Nine Emerging and Connected Organizational and Leadership Principles

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Some introductory thoughts

Our study of the science of complex adaptive systems and our work with leaders in health care and other organizations has led us to propose some principles of management that are consistent with an understanding of organizations as CASs. In the spirit of the subject matter, there is nothing sacred or permanent about this list. However, these principles do begin to give us a new way of thinking about and approaching our roles as leaders in organizations.

We are not the first to propose such a list. Our intent here is to capture practical principles that emerge from the science of complexity in language that resonates with management issues. Furthermore, astute readers will also observe that our list of principles, and CAS theory itself, has much in common with general systems thinking, the learning organization, total quality, empowerment, gestalt theory, organizational development and other approaches. It has much in common with these, but it is not any of these. CAS theory clarifies and pulls together many aspects of good thinking from the past. An understanding of CAS is an understanding of how things work in the real world. That others in the past have also understood these things and put them into various contextual frames should not be surprising. An understanding of CAS simply provides a broader, more fundamental, potentially unifying framework for these ideas.

The Nine Principles:

1. View your system through the lens of complexity.
2. Build a good-enough vision
3. When life is far from certain, lead with clockware and swarmware in tandem
4. Tune your place to the edge
5. Uncover and work with paradox and tension
6. Go for multiple actions at the fringes, let direction arise
7. Listen to the shadow system
8. Grow complex systems by chunking
9. Mix cooperation with competition

View your system through the lens of complexity

In addition to the metaphor of a machine or a military organization

The predominant metaphor used in organizations today is that of a machine. Almost equally popular is the metaphor of a military operation. If an organization is a machine, then we simply must specify the parts well and make sure that each part does its part. If an organization is a military operation, then command, control and communication needs to be hierarchical; survival is key; and sacrificial heroes are desired (although no one really wants to be one themselves). Most of today's organizational artifacts – job descriptions, rank-and-file employees, turf battles, strategic plans and so on – emerge from these largely unexpressed and undiscussed metaphors. If you buy into these metaphors, then the traditional actions of management make sense and should work.

The basic problem with these metaphors when applied to a complex adaptive system is that they ignore the individuality of agents and the effects of interaction among agents. Or worse, they simply assume that all this can be tightly controlled through better (read: more) specification. While there are many situations for which the machine and military metaphors might be useful – for example, routine surgical processes – there are also many situations for which these metaphors are grossly inadequate. When we view our system through the lens of complexity, we take on a new metaphor – that of a CAS – and, therefore, are using a different model to determine what makes sense for leaders to do.

"All theories of organization and management are based on implicit images or metaphors that lead us to see, understand and manage organizations in distinctive yet partial ways … the use of metaphor implies a way of thinking and a way of seeing that pervade how we understand our world … One of the most basic problems of modern management is that the mechanical way of thinking is so ingrained in our everyday conceptions of organization, that it is often very difficult to organize in any other way."

Gareth Morgan

Viewing the world through the complexity lens has been a marvelously stress-reducing experience for the leaders in numerous fields. Many have come to see that the massive sea of changes that they have experienced and agonized over recently – the wave of mergers, globalization, the AIDS epidemic – are natural phenomena in a complex adaptive system. Such things will happen again, each will leave its mark on industry and communities. Predicting when and where the next one will come is futile. Learning to be flexible and adaptable is the only sustainable leadership strategy.

> *"To see life as a whole - to observe what all life has in common - requires a shift in the way we normally look at things. We must look beyond the individual insect or tree or flower and seek a more panoramic perspective. We need to think as much about process as we do about structure. From this expanded viewpoint, we can see life in terms of patterns and rules. Using these rules, life builds, organizes, recycles and recreates itself."*
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> *Mahlon Hoagland*

