From Life Cycle to Ecocycle: A New Perspective on the Growth, Maturity, Destruction, and Renewal of Complex Systems

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NONTRADITIONAL RESEARCH

From Life Cycle to Ecocycle

A New Perspective on the Growth, Maturity, Destruction, and Renewal of Complex Systems

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I don't know. It's a mysterious thing. (the response of Roger Smith, former chief executive officer of General Motors, to *Fortune* magazine when asked to explain what went wrong with the company)

The sudden collapse of large, mature, apparently impregnable organizations has been a feature of the political and economic turbulence of the 1980s and 1990s. The tearing down of the Berlin Wall, the fragmentation of the Soviet Union, the shake-up at General Motors, and the sudden reversal in the fortunes of IBM all share this quality of shock and surprise. And although such events are repeated every day on a smaller scale throughout the world economies, they never fail to surprise observers and challenge our ability to explain why they take place. The phenomenon gives rise to several questions.

- Why do such events take place?
- Are they really as sudden as they seem to be, or is it just outsiders who are caught off guard?
- If these events are due to systemic causes, what are the dynamics involved?
- What can managers of organizations do about such situations?

A conceptual framework which should be useful in making sense of the situation is that of the life cycle (Kimberly & Miles, 1980; Quinn & Cameron, 1983). The life cycle concept, whether applied to a product, a process, an organization, or an industry has always had an enormous intuitive appeal. Complex systems do seem to go through an evolution from birth through growth to maturity and decline. Applied within large organizations, the concept has proved fruitful to managers, underlining the fact that no product or process survives forever and the need for constant innovation if the organization is to survive. Applied to organizations and industries by economists and others outside the system, the life cycle has supported the detached view of atomistic competition that acknowledges the need for "creative destruction" (Schumpeter, 1950) if an industry or society as a whole is to benefit.

However, the life cycle concept has proved less helpful when it has been applied by actors rather than observers; that is, when it has been applied at the same organizational level as the users. Usually this means the application of the notion to the whole organiza-

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tion, in an attempt to understand where it is in its life cycle, a need that has been made more urgent by the turbulent times in which we now find ourselves. How do managers use the life cycle concept to make sense of what is happening to their own organizations, to GM, IBM, or even what was the Soviet Union?

The major problem, in our view, is that the life cycle is not completely systemic. That is, when applied to organizations, it has usually been based on the life cycle of a single, reified organization without taking into account either internal processes or external interactions. A similar criticism—that much of the theory and research about change in organizations is presented free of its rich context—has been made recently by others (Mintzberg & Westley, 1992). That is, the life cycle is silent on where organizations really come from and what happens to them after they "die." Perhaps life cycle theory takes its cue from our cultural reluctance to talk about either death or conception. It focuses on first-order or developmental change that takes place as an organization grows from birth to maturity, but it is less helpful with the more radical second (Watzlawick, Weakland, & Fisch, 1974) or higher order (Bartunek & Moch, 1987) transformational change that takes place during organizational renewal.

Organizational progress is often depicted as a chain of successive S curves without discussion of how "the" organization (or some component of the organization) gets from one curve to the next (for an example, see Handy, 1994). In addition, the life cycle models tend to see the environment as separate from the organization, rather than seeing them as interdependent, with organizations and their environments being co-created (Emery & Trist, 1965). Thus the life cycle begs the question of what "it" is that stays the same, and thus it can be said to have been renewed when organizations go through radical change. For this purpose one needs an expanded conceptual framework, one that includes the life cycle but goes beyond it.

In this article we will describe what we have called the organizational ecocycle. The ecocycle incorporates the conventional life cycle and illustrates how mature organizations may become systemically vulnerable to catastrophe. The ecocycle also deals explicitly with what happens after complex systems die and how and in what sense they may be thought of as being renewed. In the process, we will show that the ecocycle has important practical and theoretical implications, for it provides insights into how some recent thinking from the nonlinear dynamics of complex systems and chaos theories can be used to renew established organizations. Although we do not believe that organizational immortality is possible, there is a great deal that managers can do to extend the lives of their organizations.

THE ECOCYCLE

The ecocycle model comes from ecology, where it was derived from the study of the evolution of complex ecosystems (Holling, 1986, 1987). The basic dimensions of the cycle can be seen in Figure 1.

The ecocycle differs from the life cycle via the addition of a "back loop," shown as a dotted line. This loop combines with the conventional life cycle curve to form an endless loop, the symbol of infinity. The vertical axis shows the amount of potential accumulated within a system. *Potential* represents the possibilities of a system. It is the sum of possible outcomes (or paths) times the value of these outcomes. The values can be either positive or negative. Therefore potential is affected by both the number of outcomes and the values of their outputs. As further described below, high potential organizations can consist of large informal networks (Quadrant 4) or can be more familiar, large, resource-intensive structures (Quadrant 2).

The horizontal axis reflects the degree of connectedness of a system. In this article *connectedness* refers in a general sense to properties of networks such as density, connectivity, and hierarchy (Ibarra, 1992). A weakly connected system has much in common with a loosely coupled system (Orton & Weick, 1990; Weick 1976). It is a system in which elements affect each other "suddenly (rather than continuously), occasionally (rather than constantly), indirectly (rather than directly), and eventually (rather than immediately)" (Orton & Weick, 1990, pp. 203-204). A higher degree of connectedness represents a more articulated system (Ulanowicz, 1987). When a system is highly articulated, or strongly connected, there are few alternative pathways within it. The paths of activities and the interactions that accompany them are well-developed—the effect of system elements on each other tends to be continuous, constant, direct, and immediate. The interaction of these dimensions produces the 2 × 2 matrix shown in Figure 1.

It should be noted immediately that, unlike the life cycle, a given organization cannot be thought of simply as a point moving around the infinity loop. There are qualitative changes that take place in the system as it moves from the conventional S curve of the life cycle

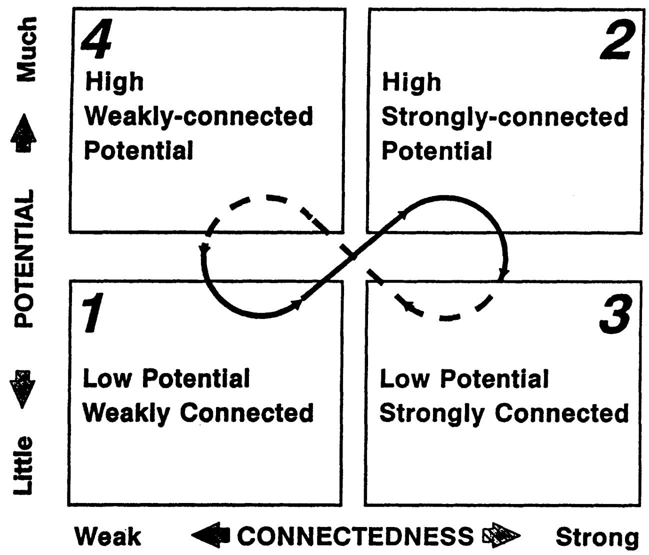

Figure 1: The dimensions of the ecocycle. Adapted from Holling (1987).

