory, or at best, ambiguous. On one hand, a partnership has been characterized as no more of an entity than a friendship. On the other, an association is at once a contract among its owners and a separate entity with its own legal identity. The owners are at once self-interested and fiduciaries to other owners and the association.

Robert R. Keatinge, *The Implications of Fiduciary Relationships in Representing Limited Liability Companies and Other Unincorporated Associations and their Partners or Members*, 25 STETSON L. REV. 389, 389-90 (1995) (footnotes omitted).

Another article explored possible sources of entity standardization, but did not limit standardization to statutory constraints, by stating that

several phenomena . . . may lead to excessive standardization in corporate contract terms. Although a standard term may well be socially optimal, each of the influences . . . creates the possibility that a corporate contract term will become widely adopted even though an alternative term would be superior from a societal perspective. Even if individual firms behave in a value-maximizing manner, learning-related informational cascades and network externalities can lead to standardization that fails to maximize the aggregate value of all firms. Moreover, when the role of the lawyer as drafting agent is introduced, agency costs and herd behavior among lawyers add to the attractive force of standard terms and introduce the possibility that a firm will adopt a term that fails to maximize its value. Finally, moving outside the realm of rational choice, cognitive biases can further enhance the attraction of standard terms over superior customized terms and lead to the adoption of standard terms that do not maximize a firm’s value.

Marcel Kahan & Michael Klausner, *Path Dependence in Corporate Contracting: Increasing Returns, Herd Behavior and Cognitive Biases*, 74 WASH. U. L.Q. 347, 365-66 (1996).

unincorporation (and certain other similar statutory manifestations of the pure contractarian ethos) seems either to banish fiduciary duties from the statutory scheme or to make such duties default rules that may be subject to contract between the parties.<sup>676</sup>

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676. See, e.g., UNIF. PARTNERSHIP ACT §§ 103, 404(b) (1996).

Mr. Keatinge's article, *Corporations, Unincorporated Organization, and Unincorporations: Check the Box and the Balkanization of Business Organizations*, see *supra* note 654, is silent as to fiduciary duties. In suggesting statutory change from a default exit strategy to no exit strategy, I think he should implicate other networked duties. At least if there is a statutory default provision, fiduciary duty becomes a matter of negotiation or, as Keatinge correctly pointed out, the lawyer avoids the negotiation by selecting a different entity. Federal estate and gift taxation, however, exert some evolutionary pressure toward removing statutory default exit strategies. See, e.g., 26 U.S.C. § 2703(b) (1994).

Let me also explain that I do not use the label "contractarian" as a pejorative term. Furthermore, to the extent that contractarians have some identity of interest with the law and economics movement (whose followers are called lawyer-economists below) the following quote observes that even contractarians recognize some minimum good faith standard:

Generally, lawyer-economists assert that the parties to a particular transaction are in the best position to value the exchange and, therefore, that the parties should be permitted to opt out of even default obligations. When asked to explain why they nevertheless favor a mandatory minimum standard of performance, the lawyer-economists respond that the standard of good faith prevents opportunism and that opportunism is indefensible because it is inefficient.

Claire Moore Dickerson, *Cycles and Pendulums: Good Faith, Norms, and the Commons*, 54 WASH. & LEE L. REV. 399, 404-05 (1997) (footnotes omitted). The quote is consistent with this article because, I assume, the economic label for one flavor of opportunism is information cost. Information cost is really at the heart of my suggestion that some sort of statutory system should be developed whereby several statutory provisions, including exit right provisions, are networked and tuned as a system, and that the public be offered more than one such system from which to choose. Professor Dickerson would seem to agree with such a networking approach because she suggested that "[t]he [g]ood [f]aith [n]orm [i]s on a [c]ontinuum from [g]ood [f]aith to [f]iduciary [d]uty." *Id.* at 405. Moreover, if one assumes that law influences behavioral norms over time (even just a little), then the absence of networking law may actually erode trustworthy behavior to the point where opportunism becomes commonplace, and to where Fukuyama would argue the level of trust is too low to support efficient economic activity. See generally FUKUYAMA, *supra* note 673, at 43-48, 50 (noting that "the most important lessons we can learn from an examination of economic life is that a nation's well being, as well as its ability to compete is conditioned by a single, pervasive cultural characteristic: the level of trust inherent in the society"). Dickerson aptly analogized fiduciary duty (trust) to "the commons," as follows:

A positive way to approach the minimum mandatory standard of good faith in the business-commercial context is to think of the good faith norm as part of the commons. We usually think of the commons in the context of environmental law, particularly when considering nonrenewable resources. The commons, for example, include the ocean and the atmosphere. . . . When there are nonrenewable resources, the incentive to act as a free rider is potent: If a person harvests one more whale, cuts down one more rain forest tree, or pours into the atmosphere one more cubic meter of pollutants, that person

appropriates one whole unit of the common good, but shares in only an infinitesimal part of the resultant cost. The other owners of the commons, together, bear the vast majority of the cost.

Dickerson, *supra*, at 433 (footnote omitted).

In the same issue of that law review, entitled *Symposium on the Future of the Unincorporated Firm*, Professor Larry E. Ribstein went on the offensive for "pure contractarian values." I strongly agree with portions of his conclusion, the first relevant part of which is that:

[F]iduciary duties should be broadly waivable in partnerships and other unincorporated firms. Because the costs and benefits of fiduciary duties vary from firm to firm, these duties must be varied to suit the particular relationship. The parties themselves are in a far better position than courts to determine precisely what level of duties should apply to their relationship.

Larry E. Ribstein, *Fiduciary Duty Contracts in Unincorporated Firms*, 54 WASH. & LEE L. REV. 537, 594 (1997). Second, I agree that: "A concern for norms and morality does not make analysis unnecessary." *Id.* In fact, there are only a few items of importance in Ribstein's conclusion with which I disagree, and those I disagree with only because they are inconsistent with network analysis. The major point with which I disagree is the ghost of negative implication inherent in the following two statements read in conjunction: "[n]ormative analysis should focus on specific problems that may be caused by permitting waivers" and "[i]t is also time that the commentators drew conclusions only from close examination of large numbers of cases rather than relying on sporadic dicta." *Id.* The ghost of implication is that you can look at any provision in this area in isolation without considering the total deal. Moreover, while I agree that duties should be largely waivable, I think looking at case law is a necessary, but insufficient, part of the analysis because many cases involve lawyered deals (at least where there exists waiver) and in most cases both parties have decided to contest the issue. In other words, the parties have determined that (1) there was enough money at stake to litigate; and (2) the opposing parties see the issues as close, meaning the parties each have expert legal information on which to base a judgment (legal representation). Thus, I think using cases as the statistical sample may be nonrepresentative of what is actually occurring.

Moreover, a large number of cases implies linear statistical reliance or averaging. It should come as no surprise that I suggest we live in a nonlinear world where even single instances of dicta may be vitally important. Finally, it is certainly consistent with this article that courts, as stated by Ribstein, have generally allowed waiver. Recall that complex systems are very sensitive to initial conditions. I have not looked at all the case opinions that Professor Ribstein cited (and without a copy of the agreement in its entirety underlying each of those opinions, the opinions are at best based upon incomplete information), but query whether the aggregate balance of provisions might fall within an overall normative pattern of commercially acceptable behavior. For example, a limited partner may be better protected, or at least more in control, by the general partner's agreement to submit annual budgets for approval by the limited partner, when coupled with a specific contractual provision requiring the general partner to render and distribute complete financial and managerial accounting reports, than by any bold imposition of the "highest punctilio" of honor and duty on the general partner. *Meinhard v. Salmon*, 164 N.E. 545 (N.Y. 1928) (imposing fiduciary duty of the highest punctilio of honor).

My point is that law should encourage parties to contract concerning the major life events and management of the firm and, within some broad aggregate parameters, provide a great deal of party-specific contract flexibility. As an aside, we apparently even need to tread

Keatinge, in commenting on free transferability of interests which he discussed concurrently with fiduciary duty, stated that "the argument in favor of the right to put an interest back into an organization should be no greater than it is for a closely held corporation."<sup>677</sup> For Keatinge's narrow and special purposes of determining what changes could be made in unincorporated entity statutes that would increase the initial popularity of those statutes upon formation, the disclaimer he offers works and is valid. Some commentators, on the other hand, have viewed the general-purpose business corporation laws as rather ill-suited for the small closely held corporation<sup>678</sup> because of a market imperfection: the lack of a market for their shares, which certainly weakens the force of Keatinge's disclaimer.<sup>679</sup> This lack of fit between the corporate form of business and the needs of closely held firms is widely accepted. Indeed, as evidenced by a student note: "deadlock is inherent to close corporations,"<sup>680</sup> and that "a greater potential danger exists [in close corporations] than in public corporations that minority shareholders will be treated inequitably,"<sup>681</sup> and further, that "[o]ther problems inherent in the lack of a public market for the close

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carefully in assuming that Americans, as a group, dislike regulation. Perhaps, as observed in the *Economist*, it is regulation, or more importantly in my opinion, the expectation that such regulation exists as a safety net, that allows contractual freedom:

[i]t may be perverse, given the consumer benefits that have come from the deregulation of airlines and telecoms, but most ordinary Americans do not, in their hearts, want less regulation. They see it as the individual's protection against "big business", and lawyers as necessary parasites. In short, regulation makes them feel comfortable.

It was ever thus. Whatever the myths of Hollywood, the reality is that Americans have from the beginning chosen to be regulated. The wagon trains rolled west only when their passengers had first signed detailed contracts . . . .

In other words, America can indulge its individualism only by setting limits to it. This is the genius of the [C]onstitution and the Bill of Rights. Checks and balances between the three branches of government protect the individual's rights by limiting the powers of the state, but make the individual subject to the law. The American citizen can then be anti-statist with a self-confidence that to the French, let alone the Confucianist Asians, is simply incredible. Anti-statism, to the American mind, has no link to anarchism.

*In Love with Regulation*, ECONOMIST, Aug. 2, 1997, at 21, 21. But see ROBERT KUTTNER, EVERYTHING FOR SALE: THE VIRTUES AND LIMITS OF MARKETS (1997).

677. Keatinge, *supra* note 654, at 244.

678. A general definition of "closely held corporation" or "close corporation" is "a corporation with relatively few shareholders and no regular markets for its shares. Close corporations usually have never made a public offering of shares and the shares themselves may be subject to restrictions on transfer." ROBERT W. HAMILTON, THE LAW OF CORPORATIONS IN A NUTSHELL 563 (4th ed.1996).

679. See generally *id.*

680. Tara J. Wortman, Note, *Unlocking Lock-In: Limited Liability Companies and the Key to Underutilization of Close Corporation Statutes*, 70 N.Y.U. L. REV. 1362, 1369 (1995).

681. *Id.* at 1370 (footnote omitted).



corporation's shares include high uncertainty in the valuation of residual claims and the loss of the stock market as an aid to monitoring performance."<sup>682</sup>

These and other problems caused by the poor fit between general business corporation law and closely held businesses have led one of the leading chroniclers of close corporations to summarize as follows:

The legislation and judicial decisions providing for enhanced fiduciary duties, an individual cause of action for majority oppression, expanding dissolution rights and alternative remedies reflect this reality more accurately than the traditional statutory and fiduciary norms, which overlooked the intimacy of the participants' relationship, the illiquidity of their investment, and the inability of participants in such enterprises to plan adequately for disharmony.<sup>683</sup>

Furthermore, "[i]nvestors often fail to anticipate the failure of their enterprise, or they demonstrate an overly optimistic trust in those with whom they are undertaking the venture."<sup>684</sup> Indeed, courts often "apply partnership principles to relationships of the shareholders in the corporation and to provide partnership remedies when those principles are violated."<sup>685</sup> While Keatinge asserted that partnership principles are based on agency law, it seems that an agency relationship based on underlying business relationships would exist in many of the unincorporated organizations even if not so deemed by partnership law in the context of close firms. By their very nature, those other agency relationships would drag fiduciary duties back into the firm.

Beyond agency law, contract law also provides an independent source for imposing fiduciary-like duties. After-all, the first section of the multi-volume treatise *Corbin on Contracts* is entitled: "The Main Purpose of Contract Law is the Realization of Reasonable Expectations Induced by Promises."<sup>686</sup> Corbin explained that the term "reasonable" was explicitly based on normative social values because:

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682. *Id.* (footnote omitted).

683. 2 F. HODGE O'NEAL & ROBERT B. THOMPSON, O'NEAL'S OPPRESSION OF MINORITY SHAREHOLDERS § 7:02, at 8 (2d ed. 1993).

684. *Id.* at 7-8 (footnote omitted).

685. *Id.* § 7:05, at 41 (footnote omitted). For a recent article that addresses fiduciary relationships and that cites to other sources on that subject, see Scott FitzGibbon, *Fiduciary Relationships Are Not Contracts*, 82 MARQ. L. REV. 303, 303 n.2. (1999).

686. 1 ARTHUR LINTON CORBIN, CORBIN ON CONTRACTS: A COMPREHENSIVE TREATISE ON THE WORKING RULES OF CONTRACT LAW § 1, at 1 (1963).

It must not be supposed that contract problems have been solved by the dictum that expectations must be "reasonable." Reasonableness is no more absolute in character than is justice or morality. Like them it is an expression of the customs and mores of men—the customs and mores that are themselves complex, variable with time and place, inconsistent and contradictory. Nevertheless, the term is useful, giving direction to judicial research, and producing workable results. The reasonably prudent man, reasonable care and diligence, reasonable expectations, are terms that are not to be abandoned, at least until we can demonstrate that others will work better.<sup>687</sup>

Indeed, some courts have already used "reasonable expectations" of the parties as the behavioral standard to be applied in closely held corporation disputes.<sup>688</sup> All of the foregoing suggest that courts will continue to adopt ways to effect fundamental fairness, within normative cultural standards, upon exit, even from the corporation.<sup>689</sup>

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687. *Id.* at 2.

