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A Naturological View of the Corporate Social Role

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The corporation's social role is usually presented as a cultural phenomenon in which the corporation learns socially acceptable behaviors through voluntary social responsibility, government regulations/public policies, and/or acceptance of ethics principles. This article presents an alternative view of corporation-community relations as a natural phenomenon based on complexity-chaos theory and a biological-physical conception of corporate values. Corporation and community are depicted as interacting nonlinear adaptive systems having unpredictable futures, the corporate social role is depicted as largely indeterminate, and competing values are depicted as key factors driving change in corporation-community linkages. Normative duties of corporate and community leaders are described.

A *naturological* explanation draws on natural science for description, evidence, and verification. By contrast, a *culturological* explanation proceeds from a base in social science to describe, verify, and provide evidence of theoretical hypotheses and research propositions. Although both approaches are grounded in scientific methods and scientific rules of inquiry, and therefore can be expected to produce knowledge of relatively uniform and universal substance, they often, perhaps even typically, provide contrasting and contradictory accounts of what might be taken to be

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the same phenomenon. That state of affairs is no doubt an artifact of the recent history of inquiry in the Western world, which has found natural scientists organized around one set of assumptions and preconceptions about how to find the truth, whereas social scientists, especially during the 20th century, have held to contrasting but not entirely different assumptions and ways to discover and reveal behavioral truths. As others have observed (Degler, 1991), culturological explanations have dominated behavioral inquiry during most of the 20th century, with psychology, sociology, anthropology, political science, economics, and education drawing heavily on the *tabula rasa* interpretation of human learning and development. In a word, *culture* is all, and all one needs. The view here will be different.

This article's major goal is to present a naturological account of corporation-community relationships. The conventional, culturological picture of this relationship has produced the concept of the stakeholder corporation that is said to have obligations to a wide range of stakeholders both within and outside of the corporation. New theoretical developments originating in natural science now permit one to go beyond this conventional concept of corporation-and-stakeholder ties to explore a deeper and more fundamental set of *nature-based* interrelationships that, in effect, underwrite and sustain the stakeholder idea while giving a much richer picture of corporation-community linkages.

This new naturological way of thinking is centered in complexity theory, a variant of chaos theory that explains the organizational and evolutionary dynamics that occur as complex living systems interact with each other and with their environments (Guastello, 1995). The overarching theme will be that both corporation and community are natural systems interacting and coevolving in response to biological and physical processes. The corporation is hypothesized as a complex adaptive system; the host community is hypothesized as a dense interactive network of diverse adaptive systems. The goal is to find and describe the role that the corporation plays, and should play, in its interactions with the host community. The solution emerges from the *naturalistic base* that sustains both business and community activities through evolutionary time. Within that base, one finds the value sets that drive corporate decisions and policies, as well as the community's preferred values. At times, these value sets compete; at other times, they work in harmony. However, at all times, they are in constant motion and constant tension. In this view, the normative relationship between corporation and community, although stabilized by the value commitments of each system, remains open to continuous change and redefinition over time stemming from the dynamics of the two

complex living systems and the relative strengths of the ever-shifting values found in each.

But can values, especially those that animate the corporation, also be understood as natural phenomena? The answer is yes, according to the central theme of *Values, Nature, and Culture in the American Corporation* (Frederick, 1995), in which the business corporation is hypothesized as a manifestation of natural processes. This theory of business values, when matched to complexity theory's perspective on organizational dynamics, provides a powerful statement of nature's hold on the marketplace.

Such a natural science approach to business-and-society relationships opens up an imaginative, and possibly fruitful, way for organization theorists, strategic management scholars, corporate practitioners, and civic officials to understand their respective roles in shaping the decisions, policies, and practices of corporations within their host communities.

Using Nature as an Explanatory Variable

Naturological explanations of human (and business) behavior are not as popular or as well known as culturological ones, especially among social scientists and those with derivative social science backgrounds found throughout the business school. Natural science approaches tend to create a decided sense of disciplinary discomfort, such as the professional risk of venturing into an unfamiliar discipline as well as the ideological unease and fear of endorsing uncontrollable behavioral constraints and thereby surrendering personal autonomy.

In spite of these sometimes well-founded reservations, it becomes increasingly difficult to ignore nature's beckoning calls when thinking about the modern corporation and global economics. El Niño alone has revealed the scope of economic havoc wreaked by natural forces—from California's battered coasts, to Canadians ravaged by a massive ice storm, to Indonesia's forest fires so vast that they blanketed much of Southeastern Asia, to Papua New Guinea's devastating drought and destructive tidal waves, to African climatic shifts that spell future trouble, and brutal heat waves that shrivel farm crops here and elsewhere. Even in more "normal" times, floods, earthquakes, volcanic eruptions, tornadoes, hurricanes, monsoons, red tides, snowstorms, avalanches, sand storms, and other natural disasters disrupt settled life and the economic prospects of business and agriculture. Then, there is the well-known list of environmental threats—global warming, rain forest depletion, acid rain, declining groundwater tables, creeping desertification on one quarter of earth's land

area, salinization of freshwater supplies, radiation perils, industrial pollution, arable land erosion, chemical runoffs from industry and agriculture, and so forth—that make inroads on corporate earnings and require new corporate strategies. Add to this the genetics revolution that threatens to supplement, if not displace, the culturological explanations of human behavior *on which all management and organization theories are founded.*

At some point, one must ask, "Can business scholars afford to ignore nature or pretend that it falls outside of the normal scope of corporate operations? Can we continue to act as though a pesky nature will sooner or later go away, thereby allowing us to spin out our theories in a culture-centered, nature-free way?" The risks of doing so are great. More important, they can be avoided by embracing, not ignoring, what the natural sciences have to say about human behavior, including business behavior.

CULTUROLOGY'S VIEW OF THE CORPORATE SOCIAL ROLE

During the last half of the 20th century, business and society scholars have offered three solutions to the question of business's community role. They require only brief summarizing here.

Social Responsibility

Beginning in the 1950s, the most popular, although hardly the most effective, proposal has been that corporations should voluntarily shoulder many social burdens, largely through philanthropic support and/or lending executive expertise to community agencies, schools, art institutions, local government, the United Way, and other such nonprofit community groups. Here, business's civic role is like that of any public-spirited citizen. A somewhat expanded version of social responsibility has become prominent in the 1990s, known as the stakeholder theory of the firm, which requires corporations to pay some attention to everyone in the community who has a "stake" in what the company does.

Government Regulation and Public Policy

When voluntary social responsibility proved too weak and ineffectual during the 1960s and 1970s to confront and solve troublesome social

problems attributed to business (e.g., racism, sexism, consumerism, pollution, war-and-peace, etc.), government and politics were called on to put the social reins on big (and small) business. Therefore, business's community role was to be defined by public policy guidelines, laws, and regulations, all enforced by the courts.

Business Ethics

With the ethics scandals of the 1980s (Wall Street junk-bond kings, the savings and loan debacle, rampant "Me"ism), business ethics was thrust forward as yet another approach. The idea here was to school, or retool, top-level executives in workplace ethics, giving them a stronger regard for human rights, fairness, and justice and reminding them that their own role behavior could set an inspiring ethical tone for all employees. Training in virtue ethics was to develop ethical character, with the presumption that such corporate leadership would improve a company's relations with the public.

Something can be said for all three approaches, and there is an impressive research literature supporting each way of defining and operationalizing business' social role (Clarkson, 1998; Swanson, 1995; Wood, 1991). However—and this is the reason for rehearsing this history—*to date there is no resolution of the basic issue—no "Eureka!" Fifty years of top-flight scholarship has not produced a satisfactory, or even an approximate, answer.* There is still no point at which one can say with confidence that the community role of business is *X* or *Y* or *Z* or that business's civic responsibility is discharged when it does *A* or *B* or *C*.