Build a good-enough vision

Provide minimum specifications, rather than trying to plan every little detail

Since the behavior of a CAS emerges from the interaction among the agents, and since the detailed behavior of the system is fundamentally unpredictable, it does little good to spend all the time that most organizations spend in detailed planning. Most organizational leaders have participated in very detailed planning, only to find that assumptions and inputs must be changed almost immediately after the plan is finalized. Complexity science suggests that we would be better off with minimum specifications and general senses of direction, and then allow appropriate autonomy for individuals to self-organize and adapt as time goes by. The science behind this principle traces it roots back to a computer simulation called "Boids," developed in 1987 by Craig Reynolds. The simulation consists of a collection of autonomous agents – the boids – in a environment with obstacles. In addition to the basic laws of physics, each agent follows three simple rules: (1) try to maintain a minimum distance from all other boids and objects; (2) try to match speed with neighboring boids; and, (3) try to move toward the center of mass of the boids in your neighborhood. Remarkably, when the simulation is run, the boids exhibit the very lifelike behavior of flying in flocks around the objects on the screen. They flock, a complex behavior pattern, even though there is no rule explicitly telling them to do so. While this does not prove that birds actually use these simple rules, it does show that simple rules – minimum specifications – can lead to complex behaviors. These complex behaviors emerge from the interactions among agents, rather than being imposed upon the CAS by an outside agent or an explicit, detailed description.

In contrast, we often over-specify things when designing or planning new activities in our organizations. This follows from the paradigm of "organization as a machine." If you are designing a machine, you had better think of everything, because the machine cannot think for itself. Of course, in some cases, organizations do act enough like machines to justify selected use of this metaphor. For example, if you are having your gall bladder removed, you'd like the surgical team to operate as a precision machine; save that emerging, creative behavior for another time!

Maximum specifications and the elimination of variation might be appropriate in such situations.

Most of the time, however, organizations are not machine-like; they are complex adaptive systems. The key learning from the simulations is that in the case of a CAS, minimum specifications and purposeful variation are the way to go.

"The principle of min specs [minimum specifications] suggests that managers should define no more than is absolutely necessary to launch a particular initiative or activity on its way. They have to avoid the role of 'grand designer' in favor of one that focuses on facilitation, orchestration and boundary management, creating 'enabling conditions' that allow a system to find its own form."

Gareth Morgan

This principle would suggest, for example, that intricate strategic plans be replaced by simple documents that describe the general direction the organization is pursuing and a few basic principles for how the organization should get there. The rest is left to the flexibility, adaptability and creativity of the system as the context continually changes. This, of course, is a frightening thought for leaders classically trained in the machine and military metaphors. But the key questions are: Are these traditional metaphors working for us today? Are we able to lay out detailed plans and then just do it with a guaranteed outcome? If not, do we really think that planning harder will be any better?

The quintessential organizational example of this principle of good-enough vision and minimum specifications is the credit-card company, Visa International. Despite its $1 trillion annual sales volume and roughly half-billion clients, few people could tell you where it is headquartered or how it is governed. It's founding chief executive officer, Dee Hock describes it as a nonstock, for-profit membership corporation in which members (typically, banks that issue the Visa cards) cooperate intensely "in a narrow band of activity essential to the success of the whole" (for example, the graphic layout of the card and common clearinghouse operations), while competing fiercely and innovatively in all else (including going after each other's customers!). This blend of minimum specifications in the essential areas of cooperation, and complete freedom for creative energy in all else, has allowed Visa to grow 10,000 percent since 1970, despite the incredibly complex worldwide system of different currencies, customs, legal systems and the like. "It was beyond the power of reason to design an organization to deal with such complexity," Hock explained. "The organization had to be based on biological concepts to evolve, in effect, to invent and organize itself."

> *"Managers therefore cannot form a vision of some future state toward which the business can be moved; the futures open to the system are too many, and the links between a future and the actions leading to it are too obscure. Chaotic dynamics lead us to see strategy as a direction into the future that emerges from what managers do. In chaotic conditions, strategy cannot be driven by pure intentions. Instead, it represents the unintentional creation of order out of chaos."*
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> *Ralph Stacey*

When life is far from certain, lead with clockware and swarmware in tandem.

Balance data and intuition, planning and acting, safety and risk, giving due honor to each.