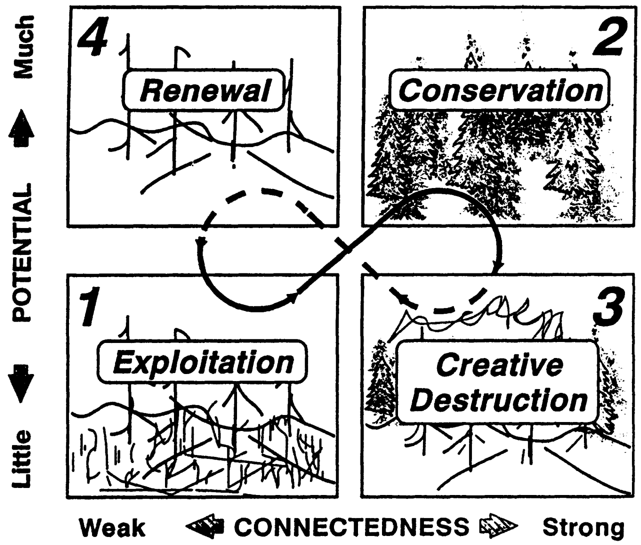

Figure 2: The birth, growth, destruction, and renewal of a forest. Adapted from Holling (1987).

onto the back loop, as well as when it moves back to the conventional cycle. These transitions are accompanied by discrete jumps in the level or scale of the organization being observed. On the right-hand side of the ecocycle, the death of the organization is represented by its disintegration into smaller, lower-level components, as it transits from Phase 2 to Phase 3. On the long dotted line diagonal of the back loop, as the system moves from Phase 3 to Phase 4, these fragments become reformed into a new, high-potential configuration, that of a large weakly connected network. This sets the context for the conception and emergence of new organizations. This is shown on the left-hand side of the ecocycle when, in a move from Phase 4 to Phase 1, the organization crystallizes out of the matrix provided by the high potential, weakly connected network. Thus the ecocycle places complex systems in a cycle of continual transformation, which includes movements up to higher levels of potential, as well as breakdowns to lower levels of aggregation. This means that the ecocycle tracks a dynamic that can be observed operating across several different levels of analysis: individuals, subunits, organizations, populations, and communities (Hannan & Freeman, 1977).

To understand how this framework was developed, it is helpful to track a natural system through the ecocycle. A forest is an example of a complex, natural system with which everyone is somewhat familiar. A simplified representation of its states is shown in Figure 2.

THE ECOCYCLE OF A FOREST

A forest, like all complex organizations, is a collective noun. That is, it is composed of a myriad, interacting smaller organizational structures, all of which go through their own processes of change. Many of these subsystems—particular groups of trees, for example, or patches within the forest—will resemble the forest as a whole. That is, they will have a holographic quality (Morgan, 1986), a so-called fractal relationship with the larger system (Mandelbrot, 1982; Zimmerman & Hurst, 1993). The overall cycle of the forest is an emergent quality of the system which results from the individual changes in these elements, their interactions with each other, and exchanges with the larger external environment.

Systems such as forests have been described as complex systems. Other examples of such systems are the economy, the brain, the immune system, social systems, and political parties (Waldrop, 1992). Complex systems have two characteristics in common which are relevant to our understanding of the ecocycle:

1. *Multiple agents and dispersed control*: They have networks of many agents acting in parallel. Each agent finds itself in an environment produced by its interactions with other agents. For a forest, the species of trees, plants, and animals are its agents. In a similar way, individuals are the agents in an economy, and firms are agents in a business cycle. Therefore control of a complex system is widely dispersed. There is no "master neuron" (Waldrop, 1992, p. 145).

2. *Perpetual novelty*: Complex systems typically have many niches. Filling a niche opens another. There is no such thing as equilibrium for complex systems (Waldrop, 1992, p. 147).

The self-organizing behavior of a complex system, such as a forest or a social system (Drazin & Sandelands, 1992), is based upon the repeated application of relatively simple rules at many levels or by many agents acting on the system. In this way control is dispersed, and yet there is an order to the interactions between the agents.

The phases and the transitions between them described here are widely observed tendencies of complex systems. Due to the many degrees of freedom in these systems, there is nothing inevitable about the timing of the changes, but it seems that most ecosystems will go through the phases in some form or another and in the order suggested here. Because the cycle is a continuous one, the numbering of the phases is arbitrary, and the numbers are used here only for ease of reference. We begin with the conventional life cycle in the birth phase or exploitation, as it is called in ecology. The word *exploitation* has pejorative connotations when used in discussing human systems. This is a meaning which developed late in the life of the word. One of the early meanings of *exploit* is "to act with effect," and it is in this sense that we use the word.

Phase 1—Exploitation

This phase of the ecosystem is characterized by a number of processes that lead to the rapid colonization of an available space. For example, when a gap appears in a forest due to (say) the fall of a large tree, a miniature "microclimate" is created. The open patch offers equal access to energy and resources to many organisms. In what has been called an "immediate-return" economy (Woodburn, 1982), the resources are easily available and require little investment to be harvested. Thus the clearing will be colonized initially by a large variety of plants and other life.

Many of these organisms will be what some ecologists call *r-strategists* (to be discussed in more detail shortly); that is, they will be species that are highly productive and mobile, producing large quantities of offspring. Available space allows the early inhabitants of the patch to grow without either running out of resources or bumping into each other. Such a system is weakly connected—there are many different ways for resources to flow through it. The r-strategists are the pioneers, the opportunists who can take quick advantage of the open space that has appeared.

As these first movers grow, some species will flourish better than others. What was once an open space starts to become crowded, and the plants begin to interfere with each other—the connections among the different species become stronger. Taller plants will shade shorter ones, those that have spreading root and branch systems may choke those that do not, and so on. The generalists, those who could survive under a variety of conditions, will start to give way to niche specialists in an environment that is becoming more stable and predictable. Slowly the open field becomes dominated by a few large systems and differentiated into a hierarchy of smaller niches, creating a relatively gradual transition to the next phase of the ecocycle.