688. See, e.g., *Stefano v. Coppock*, 705 P.2d 443 (Alaska 1985); *Fox v. 7L Bar Ranch Co.*, 645 P.2d 929 (Mont. 1982); *Brenner v. Berkowitz*, 634 A.2d 1019 (N.J. 1993); *Meiselman v. Meiselman*, 307 S.E.2d 551 (N.C. 1983).

689. Trust may be just another societal norm that aids the development of business and a capitalistic economy. Fusing trust and the idea of self-enforcing law, which implicates the existence and necessary operation of feedback loops which are important in CAS systems, Professors Black and Kraakman suggested that:

A further reason why developed countries can make do with weak formal corporate law rules is that managers and shareholders are embedded in a culture that discourages opportunism. In part, the culture reflects the underlying legal norms and the penalties for violating those norms. But cultural attitudes also exist independently of and reinforce the legal norms, so that formal enforcement is infrequently needed.

Bernard Black & Reinier Kraakman, *A Self-Enforcing Model of Corporate Law*, 109 HARV. L. REV. 1911, 1928 (1996). This might explain why management guru Tom Peters has been criticized for his love affair with free markets—it is simply inefficient to continually haggle over price with external sources:

It may well be harder to keep the loyalty of your remaining workers as they see their colleagues replaced by people wearing Accountants R Us buttons. . . . More important, doing work in-house keeps you from having to argue with suppliers over price, lets you keep a tight rein on quality, and gives you control over production. Peters exaggerates the perfection of the market in that respect. General Motors outsourced the production of the bodies of its cars until it grew tired of its suppliers' constant attempts to hold up production in exchange for a better price. Nike keeps insisting that it wants its factories to pay the minimum wage and not employ children, but, since it doesn't actually run the factories, it can only cajole and threaten; it can't just do it.

James Surowiecki, *Company Man*, NEW YORKER, Jan. 19, 1998, at 72, 80. Thus, markets may create transaction costs, and therefore, there is a trade-off for having to bid or outsource all the goods and services of the firm. Perhaps the trust needed to lower transaction costs will be developed through the discipline of the market or long-term relational contracts.

On the other hand, consistent with CAS theory, there is a limit to the benefit provided by additional procedural (operational) rules.<sup>690</sup> Therefore, it is also consistent with CAS theory to suggest that allowing individuals to freely contract within any closely held organizational structure, including the corporate structure, may be advisable for the reasons that Keatinge, Ribstein, and others have argued. Arguably, even providing strong de-linked default rules is not a sufficiently rigid statutory framework to support robustness according to CAS theory. Paradoxically, overly detailed rules do not allow for sensitivity to the context inherent in chaos theory or allow for the flexibility necessary for adaptation in response to learning as suggested by CAS. In other words, the traditional approach of making single free standing sections either immutable or default fails to reflect the importance of the relationship between those sections. Statutes, therefore, need to provide the stability necessary to reach the critical edge of chaos, while at the same time, allowing for self-organization through contractual freedom from statutory constraints.

In fact, the hub-and-spokes statutory organization, various formulations of the unincorporation, and wholesale adoption of contractarian principles, including the absolute right to opt out of all or most statutory norms, all focus on individual statutory provisions. As such, individual parts of the

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Those long-term relational contracts, however, are close in function and form with business organizations. Business organizations, therefore, are paradoxical:

The paradox of the traditional corporation, after all, is that externally it competes in the free market but internally it's centrally planned. If you want to design a new car, for instance, you don't put the project up for bids by different outside teams to find out which one will give you the best price. Instead, you pick your team from among your employees and let it design the car. Similarly, if you need an engine repaired you don't shop around for the best deal. You call your maintenance man and tell him to repair it. Because the maintenance man works for your corporation, it's quicker and easier to have him do it. You trust him to do a good job for his employer, and he trusts you not to make him bargain for a job every time a need arises.

*Id.* at 79-80.

690. As stated in the *Economist* about business governance generally:

[So much] energy has gone in recent years into attempts to reform the way in which companies are governed that an innocent observer could be forgiven for concluding that running a big company is a breeze. All that matters, it begins to seem, is the introduction of proper boardroom procedures. Once managers are held suitably accountable, on this view, they will be forced to take the obvious decisions that everyone knows will boost their firms' performance.

In fact, of course, finding new ways to turn a profit is a mite more complicated than this approach would suggest. And yet the "corporate governance" movement continues to focus on narrow rules and regulations, to the point where producing rulebooks for boardrooms has become something of a cottage industry. In America, Calpers, one of the country's largest public pension funds, recently issued its own new list of boardroom "best practices" . . . .

*Reforming the Firm*, *ECONOMIST*, Aug. 9, 1997, at 16.

statute are de-linked from one another and, therefore, do not communicate with each other. For example, a company opting for a higher (or lower) fiduciary duty than the default statutory provision would normally provide, does not thereby reduce (or increase) the statutory default standard governing exit or informational rights.

A comparison to the history of biology is poignantly illustrative. According to Capra, during the nineteenth century, cell theory grew into the microbiology of Louis Pasteur and became "a new field that revealed an unsuspected richness and complexity of microscopic living organisms."<sup>691</sup> Ultimately this field was reduced to the idea that nature was a mechanism that could be understood by the exclusive study of its parts.<sup>692</sup> Two groups, organismic biologists and vitalists, resisted, to one degree or another, this mechanistic (reductionist) movement.<sup>693</sup>

"Vitalists assert that some nonphysical entity, force, or field must be added to the laws of physics and chemistry to understand life. Organismic biologists maintain that the additional ingredient is the understanding of 'organization,' or 'organizing relations.'"<sup>694</sup> Again according to Capra, "[t]he new science of ecology emerged out of the organismic school of biology during the nineteenth century, when biologists began to study communities of organisms."<sup>695</sup> "As the ecologist Bernard Patten put it . . . 'Ecology is networks. . . . To understand ecosystems, ultimately will be to understand networks.'"<sup>696</sup> Capra then completes the connection this way: "Indeed, during the second half of the century the network concept has been the key to the recent advances in the scientific understanding not only of ecosystems but of the very nature of life."<sup>697</sup>

This organismic or network perspective, especially in comparison with the perspective of currently proposed statutory techniques (*e.g.*, hub-and-spokes, unincorporation), seems to strongly suggest that statutory drafters exercise caution in not becoming automatically focused on single statutory provisions, such as those governing exit or fiduciary duties. This is because such a focus may destroy the linkage necessary for the effectiveness of the entire statutory scheme, thereby destroying the advantages offered by flexibility and structure in tandem. It seems that the default rules of many of the statutes probably are drafted with the whole in mind and that many, if not most, sophisticated "negotiated" entities are also probably drafted as an integrated whole. It is those in-between deals that need the structural

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691. CAPRA, *supra* note 307, at 23.

692. *Id.* at 24-25.

693. *Id.* at 25-27.

694. *Id.* at 25.

695. *Id.* at 32.

696. *Id.* at 35 (footnote omitted).

697. *Id.*

benefit of networked statutory drafting to help the parties recognize the interrelationships between the governing statutory sections.

One way to provide for both more certainty and flexibility while allowing organizers to customize their entities to approach the adaptable and viable critical phase-state consistent with current management and complexity theory, is to first identify the dimensions or characteristics that provide constraints under current organizational law. Hypothetically, assume that the following dimensions were identified: (1) the existence or the creation of a market (real or artificial) for ownership interests and free transferability of those interests; (2) agency authority in the management of the business (perhaps analogous to executive officer authority in corporations); (3) the ability to vote meaningfully on a regular basis to select or remove executive officers or the members of a policy making board (*e.g.*, the board of directors position in a corporation); (4) the standard of care applicable to management (*e.g.*, a type of fiduciary duty typically based on negligence or gross negligence standards of care); (5) the degree of loyalty required, or the conflicts of interest allowed, for both managers and owners (another type of fiduciary duty); (6) information rights and the duty of management to provide regular reports including, but not limited to, financial reports; (7) the total number of owners of the business; and (8) provisions concerning indemnification or insurance.

Because most of these dimensions exist on a continuum of normative business behavior, one approach, consistent with CAS theory, would be to assign a numerical value to the poles of each continuum. For example, if the standard of care for management was gross negligence, then the statute might assign the numerical value of one, but if the standard was simply ordinary negligence, the assigned numerical value might be five. Similarly, the statute concerning free transferability and the existence of a market for the entities' ownership interests might assign the value of twenty to an organization that is either listed on the New York Stock Exchange or that provides for an unconditional right to put shares back to the entity upon sixty days notice. The statute would then require the numerical values to be added together and compared with an immutable numerical standard. In this example, the mandatory standard might be assigned a point value of thirty-five.<sup>698</sup>

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698. Of course, this idea can be mapped in multidimensional phase-space. The flexibility and creativity available in such a system is remarkable. For example, the human sense of taste is only a four-dimensional space—one dimension each for sweet, bitter, salty, and sour. To identify any single taste is to recognize the pattern in four-dimensional taste space. For example:

Any peach, at a comparable stage of maturity, will produce almost exactly the same pattern of activation. That pattern is a kind of signature or fingerprint, specific to peaches in particular. It is not a "mixing together" of four "basic" tastes, as one might be tempted to suppose. Rather, any taste at all, even one of the so called basic tastes,

The advantage of such an approach is that it would measure the bundle of protective rights while acknowledging that the protections are cumulative and related, rather than atomistic. It would also provide far greater flexibility than mandating individual standards that may or may not make business sense in the context of any single business organization. Paradoxically, of course, it would make planning more indeterminate, and therefore, more complex even though it would likely provide a better framework for analysis by courts. Such a statute could be free standing and be applied across organizational boundaries and, therefore, could fit nicely into either a hub-and-spokes statutory structure or an unincorporation structure. In other words, this is a novel protective statutory cocktail approach to providing both normative behavioral boundaries and broad individual contractual latitude.

This theory is, in some ways, similar to the "menu" default approach suggested for corporate law by Professor Michael Klausner.<sup>699</sup> The menu default approach, theoretically based on economics, recognizes that standardization may have a value for the consumer or user of the product.<sup>700</sup>

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is a unique pattern of activations across all four of the four cell types. CHURCHLAND, *supra* note 325, at 22. The beauty is that "[s]uch a simple system hides an unexpected strength." *Id.* at 23. That strength is that "[i]f one can usefully discriminate, say, only ten distinct levels of activation along each of the four axes, then the total number of four-element patterns one can discriminate will be  $10 \times 10 \times 10 \times 10 = 10,000$ ." *Id.* Here, the legal "smell test" (which is often vilified) simply begs to be noted. Because humans "possess at least six distinct types of olfactory receptors . . . [t]he capacity to discriminate only ten positions along each of these six axes would yield the overall capacity to discriminate 106, or fully one million, distinct aromas." *Id.* at 27. If a legal decision has only six factors, each representing one dimension, and none of the legal factors are outcome determinative (*i.e.*, requiring a facts and circumstances test), then the facts of the case can generate fully one million variations through which the hornbook author needs to sift. This seems to implicate the extreme importance of the initial conditions (facts) in which the taste system finds itself. This sensitivity to initial conditions is one of the attributes of both chaos and complexity theory.

699. See Klausner, *supra* note 670, at 757.

700. *Id.* at 763. These values are known as "network externalities." *Id.* (footnote omitted). Examples given by Klausner include VHS video cassette recorder/players and IBM-compatible personal computers because the value of the VHS recorder to the consumer, for example, is dependent on how many other consumers select the VHS format rather than the Beta format. *Id.* at 763 n.14. It is most easily illustrated (I think) with the following hypothetical. Assume you want to buy a video cassette player for occasional personal use. You go to a garage sale and you may purchase either a Beta or VHS format recorder for \$25. Assuming they both work, which do you buy? You would probably buy the VHS, because more people use that format, and as a result there are more VHS movies available, among other things. The difference between the value of the VHS and Beta formats is an example of network externalities.

Klausner suggested that there might be positive network externalities for a corporate statute that, rather than simply providing default provisions which could be contracted over,

The feature that the menu approach fulfills better than the protective cocktail is greater certainty through more standardization.

Note, however, that the menu approach gets farther away from the contractarian ideal of uniquely customized provisions, because the drafter is required to select one of the provisions provided by statute. This limits the strong contractarian tradition of individual organizations overriding the statutory default provisions. Of course, networking could be accomplished under the menu default approach by assigning point values as is done under the protective cocktail approach, which would provide the flexibility to make it practical for actual use. This menu plus value assignment might be a very appropriate approach to corporations, if one assumes that corporations will remain the entity of choice for publicly held companies. Network externalities would seem to be greater in widely held publicly traded organizations as more investors require information unique to the product. Thus, standardization through the menu approach might result in less information cost to the market.

Obviously, the protective cocktail approach is far outside mainstream thinking and outside even the most expansive view of political possibility.<sup>701</sup> With the foregoing admonition, however, the protective cocktail approach illustrates how CAS theory might be used to influence both statutory drafting and regulatory approaches. Although it is not yet a ripe prescrip-

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would provide a "menu" of three or four standardized choices on various important provisions. The positive externality, according to Klausner, may come from several sources: "More judicial precedents can be expected, on average, to enhance the clarity of the term. Common business practices implementing the term may become established, further reducing uncertainty. Legal advice, opinion letters and related documentation will be more readily available, more timely, less costly, and more certain." *Id.* at 761. It appears that the network idea has caught fire among institutional economists:

The science of economics was born from a metaphor when François Quesnay applied the concept of blood circulation to the distribution of market products. The metaphor was applied by researchers attempting to gain insights into the new field, and eventually the new concepts were adapted to the object of research, thus creating a new field of knowledge. I attempt here to repeat the process with a new concept, namely that of a network, now very much in vogue. Networks of firms are associated with the search for improvement of technical efficiency of productive systems. In the same way, we can create conceptual networks as a new methodology with the purpose of enhancing previously isolated concepts.

Fábio Sá Earp, *Transactions, Circuits, and Identity: Proposing a Conceptual Network*, 30 J. ECON. ISSUES 407, 407 (1996) (footnote omitted).