Communities and corporations throughout the world now confront a range of daunting issues involving corporate practices and community welfare. Should Third World nations welcome pollution-prone corporate operations that provide capital and jobs but exploit low-wage workers and threaten public health? Should companies do business in dictator-run countries whose people have no political or religious freedom? Should a community's public revenues finance multimillion dollar sports complexes that subsidize the profits of private owners and their highly paid players? In these and similar cases, consensus on the respective roles of corporation and community remains elusive. Conventional culturology has yet to find its way toward clear answers.

This article's naturological argument is made in three parts. The first part outlines the essential elements of complexity theory. The second part

argues that the corporation is a type of complex adaptive system driven by nature-based value clusters. The third section defines the community as a dense network of diverse, complex adaptive systems. A concluding section presents a naturological answer to culturology's 50-year-old (unanswered) question: What is business' social role in the community?

COMPLEXITY THEORY: AN OVERVIEW

Anyone approaching complexity theory for the first time is well advised to brace for an onslaught of technical jargon. It fairly bristles with exotic, obscure terms and concepts. A newcomer is assaulted with *autocatalytic change*, *fitness landscapes*, *Feigenbaum constants*, *Mandelbrot sets*, *saddle points*, *chaotic attractors*, *bifurcations*, *phase transitions*, *limit cycles*, *fractals*, *butterfly effects*, and other imaginative and often untranslatable notions. In its initial and purest formulation, its language was and remains mathematics—not your garden-variety mathematics either but one ranging far and wide into nonlinear differential equations, three- and four-dimensional graphics, and other numerical exotica. Its original applied venue was meteorology, arising from the uncertainties and frustrations of trying to predict the weather. Biology and biological change followed closely after as attempts were made to model evolutionary change. Presently, as noted by one complexity theorist, "these new concepts from the natural sciences can be successfully transferred to other sciences such as economics, sociology or political sciences. If carefully applied, they can provide important clues even for the understanding of nature and human culture" (Rau, 1990: 261).

Chaos theory, complexity theory, and catastrophe theory are related, although they are distinct from one another (Guastello, 1995: 2-3). *Chaos theory* mathematically describes the behavior of nonlinear dynamic systems, which are found widely in nature (e.g., weather, heartbeat rhythms, predator-prey population links). *Complexity theory*, also mathematical in its original form, has been used to understand the qualitative traits of nonlinear systems, such as business organizations. *Catastrophe theory* deals with sudden, discontinuous changes in the behavior of such systems. Complexity theory is the most useful of the three for clarifying corporation-community relationships. The essentials, absent the mathematics, are easily grasped.[1]

It helps to know that complexity theory is a variant or offspring of Darwinian evolutionary theory. Darwin argued that biological evolution

occurs through natural selection as organisms interact with an environment presenting both opportunities and threats. Those traits—behavioral, morphological, and physiological—that help an organism survive are selected for through a constant interplay of organism and environment. The result is a fit between the two as an organism finds an adaptive environmental niche. Such fit organisms then pass their fitness traits along to their offspring, whereas less fit organisms are weeded out over the long term.

Darwin's successors in the 20th century—called neo-Darwinians—added the wrinkle of genetic change to the evolutionary story. They say that the genes (DNA) that reside in each organism's cells are the driving and guiding force of evolution. By determining organic processes, physiology, structure, and behavioral impulses, the genes in effect make the organism behave in ways that guarantee the genes' own replication. Thus, genes are said to be "selfish," centered on their own replication and survival (Dawkins, 1976). For neo-Darwinians, no trait will survive the natural selection process unless it serves its genetic masters. This proposition has become highly controversial in societies that value freedom, autonomy, and flexibility. Most people resist the idea of being a genetic calculating machine and therefore may welcome the openness and implicit optimism of complexity theory's main thrust.

Complexity theory takes one step beyond Darwinism and neo-Darwinism and is a kind of overlay on or supplement to them. *Its principal contention is that organization arises spontaneously and is adaptive.* That means that organic life emerged spontaneously and then adapted to its environment and survived to reproduce itself. The same principle or process operates in all forms of organic life, including humans, plants, and animals. Another more dramatic and comprehensive way of stating the idea is that *organic order is built into the universe—it emerges without external guidance* (Kauffman, 1995).[2]

Complexity theory's main focus has been on the behavior of nonlinear biological systems, which bear three distinguishing marks. First, the system's component parts do not interact in a straight-line, direct cause-and-effect sequence but rather display nonlinear, oscillating, random-like dynamics. Second, being nonlinear, their movements are not precisely predictable. Third, such systems are greatly sensitive to their originating or initial condition—rather like a seed with explosive, unexpected results—and can be expected to exhibit variability and diversity of movement over time (Coveney and Highfield, 1995; Goodwin, 1994; Guastello, 1995).[3]

Four Core Concepts Anchor the Theory

In the abbreviated account given here, four leading concepts are featured. The first is *Self-Organization*, a spontaneous ordering process that can occur in organisms and in nonliving material components. The self-assembly can take place at the atomic, molecular, and cellular levels. For example, molecules of certain chemicals, when mixed together, organize themselves into amazing patterns, whorls, circles, arcs, and designs. This is the famous Belousov-Zhabotinskii reaction, which illustrates symmetry breaking, another of nature's latent features (Stewart, 1995: chap. 6). At the atomic level, electrons and protons in various combinations comprise the periodic table of chemical elements and under certain conditions, such as bombardment by radiation, they recombine to produce yet other kinds of components and elements. No one, or no single source, directs molecules or atoms to organize themselves into the forms they assume. They do so spontaneously and according to various combinatorial regularities that seem to be inherent in the materials themselves.[4]

Self-assembly is the hallmark of all organic life. Cells, when provided with energy in the form of light or heat or other nutrients, spontaneously move into combination with other cells to form organs and to regulate vital processes. A developing embryo self-assembles once the egg is fertilized. A tree self-assembles from the seed. A tadpole spontaneously becomes a frog, a larval worm a butterfly. Although genetic encoding sketches out the general pathways to be followed, the genetic imprint is activated by interactions among the many cellular and molecular components involved. The encoded order blooms under the influence of the spontaneously interacting parts. More important for present purposes, this self-organizing tendency is also a potential presence in all forms of human organization, including corporations (Guastello, 1995; Kauffman, 1995). The ubiquity of self-organization throughout nature hints at some kind of subtle, hidden, innate order.[5]

This kind of self-organization is greatly assisted by one of those jawbreaker terms complexifiers love to use—*Autocatalysis*. The idea, if not the term, is simple enough. It means that the parts being combined speed up the combination or the self-assembly process. In other and simpler words, if you remember your high school chemistry, there is one or more catalysts at work (i.e., typically a neutral agent that activates and accelerates the combination). In even simpler terms, it means that there is an active feedback process going on so that what one cell does stimulates action by other cells and then those other cells interact with the original

cell and on and on in an accelerating process. As we shall see, autocatalytic change in self-organized systems can lead to very rapid rates of change and varying directions of change until a state of chaos is threatened.

Third is the idea of a *Complex Adaptive System (CAS)*. When self-assembly occurs in living systems, the result is the formation of an interrelated and usually complex set of cells, atoms, molecules, organs, and so forth that collectively have the ability to adapt to the environment in a systematic way. Every living organism, whether mosquito, orchid, kangaroo, or human being, is a CAS. So too are organized groups of organisms (e.g., a beehive, a pride of lions, a church, a corporation). In one way or another, each CAS manages to adapt to the surrounding conditions it finds—or it may not adapt.[6]

Whether it will be successful depends on its skills in maneuvering around, through, and across what is called a *Fitness Landscape*, which is the fourth core concept. Picture a broad landscape composed of mountains and valleys and hills and plains of varying height and expanse. Getting around is a test of an organism's ability to fit in or adapt. Scaling the highest peaks symbolizes good fitness. Some get to the top, others settle for the lower slopes, and still others take up abode in the valleys and plains (Kauffman, 1995). Fitness landscapes are dangerous places—one misstep is all it takes. A fish swimming too close to the water's surface becomes an osprey's lunch. A maker of buggy whips—or Apple computers?—soon joins the jobless ranks. A command-and-control economy loses out in the competitive global race. To avoid this fate, each CAS seeks out a secure niche within the particular fitness landscape that is its home. Vigilance, cleverness, flexibility, and creativity are the qualities that maximize its chances of success.