We have vastly oversimplified the description of this stage of the ecosystem. The so-called "patch dynamics" (Terborgh, 1992) of real forests are incredibly complex, and there are systematic differences, for example, between the structures of forests in the tropics and those in more temperate zones. Nevertheless the presence of these exploitative processes in r-selection environments seems to characterize all forests in this phase of the cycle.

The Analogous Phase in Human Organizations

The analogies between the growth of a forest and the emergence of an organization are clear. Nike®'s growth during the 1970s, for example, is a classic illustration of an r-strategy in action (Strasser & Becklund, 1991). Having established the company in high-performance track and field shoes, Nike managers developed products for a succession of other sports. With little investment in plants and facilities and an informal organization, they were highly flexible as they moved from basketball to tennis, football, soccer, and a host of other sporting activities.

Their progression was a combination of planning and opportunism in an unexploited field. In the early days, for example, the endorsement of footwear by professional athletes and their coaches was in its infancy, and there were no published guidelines. The rules of sponsorship for athletes in events such as the Olympic Games were being rewritten amid a morass of under-the-table deals. There were few precedents to be followed, and competing firms did more or less what they wanted. The unstructured environment was such that the results of actions were almost immediately apparent. This is typical of an immediate-return economy: Product trials do not require large investments, and the rapid feedback encourages trial-and-error learning. Activities that pay off are extended; those that do not are stopped. During this phase of the cycle, strategies often emerge as a retrospective rationalization of what worked. Thus many of Nike's strategies emerged over an extended period of time as they exploited what turned out to be a huge, untapped market.

In contrast, in the 1980s, as the market for sports shoes grew, the niches became increasingly defined and specialized. Whereas the undifferentiated sneaker had performed a wide range of functions in 1950s, now each sport began to require its own specialized equipment. The application of research and the development of new materials and manufacturing techniques constituted an emerging technical system that allowed specialization to flourish. Nike began to be attacked by competitors such as Reebok® who were also exhibiting r-strategies, but targeting particular segments—the aerobics market, in the case of Reebok. The environment was becoming crowded, encouraging both specialization and efficiency.

r-selection and K-selection Environments

The differences between organisms in Phase 1 and Phase 2 of the ecocycle are so striking that some population biologists have distinguished between two particular kinds of environment, based upon the kinds of selection pressures that they impose on their inhabitants. When these are thought of as attributes of organizations rather than of their environments, they are described as r-strategies and K-strategies.

The two major types, the so-called r-selection and K-selection environments, seem to favor the formation of two different kinds of systems. The prefixes *r* and *K* are derived from the Pearl-Verhulst logistics equation, where the rate of growth of a population (X) over time (t) is a function both of the natural reproductive rate (r) in the population and the carrying capacity (K) of the environment. The equation for the change in the population over time is $Dx/dt = rX(K–X)/K$. Initially, when K is very large compared to X, the growth rate in the population is very close to r, its natural growth rate. As K grows, the carrying capacity of the environment becomes more and more of a factor until, when $X = K$, no further growth in the population is possible. The equation generates the familiar S shaped curve of the life cycle. The terms *r-selection* and *K-selection* were coined by MacArthur and Wilson (1967). Table 1, adapted slightly from Pianka (1974) describes each of the environments and its correlates.

Environments where r-selection predominates encourage highly productive organizations, whereas K-selection environments favor efficiency. However, the two types of selection are at the opposite poles of a continuum, and no organism is selected entirely by one environment. Thus every organism has to reach some kind of dynamic compromise between the two.

Transition: Phase 1 to Phase 2: From Exploitation to Conservation

As a forest ecospace becomes crowded, competitiveness grows and the need for efficiency increases in importance. Organisms that survive exhibit behavior very different from those of the profligate pioneers. In these so-called K-selection environments, successful organisms produce fewer progeny and invest their energy in protecting them for longer periods of time and in defending their territories. This leads to the emergence of large-scale hierarchical organizations. The structure of the forest and the trees represents accumulated potential that now controls the usage of energy and materials in the ecospace. The system as a whole is now strongly connected—there are relatively few ways in which resources can flow through the system.

In forests, the peak of this stage represents a cyclical climax. The system will be dominated by large hierarchical structures that control a set of niches beneath them, allowing a variety of specialists to flourish. Because of the great length of the growth cycle of trees, the trees and the niches they shield will appear to be relatively stable to human observers. So-called climax forests are characterized by their apparent steady state and, viewed at a distance, the forest will look impressive. However, although many organisms in the system will be specialists, the total variety of the system will be lower than in the exploitation phase. In temperate zones in particular, there may be relatively little variety in the types of tree in the forest. In extreme cases in wild natural forests, a stagnant monoculture may develop.

It is precisely the homogeneity of such systems in age, species type, and their specialized adaptation to protected niches that renders them brittle and vulnerable to catastrophe. Forests composed of only a few varieties of tree are especially susceptible to insect

Table 1
Contrasting r-Selection and K-Selection Environments

Type	*r-Selection*	*K-Selection*
Climate	Variable and/or unpredictable, uncertain	Fairly constant and/or predictable, more certain
Population	Variable in time, nonequilibrium; usually well below the carrying capacity of the environment	Fairly constant in time, near equilibrium; at or near carrying capacity of the environment
Competition	Variable, often lax	Usually keen
Selection favors	Rapid development, many trials, small size	Slower development, fewer trials, larger size
Locus of control	Bottom up	Top down
Economy	Immediate return	Delayed return

attack and disease. Mature forests contain huge amounts of burnable materials and, as they age, the conditions for disaster become more favorable, as dead wood accumulates on the ground. This is why, in natural forests, efforts to preserve this stability too rigidly—by preventing forest fires, for example—have proven to be misguided. The U.S. National Park Service abandoned a policy of putting out all fires 20 years ago (Jeffery, 1989; Wright & Bailey, 1982). If all fires are extinguished, this will tend to reduce the variety of the forest further, as the mature trees choke other organisms. It will also build fuel on the ground and prevent the formation of natural fire breaks. This reduction of flexibility, variety, and resilience means that, when there is a fire, it may be catastrophic. Similar disasters, often caused by disease, occur in cultivated forests where monocultures are encouraged.

Ideally, a healthy forest should consist of a mosaic of patches, which developmentally are located all over the ecocycle. The optimal spread will depend upon a myriad factors. This implies that, in healthy ecosystems, the dynamics of the ecocycle would be observed operating at and across many levels; in communities, in populations, in groups, and in their subunits.