701. I am particularly sensitive to the observation by the *Wall Street Journal* about a law professor's testimony to Congress about political voting rights which questioned "[w]hy is it that the 43-year-old legal educator had no inkling of how unrealistic were her prescriptions for one of America's gravest social issues? The fact is, by [the professor's] . . . student days in the '70s, the nation's elite law schools were increasingly exalting theory over practice." Mary Ann Glendon, *What's Wrong with the Elite Law Schools*, WALL ST. J., June 8, 1993, at A16.

tion, it is a powerful idea borrowed from science. Moreover, these dimensions would provide a strong structure for the development of the common law and would seem to be no more difficult to use than a host of other "facts and circumstances" or "economic realities tests" already used by courts in a relational setting.

#### V. CONCLUSIONS ABOUT ENTITIES, THE PRACTICE AND BUSINESS OF LAW, AND COMPLEXITY

"The environment is the theatre . . . and evolution is the play."<sup>702</sup>

Because the business of the law firm will be subject to the same evolutionary forces as the rest of business, the litany of advice from business consultants might be equally applicable to lawyers and law firms. Thus, for example, technology, speed, the use of paraprofessionals, and the need for innovation will challenge the law business just as it has challenged business in general.

In his article, *Opening the Mind's Eye*, Steven Keeva gave consulting advice specifically addressed to lawyers. Therein, he wrote that much like the corporate business environment, "increased competition has created an environment in which the need for a unique palette of products and services mirrors the business world like never before. Yet the legal profession does not emphasize creativity the way business does. That has to change."<sup>703</sup> As "18th-century British statesman and orator Edmund Burke remarked . . . a legal education sharpens the mind by narrowing it. True enough. And a mind narrowed by a legal education can be an extraordinarily incisive, useful tool. But a narrowed mind also can overlook a great deal."<sup>704</sup> Indeed, "[p]eople who study the creative process say it is often the outsider—the person from a different culture or discipline—who brings the freshest approach to problems."<sup>705</sup> This does not now seem surprising, because in the jargon of CAS, this is just another way of suggesting that diversity has its advantages.<sup>706</sup>

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702. See EDWARD O. WILSON, *THE DIVERSITY OF LIFE* 80 (1992) (attributing the remark to ecologist G. Evelyn Hutchinson).

703. Steven Keeva, *Opening the Mind's Eye*, A.B.A. J., June 1996, at 48, 49.

704. *Id.* at 50.

705. *Id.* at 51. Peters quoted Chicago Bulls basketball coach Phil Jackson as saying that Dennis Rodman "'was respected, because he brought a reality change.'" TOM PETERS, *THE CIRCLE OF INNOVATION: YOU CAN'T SHRINK YOUR WAY TO GREATNESS* 367 (1997). He further reported that Jackson compared Rodman to the "Sioux heyoka, the cross-dressing, backward-talking tribal clown." *Id.*

706. The diversity of perspectives on law in academia was evidenced by a program



entitled "Perspectives on Law," which was presented and sponsored by the American Association of Law Schools on January 4, 1996. The following perspectives were acknowledged in the program: Critical Legal Studies, Critical Race Theory, Feminist Theory, Game Theory, Gay & Lesbian Theory, Law & Economics, Law & Literature, Law & Society, Organizational Theory, Pragmatism, Public Choice, Republicanism, and Storytelling.

In my opinion as an academic lawyer, one of the real values that CAS theory might add to academia is that it validates (and indeed celebrates) all these views, because complex adaptive systems need diversity. For a scathing attack on the lack of tolerance and diversity in the universe of all academia, see generally MARTIN ANDERSON, IMPOSTORS IN THE TEMPLE (1992). Much of the foregoing was hinted by Professor Linz Audain in a 1992 article:

[T]he foregoing argument puts the intellectual cart before its horse. Indeed, the primary objective of this Article is to present an analysis of the "dialogic structure" of the three main jurisprudential movements (*i.e.*, CLS, Feminism, and L&Ec). I argue that it is the dearth of intellectual tolerance which has prevented the participants within each movement from engaging in "full dialogue."

Linz Audain, *Critical Legal Studies, Feminism, Law and Economics, and the Veil of Intellectual Tolerance: A Tentative Case for Cross-Jurisprudential Dialogue*, 20 HOFSTRA L. REV. 1017, 1021 (1992) (footnotes omitted). Thus, perhaps complexity theory, which is holistic and inclusive as opposed to reductionist, will help start the collaboration because it validates many different reductionist academic and scientific pursuits and recognizes the importance of each. This would require a shift in thinking. As stated by Arthur Burks over twenty years ago:

Reality is a host of complex systems: dynamical, biological, chemical, evolutionary, thermodynamical, ideological, etc., etc. Because of their complexity, to learn about any one of them man must begin with a simplified, idealized view or model of it and, on the basis of empirical data, improve this model by successive approximations. Hence a scientific theory represents certain aspects or features of reality, but not all. No theory can tell us everything about reality, because reality is more complex than any theory could be.

ARTHUR W. BURKS, CHANCE, CAUSE, REASON: AN INQUIRY INTO THE NATURE OF SCIENTIFIC EVIDENCE 31 (1977).

Perhaps one way to start this dialogue would be to look for commonality, rather than diversity, as an aid for understanding and collaboration such that diversity of opinion could later be celebrated. For example:

In the past, the humanities and the sciences of human behaviour have been dominated by their celebration of the diversity of human behaviour. Anthropologists were delighted to find new customs, novel habits, and different practices the world over. Common factors were ignored as uninteresting. Sometimes it became a little too easy to find . . . the truth that one wants; not by inventing it, but by allowing the emergence of only that part of the whole truth that one wants to hear.

BARROW, *supra* note 393, at 246. However, dialogue requires a willingness to learn and modify previous positions. Debate without dialogue, it seems to me, crystallizes our single-perspective world-view. Some of this pedanticism may be because we are locked in a linear cause and effect way of thinking. There is a parable in the following Solzhenitsyn quote:

Two years later, in September, 1930, the *famine organizers* were tried with a great hue and cry. (They were the ones! There they are!) There were forty-eight wreckers in the food industry. . . .

In counseling business clients and creating organizations for those clients, nonetheless, the quip that “[w]e have met the enemy and it is us,”<sup>707</sup> is particularly relevant because, as Tom Peters and others have asserted, the model for knowledge-based organizations will be the professional service firm.<sup>708</sup> Many organizations will attempt to copy the law firm’s organization to the extent that the traditional law firm was project-oriented and largely decentralized, reorganizing itself to complete each given project by applying knowledge.

Therefore, in an interesting paradox, studying law and other professional service firms is not only a planning exercise for those firms but for their business clients as well. Unfortunately, that means that the law firm will transfer to its clients its difficulties and complexities. Inevitably, some of the intractable organizational problems that now confront professional

Stalin carried out the first such effort in connection with the trial of the *famine organizers*—and how could it not succeed when everyone was starving in bounteous Russia, and everyone was always looking about and asking: “Where did all our dear bread get to?” Therefore, before the court verdict, the workers and employees wrathfully voted for the death penalty for the scoundrels on trial. . . . It was the newspaper march of millions, and the roar rose outside the windows of the courtroom: “Death! Death! Death!”

1 SOLZHENITSYN, *supra* note 378, at 47-48.

707. Walter Kelly, cartoonist (quoting his comic-strip character *Pogo*) (on file with author). I would like to thank John Hagemann, professor, law librarian, and friend, for his help in finding this and many other miscellaneous citations for this article and through our ten-year association.

708. In his book *Liberation Management*, Tom Peters stated:

Though I’d worked at the big consulting company McKinsey, revelation came while doing research at CNN, then reviewing research that colleagues had done . . . [a]ll firms are becoming professional service firms.

The wonderful news: Professional service firms have long been organized in a different manner, to deal with their historically more fickle environment of shifting, temporary assignments.

TOM PETERS, *LIBERATION MANAGEMENT: NECESSARY DISORGANIZATION FOR THE NANOSECOND NINETIES* 11 (1992). Peters renewed this call in his newest book:

Professional service delivery is pure, raw brainwork. The assets of professional service firms aren’t “hard.” (They rarely own the buildings they occupy . . . or their computers . . . or even the plants in the entry way.) It all boils down to the expertise of its people, masses of them, booking, in some cases, BILLIONS OF DOLLARS in revenues.

My goal is to help you learn from the best of the best: real, top-flight professional service firms (KPMG, Deloitte & Touche, IDEO, Andersen Consulting, McKinsey). And my suggestion is that you seriously consider . . . NOW . . . transforming your department, your unit into a professional service firm.

PETERS, *supra* note 705, at 200.

service firms will soon confront other organizations. Nonetheless, lawyers should take comfort in their collective history. Historian Daniel J. Boorstin, for example, entitled a chapter in one of his books "Generalized Go-Getters: Lawyers."<sup>709</sup> Therein, he observed that the flow of investment from the eastern cities to places like Montana, Wyoming, and Colorado in the late 1800s "opened the way for enterprising lawyers who had new duties and opportunities as promoters, organizers, and intelligence agents."<sup>710</sup> Boorstin's list included many, strictly speaking, non-law functions which are today representing an increased competition from non-lawyers.<sup>711</sup> Foreshadowing the current economy's substitution of knowledge for capital, Boorstin wrote:

It was the day of the organizer, the man who prospered by inventing new ways of drawing small units into more profitable large combinations. In the sprawling nation, the lawyer was apt to know how it could (and couldn't) be done. If he was clever, ambitious, and energetic, his know-how could serve him for capital.<sup>712</sup>

Turning from the *business* of law to the *profession* of law, Boorstin also credited Langdell's case method of instruction in law schools as an

709. DANIEL J. BOORSTIN, *THE AMERICANS: THE DEMOCRATIC EXPERIENCE* 53 (1973). Lest we lawyers succumb to hubris, it should be noted that, among the other characters listed as "Go-Getters" are "Lawless Sheriffs and Honest Desperadoes." *Id.* at xi.

710. *Id.* at 53. The phrase "intelligence agents" probably means lawyers performing factual due diligence functions.

711. To some, the conflict between the professions that deliver legal services and those that deliver accounting services, boils down to the "accountants' duty toward objectivity and public disclosure of financial statements, and lawyers' obligations to act as advocates and guard their clients' secrets." John Gibeaut, *Squeeze Play: As Accountants Edge into the Legal Market, Lawyers May Find Themselves Not Only Blindsided by the Assault but also Limited by Professional Rules*, A.B.A. J., Feb. 1998, at 42, 43. It seems to me those traditional definitions are extreme enough to be caricatures of the professions rather than any depiction of professional reality.

Interestingly, the professional competitive dispute directly implicates efficiency and international trade. Concerning efficiency: "Accountants say they can deliver cheaper services more efficiently than law firms. And, while the accounting firms insist they are not practicing law, it may all be a matter of semantics." *Id.* at 44. Concerning international trade:

Perhaps more troubling is the GATT treaty, which governs most international trade matters, says Ward Bower, a Newtown Square, Pa., lawyer who chairs an International Bar Association committee on multidisciplinary practices. GATT purports to bestow jurisdiction over the professions through the World Trade Organization, which historically has been biased against self-interested regulation.

*Id.*

712. BOORSTIN, *supra* note 709, at 56.

important advancement because its purpose “was not merely to acquaint the law student with the doctrines of law but . . . to give him ‘such a mastery of these as to be able to apply them . . . to the evertangled skein of human affairs.’”<sup>713</sup> Thus: “While the training of lawyers was given a new academic dignity, law students were rapidly given a wide and usable knowledge of practical legal situations. The law, once a metaphysic, had become a social science.”<sup>714</sup>

There have been, however, some troubling criticisms of the legal profession that should concern us from a CAS perspective. First, the trend toward more de facto legal specialization at the educational level may be troubling because it may constrain the ability of the profession to adapt. A related point is the depth of the law’s “detail” for purposes of providing more certainly (less discretion). Cardozo explained that “‘over-emphasis on certainty may lead us to . . . intolerable rigidity. Justice . . . is a concept by far more subtle and indefinite than is yielded by mere obedience to a rule.’”<sup>715</sup> As Economist Friedrich Hayek noted, “Law is not coercive . . . if ‘it permits you to adapt.’ But if it tells you exactly what to do, it has all the characteristics of coercion.”<sup>716</sup> Thus, presaging CAS analysis, Hayek suggested that too many “[r]ules preclude initiative. Regimentation precludes evolution.”<sup>717</sup> Hayek added that,

This trend toward legal detail was not confined to government. Business agreements in the United States now run to several hundred pages of single-spaced typing as the parties try to contemplate and negotiate every eventuality. . . . When working on a contract, one lawyer received a proposed definition of the words *and/or* that was over three hundred words in length.<sup>718</sup>

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713. *Id.* at 63. Professor Ronald J. Gilson has also observed, like the quote in the text, that much of what business lawyers do is non-law related:

Recognition that business lawyers play the role of transaction cost engineers, and that their historical domination of that role rests neither on its inherently legal character nor . . . on skills acquired through traditional legal training, yields two visions of the future. In one, the legal profession continues to play a central role in designing the structure of business transactions. In the other, however, the profession’s transactional role is reduced from engineer to draftsman, at the expense of lawyers’ prosperity and the intellectual interest of their work.

Ronald J. Gilson, *Value Creation by Business Lawyers: Legal Skills and Asset Pricing*, 94 YALE L.J. 239, 301 (1984).

714. BOORSTIN, *supra* note 709, at 64.

715. HOWARD, *supra* note 558, at 52.

716. *Id.* at 53.

717. *Id.* at 50.

718. *Id.* at 26.

The existence of a legal trend for detail is evidenced by the partnering phenomenon in the construction industry. This trend seems to add too much rigidity to chaos, which inhibits creativity and adaptability as law moves out of complexity at the edge of chaos.