"Clockware" is a term, coined by Kevin Kelly, that describes the management processes we all know that involve operating the core production processes of the organization in a manner that is rational, planned, standardized, repeatable, controlled and measured. In contrast, Kelly's term "swarmware" refers to management processes that explore new possibilities through experimentation, trials, autonomy, freedom, intuition and working at the edge of knowledge and experience. Good-enough vision, minimum specifications and metaphor are examples of swarmware that we have already seen. The idea is to say just enough to paint a picture or describe the absolute boundaries, and then let the people in the CAS become active in trying whatever they think might work.

In an informed approach to complexity, it is not a question of saying that one is good and the other is bad. The issue is about finding an appropriate mix for a given situation. Where the world is certain and there is a high level of agreement among agents (for example, the need for consistent variable names and programming language syntax in a large software system, or the activities in the operating room during a routine surgery) clockware is appropriate. In a clockware situation, agents give up some of their freedom and mental models to accomplish something they have

> *"For jobs where supreme control is demanded, good old clockware is the way to go. Where supreme adaptability is required, out-of-control swarmware is what you want."*
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> *Kevin Kelly*
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> *"Cohesive teams are needed for day-to-day issues. Spontaneous learning networks that have open conflict and dialogue are vital to handling strategic issues."*
>
> *Ralph Stacey*

collectively agreed upon. The CAS displays less emergent, creative behavior, and begins to act more like a machine. There is nothing wrong with this.

However, where the world is far from certainty and agreement (near the edge of chaos) swarmware is needed with its adaptability, openness to new learning and flexibility. Swarmware is also needed in situations for which the old clockware processes are no longer adequate for accomplishing the purpose, in situations for which the purpose has changed or in situations in which creativity is desirable for its own sake.

Tune your place to the edge

Foster the "right" degree of information flow, diversity and difference, connections inside and outside the organization, power differential and anxiety, instead of controlling information, forcing agreement, dealing separately with contentious groups, working systematically down all the layers of the hierarchy in sequence and seeking comfort

Theoretical studies of complex adaptive systems suggest that creative self-organization occurs when there is just enough information flow, diversity, connectivity, power differential and anxiety among the agents. Too much of any of these can lead to chaotic system behavior; too little and the system remains stuck in a pattern of behavior.

Again, we can look to biological sciences for a dramatic illustration of this principle. Dr. Ary Goldberger is a cardiac specialist at Harvard Medical School who has done much research in the role of complexity in physiologic systems such as the beat-to-beat record of a healthy heart. It shows an irregular, wrinkly appearance – not a smooth, regular tracing. Furthermore, when this tracing is magnified, there is even more wrinkly detail. This complex pattern of irregular fluctuations is a fractal. Surprisingly, if you were to view an equally detailed heart-rate tracing of a patient before cardiac arrest, you would probably not see more chaotic activity, as you might expect, but rather virtual consistency and regularity. Thus, predictable and regular activity can lead to a heart attack; unpredictability and fractal (chaotic-like) variability are associated with health and stability. (Note that this pattern can also be observed in other biological systems: in sleep, chaotic patterns have been shown to produce restful sleep and extreme regularity may indicate a coma; and in muscles, chaos indicates healthy functioning and stability indicates seizure or degenerative disease.)

Of course, the trick in a human CAS lies in gauging the "right" amount of information flow, diversity, connectivity, power differential and anxiety among the agents. Since the predominant metaphors of organizational life are those of a machine and military operation, most organizations today have too little information flow and diversity, and too much power differential. The degree of connectivity and anxiety can go either way. This is a general observation that could of course be different in any specific context. If you are in a CAS, you will have your own mental model about such things, as will the other agents in the system.

Since the detailed behavior of a CAS is fundamentally unpredictable, there is no way to arrive analytically at an answer for what amount of information flow, diversity, connections inside and outside the organization, power differential and anxiety among the agents is proper.

You can have more- or less-correct intuitions, and some sense of general direction, but that's inherently the best you can do. You'll just have to try tuning up or down the various factors and reflect on what happens.