Analogous Transitions in Human Organizations

The analogies between the growth of a climax forest to maturity and the development of a successful human organization are compelling. From a product and technological perspective, the transition is marked by the emergence of what has been called a "dominant design" (Abernathy & Utterback, 1978). This design embodies all the features that customers now regard as basic requirements. As such, its emergence often signals the end of radical product innovation in an industry (or organization) and a move toward improvement in the production process. It also marks the peak in the number of different firms involved in an industry (Utterback, 1994).

In individual organizations, managers will naturally tend to restrict activities to those that have proven to work, leading to tightly coupled practices (Hedberg, Nystrom, & Starbuck, 1976; Tushman & Romanelli, 1985). Successful strategies will be elaborated upon and expanded. Considerable effort and capital will be invested in describing these activities and embedding them in technology and in formal organizational procedures to perpetuate their performance. Activities within the system will become strongly connected with each other via production technology of all kinds, and there will be limited variety in the ways in which procedures are performed. The organization will specialize, "stick to its knitting," and emphasize efficiency. This will make it even more successful than it might otherwise have been.

From r-strategy to K-strategy

Although the transition from r-strategy to K-strategy is common, this does not mean that it is an easy passage for managers to navigate. This is illustrated by the recent, well-publicized, jolting transitions at Compaq® (Forest & Arnst, 1992; Francis, 1992; Ivey & Levine, 1991; Ivey, Depke, & Peterson, 1991; Webber, 1990).

The story of Compaq is well-known. The company was founded in early 1982 by three former Texas Instruments (TI) employees. Led by Rod Canion, Compaq's emphasis was on introducing personal computers with leading edge technology as soon as it became available. The manufacturing emphasis was on quality, flexibility in shifting products, and speed in bringing new products to market. Cost considerations were "way down the list." This is exactly what one would expect of an r-strategy organization.

Compaq reached the *Fortune* 500 after only 4 years of operation: the shortest time on record. Sales reached over $1 billion by 1987 and nearly $3 billion by 1989. By 1990, however, Compaq's growth rate had slowed dramatically to less than 4% in the United States. Competitors were undercutting its prices by as much as 35% on machines with comparable features. In 1991 sales fell for the first time—by 9%—and Compaq had its first-ever losses and layoffs. There were two competing rationales for the situation. The first was Chief Executive Officer (CEO) Canion's belief that the worldwide recession was largely to blame, with the implication that no change in strategy was necessary. The second argument was based on Chief Operating Officer (COO) Eckhard Pfeiffer's conviction that the market had changed and that Compaq would have to change its strategy. Where Canion saw a temporary interruption in Compaq's growth, Pfeiffer saw a more sinister pattern. He realized that what had once been a unique Compaq product configuration was now the dominant design being offered by many competitors. In his view the firm now needed to focus on the efficient production of this established design.

The business world was shocked when, on October 25, 1991, the board of Compaq accepted Pfeiffer's view and fired Canion. Pfeiffer set about immediately to introduce what is easily recognizable as a K-strategy. The company was split into two divisions, the one to take on the lower cost clones, the other to sell the more complex systems where a feature-based strategy would still be viable. At the same time Pfeiffer launched a series of wide-ranging cost-cutting initiatives with the objective of still building high-quality computers but at radically lower cost. In the first phase, the workforce was cut by 25% to 9,000 people. In a K-strategy, cost reductions and efficiency are at the top of the list.

Pfeiffer's view of the situation seems to have been a timely one. Compaq's sales growth has returned as have profits, although gross margins are down by a third due to savage cuts in selling prices.

Threats to the Viability of K-strategists

Immediately after World War II the North American economy probably favored r-strategists in many industries. Through the late 1940s, '50s and early '60s there was a pent-up demand for consumer goods, together with the need to rebuild a war-shattered Europe and Japan. However, by the late 1960s and early 1970s, this growth began to slow. Major markets began to become saturated as demand for steel, autos, and housing peaked and then started to fall. By the 1980s the majority of the *Fortune* 1000 were probably conservation-oriented structures pursuing K-strategies in their domestic markets. Even the conglomerates, like climax forests, were often made up of mature units.

However, while institutionalizing their successes and pursuing efficiency, conservative organizations sacrifice resilience and flexibility and become more vulnerable to sudden change. As Hannan and Freeman (1977) have pointed out, these constraints arise from both internal structural arrangements and environmental considerations: nonfungible assets, inadequate information, political tensions, barriers to entry and exit, and a myriad other elements come into play. Earlier in the ecocycle, these organizations might have been able to adapt to their environment. Now the danger is that they will be selected out.

The effects of turmoil—recessions and revolutions—on innovation in organizations have been remarked on before (Carroll, Delacroix, & Goodstein, 1990), but the ecocycle is helpful as a systemic explanation. Although all systems (r or K) can be threatened by such environmental events, we tend to be aware of the destruction when all of the "trees" are gone—when an established system (forest, organization, or industry) has been obliterated. Indeed the thought derived from the forest fire analogy—that efforts to make large systems hyperstable may actually render them brittle and vulnerable—is an intriguing one. The seeds of failure may be contained in the fruits of success (Hedberg et al., 1976; Miller, 1993).

A particularly poignant instance of this involves members of the U.S. integrated steel industry. The preservation of their production facilities from attack during World War II gave them a tremendous production advantage in its aftermath, and in 1946 U.S. steel companies accounted for 54.1% of the world's raw steel production. However, that success was accompanied by a failure to innovate, either in products or production processes, and U.S. companies stuck with the massive technology of the open-hearth furnace and the ingot process long after they were obsolete. Their market share fell to 20.1% by 1970 and to 11.8% by 1984 (Hoerr, 1988, p. 94). In the aftermath of the war, their rivals, often with economies devastated by the conflict, had nothing left to preserve. They adopted novel production methods developed by people largely outside the steel companies (Jewkes, Sawers, & Stillerman, 1969). The American integrated mills thus found themselves under ferocious attack from a new smaller scale, more flexible production technology: the scrap-fed, electric furnace mini-mill using a continuous casting process.

Transition: Phase 2 to Phase 3: From Conservation to Creative Destruction

The third stage in the evolution of the forest is the forest fire. This phase is aptly described as "creative destruction" because the system is not destroyed completely—it is partially destroyed in order to be renewed. Nevertheless, in natural systems, this phase often sees much of the potential (or the value of the outcomes) that has been realized in large-scale structures during the period of growth quickly destroyed as the system becomes disorganized.

The ecosystem is invaded by processes to which its age, specialization, low variety, and loss of resilience have made it peculiarly vulnerable. The highly articulated structure is shattered, as the former strengths of the system—their strong connectedness—are now seen to act as pathways to destruction. The system remains strongly connected but, as the physical capital is destroyed, it is now the destroying process that connects all the elements.

