— SEVEN —

Living in a World of Systems

> The real trouble with this world of ours is not that it is an unreasonable world, nor even that it is a reasonable one. The commonest kind of trouble is that it is nearly reasonable, but not quite. Life is not an illogicality; yet it is a trap for logicians. It looks just a little more mathematical and regular than it is.
>
> —G. K. Chesterton,[1] 20th century writer

People who are raised in the industrial world and who get enthused about systems thinking are likely to make a terrible mistake. They are likely to assume that here, in systems analysis, in interconnection and complication, in the power of the computer, here at last, is the key to prediction and control. This mistake is likely because the mind-set of the industrial world assumes that there is a key to prediction and control.

I assumed that at first too. We all assumed it, as eager systems students at the great institution called MIT. More or less innocently, enchanted by what we could see through our new lens, we did what many discoverers do. We exaggerated our findings. We did so not with any intent to deceive others, but in the expression of our own expectations and hopes. Systems thinking for us was more than subtle, complicated mind play. It was going to *make systems work*.

Like the explorers searching for the passage to India who ran into the Western Hemisphere instead, we had found something, but it wasn't what we thought we had found. It was something so different from what we had been looking for that we didn't know what to make of it. As we got to know systems thinking better, it turned out to have greater worth than we had thought, but not in the way we had thought.

Our first comeuppance came as we learned that it's one thing to under-

stand how to fix a system and quite another to wade in and fix it. We had many earnest discussions on the topic of "implementation," by which we meant "how to get managers and mayors and agency heads to follow our advice."

The truth was, *we* didn't even follow our advice. We gave learned lectures on the structure of addiction and could not give up coffee. We knew all about the dynamics of eroding goals and eroded our own jogging programs. We warned against the traps of escalation and shifting the burden and then created them in our own marriages.

Social systems are the external manifestations of cultural thinking patterns and of profound human needs, emotions, strengths, and weaknesses. Changing them is not as simple as saying "now all change," or of trusting that he who knows the good shall do the good.

We ran into another problem. Our systems insights helped us understand many things we hadn't understood before, but they didn't help us understand *everything*. In fact, they raised at least as many questions as they answered. Like all the other lenses humanity has developed with which to peer into macrocosms and microcosms, this one too revealed wondrous new things, many of which were wondrous new mysteries. The mysteries our new tool revealed lay especially within the human mind and heart and soul. Here are just few of the questions that were prompted by our insights into how systems work.

A systems insight . . . can raise more questions!

Systems thinkers are by no means the first or only people to ask questions like these. When we started asking them, we found whole disciplines, libraries, histories, asking the same questions, and to some extent offering answers. What was unique about our search was not our answers, or even our questions, but the fact that the tool of systems thinking, born out of engineering and mathematics, implemented in computers, drawn from a mechanistic mind-set and a quest for prediction and control, leads its practitioners, inexorably I believe, to confront the most deeply human mysteries. Systems thinking makes clear even to the most committed technocrat that getting along in this world of complex systems requires more than technocracy.

Self-organizing, nonlinear, feedback systems are inherently unpredictable. They are not controllable. They are understandable only in the most general way. The goal of foreseeing the future exactly and preparing for it

A new information feedback loop at *this* point in this system will make it behave much better. But the decision makers are resistant to the information they need! They don't pay attention to it, they don't believe it, they don't know how to interpret it.

If *this* feedback loop could just be oriented around *that* value, the system would produce a result that everyone wants. (Not more energy, but more energy services. Not GNP, but material sufficiency and security. Not growth, but progress.) We don't have to change anyone's values, we just have to get the system to operate around real values.

Here is a system that seems perverse on all counts. It produces inefficiency, ugliness, environmental degradation, and human misery. But if we sweep it away, we will have no system. Nothing is more frightening than that. (As I write, I have the former communist system of the Soviet Union in mind, but that is not the only possible example.)