Reflection is, therefore, a key skill for anyone in a CAS. Good leaders in a CAS lead not by telling people what to do, but by being open to experimentation, followed by thoughtful and honest reflection on what happens.

> *"At the ideal number of connections, the ideal amount of information flows between agents, and the system as a whole finds optimal solutions consistently … which in a rapidly changing environment allows the whole to persist."*
>
> *Stuart Kauffman*
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> *"Living systems are very close to the edge of chaos phase transitions where things are loose and fluid … Systems that are most adaptive are so loose they are a hairbreadth away from [being] out of control."*
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> *M. M. Waldrop*
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> *"The emphasis on managing long-term specific outcomes is completely misplaced. They cannot be managed, but it is possible to influence control parameters...managers still need strategic plans; however, they relate not to outcomes and actions to achieve them, but to methods of affecting anxiety, power, difference, and connectivity."*

Uncover and work with paradox and tension.

Do not shy away from them as if they were unnatural

Because the behavior of a CAS emerges from the interaction among agents, and because of nonlinear effects, "weird" stuff seems to happen. Of course, it is only weird because we do not yet have a way to understand it.

In a CAS, creativity and innovation have the best chance to emerge precisely at the point of greatest tension and apparent irreconcilable differences. Rather than smoothing over these differences – the typical leadership intuition from the machine and military metaphors – we should focus on them and seek a new way forward.

An organization in which tension and stresses are quickly smoothed over or even denied is one that isn't learning or adapting very efficiently. Consider an organization embroiled in internal conflict over some kind of change, in which one group wants radical change and the other is holding steadfastly to the status quo. There may be a temptation for leaders to compromise, try to deliver to both groups, or prematurely stand by one position while discounting the other. How might you work with paradox and tension in this case? The approach one leader took was to mix the two warring factions (the "radical change" people and the "status quo" people) into a single group and give them the task of finding a "radical way to hold on to the status quo." This is a paradox; it makes no sense according to the prevailing mental models.

However, working on it placed the group at the edge of chaos and increased the likelihood that creative approaches would emerge. Here are some other paradoxical questions to consider. Can you think of others that are relevant to your context?

"The chaos manager must recognize these 'forks in the road' and create a context supporting the new line of development by finding interventions that transcend the paradoxes or make them irrelevant … The task hinges on finding new understandings or new actions that can reframe the paradox in a way that unleashes system energies in favor of the new line of development."

Gareth Morgan

- How can we give direction without giving directives?
- How can we lead by serving?
- How can we maintain authority without having control?
- How can we set direction when we don't know the future?
- How can we oppose change by accepting it? How can we accept change by opposing it?
- How can a large organization be small? How can a small one be large?
- How can we be both a system and many independent parts?

Another way to uncover paradox is to ask "wicked questions." These are questions that have no obvious answers, but expose our assumptions. For example, in an organization that was trying to build a more-enabled environment, one leader asked, "Are we really ready to put responsibility for the work on the shoulders of the people who do the work?" Perhaps you can sense the discomfort in such a question. But challenging the sacred cows is an activity that can put you at the edge of chaos, and begin to reveal the hidden assumptions.

> *"Clearly leadership has to do with the sustaining of creative tension in organizations. Creative tension is derived through strategic imbalance, which occurs when operating at the limits of organizational consensus or the boundaries of the organization. Innovation takes place on the edges of the organization where the potential for far-from-equilibrium conditions is optimal."*

Go for multiple actions at the fringes, let direction arise

You don't have to be "sure" before you proceed with anything

As we have already noted, in a CAS it does little good to plan the details. You can never know exactly what will happen until you do it. So, allowing the flexibility of multiple approaches is a very reasonable thing to do. Of course, such a flexible approach is unreasonable when we view the situation through the metaphor of a machine or military organization. A machine can work only one way, and an old-style military organization must follow procedures and regulations.