The large hierarchical components of the system (the old trees, in the case of forests) are peculiarly vulnerable. As they disintegrate they are broken down into much smaller components in a dramatic reduction in organizational scale. The elaborate hierarchy of niches which had developed under the protection of the larger, stronger components is exposed to the full variability of the environment. Strengths developed in other contexts, and the stability that they conferred, are of little help against the invading processes because they often feed on these strengths. Only the mobile (forest animals for example), those prepared for the situation, and the lucky can survive. For example, several varieties of coniferous trees, such as lodgepole pine and jack pine, grow special fire-resistant cones that open only when heated, thus allowing their seeds to survive.

Analogous Transitions in Human Systems

The description of the effects of a forest fire resonates with the carnage we see these days among what were once thought to be large invulnerable organizations. Just as in the case of the forest, it seems as if the very factors that once made major companies supreme have suddenly made them vulnerable. And the stronger they were, the more slowly they became aware of their vulnerability to catastrophe. The story of the fall of the Big Three U.S. auto manufacturers (Halberstam, 1986) illustrates the phenomenon neatly.

The number of players in the U.S. auto industry peaked in the early 1920s with the emergence of the all-steel body as the dominant design (Utterback, 1994), and the key success factors for automakers became production efficiencies and economies of scale. From the mid-1930s to the mid-1970s, GM, Ford, and Chrysler appeared to be invulnerable. They had all institutionalized the technologies and systems necessary to perfect the mass production of large automobiles for the U.S. market, but GM had been the most rigorous in this process and was the most integrated (strongly connected) of the three. The largest enterprise on every scale, GM generated the highest margins and returns over this period. Chrysler, by contrast, was much less integrated, more of an assembler than a manufacturer. In consequence, Chrysler's margins and returns were the lowest of the three. Chrysler was the first to experience trouble in the wake of the oil shocks and the Japanese auto invasion of the 1970s. Ford followed with its massive financial losses in the late 1970s. GM, with it huge resources, was able to sustain its managers' belief that the downturns were cyclical rather than secular. It was not until 1982 that GM officials began to realize the scope of the problems they faced to combat the Japanese "lean" production system (Womack, Jones, & Roos, 1991).

The main problem for all three auto producers was in the domestic U.S. marketplace: the place where they had perfected their systems. However, in the subsequent turmoil, the star roles have been reversed. Chrysler and Ford have shown themselves to be much more flexible than GM. The strongly connected GM system is at the heart of the company's inability to change. Chrysler, which always subcontracted a significant portion of its manufacturing, has been able to change suppliers and form new relationships relatively quickly. Costs have been reduced and quality improved. GM, on the other hand, has faced a series of agonizing "make or buy" decisions, hampered by its heavy investment in plants, outmoded facilities, restrictive labor contracts, pension obligations, and so on. The very strengths that allowed GM to perform so superbly on the front loop of the ecocycle are now weaknesses, making it vulnerable to disaster. One could make an almost identical case for IBM and the downside of its success in computer mainframes.

It seems that just as the trees in the forest go up in smoke when faced with fire, rigid inertial structures and systems within organizations can be destroyed only by crisis. Managers become constrained by the size and scale of the institutions they have helped develop and, even if they see the problems individually, they may not be able to mobilize collective action without such a crisis (Hurst, 1991). A "Schumpeterian shock" is the equivalent of a fire for an organization. It is a threat that consumes them if they cannot adapt. Like trees that cannot survive fires because their roots are fixed to the ground, organizations that are strongly connected and inflexible are consumed by Schumpeterian shocks. The change from Phase 2 to Phase 3 can take place with amazing rapidity, in contrast with the long, slow transition from Phase 1 to Phase 2.

Transition: From Phase 3 to Phase 4—Mobilization and Renewal

Whereas organizations in Phase 2 of the ecocycle exhibit to observers an apparently steady state, in Phase 3 systems enter far-from-equilibrium conditions. The term *far from equilibrium* has a special meaning in the study of nonlinear systems, especially in chaos theory, a term sometimes applied to a broad field of study also called nonlinear dynamics, bifurcation, or self-organizing theory (Loye & Eisler, 1987). Nonlinear systems (like the Earth's weather, for example) are weakly connected networks that have patterns and regularities unlike those of the more familiar linear systems (like those on a billiard table). When a nonlinear system is far from equilibrium, it is acutely sensitive to small changes in inputs to the system. Small inputs can produce large outputs. From the study of weather patterns, this phenomenon is known as the "butterfly effect"—from the notion that a butterfly, by flapping its wings in Peking today, can change the storm systems in New York next month (Lorenz, 1963).

Whereas linear systems often have structures built up from stable components, nonlinear systems exhibit structures that are shaped and sustained by processes. They are continually consuming energy and, because they require a significant throughput of energy to sustain their far-from-equilibrium condition, they are known as dissipative structures (Prigogine & Stengers, 1984). This is to distinguish them from the more common conservative structures found in Phase 2 of the ecocycle. To borrow William James's happy phrase, which he used to describe consciousness, dissipative systems are like a "rainbow on the waterfall" (Wilshire, 1971, p. 126). As long as the sun shines and the water flows, we can see them and they exist.

The move to the fourth stage in the evolution of an ecosystem involves the reconception of the system. This is the most ephemeral of the stages in the ecocycle, particularly in human affairs. Even in natural systems the dynamics are hard to observe. One reason for this is that, after the structural disintegration of Phase 3, it is often very difficult to distinguish the organization from its environment—the boundary that separates and defines them has disappeared. In our forest analogy, Phase 3 has left the landscape flattened but fertile. Where is the forest? Without memories, how does one differentiate the bare, scorched earth from open land? It is difficult to do this without identifiable, stable structures to point at: One can't see the forest because there aren't any trees.

More broadly, the trees of the climax forest can be thought of as just so many conservative, hierarchical systems that dominated the sources of energy and nutrients within the ecospace. In Phase 2 of the ecocycle their structures and their strongly connected interactions allowed significant output of specific types of outcomes. In that process they limited the variety of creative possibilities in the development of that space. With their destruction in Phase 3 and the system's reduction to smaller elements, the stage is set for new connections to be made. Resources are no longer concentrated in specific structures and spaces; they are widely scattered. Nutrients are easily accessible, and energy, in the form of sunlight, is available to all. Little investment is required to harvest these resources. In Phase 4 of the ecocycle, the system is a vast, weakly connected network. The ecospace is again an immediate-return economy, and the stage is set for it to be recolonized. Within the constraints of the overall climate, anything is possible in this high potential, far-from-equilibrium system.