The people in this system are putting up with deleterious behavior because they are afraid of change. They don't trust that a better system is possible. They feel they have no power to demand or bring about improvement.

perfectly is unrealizable. The idea of making a complex system do just what you want it to do can be achieved only temporarily, at best. We can never fully understand our world, not in the way our reductionist science has led us to expect. Our science itself, from quantum theory to the mathematics of chaos, leads us into irreducible uncertainty. For any objective other than the most trivial, we can't optimize; we don't even know what to optimize. We can't keep track of everything. We can't find a proper, sustainable relationship to nature, each other, or the institutions we create, if we try to do it from the role of omniscient conqueror.

For those who stake their identity on the role of omniscient conqueror,

Why do people actively sort and screen information the way they do? How do they determine what to let in and what to let bounce off, what to reckon with and what to ignore or disparage? How is it that, exposed to the same information, different people absorb different messages, and draw different conclusions?

What are values? Where do they come from? Are they universal, or culturally determined? What causes a person or a society to give up on attaining "real values" and to settle for cheap substitutes? How can you key a feedback loop to qualities you can't measure, rather than to quantities you can?

Why is it that periods of minimum structure and maximum freedom to create are so frightening? How is it that one way of seeing the world becomes so widely shared that institutions, technologies, production systems, buildings, cities, become shaped around that way of seeing? How do systems create cultures? How do cultures create systems? Once a culture and system have been found lacking, do they have to change through breakdown and chaos?

Why are people so easily convinced of their powerlessness? How do they become so cynical about their ability to achieve their visions? Why are they more likely to listen to people who tell them they can't make changes than they are to people who tell them they can?

the uncertainty exposed by systems thinking is hard to take. If you can't understand, predict, and control, what is there to do?

Systems thinking leads to another conclusion, however, waiting, shining, obvious, as soon as we stop being blinded by the illusion of control. It says that there is plenty to do, of a different sort of "doing." The future can't be predicted, but it can be envisioned and brought lovingly into being. Systems can't be controlled, but they can be designed and redesigned. We can't surge forward with certainty into a world of no surprises, but we can expect surprises and learn from them and even profit from them. We can't impose our will on a system. We can listen to what the system tells

us, and discover how its properties and our values can work together to bring forth something much better than could ever be produced by our will alone.

We can't control systems or figure them out. But we can dance with them!

I already knew that, in a way. I had learned about dancing with great powers from whitewater kayaking, from gardening, from playing music, from skiing. All those endeavors require one to stay wide awake, pay close attention, participate flat out, and respond to feedback. It had never occurred to me that those same requirements might apply to intellectual work, to management, to government, to getting along with people.

But there it was, the message emerging from every computer model we made. Living successfully in a world of systems requires more of us than our ability to calculate. It requires our full humanity—our rationality, our ability to sort out truth from falsehood, our intuition, our compassion, our vision, and our morality.[2]

I want to end this chapter and this book by trying to summarize the most general "systems wisdoms" I have absorbed from modeling complex systems and from hanging out with modelers. These are the take-home lessons, the concepts and practices that penetrate the discipline of systems so deeply that one begins, however imperfectly, to practice them not just in one's profession, but in all of life. They are the behaviorial consequences of a worldview based on the ideas of feedback, nonlinearity, and systems responsible for their own behavior. When that engineering professor at Dartmouth noticed that we systems folks were "different" and wondered why, these, I think, were the differences he noticed.

The list probably isn't complete, because I am still a student in the school of systems. And it isn't a list that is unique to systems thinking; there are many ways to learn to dance. But here, as a start-off dancing lesson, are the practices I see my colleagues adopting, consciously or unconsciously, as they encounter new systems.

Get the Beat of the System

Before you disturb the system in any way, watch how it behaves. If it's a piece of music or a whitewater rapid or a fluctuation in a commodity price, study its beat. If it's a social system, watch it work. Learn its history. Ask

people who've been around a long time to tell you what has happened. If possible, find or make a time graph of actual data from the system—peoples' memories are not always reliable when it comes to timing.

This guideline is deceptively simple. Until you make it a practice, you won't believe how many wrong turns it helps you avoid. Starting with the behavior of the system forces you to focus on facts, not theories. It keeps you from falling too quickly into your own beliefs or misconceptions, or those of others.