The kinship of these four concepts to Darwinian evolution is too obvious to miss. Only the language is new. Living forms emerge, evolve into more complex forms, and adapt to their environment—only the fittest ones survive. But there is a fork in the evolutionary road. Complexity theory takes the unfamiliar path.

The Edge of Chaos

CASs, when moving around on their fitness landscapes, face another problem of profound importance—so profound that it involves nothing less than their survival. This time, the threat comes from the internal

dynamics of self-organizing systems. Because they are autocatalytic systems that are subject to rapid and unpredictable change, CASs are potentially unstable. They may evolve so rapidly and in such diverse ways that they self-destruct. In other words, self-organization may lead to self-destruction.[7] An organism's self-assembly may produce poor adaptational skills—there is no Darwinian guarantee written into the process; or autocatalytic change may get out of control and drive the CAS to destroy itself, as with cancer or AIDS; or a better-assembled competitor with superior autocatalytic abilities may push another CAS out of its niche.

CASs that change in this way enter a zone of random-like behavior verging on chaos. Too far into that zone, their wild movements and gyrations appear to be completely out of control—or, as organizational theorists would say, they become unmanageable. Their ability to find a niche in the fitness landscape disappears in a flurry of uncontrollable, dizzying oscillations. They have gone over the edge of stability into the chaos zone *and beyond*. They die. A plant closes down. A savings and loan defaults. A nation's economy plunges into misery. Stock markets crash. The jobless go hungry, or riot, and sink further into poverty.

The idea of chaos, in the hands of complexity theorists, takes on a special meaning. In spite of outward appearances, it does not mean totally out-of-control behavior. *Within the chaos* zone, a hidden order may be concealed beneath what looks like utter randomness. These latent regularities are difficult to discern because chaotic change usually occurs in the form of branching, chain-reaction, accelerated movement. It is a little like trying to watch the rotating blades of an electric fan—it is difficult to see each single blade as it moves around while only the blur of all the blades moving together can be made out. The more branching points (i.e., bifurcations) there are, the more complex and potentially catastrophic the changes become. Thus, chaotic change within an organization occurs in these branching layers or bands and can quickly lead to precipitous, catastrophic decline and disorder.[8]

For the best CASs there may be a way to escape this fate. The key to survival turns out to be the latent and subtle orderliness lurking within the chaos zone. Once having gained a foothold on one of those fitness peaks, a CAS has demonstrated its skill in adapting to its environment. If it can channel its own autocatalytic tendencies just enough to stay there and possibly even inch up higher, it may enjoy a long life rather than plunging into the abyss of utter randomness and decay.

The trick is to hover between too rapid, directionless change and too little change, where it might be overtaken by unfriendly environmental

forces. Its best chance occurs at the *Edge of Chaos (EOC)*. Evolution carries each CAS to a zone or region between order and disorder called the EOC, which is the CAS's point of maximum fitness and adaptability. It is the CAS's "best of worlds"—and its potentially worst nightmare. Poised on this evolutionary edge, one critical misstep can unleash a cascade of disastrous events.[9] If the CAS—a corporation, an economy, a family, a religion—clings too tightly to the factors that helped it attain its present niche, it will be overtaken and pushed out by more determined CASs—a competitor firm, a more flexible economic system, separation-divorce-remarriage, more inspiring belief systems. But if the CAS can step right up to the edge of chaos—in other words, if it can let its autocatalytic forces generate new adaptive skills (e.g., technological innovations for the firm, more market freedom for the economy, interpersonal understandings among couples and their children, an expansion of faith's boundaries)—then and there is where it maximizes its future possibilities and can realize its inherent potentials.

Getting to that critical point and staying there depends on what complexity theorists call a "strange attractor." It is the key to fitness success when a CAS faces a chaos/beyond-chaos choice.

Strange Attractor

Of all the bizarre, exotic ideas to be found in complexity theory, none tops the notion of *Strange Attractor.* Two reasons explain why. In its original form, the idea was (and remains) a nonlinear mathematical expression referring to a particular kind of mathematical state, and it has been difficult to translate the numerical-graphical meaning into everyday, ordinary language.[10] Second, even when translated, the idea refers to a fairly unusual kind of situation and, additionally, one that constantly changes. So, when you think you have its definition pinned down, it may dart away and even assume another shape or form. It is, indeed, strange. Nevertheless, its meaning and significance can be made reasonably clear for present purposes.

A CAS's strange attractor does two things. It describes the CAS's movements through time and space—the many pathways the CAS takes from day-to-day, month-to-month, and year-to-year (if it lasts that long). *These pathways are never exactly the same and are not precisely predictable.* In a sense, any CAS associated with a strange attractor continually explores the terrain of its fitness landscape, seeking new footholds that

may boost it up to higher levels on the fitness peaks. Innovation is a built-in quality of any strange attractor because of the differential orbits it prescribes for the CAS. Who knows what it will encounter on these unpredictable journeys—perhaps risks and dangers, perhaps novel opportunities?

However, while generating variety and diversity of adaptation, the strange attractor also literally "attracts" or pulls the CAS toward a broad range of behaviors. If it could do so, a CAS would maintain a steady, although variable, state laid down by its strange attractor. In other words, it would show variety but only within fairly well-defined boundaries. It is drawn toward an inertial state but displays a dynamic one. Even more simply, a strange attractor permits change while providing order.

Aha! That must mean that it can lead a CAS (e.g., an organization) just up to the EOC but hold it back from plunging over the edge into extreme, destructive, disordered behavior. In simpler terms, the organization may want to do a bungee jump but the elastic rope pulls it back up just in time to avoid total calamity. This means that an organization's (a CAS's) key to survival and continued fitness success is to be found in its bungee rope that is its strange attractor. As revealed further along in the discussion, strange attractors play a critical role—perhaps the key role—in corporation-and-community relations.

This brief summary of the main ideas gives us enough complexity theory for the purpose of tracking down the social, or community, role of business.[11] It is time now to take a closer look at the corporation, one of the two main protagonists in this drama.

A NATUROLOGICAL VIEW OF THE CORPORATION

A complexity theorist trying to understand corporate behavior might ask the following question: "Is the corporation a self-organized CAS housing an autocatalytic component, operating on a fitness landscape, and exposed to the risk of chaotic change while being held in its niche by a strange attractor?" It is an intriguing, challenging, perhaps even disturbing query of the kind that naturologists might pose. It would imply that today's primary form of business activity can be understood as if it were a manifestation of natural forces. It would be equivalent to asking if the corporation is as Darwinian as a frog. That is the view taken here, which somewhat surprisingly reveals more about business-and-community relations than does a culturological perspective.

The Corporation as a Manifestation of Nature

In *Values, Nature, and Culture in the American Corporation* (Frederick, 1995), a picture is drawn of the business corporation as a manifestation of natural processes. That story can be briefly summarized here.[12]

From a natural science point of view, the corporation is an energy-transforming operation. It draws energy in the form of natural and human resources from its environment and converts them into new forms of energy called goods and services. In doing so, it replicates the behavior of all living things (e.g., plants, animals, bacteria, etc.), all of whom must also obtain energy from their environment if they are to survive. Each must draw energy from the environment to support its metabolic processes, to grow, to develop within the limits of its genetic potentials, and to sustain and enhance its reproductive capacity. This energy-conversion process is called *economizing* and, in the case of human beings, it gives rise to *economizing values*, which are the core values of the modern corporation.

A natural scientist would say that economizing is an offset to entropy, or to the natural tendency of living (and nonliving) systems to run down and to disperse their carefully marshaled energy until no more is available to maintain the system. A system at entropic equilibrium is motionless, lifeless, at total rest. It can stave off entropic death only by economizing—by absorbing more energy than it expends. That is the modern corporation's major mission—to economize so it can live to see another accounting quarter (and perchance to replicate itself indefinitely?). For society as a whole, this corporate function is a vital necessity because it has become the main economizing vehicle on which organized human life depends.