Analogous Transitions in Human Systems

Natural living systems are mixtures of conservative and dissipative structures. In Phase 2 of the ecocycle their conservative aspects are most visible. In a forest we can view the mature trees. In a mature business we can observe the buildings, the equipment, and the systems and procedures. In Phase 4 the dissipative aspects of the system are paramount. What distinguishes this phase from Phase 3 is that now the elements of Phase 3 are weakly connected with each other via a network of interactions that constitute a system.

As the dimensions of the ecocycle suggest, these connections constitute potential of some kind, but it is not the strongly connected potential of Phase 2, which is almost synonymous with the economic concept of physical capital. This weakly connected potential is a systemic property of a weakly connected network. From the perspective of individuals within a network, it is social capital, one of several kinds that they can accumulate (Burt, 1992). It is a set of relationships with friends and colleagues through which they receive opportunities to use their personal and financial capital. At the level of the system as a whole, the degree of connectedness in the network and the variety in the nodes indicates the potential of the relationships available in the network before Phase 1 opportunistic ventures begin to condense out of it with individuals as their nuclei. The ways in which weakly connected social systems can accomplish this have been addressed by Granovetter (1973). Indeed the network perspective itself on both ecosystems and social structures seems to be a growing field with exciting potential (Nohria & Eccles, 1992; Snow, Miles, & Coleman, 1992).

In the case of a new organization (as opposed to one that is being renewed) at this fourth phase in the ecocycle, *the* organization is barely discernible from its environment: the absence of physical capital makes it difficult to see, and there are no clear boundaries. What will become the future organization and its future environment are co-evolving together.

We can look at Nike in the 1960s in this way. (It seems strange to talk about a business as beginning in Phase 4 of the ecocycle, but that just underlines the arbitrariness of the numbers and the continuous nature of the cycle. Strictly speaking there is no beginning.) Nike in the 1960s was called Blue Ribbon Sports (BRS) and had no permanent employees. In this period a weakly connected network of athletes and suppliers was forming, anchored and sustained by the visions and passions of a University of Oregon track team member, Phil Knight, and his coach, Bill Bowerman. To an outside observer at that time, the organization would have been invisible or, at the very least, diaphanous. One would have looked right through it and seen only an empty field. Yet this was the time when BRS was most acutely sensitive to its environment, when small insignificant events had what would turn out to be very significant consequences.

In the case of Nike, over time, the weakly connected network began to pulse in a pattern. If our hypothetical observer had attended the track meetings where the athletes gathered to compete (and talk about their equipment), he or she might have observed how, after a brief period of bonding, the patterns in the weakly connected network began to change. A more regular pattern of interactions began to emerge as the contacts and events became linked into coherent flows, creating better articulated, more strongly connected links. Soon a small, simple structure formed and moved into Phase 1 of the ecocycle. At this time, although insignificant in size, the company became clearly visible to outside observers.

Renewal by Fire in Practice—The Case of GE

One of the best-documented examples of a planned effort to renew a major organization is Jack Welch's efforts to transform GE (Tichy & Sherman, 1993). Welch was appointed CEO in 1981, a time when, although it faced no crisis, GE was widely known as a GNP company. That is, it was so large and involved in so many sectors of the economy that its performance was dominated by that of the economy as a whole. Welch set about to create his own crisis. He raised the yardsticks of evaluation for each division, demanding that each be either No. 1 or No. 2 in its respective market. From 1981 to 1984—a period during which he was nicknamed "Neutron Jack"—he "delayered" the management hierarchy, reduced corporate staff, and slashed 100,000 employees to focus on what he believed to be the core elements of the business (Petre, 1986).

After this initial phase of breaking the strongly connected system, he set about to release people's emotional energy and creativity to capitalize on the opportunities offered by changes in GE's environment. According to him the jobs of middle managers had to be "redefined as a combination of teacher, cheerleader, and liberator, not controller" (Tichy & Charan, 1989, p. 115). His emphasis has been on the restoration of open communication: "Real communication takes countless hours of eyeball to eyeball, back and forth. It means more listening than talking. . . . It is human beings coming to see and accept things through a constant interactive process aimed at consensus" (Tichy & Charan, 1989, p. 113).

Welch's personal behavior and that of his senior managers has been consistent with the new nonhierarchical, egalitarian values he espouses. In the so-called "work-out" sessions, managers appear face-to-face with their people to deal with pressing issues that have already been raised in open dialogue. The objective is

> to unravel, evaluate, and reconsider the complex web of personal relationships, cross-functional interactions and formal work procedures through which the business of (GE) gets done. Cross-functional teams cooperated to address actual business problems. Each functional team developed a vision of where its operations are headed. (Tichy & Charan, 1989, p. 117)

The jury is still out on GE's transformation process, and we can track it no further along the back loop of the ecocycle. As was stated at the outset, weakly connected networks cannot be expected to deliver desired results on time in the same way that strongly connected systems can. The weak nature of their connectedness precludes this. However, the logic of the renewal cycle suggests that via such a network, groups of individuals will begin to gel around a variety of opportunities and projects and start to take entrepreneurial action. The individuals will have interacted with each other on the boundaryless networks developed in the contexts created by Jack Welch and his senior managers. The opportunities will have been generated in the same way. In keeping with the emergent quality of management action in this phase of the ecocycle (Cohen, March, & Olsen, 1972), the formation of the small work groups and the projects themselves will appear to be spontaneous and "lucky," rather than planned.

The emergence of entrepreneurial project-based groups indicates the movement of r-strategists into an open ecospace. In GE's case, when we, the observers, see this, we will tend to say that it is GE that has been renewed, rather than identify these ventures as brand new organizations. For it seems that the organization has been renewed as it moves from Phase 4 to Phase 1. We will return at the end of the article to discuss in what sense this may be true.

PUTTING IT ALL TOGETHER

Figure 3 shows the concept of a systems ecocycle transferred into the context of human organizations.

Before discussing the implications of this model for management practice, it is worth emphasizing the key features of ecocycle:

- Change is continuous, although the pace and nature of it vary greatly. Sometimes it is smooth and almost linear (from Phase 1 to Phase 2, for example). These are times when organizations appear to be relatively stable. At other times change is rapid and nonlinear (from Phase 2 to Phase 3, for example).
- Renewal requires destruction—the only way to open up spaces in the forest is to creatively destroy the strongly connected structures that tend to monopolize the resources.
- The dimensions are unusual—the concepts of *potential* and *connectedness* force one to think about the many components that make up complex organizations and the nature of the relationships among them that allow us to infer the existence of an organization. One cannot track the organization around the infinity loop because the meaning of organization changes as we move from phase to phase.
- Self-organizing processes are critical—the plants and trees that will make up the mature forest emerge from the open patches, grow, and are selected by the constraints imposed by the environments in which they find themselves.