A second trend is the continued disparaging public perception of lawyers and what they accomplish. The following quote from a management consultant disturbingly illustrates the perception of the profession's limited role: "It is not surprising that lawyers have not concerned themselves with this . . . phenomenon. 'Organization' is not a legal term any more than are 'community' or 'society.'"<sup>719</sup>

Perhaps the foregoing criticism implicates one of business consulting's buzz words: trust. Tom Peters devoted an entire chapter to trust, calling it "[t]he [m]issing 'X-Factor.'"<sup>720</sup> Francis Fukuyama devoted an entire book, *Trust: The Social Virtues & The Creation of Prosperity*,<sup>721</sup> to it. Fukuyama forcefully stated that "one of the most important lessons we can learn from an examination of economic life is that a nation's well-being, as well as its ability to compete, is conditioned by a single, pervasive cultural characteristic: the level of trust inherent in the society."<sup>722</sup> Perhaps by encouraging rather than discouraging cooperation, and thereby trust (as a CAS approach demands), lawyers could foster trust to help facilitate the evolution of organizational structures. Such an approach might also help lawyers find meaning and value in their own work.<sup>723</sup>

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719. PETER F. DRUCKER, POST-CAPITALIST SOCIETY 50-51 (1993). Perceptions, for current purposes, are as important as reality. Nonetheless, there was much ado made about the difference in the number of lawyers in the United States and Japan. In an article that has become a classic, Professor Gilson suggested that part of the reason for the difference is cultural, in that "[t]he Japanese do not behave opportunistically *vis-à-vis* each other; Americans do. Each country has thus adopted an approach to contracting that best fits its national character." Gilson, *supra* note 713, at 308. He also speculated that part of the reason the Japanese are less opportunistic in their deals is because of the *Nenko* System, which results in repeated bargaining between the same negotiators as both climb the corporate ladder in their respective companies. *Id.* at 309. Gilson then suggested that "[i]f the individual behaves opportunistically in one transaction, his credibility in future transactions with the same parties, and therefore the value of his human capital—his value to his employer—is reduced. The result is that a manager can expect personally to bear the cost of his opportunistic behavior, and the incentive to take advantage of a situation is therefore drastically reduced." *Id.* Gilson then cited evidence from a study on American contracting in the "small world" of Wisconsin businessmen, which contextually resembled the Japanese system, as support for his hypotheses. *Id.* at 310.

720. PETERS, *supra* note 708, at 249.

721. FUKUYAMA, *supra* note 673, at 11.

722. *Id.* at 13.

723. Here is the lead from an article that appeared in the *Washington Lawyer* (the official journal of the D.C. Bar):

Question: What do Howard Cosell, Mahatma Gandhi, Molière and Geraldo Rivera have in Common? Answer: All were lawyers who left the law to do something they

As this article has suggested by taking a cue from chaos theory, it is sometimes difficult to see big patterns over time. Yale Law School Dean and Professor Anthony T. Kronman wrote of the tension inherent in the practice of law as a profession. In doing so, he identified both a possible long-term pattern of professional attitudes and, more importantly, one of the sources of tension within the profession that may continually push it toward the adaptive and learning edge of chaos. Echoing a tension similar to the contractarian and fiduciary approaches to business organizational law, Kronman writes the following about the role of the American lawyer:

Just as the view we take of our political system oscillates between republican and contractarian extremes, so too does our view of the legal profession. There are, in fact, two opposing ways of describing the American lawyer's role and responsibilities, one that starts from republican

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considered more interesting. . . .

Thanks for that information go to *Alternative Careers for Lawyers*, a new book by Hilary Mantis, director of Fordham Law School's Career Planning Center . . . . Mantis opens with a statistical presentation of the bad news. "According to a 1992 poll conducted by *California Lawyer* magazine, 70 percent of lawyers surveyed said they would start a new career if they could. A 1990 American Bar Association survey indicated that 23 percent of all lawyers were dissatisfied with their careers. A 1990 Johns Hopkins University study found that lawyers had a greater rate of depression than workers in any of the 104 other occupations studied."

John Greenya, *Outside the Law*, WASH. LAW., July-Aug. 1997, at 19, 19. One of the "recovering lawyers" featured in the article is Harvard Law School graduate Arthur Pearlstein. His recollections and opinion about the practice are telling:

"The problem was that the more I did the things I had always thought I wanted to do in law, the more I found. . . ." He shakes his head, and starts over: "I always felt I was losing people's money. Most of my clients had been small to medium-sized businesses, start-up entrepreneurs whose whole livelihood was tied up in the business. No matter how good a game the lawyers talked, litigation was always a major financial drain for them. I tried to make them understand this from the get-go, but it was a no-win situation.["]

"As time went on, I came to feel that we really are a desperately overlitigated society. It's bad. It's bad for business, it's bad for people, and I really didn't take a great deal of satisfaction from being a part of that. I also found that lawyers can be very unscrupulous. I got tired of that, and I started taking things too personally."

*Id.* at 22 (omissions in original). As Professor Allegretti stated in his book, *The Lawyer's Calling: Christian Faith and Legal Practice*:

I have discussed these issues with those who profess no religious faith. Even here, I have found more points of convergence and agreement than disagreement. Regardless of their theological differences, lawyers are *hungry* for meaning. They want their work to count for something. They want it to connect with the fundamental values that sustain them.

JOSEPH G. ALLEGRETTI, *THE LAWYER'S CALLING: CHRISTIAN FAITH AND LEGAL PRACTICE* 5 (1996).

and the other from contractarian premises. Each description yields a sharply different view of what lawyers do and ought to do, of their function and duties in the American political system. Though each pretends to be a complete account, neither, in the end, can be, for the nature of the American legal profession, like that of the larger society it serves, has from the start been defined, with a kind of moral schizophrenia, partly in republican and partly in contractarian terms. This schizophrenia is the source of a permanent division in our thinking about the legal profession, and many of the most familiar dilemmas of legal ethics, which can be restated with endless variety but never really solved, trace their origins to it.<sup>724</sup>

Kronman ultimately suggests that the legal profession is one of oscillation, where the dominance of one view (currently contractarian) is replaced in dominance by another view (republican).<sup>725</sup> Without using the term, he observes certain path dependencies that will slow and limit the effect of the “republican revival in legal ethics.”<sup>726</sup> Kronman’s spoiler was the law and economics movement, which has tended to support the contractarian approach to legal ethics, and “which remains today the most potent force in American academic law, as it has been for more than a quarter-century.”<sup>727</sup> Kronman prognosticated:

Whether the law and economics movement retains its present influence or is, instead, unhorsed by a counter-movement that effectively challenges its foundational assumptions—feminism perhaps, or law and literature perhaps, or neorepublicanism perhaps, or perhaps, most promising of all, a united front comprising all three—will therefore have a large effect on the direction of teaching in our field, and on our ability to restore some measure of balance between the opposing traditions of thought that we have joined in our wonderfully contradictory American venture.<sup>728</sup>

The movements suggested by Kronman might “unhorse” the law and economics academics or the contractarian approach to ethics. Indeed, those movements and others, including the heterogeneous critical legal studies movement, critical race studies movement, and the broader communitarian movement, have probably helped inform the world view of law by providing

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724. Anthony T. Kronman, *The Fault in Legal Ethics*, 100 DICK. L. REV. 489, 493 (1996).

725. *Id.* at 501.

726. *Id.* at 502.

727. *Id.* at 503.

728. *Id.*

diverse thought. In some ways, those movements have contributed, perhaps nonlinearly, to Kronman's perception of direction and change.

Another way of undermining the law and economics movement would be to discredit economic assumptions or, more subtly, *change* economic theory. Certainly, it cannot help the law and economics movement when the *Economist* headlines its cover: "The puzzling failure of economics."<sup>729</sup> While that title is somewhat misleading, one article admonished that: "As long as economists choose to talk loudest about the things they understand least well and to remain silent about the underlying ideas that unite them, this [public perception that economists disagree about everything and know nothing] is unlikely to change."<sup>730</sup>

It is possible, however, that the law and economics movement may become stronger by adapting to such criticism. If it does, it will change itself in a manner that is consistent both with complexity theory and Kronman's idea of directional change.<sup>731</sup> Given the power law distribution of chaos theory, however, any change in economic theory will probably be more like an internal management coup than an external hostile takeover as the science of mainstream economics begins to fully integrate complexity theory,<sup>732</sup> including the theory of complex adaptive systems.<sup>733</sup> As economic theories change, the neoclassical economists may once again welcome economic historians and institutional and political economists into the mainstream of thought. Indeed, technology economists, who use positive feedback in their analysis as represented by Paul Romer, are now literally banging at the neoclassical door and have already been accepted in such

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729. *The Puzzling Failure of Economics*, *ECONOMIST*, Aug. 23, 1997, at 11.

730. *Id.* Further:

Crucial ideas about the role of prices and markets, the basic principles of microeconomics, are uncontroversial among economists. These are the first ideas that politicians and the public need to grasp if they are to think intelligently about public policy, and the fact is that they are not widely understood. Yet because economists take these essential ideas for granted, *they spend their time arguing about much more contentious notions, developed in one disputed way or another from those common underlying principles.*

*Id.* (emphasis added). That was one of three reasons that were listed in the article, apparently in the opinion of the *Economist*, for the failure of economics. The other two reasons given were (1) the perceptions of the public and politicians, in that "whereas most people will admit their ignorance of physics or biology, the armchair economist is convinced that he knows exactly what he is talking about," *id.*; and (2) the fact that many economists simply get the policy wrong by seeing too many market failures and "expect[ing] too much of government," *id.*

731. For a discussion of complexity theory, see Appendix, pt. B, *infra*.

732. For a discussion of catastrophe theory, see *id.*; for a discussion of chaos theory, see Appendix, pt. A, *infra*.

733. For a discussion of complex adaptive systems, see HOLLAND, *supra* note 418.



cross-disciplinary areas as antitrust law.<sup>734</sup> Thus, the new science may

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734. An example of how the "new" economics, in its application to antitrust litigation, has directly affected law, was evidenced in the first high-profile Microsoft antitrust case. According to the *New Yorker* magazine:

In a way, Bill Gates's current troubles with the Justice Department grew out of an economics seminar that took place thirteen years ago, in December of 1984, at Harvard's John F. Kennedy School of Government. The guest speaker was Brian Arthur, a little-known Stanford economist who was having difficulty getting his articles published in professional journals. The paper Arthur now read—"Competing Technologies and Lock-in by Historical Small Events: The Dynamics of Choice Under Increasing Returns"—drew a strong, and largely hostile, response. One Harvard economist, Richard Zeckhauser, stood up afterward and said, "If you are right, capitalism can't work." A few months later, when Arthur read the same paper . . . in Moscow, an equally eminent Russian economist declaimed, "Your argument cannot be true!" Such was Arthur's challenge to economic orthodoxy that it would be another five years before he succeeded in getting this paper published.

John Cassidy, *The Force of an Idea*, NEW YORKER, Jan. 12, 1998, at 32, 32. Basically, according to the Justice Department, and in accordance with chaos theory-based economics:

Microsoft's power comes from its ability to exploit what economists call "network externalities." (Arthur uses the phrase "increasing returns," but he is talking about the same thing.) In plain English, "network externalities" means that the value of a product increases along with the number of other people who are already using it. This is not generally true—few people care how many others are buying the same brand of soap or cornflakes—but it usually applies to high-tech goods, for two reasons: they have to be compatible with one another (a Betamax videocassette player is of no use these days, because it can't play VHS cassettes), and they are often linked to a network, in which case the more people there are on the network the more valuable the product becomes. (A telephone is worthless if you're the only person who owns one.)

*Id.* at 35. In these markets, "[e]ventually, the entire market tips into the hands of one firm, and that company's technology [even though possibly inferior] 'locks-in.'" *Id.* According to Arthur:

In these fast-growing sectors . . . there is no guarantee that the market, left to its own devices, will select the best products and maximize benefits to the consumer. Instead . . . inferior products can beat out superior products merely because of happenstance—by being first to the store shelf, say—and they can remain in a dominant position for a long time. Small events, such as a misleading marketing campaign, can be magnified into big changes in sales.

*Id.* at 32. Thus, prepackaging stand-alone products might surge the momentum of network externalities. For example, the complaint in *Microsoft Corp. v. Intuit, Inc.*, No. C95 1393, WHO (N.D. Cal. filed May 2, 1995), stated that large market shares for personal finance software could be "a cornerstone asset that could be used with its existing dominant position in operating systems for personal computers to seize control of markets of the future, including PC-based home banking." Ilene Knable Gotts, *The "Innovation Market": Competitive Fact or Regulatory Fantasy?*, PRACT. LAW., Jan. 1998, at 79, 85-87 (concluding that in many cases there are too many unknowns for responsible analysis using "innovation market" techniques, which according to Arthur, include the ideas of network externalities and lock-in). For a brief discussion of the work of economist Paul Romer that has knocked at

change economic theory to value a broad individual freedom of choice bound to encourage maintenance of systemic criticality at the edge of chaos.

Given the limits of law to change human behavior, and the limits of a lawyer counseling clients, it seems unlikely that lawyers can embrace encouraging their clients to "trust." An appreciation for the economic changes facing business clients, nonetheless, should make lawyers appreciate the necessity for both speed and flexibility. That appreciation may change the analysis in selecting an overarching drafting approach to documents or the tone of the advice that lawyers give their clients by acknowledging the need for some room for adaptability in the deal. For example, clients may find that in certain circumstances the advantages of speed and flexibility outweigh the advantages of certainty. Consequently, clients may demand and lawyers will provide shorter documents, perhaps more in the style of "partnering" agreements.

The structure of both law and the way its practitioners are organized are probably in a coevolutionary dance with what exists in their common environment. For example, if in-house corporate counsel begin demanding more from their outside counsel "than simply handling their client's legal work," then the evolutionary model would predict that the nature of the product delivered would probably change to meet those client expectations.<sup>735</sup> And it has. According to a recent professional journal, lawyers "are responding to the demands of today's corporate counsel, who are beginning to insist that their outside lawyers think as if they are part of senior management and . . . look out for a company's overall well-being."<sup>736</sup> In fact, the same article quotes Charles Morgan, a partner in a major Chicago law firm and former general counsel for Chiquita Brands, as saying:

"We will all work together better if we can make our relationships with clients more of a partnership," Morgan says. "It is not easy, however." A true partnership requires a significant amount of trust, he adds. "Each party has to look at how to enhance the relationship over the long term." It is a different outlook than most lawyers currently have.<sup>737</sup>

Indeed, "[i]n some sense, this model for practicing law is not new at all. It is really a throwback to when lawyers truly acted as counselors—when skills such as managing and team playing were essential in most lawyer-client

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the door of mainstream neoclassical economists, see Peter Robinson, *Paul Romer*, FORBES ASAP, June 5, 1995, at 66.