It's amazing how many misconceptions there can be. People will swear that rainfall is decreasing, say, but when you look at the data, you find that what is really happening is that variability is increasing—the droughts are deeper, but the floods are greater too. I have been told with great authority that the price of milk was going up when it was going down, that real interest rates were falling when they were rising, that the deficit was a higher fraction of the GNP than ever before when it wasn't.

It's especially interesting to watch how the various elements in the system do or do not vary together. Watching what really happens, instead of listening to peoples' theories of what happens, can explode many careless causal hypotheses. Every selectman in the state of New Hampshire seems to be positive that growth in a town will lower taxes, but if you plot growth rates against tax rates, you find a scatter as random as the stars in a New Hampshire winter sky. There is no discernible relationship at all.

Starting with the behavior of the system directs one's thoughts to dynamic, not static, analysis—not only to "What's wrong?" but also to "How did we get there?" "What other behavior modes are possible?" "If we don't change direction, where are we going to end up?" And looking to the strengths of the system, one can ask "What's working well here?" Starting with the history of several variables plotted together begins to suggest not only what elements are in the system, but how they might be interconnected.

And finally, starting with history discourages the common and distracting tendency we all have to define a problem not by the system's actual behavior, but by the lack of our favorite solution. (The problem is, we need to find more oil. The problem is, we need to ban abortion. The problem is, we don't have enough salesmen. The problem is, how can we attract more growth to this town?) Listen to any discussion, in your family or a committee meeting at work or among the pundits in the media, and watch people leap to solutions, usually solutions in "predict, control, or impose

your will" mode, without having paid any attention to what the system is doing and why it's doing it.

Expose Your Mental Models to the Light of Day

When we draw structural diagrams and then write equations, we are forced to make our assumptions visible and to express them with rigor. We have to put every one of our assumptions about the system out where others (and we ourselves) can see them. Our models have to be complete, and they have to add up, and they have to be consistent. Our assumptions can no longer slide around (mental models are very slippery), assuming one thing for purposes of one discussion and something else contradictory for purposes of the next discussion.

You don't have to put forth your mental model with diagrams and equations, although doing so is a good practice. You can do it with words or lists or pictures or arrows showing what you think is connected to what. The more you do that, in any form, the clearer your thinking will become, the faster you will admit your uncertainties and correct your mistakes, and the more flexible you will learn to be. Mental flexibility—the willingness to redraw boundaries, to notice that a system has shifted into a new mode, to see how to redesign structure—is a necessity when you live in a world of flexible systems.

Remember, always, that everything you know, and everything everyone knows, is only a model. Get your model out there where it can be viewed. Invite others to challenge your assumptions and add their own. Instead of becoming a champion for one possible explanation or hypothesis or model, collect as many as possible. Consider all of them to be plausible until you find some evidence that causes you to rule one out. That way you will be emotionally able to see the evidence that rules out an assumption that may become entangled with your own identity.

Getting models out into the light of day, making them as rigorous as possible, testing them against the evidence, and being willing to scuttle them if they are no longer supported is nothing more than practicing the scientific method—something that is done too seldom even in science, and is done hardly at all in social science or management or government or everyday life.

Honor, Respect, and Distribute Information

You've seen how information holds systems together and how delayed, biased, scattered, or missing information can make feedback loops malfunction. Decision makers can't respond to information they don't have, can't respond accurately to information that is inaccurate, and can't respond in a timely way to information that is late. I would guess that most of what goes wrong in systems goes wrong because of biased, late, or missing information.

If I could, I would add an eleventh commandment to the first ten: *Thou shalt not distort, delay, or withhold information.* You can drive a system crazy by muddying its information streams. You can make a system work better with surprising ease if you can give it more timely, more accurate, more complete information.

For example, in 1986, new federal legislation, the Toxic Release Inventory, required U.S. companies to report all hazardous air pollutants emitted from each of their factories each year. Through the Freedom of Information Act (from a systems point of view, one of the most important laws in the nation), that information became a matter of public record. In July 1988, the first data on chemical emissions became available. The reported emissions were not illegal, but they didn't look very good when they were published in local papers by enterprising reporters, who had a tendency to make lists of "the top ten local polluters." That's all that happened. There were no lawsuits, no required reductions, no fines, no penalties. But within two years chemical emissions nationwide (at least as reported, and presumably also in fact) had decreased by 40 percent. Some companies were launching policies to bring their emissions down by 90 percent, just because of the release of previously withheld information.[3]

Information is power. Anyone interested in power grasps that idea very quickly. The media, the public relations people, the politicians, and advertisers who regulate much of the public flow of information have far more power than most people realize. They filter and channel information. Often they do so for short-term, self-interested purposes. It's no wonder our that social systems so often run amok.