The science that supports this principle of CAS behavior comes primarily from the study of gene pools in evolutionary biology. David Ackley points outs that, "Researchers have shown clearly and unequivocally how populations of organisms that are learning (that is, exploring their fitness possibilities by changing behavior) evolve faster than populations that are not learning." We do not think it strains the metaphor here to suggest that our managerial instincts to drive for organizational consensus around a single option might be equivalent to inbreeding in a gene pool. And we all know the kinds of dysfunction that inbreeding in nature can spawn. We are personally struck by the fact that even though the words "organization" and "organism" have a common root, we have learned to think about them in such remarkably different ways.

The fringes that we are referring to here are the issues that are far from the zone of certainty and agreement. Recall that we pointed out that it was not a question of the machine metaphor being wrong and the CAS metaphor being right, nor is it about throwing out clockware and replacing it with swarmware. Neither approach is inherently right or wrong; but either approach can be inappropriate and ineffective in a given context. The leadership skill lies in the intuition to know which approach is needed in the context one is in. The degree of certainty and agreement is a good guide.

> *"A healthy fringe speeds adaptation, increases resilience and almost always is the source of innovations."*
>
> *Kevin Kelly*

However, when we do find ourselves in situations far from certainty and agreement, the management advice contained in this principle is to quit agonizing over it, quit trying to analyze it to certainty. Try several

small experiments, reflect carefully on what happens and gradually shift time and attention toward those things that seem to be working the best (that is, let direction arise). These multiple actions at the fringes also serve the purpose of providing us with additional insights about the larger systems within which every system is inevitably buried.

A concrete example of this principle is the health care organization that is trying to come up with a new financial incentive plan for physicians. There are many options, with success and failure stories for each one. Therefore, we are far from certainty and agreement. Rather than meeting endlessly over it trying to pick the right approach, experiment with several approaches. See what happens, see what seems to work and in what context. Over time, you may find a right way for you, or you may find several right ways.

> *"Successful experiments can go a long way in creating a foothold in a new reality. In particular, they offer important insights on the feedback loops and defensive routines that sustain a dominant attractor pattern and what can be done to help a new one to emerge."*
>
> *Gareth Morgan*

Listen to the shadow system

That is, realize that informal relationships, gossip, rumor and hallway conversations contribute significantly to agents' mental models and subsequent actions

Complexity theorist Ralph Stacey points out that every organization actually consists of two organizations: the legitimate and shadow systems. Everyone in an organization is part of both. The legitimate system consists of the formal hierarchy, rules and communications patterns in the organization. The shadow organization lies behind the scenes. It consists of hallway conversation, the grapevine, the rumor mill and the informal procedures for getting things done. Most traditional management theory either ignores the shadow system, or speaks of it as something leaders must battle against (as in, "overcome resistance to change" – it's that military metaphor again).

Stacey further points out that because the shadow system harbors such diversity of thought and approach, it is often the place where much of the creativity resides within an organization. While the legitimate system is often focused on procedures, routines and the like, the shadow system has few rules and constraints. The diversity, tension and paradox of these two organizations that coexist within one can be a great source of innovation if leaders could just learn to listen to, rather than battle against, the shadow.

One health care executive entered the shadow system when he joined a group of doctors and nurses talking in the cafeteria one day. He was so fascinated by their

discussion of improving the process for delivering anti-coagulants, he soon became part of this underground ad-hoc team. In doing so, he quietly sidestepped the difficult, formal process for approving quality improvement projects instituted by the hospital. The resulting work was so successful, it led to a close re-examination of the approval process that had been unintentionally discouraging such innovation.

When we see our organizations as CASs, we realize that the shadow system is just a natural part of the larger system. It is simply more interconnections among agents, often stronger interconnections than those in the legitimate system. Leaders who lead from an understanding of CASs, will not have a need to discredit, agonize over, or combat the shadow systems in their organizations. Rather, they will recognize and listen to the shadow organization, using the interconnections it represents as another avenue for tuning information flow, diversity of opinion, anxiety, and power differential.

> *"When the legitimate and shadow system operate against each other, an organization is in the phase transition at the edge of chaos; it is only here that it is changeable, because it is only here that it is capable of double-loop learning…. When an organization is in this state, at least some of its members play by engaging in exploratory dialogue, utilizing analogies and metaphors, and employing self-reflection to develop new knowledge …. If this change is then amplified throughout the organization to become the dominant schema of the organization, potential innovation has occurred."*
>
> *Ralph Stacey*

Grow complex systems by chunking.