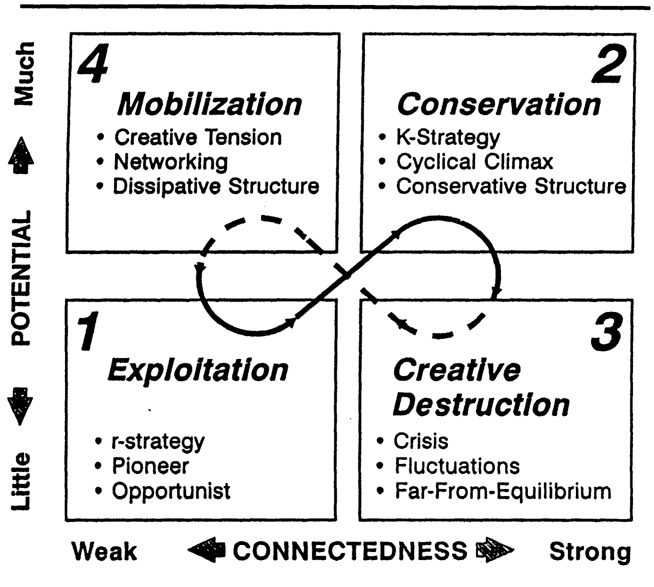

Figure 3: The organizational ecocyle. Adapted from Holling (1987).

Implications for Management Practice

One look at Phase 3 concentrates the mind of a practicing manager wonderfully. For managers "creative destruction" is a disturbing term. In human organizations, destruction is likely to seem creative only to those who are either at one level above the system being destroyed or outside the situation altogether. For those inside the system being destroyed, the implications are disturbing because, as individuals, they are the elements of the system. This phase of an organization's life is characterized by crises, discontinuities, and wide fluctuations in variables such as sales and prices, which have traditionally been stable. It is the individuals inside the system who are the subjects of change, and their feelings of fear and uncertainty contrast unfavorably with the feelings of control and even omnipotence that characterized the previous phase of the organizational ecocycle.

Several questions come to mind immediately: What does the ecocycle mean for established organizations? Is their decline inevitable? Are managers powerless? The answers to the latter two questions are probably yes and no, but each needs to be qualified. Our ecological analogy suggests that organizational decline from Phase 2 is inevitable, but that life extension is possible, even if immortality is not. For example, the Roman Catholic Church is often cited (Drucker, 1974) as an example of an organization that has lasted for nearly 2,000 years. The organizational ecocycle helps us understand the sense in which this is true and helps us think about what we really mean by organization. The Roman Catholic Church has not survived intact as a Phase 2, conservative structure. It has been through partial destruction and renewal several times. Several of the various monastic orders can be seen as institutionalized, open patches in which new ideas could grow before being used to reform the main body of the church. The Society of Jesus, or Jesuits, for example, emerged in the aftermath of the Reformation to have a profound influence on the Catholic Church as a whole.

It seems that to extend the lives of their organizations, managers have to create the organizational equivalent of firebreaks—clearings in the forest—microclimates in which patch dynamics can work. These are immediate-return environments, where opportunistic experiments can thrive and perpetuate the variety necessary to preserve the system as a whole. Inevitably this activity entails the creation of crises for existing mature operations.

This need to deal with existing operations does not, by definition, interfere with the activities of new start-up companies. In Nike (BRS) in the early 1960s, there was no status quo that Phil Knight and Bill Bowerman needed to defend. In the early years both men earned a living outside the athletic shoe business. Creative tension and consequent personal drive was generated by the perceived gap between the current situation and their vision of the future (Senge, 1990), but they had no investment in the current situation. In established organizations, in contrast, there is a status quo to be defended—parts of the existing conservative structures—which had better be maintained if the organization as a whole is to be given the time required to reinvent the business.

But there is a paradox here: Any vision of what the reinvented organization should look like will inevitably be weakened to the extent that existing operations are successful. It is the success of the status quo that is partly responsible for the organizational inertia commonly observed in established organizations.

A second penalty imposed on an established organization is the likely mismatch between the skills, aptitudes, and preferences of their people and the requirements of the mobilization phase. During what can be a lengthy transition from Phase 1 to Phase 2, successful, mature organizations institutionalize their success by specialization, both of people and technology. Accustomed to hierarchy and narrowly specialized in their skill sets—traits for which they have been selected—these employees may not be well-suited to the challenges that reinvention poses. This mismatch is a second cause of organizational inertia.

We have singled out the clash between the vision and the status quo and the mismatch in people's skills, but in reality all the elements of the successful organization act as hindrances to the renewal process. The compensation system will likely be rewarding the wrong kind of behavior; the information systems will be supplying inappropriate data; and the dead hands of past administrators will continue to govern via policy manuals and standard operating procedures. If managers are to avoid having the entire structure of their organizations destroyed in a Phase 3 catastrophe, it seems likely that they must create a series of preemptive crises in what are successful operations. It is the equivalent of controlled fires. One can't stop the forest from having fires, but one can mitigate their destructive effects by keeping the fires small and perhaps even starting some fires to create firebreaks. It is for this reason that renewal demands constructive damage to the status quo.

Crisis as Challenge

The word *crisis* is derived from the Greek *krinein* meaning to sift. We think that by going back to this original meaning, one can come up with a better understanding of the kind of process required. Some managers do operate by creating crises—emotional crises for other people. Through a combination of fear and intimidation, they can get compliance with almost any action they want. Unfortunately, in the process, they create the conditions that reinforce the dominant-submissive relationships of the formal hierarchy. Thus excessive stress freezes a system because it locks in the hierarchical, strongly connected structure and prevents the regeneration of a weakly connected network.

However, the notion of crisis as sifting appeals as a more measured process. Certainly emotional mobilization may sometimes be required, but there also has to be intellectual crisis, the realization that the status quo can be looked at from many different perspectives and scenarios, not all of which will support the view of monolithic success.

In organizational renewal, then, in the absence of visionary genius, the challenge is not just to make things happen but to first create the conditions under which the "things" are allowed to happen: to manage the organization's change ability (Zimmerman, 1992) rather than change. Creating the conditions includes a variety of processes, such as changing the measuring yardstick as in GE or changing the formal structure or performance evaluation policies.