735. Jill Schachner Chanen, *Constructing Team Spirit*, 83 A.B.A. J., Aug. 1997, at 58, 59.

736. *Id.*

737. *Id.* at 60.

relationships.”<sup>738</sup> It also seems similar to the building of biological ecosystems to which CAS theory applies.

There is anecdotal evidence that networks among lawyers are expanding and new legal services systems are being developed.<sup>739</sup> Some of these

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738. *Id.* at 59.

739. These networks include delivery, advice, and education networks, all of which raise ethical and professional responsibilities issues. Following are a few examples of such “networks.” The first example is electronic networks, which already exist for lawyers and law-related issues. On August 19, 1997, I received an e-mail advertisement for a product that purported to index 1200 law and law-related discussion list-servers where lawyers may go with questions and comments. Allegedly a free service, it gave the following address: [www.counselweb.com](http://www.counselweb.com). I help moderate a list on unincorporated entities, at [lnet-llc@access.usa.com](mailto:lnet-llc@access.usa.com), and also participated in an on-line CLE the Fall of 1996 on LLCs and again the Spring of 1997 on the ethics of entity selection.

There have also been developments in what has been dubbed the wholesale practice of law. The following quote not only evidences and identifies the wholesale market, but also distinguishes wholesale lawyers from temporary lawyers:

The concept of wholesale lawyering is not entirely new. There have always been wholesale lawyers. They have been called contract lawyers, per-diem lawyers, independent contractor counsel, consulting lawyers, project-specific of counsel, and, over the last year or two, virtual associates. I prefer the term “wholesale lawyer” because it truly captures the essence of what freelance legal researchers/writers/consultants do. They sell their services to “retail lawyers” who, in turn, use these services for the benefit of the ultimate consumer: the client.

A wholesale lawyer is *not* the same as a “temporary lawyer.” A temporary lawyer usually is a lawyer employed by an employment agency . . . . The temp usually works normal business hours onsite . . . for only one law firm or corporation at a time. David A. Robinson, *Some Attorneys Find Happiness Selling Their Services “Wholesale,”* LAW PRAC. MGMT., July-Aug. 1997, at 22, 22-24.

The wholesale lawyer may bring specialized expertise to the relationship, but, for purposes of this article, as important as specific knowledge is the fact that the relationship allows for collaboration:

Even the most brilliant retail lawyer cannot think of everything. The wholesale lawyer may think of factual and legal issues the retail lawyer has missed, and provide another element of objectivity. The wholesale lawyer is to the retail lawyer what the trainer is to the boxer, the editor to the author, the campaign manager to the political candidate. The synergism between two people working toward a common goal is empowering, enlightening and enjoyable to both. Simply put, two heads are better than one.

*Id.* at 24.

A seminal work in the area of lawyer networking was published in 1987, and there is currently a group affiliated with the ABA, with John DeBruyn from Denver, Colorado, as its catalyst, that is attempting to update and modify it for the electronic world. See A.B.A. REAL PROPERTY, PROBATE, & TRUST LAW SECTION, LAW OFFICE WITHOUT WALLS: A HANDBOOK FOR THE CORRESPONDENT RELATIONSHIP AMONG ATTORNEYS (1987) (covering such topics as professional negligence and ethical considerations as well as how to identify and contract the correspondent relationship). This work, to me, was ahead of its time because, for example, it discussed and encouraged the use of electronic communication at

innovations may be either precursors to, or harbingers of, a new generation of increased competition among legal service providers, including network relationships between accounting and law firms:

Price Waterhouse [one of the "Big Six" international accounting firms] approached . . . Miller & Chevalier [a U.S. law firm] to create what may be a first of its kind, at least on such a grand scale: a nationwide marketing alliance with its 55-lawyer tax department, mostly based in D.C., which emphasizes civil court litigation (from which the Big Six firms' practitioners are definitely excluded).

Miller & Chevalier agreed to the deal so long as it was clear that the two professional entities otherwise remained independent of one another. "We plan to go to the clients together, do seminars together and do the work together," says Mr. Sharpiro. But there will be no fee-sharing, and costs will be sorted.<sup>740</sup>

Over time, this kind of alliance may itself evolve into something different. For example, although technically denied, "[i]n a recent issue, the British publication *Commercial Lawyer* reported that 'with an international firm of 1,000 lawyers already in place, year 2003 at the latest, 2001 earliest, is the target date for the creation of [Andersen's] full global law firm.'"<sup>741</sup> As a Price Waterhouse partner stated, consistent with parts I and II of this article, "Blame it on the global economy."<sup>742</sup> Other law firms are associat-

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a time when a minimum suggested computer memory was 265K. *Id.* at 136.

Another resource and a project worth noting is the lawyer *Mentor Program*, which states in its materials that:

Most successful lawyers can identify one or more lawyers who have helped them become better practitioners. These mentors have guided their proteges through the often turbulent waters of law practice. Increasingly, however, traditional patterns of mentoring, in firms and communities, are threatened by the economic pressures and other realities of modern life and lawyering. As a result, many bar associations have recognized the importance of an organized mentor program for the positive professional development of less experienced lawyers.

SENIOR LAW. DIV., A.B.A., MENTOR PROGRAM: RESOURCE GUIDE 1 (1996). The *Resource Guide* identifies several types of programs. Statewide programs are available in New Mexico, North Carolina, Texas, and Wisconsin. *Id.* at 31. Accredited law schools in Georgia and the University of Memphis School of Law, at least, have law school mentoring programs that match students with practicing lawyers. *Id.* at 112-13, 118.

740. Darryl Van Duch, *Big Six in Hot Pursuit of Legal Biz*, NAT'L L.J., Aug. 18, 1997, at A1, A13.

741. *Id.*

742. *Id.* The partner was formerly "chief of staff of the congressional Joint Committee on Taxation and is currently the managing partner in charge of policy and strategy for Price-Waterhouse." *Id.* See generally ELLIOTT A. KRAUSE, DEATH OF THE GUILDS: PROFESSIONS, STATES, AND THE ADVANCE OF CAPITALISM, 1930 TO THE PRESENT (1996) (examining the

ing together in the franchise format.<sup>743</sup> Beyond reactionary changes, Kronman also posited that:

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decline of the reputation, autonomy, and in some cases income, of the American medical establishment, British solicitors, academics in Germany and Britain, engineers around the world, and other professions in the U.S., Britain, France, Italy, and Germany).

743. According to a book on franchise law firms:

Franchise law firms can be best understood as part of a process in American society Ritzer (1996) has called "McDonaldization." McDonaldization combines the principles of franchises, bureaucracies, scientific management and assembly lines to achieve a maximum level of rationalization in the creation and delivery of products and services. Within the context of law this means organizing the law firm and legal work to minimize the efforts of lawyers as experts and put more responsibility into the hands of support staff.

JERRY VAN HOY, *FRANCHISE LAW FIRMS AND THE TRANSFORMATION OF PERSONAL LEGAL SERVICES* 27-28 (1997). The premise of these firms is to sell standardized basic services. Problems that the standardized system is "not equipped to handle are usually turned away. . . . This suggests there is little reason to believe clients are receiving inadequate services." *Id.* at 60. Neither are they being provided any unique or customized services.

The economics of these firms rests, at least in part, on three legs: (1) the need for relatively inexpensive basic services; (2) the gap between academic and mental skills taught in law school and what is expected of lawyers by clients; and (3) a market overhang of young inexperienced lawyers needing both experience and a paycheck. As a branch manager for a franchise firm bluntly stated:

There's a great resource out there of young attorneys. Every year the law schools are turning them out. Huge amounts, right? This year we're going to have maybe 4,000-5,000 passing the bar, being admitted and looking for jobs. They're willing—we started [my staff attorney] at the salary of \$24,000. They're willing to work for \$24,000 for the experience alone! Law school has been 50 percent of what they're doing. Now it's actual practice. It's dealing with people. It's all the guidelines that they can't do alone. We're almost at a point where, if we wanted to, we could be like the medical profession and drive them down to an intern's fee of \$15,000 or \$10,000 because of the need for experience. And it's getting to be that way because there is a huge surplus of young attorneys out there. I don't need him to do all the work that's necessary for fill-ins. If it's a serious case, I'll handle it. I could turn over an attorney every two years, and that's the way it works.

*Id.* at 37. The legal profession, therefore, joins "for-profit emergency medical clinics, franchise-style income tax preparation services and a growing number of chains [*e.g.*, mall optometrists and funeral directors] that offer other limited professional services." *Id.* at vii. Mistaking the character of a system as closed, open (dissipative) or autopoietic has dire analytical consequences in analyzing law firm competition. For example, Van Hoy argued that Abbot and others who have "developed a complex ecological theory of a system of professions . . . [based on the argument] that professions and other occupations compete in an essentially closed social system for the resources to define and control a limited number of esoteric knowledge jurisdictions" have missed the mark. *Id.* at 4. Thus, "by excluding market forces from their analyses, theories of the professions have excluded an important element of the environment in which professionals interact with clients, their employers and the larger society." *Id.* (citations omitted).

The most demanding and also most rewarding function that lawyers perform is to help their clients decide what it is they really want, to help them make up their minds as to what their ends should be, a function that differs importantly from the instrumental servicing of preestablished goals. It is this enterprise of codeliberation that the lawyer-statesman ideal places at the center of the lawyer's professional life.<sup>744</sup>

Undergirding Kronman's ideal is that "most clients . . . want . . . not just a string of discrete judgments about various aspects of their problem, but deliberative advice as to what they should do, all things considered. The ability to give such advice is what distinguishes the wise counselor from the technocrat."<sup>745</sup> Or, as "the famous lawyer and statesman Elihu Root said, 'About half the practice of a decent lawyer consists in telling would-be clients that they are damn fools and should stop.'"<sup>746</sup> All this really means is that lawyers need to exercise broad judgment in counseling and take note of what appears to be a movement toward relational contracting within their own sphere. It also means that they should appreciate the value of speed and flexibility to clients provided by the mutual trust attendant to the lawyer-client relationship.

Professor Mark Sargent used the following analogy to underscore the importance of the lawyer having a sense of legal geography (*i.e.*, phase-space) when advising clients in a business context:

John McPhee once described Bill Bradley's uncanny ability to make the right move as depending on "a sense of where you are" on the basketball court. This awareness is also crucial to the lawyer . . . . That lawyer must know not only the "law," but also when the rules are clear or muddy and when the "rules" are merely implicit, informal understandings. The lawyer needs to know the limits of administrative tolerance and the direction from which private litigation is likely to come. The lawyer must understand how far the public policy implicit in a regulatory system constrains the clients choices, and where it leaves room for innovation. The ability to predict the behavior of regulators and the private enforcers of regulatory prohibitions . . . depends as much on the ability to take in the whole picture as a behind-the-back, no-look pass to the corner.<sup>747</sup>

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744. See ANTHONY T. KRONMAN, *THE LOST LAWYER: FAILING IDEALS OF THE LEGAL PROFESSION* 288 (1993).

745. *Id.* at 289. Kronman also made critical observations on legal education and the judiciary, as well as practicing lawyers.

746. ALLEGRETTI, *supra* note 703, at 51 (footnote and citation omitted).

747. Mark A. Sargent, *What does it take?*, BUS. L. TODAY, July-Aug. 1996, at 11. The subheadings of his article include "Mountains, Molehills and Knowing the Difference" and "When to Use the Kandy-Kolored Tangerine-Flake Streamline Baby." *Id.* at 12-13. Concerning the latter:

Complexity theory provides a theoretical way for lawyers to understand their geography and their condition, and to accept that they cannot completely control the future any more than they controlled the past. In that regard, the practice of law is but a fitness landscape in multi-dimensional phase-space coupled with both business and legal systems, which are, in turn, locked in an evolutionary dance with each other. This emphasizes the importance of uncertainty, intuition, and timing, all of which paradoxically require study and vigilance, and which may be grounded in real science.

As previously discussed, law and society may be beginning to experience a punctuated equilibrium, and as this article has attempted to explain:

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The Kandy-Kolored Tangerine-Flake Streamline Baby was the fabulous car described by Tom Wolfe in his essay on those obsessed with customizing cars to almost impossible perfection. Business lawyers can be as obsessive as Wolfe's car cultists. They know how to customize. They can transform any agreement into a gleaming masterpiece of thoroughness and subtlety.

What is more important, however, is their ability to know when to produce the Streamline Baby and when to be content with a stock car tweaked in just the right places.

*Id.* at 13.

With these examples Professor Sargent suggested the necessity of orientation in both temporal and spatial geography. This sense of geography in the larger world was examined in a very personal and spiritual way in the book, *Dakota: A Spiritual Geography*, which observes:

It's hard for us to grasp the paradox the North Dakota priest sees in *Trees, Why Do You Wait?* that "it's outside influence that really seems to stabilize a community." Instead, we resist all outside influence in order to make our institutions what we want them to be, and end up creating institutions that are mediocre and unstable.

KATHLEEN NORRIS, *DAKOTA: A SPIRITUAL GEOGRAPHY* 51 (1993).

The haunting effects of being out of place both temporally and geographically on the high plains of eastern Montana, southeastern North Dakota, and northeastern South Dakota were described in another award-winning book as follows:

You're *here*: in a bar on Main, with Rexall's next door, and, across the street, a used-furniture showroom squatting in the remains of what was once the opera house. The essential coordinates of place are here. This is a distinct local habitation with a name. Yet something's wrong. Why is *here here*? Why is it not somewhere else altogether?

No special reason. One day in 1908, someone with a map on his desk thought it was about time to make another town, and so he sketched one in. Perhaps he was talking on the telephone, and the cross-hatched grid of the city-to-be simply drew itself on the paper where his spare hand happened to be resting. . . .