This naturalist picture of the corporation is entirely consistent with the usual ways of describing the firm. In that language, the corporation is a goal-seeking organization striving to make profits. It does so by being a good economizer. The naturological view only adds the larger natural context in which that profit seeking goes on and posits that corporations, as CASs, strive against entropic forces by cultivating economizing values and inculcating them in the company's workforce, which can be viewed as a collective, cooperating set of individual CASs. Economizing is what a CAS does as it explores and adapts to its fitness landscape.

The way corporations are organized also reflects nature's influence. Its hierarchy of managerial power, the authoritarian dominance of the managerial cadre, and the retention of decision-making and policy-forming powers in the hands of the ruling few, mirrors to a remarkable degree the power-and-dominance behaviors of many animal species. Even the most casual viewer of wildlife television films is familiar with the alpha male, the submissive females, the rationing of sexual favors by rank, the privileged access to food, and the challenges mounted by young males as the alpha leader ages. It is an organizational design deeply and anciently etched in animal behavior, in the primate order, in our hominoid near kin, in human precursors, and in today's Homo sapiens. It has carried over into the family, schools, religion, politics, military, universities, sports, and social practices generally. Attenuated at times by democratic, leveling, participatory urges bubbling up from below, the typical corporate hierarchy continues to hold sway, concentrating power at the managerial level and channeling the system's privileges—salaries, stock options, social prestige, political access, and other perks—to the alpha males (Frederick, 1995: 57-78).

These power-seeking and power-magnifying impulses produce a second kind of nature-based value set found in every corporation—*power-aggrandizing values*. These widely approved values sustain and, in the minds of most, serve to justify an organizational system resting on coercive power and a restless urge to magnify the power, prestige, and glory of both the company and the controlling power elite.[13]

Many other, highly diverse values are found within the corporation. Brought to work by countless individual employees from all walks of life, these personal values cannot be reliably predicted or precisely known; for that reason, they are called *X-factor values*, with the *X* standing for "unknown." And why, a culturologist might ask, are they natural and not cultural in origin? Recall that each living organism is a CAS that is trying to find a niche on a fitness landscape. Human fitness landscapes are made up partly, but not entirely, of cultural artifacts and processes. Moving around on them requires not only the learned skills of one's culture but a genome tested over countless generations of genetic replication—in addition to more than a little luck. The many values acquired by an individual through cultural learning are shadowed, perhaps even foreshadowed or prefigured, by the adaptational necessities imposed by nature. Moreover, nature's influence on a corporation's *X*-factor values is magnified many

times over because these personally owned values are expressed through (and sometimes squelched by) a *nature-rooted* hierarchical role structure that is itself devoted to the company's *nature-based* economizing tasks carried out in *nature-embedded*, power-aggrandizing ways. In conforming (almost by necessity) to the corporation's naturalist architecture, employees and managers, each of whom is a CAS, can be expected to adapt their personal (*X*-factor) values to the company's needs and demands. Within the corporate sphere, nature calls the tune.

Nature has put its stamp on the corporation and its values in yet another (fourth) way. In a naturological interpretation too extended to develop here (but see Frederick, 1995: 174-185), the lineage of modern technology used by the corporation can be traced far back into the early attempts of primitive life forms to develop effective economizing techniques. But for present purposes, one need only note the dynamic, innovative traits of today's corporate technology. Building a better mousetrap (*pace*, animal rights advocates) captures technology's guiding, creative spirit. It is the corporation's major change-making force. In the language of complexity theory, *technology is the corporation's principal autocatalytic change agent.* In a free enough organizational climate, technological potentials will emerge automatically and spontaneously, flowing out of laboratories, work groups, and task forces, and bubbling forth from the electronic depths of countless PCs. Discovery, innovation, inventions, and unique combinations of earlier ideas may flood the precincts of any company that is willing to brace itself for the impacts.

In the technological realm, the dominant values are pragmatism, openness, exploration, participation, expertise, and cooperative-coordinative teamwork (Frederick, 1995: 200-204). Such values invite change, literally command novelty, and generate a powerful urge to break out of traditional molds. They support the ongoing efforts of the corporation to economize, to grow, and to develop myriad new products, from exotic software programs to miracle medicines. Evolution has embedded these technological values deep inside the human brain. Once set free to express its self-organizing impulses, the human brain generates a constant stream of creative, symbolic "quanta"—packets of significance that dart here and there on the corporation's open fitness landscape. When captured, focused, and targeted on corporate goals, these symbolic quanta become powerful tools of adaptation and economizing force. They owe their life and their spontaneity entirely to the naturalistic neuronal activities generated by the

human brain. Because they arise from this source, because they assume a unique symbolic form, and because they carry out the firm's technological functions, they might reasonably be called *techno-symbolic* quanta. When hitched to the corporation's thermodynamic economizing engine, such explosively creative quanta underwrite all of the autocatalytic change most companies can reasonably sustain.

Corporation on the Edge

Corporate life is a never-ending push-pull kind of existence. Technological innovations, eagerly sought by inside wizards or fearsomely thrust forward by outside competitors, push the corporation ever onward into new ways of doing things. The best companies invite and accept this kind of challenge. However, recall the risk run by any CAS—it may change so rapidly and its new technologies may inject so much novelty and turbulence into normal operations that the entire system risks plunging over the EOC. The pressures for change are unrelenting. As one observer has pointed out, "Living creatures . . . must behave chaotically in order to respond rapidly to a changing environment" (Stewart, 1995: 123). Complexity research suggests that a CAS does best if it goes right up to the EOC but holds itself back from going over the precipice. At this point, its adaptive powers and skills are deployed to maximum benefit in maneuvering around on its fitness landscape because it has opened itself up to the creative ingenuity of its workforce and the productive potentials of its innovative technology.

Although a company's technology is its main autocatalytic change agent, turbulence and instability can also arise from other sources, such as competing CASs, or from its own internal *X*-factor value base (e.g., maverick employees with their own unorthodox ideas), or even from the overreaching, ego-centered, power-aggrandizing urges of its chief managers. Although most corporations project an air of staid, custom-bound, bureaucratic stodginess, lurking just out of sight beneath their external crust is a seething cauldron of potential turbulence. The remotest, most insignificant-seeming act—a competitor's new marketing gimmick, a simmering employee rebellion, an ill-conceived strategic plan, a government's fall—can have everyone in the corporation suddenly staring straight down into a yawning pit of chaotic disorder.[14]

The Corporation's Strange Attractor

What, then, saves the day? What denies to turbulence and chaos a victory over the corporate CAS? It is nothing less than the company's strange attractor.

Recall that two traits mark a strange attractor. It means that an organization (a CAS) orbits on a series of pathways that are never quite the same and cannot be handily predicted. So, the attractor generates variability and uncertainty. But at the same time, the attractor constrains the organization's movements or cycles within certain limits. Some theorists speak of "a basin of attraction" (Kauffman, 1995: 78-79) or a "bowl" (R. N. Knowles, personal communication, February 3, 1998) toward which a system's movements converge, thereby confining the orbits to a region of "phase space." So, the strange attractor also is a source of stability and order. Combine these two traits and you have the essence of organizational dynamics—a tendency to fly off into a chaotic muddle matched by an impulse toward order. (It puts one in mind of Dilbert's bizarre world, in which cubicles seem to embody the corporation's "basin of attraction.")

Placing these two naturological images of the corporation together—one from complexity theory, the other from naturalist corporate values—as if they were overlapped photographic negatives from a powerful Hubble-like telescope, gives a perspective never glimpsed before. It is as if we are gazing for the first time directly into the central core of a far-distant corporate galaxy. We see there a CAS that is seeking to survive on a fitness landscape while governed by a strange attractor. However, we see something even more dramatic and of profound corporate significance.