Allow complex systems to emerge out of the links among simple systems that work well and are capable of operating independently.

Question: Who built the Internet?

That's an easy one. The answer, we all know, is no one. Not Bill Gates or any other computer genius. The Internet is our most visible and oft-cited example of emergent phenomena, an elegant case study of how a complicated and vastly diverse system can self-organize … in this case, almost overnight. On close examination, we see that the Internet evolved in chunks – like a set of building blocks – with components being integrated into the system only after they had been individually refined, proven and accepted by a collective, systemic jury.

Complex systems are…well, complex. They are not easily understood or built in detail from the ground up. Chunking means that a good approach to building complex systems is to start small. Experiment to get pieces that work, and then link the pieces together. Of course, when you make the links, be aware that new interconnections may bring about unpredicted, emerging behaviors.

> *"Interesting, beguilingly complex behavior can emerge from collections of extremely simple components."*
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> *M. M. Waldrop*
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> *"A scan of history shows that technical innovations almost always arise as a particular combination of well-known building blocks."*
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> *John Holland*

This principle is the basis upon which genetic evolution proceeds. Building blocks of organism functionality (for example, webbed feet on a bird) develop and are combined through crossover of genetic material with other bits of functionality (for example, an oversized bill more suitable for scooping fish out of the water) to form increasingly complex organisms (a pelican). The good-enough genetic combinations may survive and are then available as building blocks for future combinations. The UNIX computer operating system is another good example of an ever-evolving complex system that was built from chunks. The basic – and at the time it was introduced, revolutionary – principle behind the UNIX system is that software functions should be small, simple, standalone bits of code that do only one thing well, embedded in an environment that makes it easy for each such function to pass its output on to another function for further processing.

Applying this principle to teambuilding in a mid-sized organization, for example, would suggests that leaders should look for and support small natural teams. We might provide coaching and training for these teams. Then, when these teams are functioning well, look for ways to get the teams to work together and involve others. These new links may result in weird behavior; with a CAS, this is to be expected. The leaders should be open to doing some adapting of their own. Rather than insisting on pressing forward with the training, ground rules, or procedures that worked so well in the first teams, the leaders should understand that the interconnections among teams has resulted in a fundamentally new system that may need new approaches.

Continual reflection and learning are key in building complex systems. You cannot reflect on anything until you do something. So start small, but do start.

> *"The only way to make a complex system that works is to begin with a simple system that works. Attempts to instantly install highly complex organization … without growing it, inevitably lead to failure. To assemble a prairie takes time – even if you have all the pieces. Time is needed to let each part test itself against all the others. Complexity is created, then, by assembling it incrementally from simple modules that can operate independently. "*
>
> *Kevin Kelly*

Mix cooperation with competition

It's not one or the other.

Nature competes. If you have ever glimpsed a lion stalking and devouring an elk on a PBS program before quickly changing the channel, you know this to be true.

Nature cooperates, too. Observe members of an ant colony working together to produce intricate ant-mound societies.

These dynamics are not mutually exclusive. Natural and biological systems display both cooperation and competition. And so can corporate, business and sociological systems.

Perhaps no one has explored this paradox with more vigor – or success – than Dee Hock, former chief executive officer of Visa International. The corporation's growth averages around 20 percent annually; it serves around a half-billion clients in more than 200 countries; sales volume is now passing $1 trillion.

In the massive, sprawling Visa system, the cooperation-competition paradox is a fundamental part of the structure. Fierce competition occurs among member institutions and banks that issue Visa cards, set prices and develop services … all while going after each other's customers. But these institutions must also cooperate: for the system to work, merchants and vendors must be able to accept any Visa card anywhere in the world, regardless of who issued the card. This mixture of cooperation and competition has allowed the system to grow globally, seemingly immune to traditional constraints of language, culture, currencies, politics or legal codes.