Nearly a hundred years after they were born, the accidental nature of their conception still haunts these towns. . . . Leave one in the morning, and by afternoon it might easily have drifted off to someplace else on the prairie. Such lightness is unsettling. It makes one feel too keenly one's own contingency in the order of things.

JONATHAN RABAN, *BAD LAND: AN AMERICAN ROMANCE* 21-22 (1996).

Periods of punctuated equilibrium are periods of great optimism and great pessimism. For those very good at playing the old game, the dinosaurs, they are disasters. Millions of years of supremacy disappear in a flash. Evolution along the old lines is impossible. For those who are good at adjusting to new circumstances and can learn to play new games, the mammals, periods of punctuated equilibrium are periods of enormous opportunity. . . . But during the transitions in periods of punctuated equilibrium, no one knows who will be a dinosaur and who will be a mammal.<sup>748</sup>

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748. THUROW, *supra* note 289, at 325. Perhaps the only appropriate guide for future behavior that complexity can provide is to return us with more understanding to the common sense kind of observation and advice given by Aleksandr Solzhenitsyn about prison escapes in his book *The Gulag Archipelago*:

Prison escapes, like all forms of human activity, have their own history, and their own theory. It's as well to know about them before you try your own hand.

The history is that of previous escapes.

. . . .

As for the theory of escape—it is very simple. You do it any way you can. . . . If you're caught—you haven't yet mastered it. . . . Theory further prescribes that you should know the geography as well as if you had an illuminated map in front of you. . . . A further precept: you must know the people through whose region your escape route lies. Then there is the following general advice as to method: you must constantly prepare to escape according to plan, but be ready at any minute to do it quite differently, to seize a *chance*.

3 SOLZHENITSYN, *supra* note 378, at 139-40 (emphasis added).



## APPENDIX

A. *An Overview of Chaos*

A provisional scientific definition of chaos theory was posited by Stephen H. Kellert as "the qualitative study of unstable aperiodic behavior in deterministic nonlinear dynamical systems."<sup>749</sup> More simply, chaos is the study of patterns in state-space, also known as "phase-space," and "is not a condition, but rather a continuum of conditions ranging from absolute stability to patterns of activity that are incomprehensively complex. Low-order chaos is [relatively] . . . predictable. High-order chaos [is not predictable and] appears [to be] random."<sup>750</sup> The essence of chaos theory is identifying or finding a pattern or patterns. Because chaos is really a search for patterns, "[t]heorists in this area . . . [are] quick to state the term *chaos* and the idea of chaos theory as a science are in essence misnomers for a number of reasons. The phenomenon described as chaos has an underlying order and is not really chaotic at all."<sup>751</sup>

A simple illustration of the scientific search for patterns within the lay meaning of chaos is a dripping faucet. Indeed, one of the earliest groups studying chaos was a group of graduate students at the University of California at Santa Cruz in the late 1970s. They used the dripping faucet as an organization generator:

Most people imagine the canonical dripping faucet as relentlessly periodic, but it is not necessarily so, as a moment of experimentation reveals. "It's a simple example of a system that goes from predictable behavior to unpredictable behavior . . . [i]f you turn it up a little bit, you can see a regime where the pitter-patter is irregular. As it turns out, it's not a predictable pattern beyond a short time. So even something as simple as a faucet can generate a pattern that is eternally creative."<sup>752</sup>

The study of the drumbeat of single points measured in time, caused by the falling drops, was the kind of one-dimensional research subject conducive to entry-level research. This pattern in the mind's eye is probably not visual, but rather audible. The visual graphing of equations (patterns,

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749. STEPHEN H. KELLERT, *IN THE WAKE OF CHAOS 2* (1993). Kellert teaches Philosophy of Science at Indiana University. For the first real textbook on chaos and complexity theories, see YANEER BAR-YAM, *DYNAMICS OF COMPLEX SYSTEMS* (1997).

750. PRIESMEYER, *supra* note 384, at 7.

751. MICHAEL R. BÜTZ, *CHAOS AND COMPLEXITY: IMPLICATIONS FOR PSYCHOLOGICAL THEORY AND PRACTICE 4* (1997). For a short biography of some of the pioneers of chaos theory, see *id.* at 5-8.

752. GLEICK, *supra* note 378, at 262 (quoting physicist Robert Stetson Shaw).

whether auditory or otherwise) or movement within a system requires the definition of “phase-space,” which “refers to the domain in which a system operates. It provides an arena for the system’s performance”<sup>753</sup> that is

a mathematically constructed conceptual space where each dimension corresponds to one variable of the system. Thus, every point in state [phase] space represents a full description of the system in one of its possible states, and the evolution of the system manifests itself as the tracing out of a path, or trajectory, in state [phase] space.<sup>754</sup>

This type of graphic representation should be familiar to all readers. It is simply the plotting of points on a graph and, as is usual, if the graph illustrates two variables we have a two-dimensional (flat) graph. Classic Cartesian stuff.<sup>755</sup> Indeed, we can also graph three variables and trace a line in three-dimensional space. There are, however, two nuances in the graphic representation and study of chaos.

First, and probably most important for really understanding the concept, is the choice of the variables to be graphed (mapped), that is, the labels chosen for each axis. Chaos studies change. Thus, each variable itself measures change. As Professor Priesmeyer stated:

A phase plane [two variables, two dimensional] is scaled, therefore, to reflect the changes in each variable rather than the actual values of the variable. For [a] . . . market share application, therefore, we will label one axis *changes in our market share* and the other axis *changes in our competitor’s market share*.<sup>756</sup>

As a result of mapping change, each visual representation is informationally more dense than visual representations mapping point values. In economics, for example, rather than focusing on the “momentary status of the system,” such as a single point of equilibrium between supply and demand, chaos is interested in the pattern of change.<sup>757</sup> Therefore, rather than graphing supply and demand curves, chaos theory connects the equilibrium points that represent price, where the supply and demand curves cross over time.<sup>758</sup> To some degree, collapsing data that is normally represented on its own graph into a single point and calling that point

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753. PRIESMEYER, *supra* note 384, at 18.

754. KELLERT, *supra* note 749, at 7-8.

755. See PRIESMEYER, *supra* note 384, at 18.

756. *Id.* (emphasis added).

757. *Id.* at 19.

758. PRIESMEYER, *supra* note 384, at 70.

change is abstract as well as informationally dense. It is somewhat like the time-space continuum required to understand Einstein's Theory of Relativity. Visualization might be aided by the following excerpt, which compares the time-space continuum to Cubist art:

Yet here were two artists whose disconnected planes brought forth the complex idea of the inextricability of space and time by abrogating classical causality. According to the Cubists, the world did not need to be processed in sequence. . . . These chopped-up, reflective surfaces of objects represented the maya of experience, which Picasso and Braque had cleverly rearranged to persuade the viewer that if he could see all facets of an object at once, he was seeing space as *all here*. Further, seeing all sides of an object simultaneously dares the hapless spectator to take the leap to the inescapable conclusion that the work exists in the *everlasting now*. The only place in the universe from which an observer could actually see the ideas contained within a Cubist painting would be from astride a beam of light.<sup>759</sup>

The second nuance in the graphical representation and study of chaos is the mathematical methods it uses to analyze the maps in phase-space. The use of the phase-space maps allows theorists to mathematically "study the geometric features of these trajectories without explicit knowledge of the solutions they represent."<sup>760</sup>

In phase-space there are certain recurring pattern templates that characterize the behavior of a system. For example, simple behavior that repeats itself over time (periodic behavior) may appear as a loop consisting of a single joined line. Another kind of periodic behavior, like "a pendulum steadily losing energy to friction,"<sup>761</sup> on the other hand, looks like an inward spiral "toward a point that represents a steady state—in this case, the steady state of no motion at all" because the pendulum ultimately comes to rest at the bottom of its swing.<sup>762</sup> Therefore, whenever the pendulum is disturbed, a map of the change of velocity and position will spiral toward a fixed point as if that point were attracting the movement. Indeed, that point is called a "fixed point attractor."<sup>763</sup> Conversely: "Aperiodic behavior occurs when no variable describing the state of the system undergoes a regular repetition of values."<sup>764</sup> That is, even though aperiodic behavior may have a pattern, the pattern as mapped, "never repeat[s] exactly," though it may come close

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759. LEONARD SHLAIN, *ART & PHYSICS: PARALLEL VISIONS IN SPACE, TIME & LIGHT* 190-91 (1991).

760. KELLERT, *supra* note 749, at 8.

761. GLEICK, *supra* note 378, at 137.

762. *Id.*

763. *Id.* at 134.

764. KELLERT, *supra* note 749, at 4.

to repeating most of the time.<sup>765</sup> There is, therefore, what visually appears to be “a basin of attraction . . . in which any level of performance will be drawn to follow the attractor.”<sup>766</sup> And “[t]he outer limit . . . of attraction defines the threshold between a return to established patterns and an escape to uncharted territory,”<sup>767</sup> somewhat like the outer orbit of a planet. There may be a behavioral escape from the attractor to another attractor because: “A dynamical system can have just one attractor, or several. If it has several, then depending on what conditions you start from, you may end up with different long-term behavior.”<sup>768</sup>

A system containing a strong attractor will exhibit relatively stable behavior, which may be periodic or aperiodic. Kellert distinguished stability and instability as follows:

[U]nstable behavior means that the system never settles into a form of behavior that resists small disturbances. A system marked by stability, on the other hand, will shrug off a small jostle and continue about its business like a marble which, when jarred, will come again to rest at the bottom of a bowl, or a watch, which will continue ticking reliably after receiving a slight jolt.<sup>769</sup>

A down-to-earth real-life illustration of stability was provided by John L. Casti:

Suppose you're making bread pudding and inadvertently put in a pinch too much salt. Chances are this departure from “design specs” won't do much harm to the final result, and you'll end up with something pretty close to a bona fide bread pudding. In the language of dynamical systems, the bread-pudding system is stable: a small change in the input to the system causes the output to wind up in an attractor close to that representing the perfect pudding. Of course, if you dump in a whole shaker full of salt the end result will bear little resemblance to anything we'd even charitably want to call bread pudding. This is what we mean when we say that the bread-pudding system is *locally* stable. Small changes to the input and/or to the processing rules result in small changes in the final product. But all bets are off if we make large changes. And this is not a situation confined just to the kitchen.<sup>770</sup>

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765. *Id.* at 5.

766. PRIESMEYER, *supra* note 384, at 21-22.

767. *Id.* at 22.

768. COHEN & STEWART, *supra* note 298, at 209.

769. KELLERT, *supra* note 749, at 4.

770. CASTI, *supra* note 331, at 89.

Therefore:

Close to a normal attractor, we can perturb a system and have it always return to its ["normal" pattern] . . . . But push it too far up a mountain, and it may reach a ridge or peak, a critical region in which the system faces a decision: It can either fall back to its [normal pattern] . . . or roll down the other side of the mountain into some . . . new region of behavior [basin of attraction].<sup>771</sup>

The idea of stability is directly related to the distinction between low and high level chaos. As previously stated, low-order chaos is relatively predictable. That means that the system must be relatively stable (*i.e.*, has a relatively "strong" attractor) and that attractor is a relatively simple pattern.<sup>772</sup> High-order chaos, which is unpredictable and which appears to be random, may result from a system containing a relatively weak attractor which makes the system unstable. High-order chaos, however, may also result from a strong but complicated attractor:

What must be the nature of an attractor that is capable of producing random-appearing behavior? It must be strange. Although Lorenz exposed the first such attractor by sketching just a few data points from his weather simulation, Benoit Mandelbrot provided us with the first view of their enormous intricacy. Strange attractors are intricate mathematical patterns of measureless complexity; they weave, fold, and spiral in beautiful ways to profoundly confirm that disorder is structured.<sup>773</sup>

Mathematically, it is the value of the parameter in the nonlinear equation which changes the behavior and graphic representation of the system. Turning the value-knob of the parameter constant, in effect, can change the system's behavior from low to high-order chaotic behavior and, at some value, therefore, result in the system having a strange attractor. Thus:

The continuum of chaos is marked with specific positions where disorder changes from one level to another. These transitions are called bifurcation, meaning to divide into two parts or branches. The term is appropriate because bifurcation points are those levels of disorder at which the complexity [not used here as a term of art] of behavior doubles.<sup>774</sup>

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771. F. DAVID PEAT, *THE PHILOSOPHER'S STONE: CHAOS, SYNCHRONICITY, AND THE HIDDEN ORDER OF THE WORLD* 201 (1991) (citation omitted).

772. PRIESMEYER, *supra* note 384, at 23.

773. *Id.*

774. *Id.* at 8.

Recall that the working definition of chaos for purposes of this explanation (and article) is “the qualitative study of unstable aperiodic behavior in deterministic nonlinear dynamical systems.”<sup>775</sup> The definition of the term of art “deterministic” is one of the linchpins both to understanding chaos and to applying it to the nonphysical systems discussed in this article:

A distinguishing feature of the systems studied by chaos theory, and a large part of what makes the field so exciting to researchers, is that unstable aperiodic behavior can be found in mathematically simple systems. These systems bear the label *deterministic* because they are composed of only a few (typically less than five) differential or difference equations, and because the equations make no explicit reference to chance mechanisms.<sup>776</sup>

At base, therefore, chaos theory studies complicated behavior that is the result of the interaction of relatively few underlying “causes” which take the form of mathematical equations. The equations themselves, however, are nonlinear rather than linear, which means they express relationships that are not strictly proportional:

Nonlinear systems generally cannot be . . . added together. In fluid systems and mechanical systems, the nonlinear terms tend to be the features that people want to leave out when they try to get a good, simple understanding. Friction, for example. Without friction a simple linear equation expresses the amount of energy you need to accelerate a hockey puck. With friction the relationship gets complicated, because the amount of energy changes depending on how fast the puck is already moving. Nonlinearity means that the act of playing the game has a way of changing the rules.<sup>777</sup>

The nonlinear nature of chaos implies, at least, two further observations that are often listed as characteristics of chaos.<sup>778</sup> As noted above, “[n]onlinearity means that the act of playing the game has a way of changing the rules.”<sup>779</sup> This logically implies, first, that there are “*feedback mechanisms* [within the system] that create loops in which output feeds back

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775. KELLERT, *supra* note 749, at 2.