The corporation's strange attractor—the component that permits change within constrained limits—is its value system. The main corporate value clusters, as described earlier, are economizing, power-aggrandizing, technologizing, and *X* factor. Those value clusters originated in nature and continue to express nature's powerful influence on corporate operations, practices, and culture. Together, they hold the corporation to a recognizable order—organizational roles, standard operating procedures, permitted information flows, short-range goals, allocation of work responsibilities—while opening the company to innovations, new explorations, and new discoveries that carry it along in diverse, varying, and unpredictable directions. That is precisely the function of any strange attractor of any CAS. "The long-term dynamics of a system is governed by its attractors, and the shape of the attractor determines what type

of dynamics occurs" (Stewart, 1995: 117). This theoretical view is confirmed by a seasoned corporate practitioner who uses complexity theory as a tool of management: "All organizations have strange attractors made up of our values, principles, standards, expectations, vision, and mission" (R. N. Knowles, personal communication, February 3, 1998). The push and pull of its value clusters ultimately determines the corporation's fate—its success in balancing between order and disorder, adaptation and decline, self-organization and entropy, service to humankind, and an inward-looking, power-centered self-interest.

Surely, the values embedded in a firm by its founders linger on indefinitely as a continuing influence, fading only slowly. So too do the values brought in by the founders' successors exert a growing influence on goals, directions, methods, and managerial philosophy. As a company's workforce oscillates, expands, contracts, and diversifies, its *X*-factor value component injects novelty, preserves traditions, and shifts the foundations on which managerial competence (and confidence) are erected. And always, always, always, economizing values define the central goal, just as technologizing values urge the firm onward toward those economizing purposes.

Although initially, and still, a mathematical expression, strange attractor assumes a tangible, substantive form and function within the business corporation. The total value set operative there—partially known and predictable and partially hidden, latent, and unpredictable—simultaneously gives direction and life to the corporation as a CAS while constraining its actions within a definable and understandable arena (or basin) of operation.[15]

However, this natural history of the corporation is not yet fully told because the fitness landscape on which it maneuvers is likewise sculpted by natural forces. Scholars are accustomed to calling that economic, social, and political landscape "the community." Is it possible that nature has hidden the key to business's social role somewhere within the community itself?

COMMUNITY AS ECOSYSTEM

The classic question posed by business and society scholars has been: What is a community and what is the proper way to define the relations between corporation and community? Culturological explanations of community have emphasized the personal and institutionalized ties between people living in proximity to one another (Etzioni, 1996).

Communities are seen as collections of political, governmental, societal, ethnic, tribal, religious, and cultural institutions, each with a history, a loyal following, and a stakeholder status justifying claims to considered treatment by corporate decision makers.

A naturological explanation emphasizes that a community is not a group, not a collection of institutions, not simply a legal unit, not a society nor a culture, people, or government. Nor is the community a bounded geographical space. A community may *contain* all of these things but it cannot be defined as any one of them or all of them added together.

A community is an ecological system—an ecosystem—consisting of interlinked organisms living within an abiotic (nonliving) setting. It has no center and no edges. In this sense, it is very much like the universe as a whole. It is open to global, planetary, galactic, and cosmic forces. For any ecological community anywhere, El Niño's reach is as global as Chernobyl's more subtle threat; so too is the asteroid that long ago brought an end to the dinosaurs matched by others still circling outer space and capable of equal indiscriminate ecological destruction; and earth's ecosystem communities feel the radiation fires churning within our Milky Way galaxy as they also are bombarded by photons from ancient supernovas exploding in other galaxies. All communities are ecosystems open to the widest range of external influences. They are dynamic, coevolving populations of people, plants, animals, bacteria, and so forth, linked together by natural processes, responsive to each other and to the forces that stitched them into a collective, coherent whole.

A community's dynamic is driven by the ceaseless, persistent economizing activities of its resident organisms as they respond to thermodynamic energy fluxes that penetrate all levels of the ecosystem. Each organism is a complex adaptive system entirely dependent for its life on all of the other organisms within the ecosystem.

If we train our Hubble-like telescope on this aggregation of living protoplasm called a community, it brings into focus an enormously complex overlapping interplay among diverse CASs. Sharpening the focus even more, we see that each CAS has its own strange attractor—its own preferred value set—pushing it toward the edge of chaos but holding it back from unbridled turbulence. *The corporation is one of these community CASs.* So too are governments, schools, mass media, transport systems, mail services, utilities, hospitals, museums, religious bodies, civic organizations, families, individuals, nonhuman animals, plants, bacteria, and all other forms of living matter. What appears to the naked eye as a single entity—the community—is revealed as *a mosaic of interacting values*. As

much as anything else, a community is a great staging arena in which values meet, collide, clash, compete, and blend. Or, as complexity theory would say, a community is myriad CASs hitched to diverse and sometimes competing strange attractors.

The stunning complexity can be sensed by realizing that the fitness landscape of each CAS consists of all the other CASs in the ecosystem in addition to the nonliving environmental forces of nature (climate, geology, gravity, solar energy flows, etc.). As complexity theorist Murray Gell-Mann (1995) said, "fitness landscapes . . . now give way to a picture of shifting and interdependent landscapes for the different adaptive components of the total system" (p. 16). This tangled yet strangely patterned fitness landscape constantly shifts, presenting each CAS with a never-ending challenge to adapt or perish. The fate of each one is bound up in the fate of all. Internal autocatalytic change generates a constant stream of novelties. Techno-symbolic forces create new opportunities and new threats. Physical environmental processes—volcanic eruptions, earthquakes, droughts, massive floods, and so forth—de-form and shift the fitness landscape. Value change within society modifies the force of strange attractors, increasing some and diminishing others. New competitors riding new strange attractors threaten to dislodge established CASs from their environmental niches. Amid all of this turbulence, some scale the peaks and find a niche among their neighbors, while others lose their footing and are replaced.

As complexity theory maintains, the future of this community ecosystem cannot be predicted. Both corporation and community are nonlinear systems that are linked together and driven by their respective and intertwined strange attractors—their behaviors indeterminate, unpredictable, and largely uncontrollable, although not "out of control."

One further conclusion is obvious: corporation and community are, if not one, surely tied inseparably together. Business does not stand apart but is an integral piece of the total community ecosystem. Nature teaches this profound lesson: *There is no boundary between business and society.* Their fates are as intertwined as the doubled helical strands of DNA that give life to us all.

THE PUZZLE SOLVED

After this long journey through complexity land, the long-sought answer is now at hand. Complexity theory allows us to see that *nature drives the social role of business.* Corporation and community are

engaged in a highly dramatic dance, a kind of grand ballet. It is not a *pas de deux*—a duet of company and community—but one that encompasses the entire *corps de ballet*—all members of the community—in a kind of wild orgy of swirling, dizzying, chaotic rhythms and patterns. Nature choreographs this dance of life, setting each member of company and community free to dance to the music composed by its own strange attractor.

But patterns are discernible, just as they are within any system of deterministic chaos. Remembering that "the long-term behavior of a system trapped on a strange attractor depends on the minutest details of how it was launched" (Coveney and Highfield, 1995: 172), the relations between a company and its host community reflect past history. Some began with a company-town relationship—the company was the town, and vice versa—or an industrial-financial complex predominated, as in Pittsburgh in the 19th and early 20th centuries, or a mushroom-like growth of high-technology firms in the Silicon Valley created a different set of initial conditions. The initial launching of these ties was all-important in setting the pattern of future relationships in each case—and could bring either strength or weakness. Pittsburgh's initial conditions left it economically and socially vulnerable following the collapse of its steel industry infrastructure in the 1980s, whereas California's high-tech beginnings underwrote high but sometimes unstable rates of economic growth and job creation.