One popular expression of the competition-cooperation paradox is the "tit-for-tat" strategy. It came about when political scientist Robert Axelrod tested a variety of competitive strategies using computer simulations. Time and again, the simplest strategy of all took the prize in this complex contest: University of Toronto psychologist Anatol Rapport's "Tit-for-Tat" program started out by cooperating on the first move, and then simply did exactly what the other program had done on the move before. The program was "nice" in the sense that it would never defect first. It was "tough" in the sense that it would punish uncooperative behavior by competing on the next move. It was "forgiving" in that it returned to cooperation once the other party demonstrated cooperation. And it was "clear" in the sense that it was very easy for the opposing programs to figure out exactly what it would do next. Thus, some have proposed the

> *"We are used to thinking about competitions in which there is only one winner, competitions such as football or chess. But the world is rarely like that. In a vast range of situations, mutual cooperation can be better for both sides than mutual defection. The key to doing well lies not in overcoming others, but in eliciting their cooperation."*
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> *M. M. Waldrop*

> *"It's against the interests of either predator or prey to eliminate the enemy. That's clearly irrational, yet that is clearly a force that drives nature."*
>
> *Paul Ehrlich*

heuristic that "nice, tough, forgiving and clear guys finish first."

In his 1984 book, *The Evolution of Cooperation*, Robert Axelrod showed the profound nature of this simple strategy in its application to all sorts of complex adaptive systems – trench warfare in WW1, politics and even fungus growth on rocks.

Commenting on this strategy, Waldrop said, "Consider the magical fact that competition can produce a very strong incentive for cooperation, as certain players forge alliances and symbiotic relationships with each other for mutual support. It happens at every level of, and in every kind of, complex adaptive system, from biology, to economics, to politics."

A good leader would be one who knows how to, and prefers to, cooperate, but is also a skillful competitor when provoked to competition (that is, a nice, forgiving, tough and clear person). Note that this strategy rejects both extremes as a singular strategy. While much is said these days about the importance of being cooperative and positive-thinking in business dealings, the always-cooperative leader may find his or her proverbial lunch is being eaten by others. Similarly, while sports and warrior metaphors are also popular in some leadership circles, the always-competitive leader may find himself or herself on the outside looking in as alliances are formed.

> *"[A] concept that is deeply ingrained in biology is competition. This is often described as the driving force of evolution… However, there is as much cooperation in biology as there is competition. Mutualism and symbiosis, organisms living in a state of mutual dependency…are an equally universal feature of the biological realm. Why not argue that cooperation is the great source of innovation in evolution?"*
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> *Brian Goodwin*

Conclusion

Our existing principles of leadership and management in organizations are largely based on metaphors from science that are hundreds of years old. It is time that we realized that science itself has largely replaced these metaphors with more accurate descriptions of what really happens in the world. Science is replacing its old metaphors not because they are wrong, but because they only described simplistic situations that progress has now moved us well beyond. Similarly, our organizations today are not the simple machines they were envisioned to be in the Industrial Revolution that saw the birth of scientific management. Further, people today are no longer the compliant "cogs in the machine" that we once thought them to be. We have intuitively known these things for many years. Management

innovations such as learning organizations, total quality, empowerment and so on were introduced to overcome the increasingly visible failures of the simple organization-as-machine metaphor. Still, as we have pointed out, the metaphor remains strong.

The emerging study of complex adaptive systems gives us a new lens through which we can now begin to see a new type of scientific management. This new scientific management resonates well with more modern, intuitive notions about what we must do to manage increasingly complex organizations today. More importantly, the new thinking in science provides a consistent framework to pull together these heretofore intuitive notions. Now, for example, advocates of open communications and empowerment can claim the same firmness of ground that advocates of structure and control have been claiming exclusively. Science can now say rather clearly that structure and control are great for simple, machine-like situations; but things such as open communication, diversity and so on are needed in complex adaptive systems – such as those in modern organizations. The new scientific management will, no doubt, revolutionize organizations in the coming decades much as the old scientific management changed the world in the early decades of this century.