776. *Id.* at 5 (footnote omitted) (emphasis added).

777. GLEICK, *supra* note 378, at 23-24.

778. See, e.g., HAYLES, *supra* note 384, at 11-14; cf. PRIESMEYER, *supra* note 384, at 7-19.

779. GLEICK, *supra* note 378, at 24.

into the system as input.”<sup>780</sup> Second, nonlinearity implies that chaotic systems are extremely sensitive to initial conditions.<sup>781</sup> English Professor N. Katherine Hayles compared this sensitivity to bowling where “a ball thrown in nearly identical ways can nevertheless follow very different paths.”<sup>782</sup>

Moreover, nonlinear equations may have more than one right solution.<sup>783</sup> It should be noted that the game of hockey, with the force of friction it applies to the puck, is an open system. That means that the system is dissipative in that friction causes heat and heat (energy) is lost from within the system itself.<sup>784</sup>

The last two terms yet to be discussed in the working definition of chaos adopted by this article are “dynamical” and “qualitative.” For present purposes dynamical may simply mean change over time, that is, that the system is changing or moving. More technically, dynamical also embraces the notion of feedbacks and iteration:

*A dynamical system* includes both a recipe for producing such a mathematical description of the instantaneous state of a physical system [specifying the numerical value of all quantitative features of a multi-variable system] and a rule for transforming the current state description into a description for some future, or perhaps past, time. A dynamical system is thus a simplified model for the time-varying behavior of an actual system.<sup>785</sup>

Indeed, the mapping of a chaotic system in phase space is simply a static picture of the system. What happens when this static picture is turned into a movie? “We see it in a stream of cigarette smoke that breaks up in whirls of smoke and dissipates. It occurs when we put cream in our coffee. It happens when we boil water to make spaghetti.”<sup>786</sup> It is this movie, set in phase-space and directed by nonlinear equations, which is the essence of chaos. This essence is not quantitative (although it is deterministic) and, thus, the study of the pattern is qualitative. More technically:

The nonlinearity of the equations usually renders a closed-form solution impossible. So researchers into chaotic phenomena seek a *qualitative* account of the behavior of nonlinear differentiable dynamical systems. After modeling a physical system with a set of equations, they do not

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780. HAYLES, *supra* note 384, at 14.

781. *Id.*

782. *Id.*

783. *See id.* at 11.

784. *See* KELLERT, *supra* note 749, at 13.

785. *Id.*

786. EDGAR E. PETERS, CHAOS AND ORDER IN THE CAPITAL MARKETS: A NEW VIEW OF CYCLES, PRICES, AND MARKET VOLATILITY 136 (2d ed. 1996).

concentrate on finding a formula that will make possible the exact prediction of a future state from a present one. Instead, they use mathematical techniques to "provide some idea about the long-term behavior of the solutions."<sup>787</sup>

Thus, although each term in the working definition of chaos is important by itself, the theory may be briefly stated as "*the qualitative study of unstable aperiodic behavior in deterministic nonlinear dynamical systems*."<sup>788</sup> According to physicist Richard P. Feynman, its beauty is that it enables scientists to "see" what equations look like in nature.<sup>789</sup> Such sight might lead us to applications not even contemplated now. Feynman developed what are now called Feynman diagrams:

In quantum field theory, all particle interactions can be pictured in space-time diagrams, and each diagram is associated with a mathematical expression which allows one to calculate the probability for the corresponding process to occur. The exact correspondence between the diagrams and the mathematical expressions was established in 1949 by Richard Feynman, since when [sic] the diagrams have been known as Feynman diagrams.<sup>790</sup>

Although the foregoing provides a touchstone for understanding chaos theory, it is important to appreciate that:

[i]t is not a unified field, as some may perceive. The three major distinctions in chaos theory are between *dynamical systems theory*, *self-organization theory*, and *fractal geometry*. These disciplines recognize chaos as part of a process in which simple equations can produce complex results that appear random. On the other hand, complexity theory is more a mix of fields interested in similar dynamics than subfields. For example, if one were to describe certain subfields in complexity theory, artificial life and neural nets would come the closest to approximating similar disciplines, just as self-organization theory and dynamical systems theory represent certain disciplines within chaos theory.<sup>791</sup>

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787. KELLERT, *supra* note 749, at 3 (quoting ROBERT L. DEVANEY, AN INTRODUCTION TO CHAOTIC DYNAMICAL SYSTEMS 4 (2d ed. 1989)).

788. *Id.* at 2.

789. See COHEN & STEWART, *supra* note 298, at 442 (quoting Physicist Richard P. Feynman).

790. FRITJOF CAPRA, THE TAO OF PHYSICS: AN EXPLORATION OF THE PARALLELS BETWEEN MODERN PHYSICS AND EASTERN MYSTICISM 217 (1975).

791. BÜTZ, *supra* note 751, at 8.



The chaos subfields of dynamical systems theory and self-organization theory are largely transparent from the non-technical meaning of the words and from the context of their use in the text of the article. The subfield of "fractal geometry" which implicates "self-similarity," however, is less apparent and, thus, needs further description. Indeed, Benoit Mandelbrot was able to discover fractal geometry by using computer modeling while he was employed by IBM.<sup>792</sup> As described by Bütz:

Mandelbrot's (1977) fractals seem to represent a ready visual tool for understanding the dimensional consequences of chaos and complexity theory in one of the more important aspects of this theory, *self-similarity*.

Self-similar is just as the term implies. Mandelbrot found that objects and organisms grow in a self-similar scheme. The fractal self-similarity that Mandelbrot described deals with the self-similar geometric structure of trees, lungs, and vascular systems in the human body, with their branching and bifurcating shapes. . . . As in the above examples, the branching, that occurs in a tree structure is a bifurcation that results from the structure's instability . . . and offers the tree greater stability. However, each tree's stability is unique—unlike that of any other tree. Among the many things Mandelbrot has stated about the fractal is that a fractal will have a constant "degree of irregularity . . . over different scales." What this means is that at any dimension of scale, a fractal's degree of irregularity will remain constant. You can blow it up, shrink it, cut it up, and it will still demonstrate a constant degree of irregularity.<sup>793</sup>

### *B. An Overview of Complexity*

According to John Horgan, even "complexologists" have difficulty attempting to define their field of study. Nonetheless, the most widely touted definition of complexity involves the "edge of chaos."<sup>794</sup> The basic idea is that nothing novel can emerge from systems with high degrees of order and stability, such as crystals. On the other hand, completely chaotic systems, such as turbulent fluids or heated gases, are *too* formless for more general applications. "Truly complex things—amoebae, bond traders and the like—appear at the border between rigid order and randomness."<sup>795</sup>

By way of reiteration and transition: A number of different fields and specialties are encompassed under the rubrics of chaos and complexity theory. It is not a unified field, as some may perceive. The three major distinctions in chaos theory are between dynamical systems theory, self-

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792. *Id.* at 17-18.

793. *Id.* (citations omitted).

794. Horgan, *supra* note 371, at 106; KAUFFMAN, *supra* note 310, at 28.

795. Horgan, *supra* note 371, at 106.

organization theory, and fractal geometry. These disciplines recognize chaos as part of a process in which simple equations can produce complex results that appear random. On the other hand, complexity theory is more a theoretical mix of fields interested in similar dynamics than subfields of an overarching discipline. "For example, if one were to describe certain subfields in complexity theory, artificial life and neural nets would come the closest to approximating similar disciplines, just as self-organization theory and dynamical systems theory represent certain disciplines within chaos theory."<sup>796</sup>

The remainder of this Appendix attempts to describe the general descriptive features of complex systems, although the central descriptive terms, unfortunately, sometimes melt into the generalities of which they are made.

One of the complexity community's own members, Professor John L. Casti, has made a book-length attempt at defining the science of complexity.<sup>797</sup> In the final chapter of that book, and after making the observation that "complexity is an inherently subjective concept,"<sup>798</sup> Professor Casti, a mathematician by training, illustrates that complexity is the study of all things that are not simple (a negative definition).<sup>799</sup> He concludes, in part, that complexity is a "theory of models"<sup>800</sup>; and that, currently, it is an umbrella term that embraces the following component areas of study: "Logical tangles [that result in] [p]aradoxical conclusions"; "Catastrophes [that result in] [d]iscontinuity from smoothness"; "Chaos [that results in] [d]eterministic randomness"; "Uncomputability [that results in] [o]utput [which] transcends rules"; "Irreducibility [that results in] [b]ehavior [which] cannot be decomposed into parts"; and "Emergence [that results in] [s]elf-organized patterns."<sup>801</sup> At base, he called complexity the "Science of Surprise"<sup>802</sup> and quoted French Writer Marguerite Yourcenar for a "call to arms in this battle with the complex."<sup>803</sup> He hinted at the breadth of complexity's exploration as well at its general investigative approach by quoting Yourcenar as follows:

The rules of the game: learn everything, read everything, inquire into everything. . . . When two texts, or two assertions, or perhaps two ideas, are in contradiction, be ready to reconcile them rather than cancel one by

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796. BÜTZ, *supra* note 751, at 8.

797. See generally CASTI, *supra* note 331.

798. *Id.* at 269.

799. See *id.* at 270.

800. *Id.* at 275.

801. *Id.* at 263.

802. *Id.* at 274.

803. *Id.* at 278.

the other; regard them as two different facets, or two successive stages, of the same reality, a reality convincingly human just because it is complex.<sup>804</sup>

This quote also invites comparative comment with things religious and spiritual. For example:

When we talk about the Taoist concept of change, it is important to realize that this change is not seen as occurring as a consequence of some force, but rather as a tendency which is innate in all things and situations. The movements of the *Tao* are not forced upon it, but occur naturally and spontaneously.<sup>805</sup>

Perhaps then, complexity may be broadly defined as the exploration and reconciliation of inconsistencies primarily through the use of computer modeling. Unfortunately, this broad definition is insufficient for any real analysis. The balance of this overview of complexity, therefore, will briefly describe some of complexity's component areas of study and, as was done in the description of chaos, return to the essence of complexity which is succinctly captured by the phrase the "edge of chaos."<sup>806</sup>

Chaos, a component science under the science of complexity, was defined by Stephen H. Kellert as "the qualitative study of unstable aperiodic behavior in deterministic nonlinear dynamical systems."<sup>807</sup> At its essence, however, chaos is the study of patterns in phase-space.<sup>808</sup>

Catastrophe theory as it relates to punctuated equilibria, may be introduced in terms of chaos. Catastrophe theory simply studies sudden jumps in system behavior. Similar phenomena occurs in chaotic systems at a bifurcation point.<sup>809</sup> The archetypical example used to illustrate catastrophe theory is the sandpile with "a steady drizzle of new sand grains raining down from above".<sup>810</sup>

The microscopic surfaces and edges of the grains are interlocked in every conceivable combination, and are just ready to give way. So when a falling grain hits there's no telling what might happen. Maybe nothing. Maybe just a tiny shift in a few grains. Or maybe, if one tiny collision

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804. *Id.* (quoting Marguerite Yourcenar).

805. CAPRA, *supra* note 790, at 116.

806. *See* sources cited *supra* note 774.

807. KELLERT, *supra* note 749, at 2.

808. PRIESMEYER, *supra* note 384, at 7.

809. COHEN & STEWART, *supra* note 298, at 209.

810. WALDROP, *supra* note 331, at 304.

leads to another in just the right chain reaction, a catastrophic landslide will take off one whole face of the sand pile.<sup>811</sup>

The importance of the sandpile example, however, is that the frequency of different sized shifts or avalanches, at least arguably, exhibits “‘power-law’ behavior: the average frequency of a given size of avalanche is inversely proportional to some power of its size.”<sup>812</sup> Thus, catastrophe theory is a descriptive theory concerning the frequency of large events.

Similar to chaos, the mathematics of catastrophe theory is often shown geometrically as a flat piece of paper that contains at least two folds in opposite directions so that the edge of the paper would look like a stair step. A catastrophe occurs when an imaginary marble rolls across the paper and suddenly drops off the fold onto another plane.<sup>813</sup> Casti asserted that catastrophe theory is counter-intuitive because most people’s intuition is that “[s]mall, gradual changes in causes give rise to small, gradual changes in effects.”<sup>814</sup>

While it may sound like catastrophe theory and chaos theory are the same, they are separate concepts. Technically,

[c]atastrophe theory is about steady states; chaos theory is about complicated ones. Catastrophe theory is about how states change when you alter the system a little; but in chaos theory you don’t alter the system, you just leave it running. Obviously you can combine the two ideas, and think about what happens to chaotic states when you alter the system a little; just such a synthesis is now being developed . . . it is usually called dynamical systems theory or bifurcation theory.<sup>815</sup>

The last three component sciences under the umbrella of complexity are uncomputability, irreducibility, and emergence.<sup>816</sup> Uncomputability is difficult to describe but relatively easy to illustrate. Generally, the study of uncomputability is the study of the limits of formal logic or any other systems that are finitely describable (in other words, closed systems). Uncomputability was expressed and applied to mathematics by Kurt Gödel’s First and Second Incompleteness Theorems. Gödel’s First Incompleteness Theorem is that “[f]or every consistent formalization of arithmetic, [or other

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811. *Id.* at 304-05.

812. *Id.* at 305.

813. For graphic representations of and an entire chapter devoted to catastrophe theory, see CASTI, *supra* note 331, at 43-114.

814. *Id.* at 43.

815. COHEN & STEWART, *supra* note 298, at 209.

816. See *supra* text accompanying note 802.

closed logical systems,] *there exist arithmetic truths unprovable within that formal system.*<sup>817</sup> Gödel's Second Incompleteness Theorem is that any "formal system [arithmetic for Gödel] is too weak to prove its own consistency."<sup>818</sup> This theorem relies on a rule of the formal logic system that "[t]here is no statement [within the arithmetic system] . . . that is both true and false. . . ."<sup>819</sup> For current purposes these theorems mean that formal logic and mathematical systems cannot represent all universal truths. Even to understand finite discernable closed systems, therefore, requires going outside the system.