Because corporation and community comprise one large coevolving, nonlinear system, business's civic role is always evolving and always indeterminate; it is a moving target. The corporation's *mission* is set by its value clusters—economizing, power-aggrandizing, technologizing, and *X* factor. They push the company into varying orbits, always striving for a fitness niche on its always-changing landscape. Thus, the corporation's *civic actions* are a function of the interplay of its own strange attractor values and the values of others in the ecosystem. All people within the community also economize, organize, and seek power; are part of an ecological system; display *X*-factor values in great abundance and variety; and explore the environment (i.e., the fitness landscape) in techno-symbolic ways. Although all embrace the same general kinds or types of values (hence, giving rise to order and stability in a given community tradition), the ways of realizing them can vary greatly from person to person, group to group, and company to company—thus giving rise to almost infinite variety. This corporation-community system is complex and chaotic—and therefore both self-organizing and open to infinite possibilities. The system contains its own instability and its own sense of order,

which is precisely the behavior expected of any nonlinear system linked to a strange attractor, which in this case involves multiple attractors. Corporation-community relations become a push-pull among attractors—stable and unstable, dynamic, relativistic, and turbulent. The "boundary" conditions between corporation and community are inherently uncertain, unpredictable, and potentially chaotic but not often destructive of either party.

Given the innate indeterminancy of corporation-community ties, it is little wonder that the social role of business has eluded scholars, corporate policy makers, and civic officials for so long. There are *many* civic roles for business. They vary from time to time, from community to community, and are entirely a matter determined by the interplay of natural forces that are themselves unpredictable and uncertain.[16]

THE LESSONS OF MUTUALISM

Recognizing that business has no single societal role is not equivalent to walking away from the many perplexing issues raised at the corporation-community interface. The essence of ecology—the trait that marks every ecosystem—is the presence of *mutualisms*, those symbiotic bonds that shelter and secure life for cooperating organisms. These mutual-aid bondings include not only the coordinated support found among the ants in a colony or the chimpanzees in a clan but extend to cross-species networks of mutual support—the bees that pollinate flowering plants, the bacteria that help digest our food, the photosynthetic organisms that provide oxygen to all aerobic creatures.[17]

Business is learning this central lesson that nature teaches. The Montreal Compact, the Rio Conference, the Kyoto Protocol, the Caux Principles, and the CERES-Exxon Valdez Principles testify to business's sometimes reluctant, sometimes begrudging but newly awakened ecological conscience and a willingness to think beyond the corporation's economizing bottom line. Mutualistic thinking is slowly but surely seeping into the executive mind. Whether induced by social responsibility, government regulation, or a rising ethical awareness matters little, so long as the community impulse is there.[18]

There *is* a tangible community role for managers that carries them beyond the barebones economizing process—and it begins at home, *within* the corporation. It requires great moral courage and creative moral leadership to face up to the tensions that nature breeds within corporate

value systems. The following is a partial list of what might be done by managers to improve relations between corporation and community:

- Distinguish between productive economizing growth and the bloat of expansionist glory.
- Accept the ecological limits set by nature as a constraint on bottom-line urges and marketing impulses.
- Know that technology can pulverize some as it liberates others.
- Release the latent self-organizing, innovative impulses within the company's workforce, thereby allowing this discretionary energy to flow into productive channels.
- Nourish, honor, and shield the personal values held by the corporate citizenry who devote their skills to achieving the company's goals.
- Acknowledge the presence and power of the covert spirituality quest concealed within the hearts and minds of employees and managers.
- Overcome the moral muteness so prevalent within the corporate workplace.
- Blend and harmonize the corporation's economizing mission with the strivings of others, not dominating, disrupting, trampling on, or destroying its community neighbors in the name of its own mission but seeking a niche mutually advantageous to corporation and community.

Taking these steps can only fructify, magnify, and enrich the life opportunities of all CASs within any community ecosystem. They become, in effect, the corporation's naturological responsibilities, defined by a nature long evolved and anciently patterned by the hidden order lurking within nonlinear natural systems.

But the story does not end there. The community, too, along with its leaders, must face up to nature's demands. The public is beginning to grasp and absorb some of nature's hard lessons. Indeed it must because the global ecosystem is expanding to envelop ever-widening spheres of daily life, from the U.S. heartland to the remotest Indonesian village (or as the Indonesians might say, from the Indonesian heartland to the remotest U.S. village). New fitness demands are being placed on all of the world's CASs by the onrush of new electronic technologies and the shifting economic fortunes of nations. New skills are being created and must be learned. New industries are emerging and must find resilient community homes. Within this boiling, bubbling, roiling global stew, each community must find its way, secure its niche, know and accept its diverse values, and plug in to the global network. To do otherwise within this rapidly self-organizing system is to forfeit one's place on today's fitness landscape, as people and governments in Indonesia, Thailand, North Korea, the Congo Republic, and Nigeria have been forcefully reminded. Everywhere, these are

struggles to adapt, to seek economizing niches, to plumb the creative reaches of techno-symbolism, to set in motion the autocatalytic potentials found within all complex adaptive systems, and to coevolve along pathways laid down by natural processes. Tapping nature's sometimes latent secrets of self-organization and coevolution is now a prime responsibility of community, as well as corporate, leaders.

Uri Merry (1998), a leading complexity theorist, has summed up this need very succinctly:

> CASs adapt by a combination of two basic strategies—natural selection and self-organization. . . . Both mechanisms are needed. Selection weeds out waste and encourages the more fit and the new. Self-organization builds on existing resources and through emergence creates novelty and variety. . . . Possibly, the functioning of an ecology of organizations at the edge of chaos necessitates finding a healthy proportion between both adaptive mechanisms, natural selection and self-organization—a strategy suited to the environmental conditions of the time.

As the 20th century closes down, nature is treating the world to one of its grandiose upheavals. That is the way of complexity, to push corporation and community to the edge of chaos while discovering mutually supportive values, a blend of strange attractors holding all back from the abyss, where none possesses an a priori claim of precedence and all can seek a secure niche.

But complexity theory is no magic bullet. It has little or nothing to say about the specific values, or combinations of values, that can bring corporation and community together. Such a theoretical task not only has not been undertaken but it does not appear to have been seriously contemplated by the main body of complexity theorists. The claim made here that *strange attractors embody and enact the core values of each and every complex adaptive system* is an initial, tentative step toward resolving that larger normative question. When values are understood to be the driving adaptive force of all CASs, one can better appreciate their tenacity and persistence—and indeed their necessitous nature. Their regulative function of holding an organism, a person, a corporation back from the pitfalls of total chaos gives hope. Their interwoven interdependence that creates life-support networks throughout any ecosystem community hints at common normative threads among the many diverse patterns making up the whole. The pull or "attracting" quality of interacting strange attractors (i.e., the embodied values) may prove to be more important to community

welfare than the "strangeness" of the orbits that they define. Somewhere within the community's collective "basin of attraction" reside the values that presently sustain any ongoing ecosystem community.

If this new theoretical interpretation of strange attractor is proven valid and accepted as a useful addition to the general body of complexity theory, it could mean something of overriding importance for corporate decision makers and strategic planners, for organization theorists and management scholars, for civic officials charged with community responsibilities, and for the general community citizenry. Together, they might then one day succeed in finding and putting in place the nature-based values of mutualism and cooperation that in the end will and must sustain both corporation and community.[19]

APPENDIX
Other Books on Complexity Theory

Capra, Fritjof. 1996. *The Web of Life*. New York: Anchor Doubleday.

Coveney, Peter, and Roger Highfield. 1990. *The Arrow of Time*. London: W. H. Allen.

Gleick, James. 1988. *Chaos: The Making of a New Science*. London: Heinemann.

Goldstein, Jeffrey. 1994. *The Unshackled Organization: Facing the Challenge of Unpredictability Through Spontaneous Reorganization*. Portland, OR: Productivity Press.

Holland, John B. 1975. *Adaptation in Natural and Artificial Systems*. Ann Arbor: University of Michigan Press.

Nicolis, Gregoire, and Ilya Prigogine. 1989. *Exploring Complexity: An Introduction*. New York: Freeman.

Parker, David, and Ralph Stacey. 1994. *Chaos, Management, and Economics: The Implications of Non-Linear Thinking*. London: Institute of Economic Affairs.