It is helpful to think about a company like 3M as an example of such a process. 3M, with its 60,000 products, is clearly not a climax forest. Rather, it can be thought of as a collection of patch dynamics in different phases of the ecocycle. 3M has institutionalized crisis creation by its requirement that each of its businesses produce at least 25% of its sales from products introduced within the last 5 years. This has the effect of continually sifting the business. At the same time, the organization's culture clearly encourages extracurricular activities by, for example, allowing employees to spend up to 15% of their working time on personal projects (Mitchell, 1989; Mitsch, 1992). The well-known story of the evolution of the Post-it™ note and its initial rejection by senior management suggests even more subtle cultural aspects of 3M which facilitate the mobilization of the talents of their people (Nayak & Ketteringham, 1987).

Another example of the deliberate use of creative destruction comes from a large and growing Canadian bank (Zimmerman, 1994). A senior executive described how various products and services they were involved in were playing the role of preparing them for unseen or unknowable discontinuities.

> A huge amount of the revenues in this business come from paper-based services. . . . Technology poses an enormous threat to all those paper-based systems and they are dead; it's just a question of when. So what do we do? We set up a group that is responsible for dreaming how to put the paper-based system out of commission.

This is an example of managing changeability as opposed to managing change. The future was unknowable. The only predictable is the fact that the current products and services will not exist for long. There are different skills and structures required to challenge both the status quo and the fundamental assumptions of current operations. Setting up a group whose job is to find ways to destroy the current paper-based system is one way of creating this skill base in the organization.

The bank executive talked about preventing employees from feeling secure about the success of the business.

> You know that old line that goes "nothing quite focuses the mind more than the prospect of being hanged in the morning." We try to create the prospect that the organization may be hanged every morning in our day-to-day lives.

The fear of being hanged he was trying to create was a collective—or organization level—fear, a shared concern, rather than an individual fear. Other bank executives talked about instilling a sense of uncertainty about the industry in general and the company in particular to avoid a sense of complacency in spite of the positive financial picture of the company in the past couple of years. Some of the executives talked about the bank as part of the community, in the broadest sense of the word. In each case, there was a recognition that the bank was part of an interdependent and co-evolving system.

The apparent dependency of 3M's and the Canadian bank's growth on the creation of crisis for existing operations bears a striking resemblance to the behavior in nature of the community of shrub-land plants known in the American Southwest as *chaparral*. The tough, durable chaparral-type shrub growth flourishes all over the world in Mediterranean climates. In Corsica it is called *maquis*, whence the French Resistance of WW II took its name. Chaparral is fire-dependent for its growth: Some plants within the community secrete volatile oils and esters which are highly flammable. Fire destroys decadent growth and accumulated litter, recycles nutrients, and promotes vigorous growth in seeds and shoots. For 5 years after a burn, the output of the plants has been estimated to be between 25 and 60 times their preburn levels. After 5 years the output slows, levelling off after 20 to 30 years, depending on the species of plant. Fire at roughly the same frequency keeps the chaparral healthy (Wright & Bailey, 1982, p. 179). For this reason, the ecocycle of the chaparral is also one of the principal causes of the devastating fires that occur with such regularity in Southern California.

A RETURN TO THE QUESTIONS

We began this article with several questions about the nature of the apparently sudden collapses of large, mature organizations. While space has not permitted us to analyze in detail the fall of GM, IBM, or indeed, the Soviet Union, the model we have developed does suggest where to look for the answers to these questions.

We have suggested that such events take place for systemic reasons. Successful organizations, in their worthy efforts to institutionalize their successes, become strongly connected structures that eschew innovation, first of new products and then of new processes (Utterback, 1994). This renders them systemically vulnerable to catastrophe.

The sudden changes are not just an illusion experienced by outsiders. In fact, outsiders can often see signs of looming disaster in an organization long before the insiders can, for the latter group is always more likely to be constrained physically and cognitively by the large-scale system that they have created.

The dynamics behind the massive changes are complex. Technology and technological innovation certainly play important constructive and destructive roles (Anderson & Tushman, 1990). A given technology—a product or service together with its associated production system—is a powerful organizing template. Successful organizations will naturally achieve the size and scale necessary to exploit the technology effectively. Their very success, however, as we saw in the American integrated steel mills, makes them vulnerable to destruction by scale-breaking technological innovation.

We have also suggested what managers can do about the situation: They have to constructively destroy their organizations by breaking the constraints that bind them or challenging the implicit assumptions of the organization. If they do not do so, someone or something else will, usually at a time, place, and on a scale they would not have chosen themselves. The best time to introduce such an initiative (prior to institutionalizing it, as in 3M) would seem to be when things are going well (Dumaine, 1993).

The concept of an organizational ecocycle also challenges and illuminates our notions of what we mean both by organization and renewal. These questions are in a new context, but they are old philosophical issues which have never been fully resolved. What is the "it" that survives during renewal which allows us to say that such-and-such an organization was renewed? It is not the formal organization structure. It may not be the legal corporation. The physical assets and facilities will change and so will the people. In many cases, especially when a corporation has gone through Chapter 11 bankruptcy (Wang Laboratories comes to mind as a recent example), little may be left except for the name, and even that may change. But if the company survived and even flourished only in name, what could we say had been renewed? What about someone who was too young to remember them in their previous incarnation?

Our notions, then, of organization and renewal are intimately connected with our memories, both collective and personal. To qualify as organizational renewal, change would seem to require some continuity, something to remain the same, and this can come only from the past. But it cannot be the mechanical preservation of parts of the past in a cocoon detached from the present. That would be too simple. If that qualified as renewal, all we would need would be museums. No, renewal demands the re-realization of something old in the new in a systemic way—the incorporation of something of value in present activities, a reincarnation if you will.

When members of the Society of Jesus, the Jesuits, seek renewal, they try to understand how the values of their founder can be realized in the new contexts in which they find themselves (Weick, 1990). To this end they go through the exercises developed by Ignatius of Loyola nearly 500 years ago, either doing the exercises themselves, or supervising someone else going through the process. By "walking the walk," stepping in the footsteps of their founder, they participate in the activities that led to the founding of their institution. This is not an intellectual activity. They develop no logic, no map of how to proceed. But the feelings, the appreciation of the founder's values, generated by this participation act as a compass needle, giving them a continual sense of the direction in which to head. Indeed this is probably one of the roles of ritual in all organizations, religious and secular—to remind one of the living presence of the past in the present.

This is particularly true of the people who once worked for organizations like Wang. When everything else is gone, they will still remember the visions, values, and social contexts that once inspired the commitment of thousands to work together. Wherever they are, these contexts may be re-created and knowledge of them passed on to the next generation. Thus "the company" remains as patterns of interaction in an immense, weakly connected network, vast beyond our comprehension. But through this network, the patterns have the potential to be reincarnated in new, formal strongly connected organizations at any time.

In the long run perhaps this is the only sense in which any human organization survives.

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