Finally, uncomputability also embraces related logical twists such as the one Warren J. Samuels learned in high school, which he said was important for his study of economics, in that he "not only learned about multiple systems, but also about the existence of mathematical foundationalism and the nature and epistemological consequences of pure deduction, namely, that deduction could yield logically 'valid' but not *necessarily* 'true' conclusions."<sup>820</sup>

The essence of uncomputability, however, can be identified by the term "paradox." Examples of these paradoxes include the logical double-edged paradox and the visual "impossible staircase" paradox. The double-edged paradox is illustrated "by Saint Paul in his epistle to Titus, which involves the Cretan Epimenides making the statement 'All Cretans are liars.'"<sup>821</sup> The impossible staircase paradox should be known to all readers familiar with the work of Dutch artist M. C. Escher, although it was first published by a geneticist in 1958.<sup>822</sup> According to Casti: "What's paradoxical about this staircase . . . is that as you make a complete tour of the stairs and come back to where you started, with each step you appear to be moving to a higher level, yet you come back to exactly the same level at which you began."<sup>823</sup>

Another type of visual paradox used to illustrate uncomputability was discovered by Bela Julesz in 1971.<sup>824</sup> The discovery was "that three-dimensional images could be generated by scattering black dots on a flat piece of paper."<sup>825</sup> This discovery has spawned a number of books in recent

817. CASTI, *supra* note 331, at 139.

818. *Id.* at 141.

819. *Id.*

820. Warren J. Samuels, *The Making of a Relativist and Social Constructivist: Remarks upon Receiving the Veblen-Commons Award*, 29 J. ECON. ISSUES 343, 345 (1995). The Veblen-Commons Award is awarded by the Association for Evolutionary Economics. *Id.* at 343.

821. CASTI, *supra* note 331, at 117.

822. *Id.* at 20.

823. *Id.*

824. *Id.* at 117.

825. *Id.* at 117-18.

years using illustrations built on the discovery.<sup>826</sup> According to Casti, "the Julesz figure . . . shows that the same pattern can contain more than one truth. But by following a set of rules (in this case, the rules employed by the human visual-processing system), we are able to see only one of these truths at a time—literally."<sup>827</sup>

Another of the component parts of complexity is irreducibility. Again, according to Casti, this component of the "science of surprise" under the umbrella of complexity is counterintuitive because intuition (and much of the practiced scientific method) dictates that "[c]omplicated systems can always be understood by breaking them down into simpler parts."<sup>828</sup> That is, the subject of study is reduced to its simpler component parts. Indeed, the concept of irreducibility has become one of the key philosophical tenets of complexity. For example, George A. Cowan, the seventy-year-old former head of research at Los Alamos, found his experience as a member of the White House Science Council distressing, in part because the policy problems with which he dealt were irreducible:

"These were very provocative lessons in the interlinked aspects of science, policy, economics, the environment, even religion and morality," says Cowan. Yet he felt incapable of giving relevant advice. Nor did the other academic types on the Science Council seem to be doing much better. How could they? These issues demanded expertise over a broad range. Yet as scientists . . . most of them had spent their entire lives being specialists. The corporate culture of science demanded it.<sup>829</sup>

More damning in his comments on reductionism and blind reliance on mathematics leading to trivial pursuits was that Martin Anderson:

The trivial substance of much academic research and its blissful irrelevance to the vital problems of the world was perhaps best illustrated by the response of the academic economists to the problems that pummeled the United States in the late 1970s and early 1980s. I felt this keenly, for I served as Ronald Reagan's policy adviser on a wide range of issues including economic policy during the presidential campaigns of 1976 and 1980 . . . .

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826. See, e.g., N.E. THING ENTERPRISES, THE VISIONS OF NOSTRADAMUS: A MAGIC EYE BOOK (1995).

827. CASTI, *supra* note 331, at 119.

828. *Id.* at 171.

829. WALDROP, *supra* note 331, at 60.

... As far as help from academic journals was concerned . . . .  
[t]here simply was nothing there . . . . I know. I looked.<sup>830</sup>

In fairness, however, Steven Weinberg traced the history of scientific study and clearly delineated the marvelous discoveries brought about through "reductionist science," in his book, *Dreams of a Final Theory*.<sup>831</sup> Therein, he also noted: "Talk of a final theory [in physics] seems to enrage some philosophers and scientists. One is likely to be accused of something awful, like reductionism, or even physics imperialism."<sup>832</sup> In addition, and as another partial defense of the academy, Cowan further observed: "'the royal road to a Nobel Prize has generally been through the reductionist approach . . . . And that leads to more . . . fragmentation of science. Whereas the real world demands . . . a more holistic approach.'"<sup>833</sup> In other words: "Everything affects everything else, and you have to understand that whole web of connections."<sup>834</sup>

The emphasis on connections obviously changes the role of reductionism in the sciences and, perhaps, other fields as well. Peter Drucker prognosticated both on the importance of interrelationships between academic disciplines and the individual knowledge necessary for future gainful employment by stating:

We neither need nor will get "polymaths" who are at home in many knowledges; in fact, we will probably become even more specialized. But what we do need—and what will define the educated person in the knowledge society—is the ability to *understand* the various knowledges. . . .

Without such understanding, the knowledges themselves will become sterile, will indeed cease to be "knowledges." They will become intellectually arrogant and unproductive. For the major new insights in every one of the specialized knowledges arise out of another, separate specialty, out of another one of the knowledges.<sup>835</sup>

At least some respected legal commentators agree with Drucker. For example, Judge Richard A. Posner carefully stated:

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830. ANDERSON, *supra* note 706, at 92-93. For another particularly cogent articulation of this criticism, see DRUCKER, *supra* note 719, at 216-17.

831. STEVEN WEINBERG, *DREAMS OF A FINAL THEORY* (1992) (writing of dreams of a final fundamental theory of physics).

832. *Id.* at 18.

833. WALDROP, *supra* note 331, at 60 (quoting George A. Cowan).

834. *Id.* at 60-61.

835. DRUCKER, *supra* note 719, at 217.

I hope the reader will not think that by describing the decline over the past twenty-five years of law as an autonomous discipline, I am predicting or would welcome the disappearance of traditional legal thought and scholarship. . . . I do think, though, that the law was too parochial twenty-five years ago and that despite all the false starts and silly fads that have marred its reaching out to other fields, the growth of interdisciplinary legal analysis has been a good thing, which ought to (and will) continue.<sup>836</sup>

At base, then, irreducibility recognizes synergism. It is also reminiscent of cybernetics that was originated by mathematician Norbert Wiener in 1948.<sup>837</sup> Wiener attempted "to show how a theory based on feedback and other engineering concepts could explain the operation not only of machines but also of biological and social phenomena."<sup>838</sup>

One way to begin to appreciate what is meant by irreducibility in the context of complexity is to use the terms "category" and "supercategory." An illustration of the supercategory nomenclature, using the concept of government, is that "Congress, the White House, and the Supreme Court are things—at least each of them can be physically located in space and time. The [federal] government, in contrast, is quite another category altogether. It is, in fact, a supercategory which describes the interactions of the other three."<sup>839</sup> To attempt to understand federal government in operation, therefore, requires focusing on the interrelationships between the branches as well as the reductionist study of each branch.

While the federal government example may seem simple, in complexity its simplicity is important for two reasons. First, in the context of irreducibility it conjures connective lines between the branches in the mind's eye. Next, consider another supercategory that contains the same elements as the federal government, the state government. Now consider the interrelationships represented by lines between the members of both sets. Suddenly, the analysis is much more complex.

Moreover, the mere existence of these sets suggest the even broader supercategory of government, which contains both the federal set and the state set. Thus, "[a]n almost universal feature of complex systems is that they tend to be organized in a hierarchical way, with elements at different levels in the hierarchy interacting to produce what we see as complication

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836. Richard A. Posner, *The Decline of Law as an Autonomous Discipline: 1962-1987*, 100 HARV. L. REV. 761, 777 (1987). Judge Posner also opined that "many legal scholars" would "be better employed" doing traditional research. *Id.* This quote also seems to suggest that a metaphor for law might be Gödel's First and Second Incompleteness Theorems. See *supra* notes 817-19 and accompanying text.

837. Horgan, *supra* note 371, at 108.

838. *Id.*

839. RESTAK, *supra* note 325, at 9 (paraphrasing philosopher Gilbert Ryle).



and complexity.”<sup>840</sup> Another way to describe irreducibility might be messiness:

“People realized that logic and philosophy are messy, that language is messy, that chemical kinetics is messy, that physics is messy, and finally that the economy is naturally messy. And it’s not that this is a mess created by the dirt that’s on the microscope glass. It’s that this mess is inherent in the systems themselves. You can’t capture any of them and confine them to a neat box of logic.”<sup>841</sup>

The second reason that the simple federal government example is important to complexity is that it hints at the last component science under the umbrella of complexity (itself a supercategory), which is “emergence.” Philosophers use the label emergence to mean “regularities of behavior that somehow seem to transcend their own ingredients.”<sup>842</sup> What emergence does “is help make respectable the idea that a collection of interacting components can ‘spontaneously’ develop collective properties that seem not to be implicit in any way in the individual pieces.”<sup>843</sup> For example, the bread pudding that was previously used as an example of a steady attractor in chaos is also an emergent phenomena because it is pudding, which is a different thing from a simple pile of its ingredients on the table.<sup>844</sup> Readers familiar with Article 9 of the Uniform Commercial Code might most easily see this distinction between pudding and a pile of ingredients as analogous to the difference between accessions and goods that are commingled or processed.<sup>845</sup> Thus, once observed, “[a]ttractors are emergent phenomena in dynamical systems.”<sup>846</sup> As a result, it is fair to say that “[e]mergent simplicities ‘collapse chaos’; they bring order to a system that appears to be wallowing hopelessly in a sea of random fluctuation.”<sup>847</sup>

One illustration of emergence captures much of the description of all of complexity. It is “Boids,” a computer simulation program.<sup>848</sup> The program

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840. CASTI, *supra* note 331, at 182.

841. WALDROP, *supra* note 331, at 329 (quoting economist Brian Arthur).

842. COHEN & STEWART, *supra* note 298, at 232.

843. *Id.*

844. See CASTI, *supra* note 331 and accompanying text.

845. Compare U.C.C. § 9-314 (1989) (security interest priority rules related to accessions), with U.C.C. § 9-315 (1989) (security interest priority rules related to commingled or processed goods). The official comment for commingled or processed goods explains that: “This section applies not only to cases where flour, sugar and eggs are commingled into a cake mix or cake, but also to cases where components are assembled into a machine.” U.C.C. § 9-314, cmt. 3 (1989).

846. COHEN & STEWART, *supra* note 298, at 207.

847. *Id.* at 232.

848. WALDROP, *supra* note 331, at 241.

was designed "to capture the essence of flocking behavior in birds, or herding behavior in sheep, or schooling behavior in fish."<sup>849</sup> Waldrop described "Boids" using the following narrative:

Reynolds' basic idea was to place a large collection of autonomous, birdlike agents—"boids"—into an on-screen environment full of walls and obstacles. Each boid followed three simple rules of behavior:

1. It tried to maintain a minimum distance from other objects in the environment, including other boids.
2. It tried to match velocities with boids in its neighborhood.
3. It tried to move toward the perceived center of mass of boids in its neighborhood.

... If a flock was going to form at all, it would have to do so from the bottom up, as an emergent phenomenon. And yet flocks *did* form, every time. . . . Sometimes the flock would even break into subflocks that flowed around both sides of an obstacle, rejoining on the other side . . . . In one of the runs, in fact, a boid accidentally hit a pole, fluttered around for a moment as though stunned and lost—then darted forward to rejoin the flock as it moved on.<sup>850</sup>

Flocking is nothing more than a pattern of behavior that appears complicated. As described, flocking on the computer screen emerged through the interaction of just three simple rules. In summary, "Boids" not only illustrates emergence but also chaos, irreducibility, and uncomputability (output transcends rules). Recall that these are four of Casti's six component sciences of complexity. The others are logical tangles (paradoxical conclusions) and catastrophe theory.

While the foregoing exploratory tour of complexity is intellectually unsatisfying because it is concurrently descriptive and technical, it does, nevertheless, indicate the aggregate nature of complexity.<sup>851</sup> Moreover, as the "Boids" program illustrates, the component sciences of complexity apply to different parts of the solution to the same conundrum. Indeed, the sciences themselves are interrelated and this interrelationship, in part, explains the fluidity of the definitions used to describe chaos and complexity

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849. *Id.*

850. *Id.* at 241-42 (paraphrasing Craig Reynolds of Symbolics Corporation, creator of "Boids").

851. Frankly, though, the admittedly difficult abstract distinction between aggregates (the "sciences") and the entity (complexity) should be less difficult for lawyers to grasp than others because it is the same tension found in partnership law (aggregate vs. entity).

which "highlight[s] the awkward fact that complexity exists, in some murky sense, in the eye of the beholder."<sup>852</sup>

Finally, those who are new to complexity should not fear its math because the math is mostly that of the visual sort which computers can easily perform and graphically represent:

The mathematical foundation of chaos theory and the unique vernacular of this new science can deter some researchers from exploring the dynamics of nonlinear systems. Terms such as periodicity, sensitive dependence on initial conditions, and attractors are not the usual vernacular of the social sciences. However, the modern microcomputer and electronic spreadsheet software provide means for the novice to chaos research to explore the mathematics of chaos. The graphics capabilities of spreadsheet software also provide a visual means for exploring chaotic dynamics. This is particularly important considering the reliance of chaos researchers on graphical analysis.<sup>853</sup>

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852. Horgan, *supra* note 371, at 106.

853. L. Douglas Kiel & Euel Elliot, *Exploring Nonlinear Dynamics with a Spreadsheet: A Graphical View of Chaos for Beginners*, in CHAOS THEORY IN THE SOCIAL SCIENCES: FOUNDATIONS AND APPLICATIONS 19 (L. Douglas Kiel & Euel Elliot eds., 1996).