Prigogine, Ilya. 1996. *The End of Certainty: Time, Chaos, and the New Laws of Nature*. New York: Free Press.

Stacey, Ralph D. 1992. *Managing the Unknowable: Strategic Boundaries Between Order and Chaos in Organizations*. San Francisco: Jossey-Bass.

———. 1996. *Complexity and Creativity in Organizations*. San Francisco: Berret-Koehler.

NOTES

1. The summary account of complexity theory given here runs the risk of annoying everyone. Sophisticates will feel shortchanged, whereas the uninitiated may feel overwhelmed (or underwhelmed). For those who want to explore the details and subtleties, the appendix lists several major works on complexity theory.

2. This is a point made most dramatically and authoritatively by Stuart Kauffman's (1995) *At Home in the Universe: The Search for the Laws of Self-Organization and*

Complexity. Kauffman was one of the major figures at the Santa Fe Institute, where much of complexity theory has been developed. The Santa Fe Institute's Internet address is http://www.santafe.edu.

3. A brief, readable account may be found in Ian Stewart's (1995) Chapter 8 titled "Do Dice Play God?" which inverts a famous remark once made by Albert Einstein, "God does not play dice."

4. A fascinating, far reaching, but generally overlooked explanation of self-organizing processes may be found in the work of Antonio Lima-de-Faria (1988, 1995), a cytologist at the Institute of Genetics, University of Lund, Sweden. He hypothesizes that biological evolution has been "canalized" by three earlier evolutionary processes occurring in elementary particles, chemical elements, and minerals, a process he calls "autoevolution." In his more recent work, Lima-de-Faria (1995) argues that "biological periodicity" modeled from chemistry and the periodic table is the molecular mechanism involved in organic evolution. The breadth and relevance of his perspective was shown in the following comment about self-assembly:

> Every component of the cell is built from within as a result of self-assembly. Elementary particles have the ability to organize themselves spontaneously. The assembly of atoms and macromolecules is also intrinsic and spontaneous. Viruses self-assemble from the combination of their nucleic acids and proteins, producing infectious particles. Most cell organelles self-assemble from their molecular components, e.g., ribosomes, nucleosomes and membranes. Whole organisms self-assemble from their dispersed cells. Examples are hydras, sponges, and slime molds. Human skin has been produced by allowing separate cells to self-assemble. Moreover, there is increasing evidence that indicates that the evolution of proteins and of nucleic acids is dictated by their atomic configurations. (p. 304)

In plain words, evolution is far more ancient than organic evolution; organic evolution takes its basic patterns from preceding evolutions of elementary particles, chemicals, and minerals; and self-assembly reflects an underlying, extensive regularity and orderliness within nature. The current focus of chaos and complexity theory on biological self-organization, although reinforcing the concepts of autoevolution and biological periodicity, is perhaps not sufficiently rooted in this more fundamental picture drawn by Lima-de-Faria.

5. Indeed, there is a growing trend among cosmologists to see the entire universe as a self-reproducing (i.e., self-assembling) phenomenon. In the words of one leading theorist (Linde, 1996),

> Recent versions of inflationary theory [of the universe] assert that instead of being an expanding ball of fire the universe is a huge, growing fractal. It consists of many inflating balls that produce new balls, which in turn produce more balls, ad infinitum. [In this] new cosmological paradigm . . . the universe appears to be both chaotic and homogeneous, expanding and stationary. Our cosmic home grows, fluctuates and eternally reproduces itself in all possible forms, as if adjusting itself for all possible types of life that it can support. (pp. 106, 113)

Complexity theorists will be quick to recognize the familiar fractal-like patterns of such a self-assembled universe that are produced by computer simulations, as shown in illustrations accompanying Linde's article.

6. For a more complete description of the major components of complex adaptive systems, see Holland (1995: 45-46).

7. As Lima-de-Faria (1995) almost chillingly points out,

> Self-disassembly is the counteracting process which leads to decay and destruction of self-organized structures and functions. Elementary particles decay into other particles. The same phenomenon is present at the atomic level, and has the well known name of radioactivity, in which atoms disintegrate with the emission of particles. Crystal growth in a solution is a process that involves simultaneously self-assembly and self-disassembly. DNA is a molecule that self-assembles but also disassembles when it is heated: the two strands of double helix separate from each other. . . . An obligatory event in living organisms is death whose immediate outcome is cell disassembly. (p. 278)

Lima-de-Faria's observation is closely related to a similar conclusion reached in Frederick (1995: chap. 2). What is called self-disassembly by Lima-de-Faria is one of the forms taken by entropy production, which occurs throughout nature as organized systems dissipate their sustaining energy into the environment, thereby eventually losing their integrated structure and their ability to function as a system.

8. Ian Stewart's (1995) description is succinct and to the point:

> Chaotic behavior obeys deterministic laws, but it is so irregular that to the untrained eye it looks pretty much random. Chaos is *not* just complicated, patternless behavior; it is far more subtle. Chaos is *apparently* complicated, *apparently* patternless behavior that actually has a simple, deterministic explanation. . . . Chaos is not random; it is *apparently* random behavior resulting from precise rules. Chaos is a cryptic form of order. (pp. 113, 123)

9. Stuart Kauffman (1995) puts the matter dramatically by invoking the image of someone on a fitness peak (this one a mountainous sand dune):

> 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. . . . At this poised state between order and chaos, the players cannot foretell the unfolding consequences of their actions. . . . There is unpredictability in each individual case. If one can never know if the next footstep is the one that will unleash the landslide of the century, then it pays to tread carefully. (p. 29)

Here, Kauffman refers to another of complexity theory's major concepts, self-organized criticality, which is not otherwise treated in this article, but see Bak (1996).

10. An intuitive feeling for the underlying mathematical derivation of strange attractor dynamics can be gained from the following two characterizations of strange attractor. The first employs highly technical terminology derived from nonlinear mathematics, whereas the second expresses the same set of relationships in more familiar language. For example, "bounded phase space" in the first passage becomes a "well-defined region" in the second; likewise, "trajectory" in the first passage is rendered as "orbit" in the second. A little patience in wading through the terminology pays dividends in grasping the essential meanings. The first passage follows:

> A strange attractor is the behavior of a system expressed as a trajectory through a bounded phase space where the trajectory is characterized by the following properties: instability of all motions, deterministic randomness, and sensitivity to initial conditions. The strange attractor trajectory never repeats itself, i.e., each cycle covers a new region of phase space. Plotting the trajectory of the path does not manifest ran-

> domly distributed points but a complex pattern of behavior. (Jurgens Pieterse, personal communication, February 3, 1998)

Now for the second, somewhat less technical example. Speaking of a dynamic nonlinear system, another observer said,

> The system is moving on orbits . . . such that they have some order, remaining in a well-defined region even though they are not periodic. The region of the trajectories is called an attractor, and in this case the attractor is called strange because of the way the orbits wander in an unpredictable way, while remaining confined to the region, characteristic of a system in a state of deterministic chaos. (Goodwin, 1994: 54)

In spite of their technical terminology, both passages emphasize that although nonlinear systems behave in unexpected, unpredictable ways, there is an underlying pattern to their movements. In other words, orderliness and regularity emerge out of what may at first appear to be only random movement. As Goodwin (1994) said, "Compared with a purely random process, deterministic chaos has a lot of order, but it does not show up unless one looks at the system in a particular way" (p. 56). The strange attractor concept is one such way to visualize this kind of pattern. In the discussion to follow, one should remember that the system behavior being described is a reflection of the regularities and patterns that emerge from calculations based on sets of nonlinear mathematical equations. In its dependence on mathematics, complexity theory is no different from many other natural science theories and hypotheses that rest on advanced mathematical expressions. For two reader-friendly, largely nonnumerical descriptions of the mathematics underlying scientific conceptions of nature, see Osserman (1995) and Stewart (1995).

11. Various concepts in complexity theory are omitted here because of space limitations. Two such omissions are *point attractor* and *limit cycle attractor*, both of which have interesting implications for corporate operations; however, this article's constraints do not allow them to be integrated into the following analysis of organizational structure and dynamics.

12. The following summary of the corporation's major values is based on a fuller discussion found in Frederick (1995), especially Chapters 1, 2, 3, 6, and 7.

13. The prominence and influence of power-aggrandizing values in the executive suite were displayed in the 1998 cancellation of plans to merge two pharmaceutical companies, SmithKline Beecham and Glaxo Wellcome. According to *The New York Times* (1998), the prospect of a merger of these two corporate giants "stunned the industry," and the decision to call it off "was even more shocking to many analysts and executives" (p. C1).

> What derailed a deal, analysts said, was the same issue that had broken up merger talks between SmithKline and American Home Products in January [1998]: who would run the combined company. . . . The Glaxo board was balking at [SmithKline's CEO] becoming chief executive. (*The New York Times*, 1998: C1)

The alpha male of any chimpanzee clan would, if it could peer into the executives' cage, instantly identify with the SmithKline chief executive officer. For a related discussion, see Annette Simmons's (1998) *Territorial Games*, which describes organizational "turf wars" in business.

14. One of the traits of nonlinear systems is a sensitivity to the system's "initial" state, which sets the stage for much of the subsequent unpredictability of the system's future activity. In the case of corporations, initial conditions are difficult, and to a large extent impossible, to identify with precision, or more likely, initial condition here might imply an extended sequence of critical points in the company's evolution, each of which had imparted an

enduring characteristic whose influence could then be felt throughout the firm's further development. Whether a company can weather the kinds of crises mentioned at this point in the text would depend largely on this time series of initial-condition traits.

15. It would not be at all surprising to find some mathematical complexity theorists to be dubious about rendering strange attractors as values. One such knowledgeable commentator (William L. Dougan, personal communication, May 1, 1998), speaking of strange attractors, has said,

> This definition does not require any reference to intention any more than the phenomenon of gravity requires reference to the intention of the earth or the intention of the falling rock. My perspective as a methods person was to note that strange attractors can be observed in a variety of systems, some of which have nothing to do with human beings, animals, cells, or amino acids. It is a [purely] mathematical definition, just like the term "differentiable function." I believe that the idea of intentionality came about because of the movement of discussions about non-linear, dynamic systems into the realm of "animate" entities, and particularly human entities (e.g., the often discussed notion that the human mind may be a non-linear, dynamic system). There is a strong inclination on the part of social theorists to strip the systems dynamics from its home in mathematics, leaving behind [in mathematics] the contextual information which gives meaning to the terms. It's just too darn easy to make that term "attractor" into the phrase "wants to be."

This is fair criticism worth serious consideration by all who try to elicit social, behavioral, intentional meaning from the barebones mathematical architecture of chaos and complexity theory. Dougan's view may well prevail as the correct one, particularly if current efforts by many social scientists and cognitive neuroscientists to adopt and adapt chaos-complexity theory to the human behavioral realm fail to produce grounded, verifiable, and falsifiable research propositions.

The defense offered in this article for trying to link strange attractor to values is that the mathematics describes, or appears to point to, a kind of behavioral system dynamics that matches or parallels the functions and roles played by values within human organizational systems. The point can be illustrated as follows: In the following passage taken from a description of complexity theory (Stewart, 1995), substitute the term *values* for the term *attractor*. The sentence could then be accurately read in either of two ways: (a) "The long-term dynamics of a system is governed by its *attractors* [italics added], and the shape of the *attractor* [italics added] determines what type of dynamic occurs" (the original version) or (b) "The long-term dynamics of a system is governed by its *values* [italics added], and the shape of the *values* [italics added] determines what type of dynamic occurs" (p. 117).

This article's claim about the strange attractor-values link is not intended to be a metaphorical or analogical flourish. Quite the contrary, the claim is that value sets indeed duplicate and carry forth the exact same function within human organizations as is found within the calculations of nonlinear differential equations that have produced the mathematical notion of strange attractor. In fact, the claim goes even further. A corporate system's "phase space" should be seen as the total range of value variables available to any given corporate dynamic system; its "phase portrait" is a set of swirling *values* that represents all possible behaviors starting from all possible initial conditions, to paraphrase Stewart's (1995: 116) definitions.

16. Complicating the already complicated picture of community life is the presence of all kinds of Complex Adaptive Systems (CASs) whose main function and mission reach beyond "mere" economizing to embrace other kinds of human needs—governance, artistic-

aesthetic expression, health care, education, helping-caring, and religious-spiritual interests. Although each of these CASs must attend to its economizing needs, the main focus of their respective strange attractors (i.e., their defining values) propels them in varying directions and toward diverse goals. The likelihood is great that their activities will intersect those of the corporation, thereby magnifying the complexity to be found in corporation-community relations.

17. In *Values, Nature, and Culture in the American Corporation*, Frederick (1995, chap. 6) describes an *ecologizing value cluster* consisting of linkage, diversity, homeostatic succession, and community. The effect of these values is to draw all members of an ecosystem into a close-knit skein of mutually supportive relations.

18. With good reason, some will question this optimistic assessment of business's commitment to environmental mutualism. One good example comes from 1998 midyear U.S. Congressional committee actions that reflect business lobbying against the Kyoto Protocol, especially by the automobile industry, coal producers, oil companies, and public utilities (Cushman, 1998). Under lobbying pressure from business groups to oppose the Kyoto provisions that would reduce global-warming emissions, a House of Representatives committee declared that no funds for the Environmental Protection Agency (EPA) were to be used "for the purpose of implementation, or in contemplation of implementation, of the Kyoto Protocol" (Cushman, 1998: A15). Other language ordered the EPA "to refrain from conducting educational outreach or informational seminars on policies underlying the Kyoto Protocol until, or unless, the Protocol is ratified by the Senate" (Cushman, 1998: A15). Thus, before the Kyoto Protocol had even been taken up by the treaty-approving U.S. Senate, some business groups were actively opposing its major provisions. The more optimistic view favored in this article comes from the interlinked nature of economizing and ecologizing found throughout the natural world, which argues that all forms of economizing occur within and *ultimately depend on the integrity of a surrounding ecological network* (Frederick, 1995: chap. 6). It is this broad ecological reality that many business leaders seem to be absorbing, although at a painfully slow, perhaps even a dangerously slow, pace. One suggestively optimistic example from the financial services sector is described in Schmidheiny and Zorraquin (1996).

19. An alert student of complexity theory will note two kinds of subtle ideological bias that seem to have crept into the thinking of its advocates or, contrariwise and more important, that may be unconsciously and naively insinuated into the theory by their a priori ideological commitments. Both biases tend to say more about the unspoken assumptions of the theory's followers than of the founders. One bias is *political* in nature: A human organizational CAS (e.g., a corporation) is thought to be more capable of attaining an optimum operating level if left free to explore all possible options laid out by its strange attractor, which means minimizing linear-type commands-and-controls on its actions. That translates into relative freedom of all within the corporation from authoritarian managerial control and, perhaps more significantly, a laissez-faire approach to government regulation. It is difficult to know which of these parties—corporate management or public policy makers—would be the most alarmed by this prospect. Complexity theorists have done little to confront the normative human issues involved when nonlinear systems are allowed free rein of this scope. A second bias is *teleological* in nature: One possible philosophical implication of a spontaneous self-organizing natural process, particularly when used to explain the origin of earthly (especially human) life, is that it has been *intended* to occur or has been *consciously made* to occur. Therefore, this would appear to be yet another version of the Anthropic Cosmological Principle, which posits the same purposeful outcome (Barrow and Tipler, 1986; Corey, 1993).

This kind of philosophical bias can be sensed in the title of Stuart Kauffman's (1995) *At Home in the Universe* and in several passages of similar import throughout his pathbreaking work on complexity theory. The normative questions that follow from such softly spoken assumptions are rarely aired within complexity circles but should receive more attention.

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