Use Language with Care and Enrich It with Systems Concepts

Our information streams are composed primarily of language. Our mental models are mostly verbal. Honoring information means above all avoiding language pollution—making the cleanest possible use we can of language. Second, it means expanding our language so we can talk about complexity.

Fred Kofman wrote in a systems journal:

> [Language] can serve as a medium through which we create new understandings and new realities as we begin to talk about them. In fact, we don't talk about what we see; *we see only what we can talk about.* Our perspectives on the world depend on the interaction of our nervous system and our language—both act as filters through which we perceive our world. . . . The language and information systems of an organization are not an objective means of describing an outside reality—they fundamentally structure the perceptions and actions of its members. To reshape the measurement and communication systems of a [society] is to reshape all potential interactions at the most fundamental level. Language . . . as articulation of reality is more primordial than strategy, structure, or . . . culture.[4]

A society that talks incessantly about "productivity" but that hardly understands, much less uses, the word "resilience" is going to become productive and not resilient. A society that doesn't understand or use the term "carrying capacity" will exceed its carrying capacity. A society that talks about "creating jobs" as if that's something only companies can do will not inspire the great majority of its people to create jobs, for themselves or anyone else. Nor will it appreciate its workers for their role in "creating profits." And of course a society that talks about a "Peacekeeper" missile or "collateral damage," a "Final Solution" or "ethnic cleansing," is speaking what Wendell Berry calls "tyrannese."

> My impression is that we have seen, for perhaps a hundred and fifty years, a gradual increase in language that is either meaningless or destructive of meaning. And I believe that this increasing

> unreliability of language parallels the increasing disintegration, over the same period, of persons and communities. . . .

He goes on to say:

> In this degenerative accounting, language is almost without the power of designation, because it is used conscientiously to refer to nothing in particular. Attention rests upon percentages, categories, abstract functions. . . . It is not language that the user will very likely be required to stand by or to act on, for it does not define any personal ground for standing or acting. Its only practical utility is to support with "expert opinion" a vast, impersonal technological action already begun. . . . It is a tyrannical language: tyrannese.[5]

The first step in respecting language is keeping it as concrete, meaningful, and truthful as possible—part of the job of keeping information streams clear. The second step is to enlarge language to make it consistent with our enlarged understanding of systems. If the Eskimos have so many words for snow, it's because they have studied and learned how to use snow. They have turned snow into a resource, a system with which they can dance. The industrial society is just beginning to have and use words for systems, because it is only beginning to pay attention to and use complexity. *Carrying capacity*, *structure*, *diversity*, and even *system* are old words that are coming to have richer and more precise meanings. New words are having to be invented.

My word processor has spell-check capability, which lets me add words that didn't originally come in its comprehensive dictionary. It's interesting to see what words I had to add when writing this book: *feedback*, *throughput*, *overshoot*, *self-organization*, *sustainability*.

Pay Attention to What Is Important, Not Just What Is Quantifiable

Our culture, obsessed with numbers, has given us the idea that what we can measure is more important than what we can't measure. Think about that

for a minute. It means that we make quantity more important than quality. If quantity forms the goals of our feedback loops, if quantity is the center of our attention and language and institutions, if we motivate ourselves, rate ourselves, and reward ourselves on our ability to produce quantity, then quantity will be the result. You can look around and make up your own mind about whether quantity or quality is the outstanding characteristic of the world in which you live.

As modelers we have exposed ourselves to the ridicule of our scientific colleagues more than once by putting variables labeled "prejudice," or "self-esteem," or "quality of life" into our models. Since computers require numbers, we have had to make up quantitative scales by which to measure these qualitative concepts. "Let's say prejudice is measured from –10 to +10, where 0 means you are treated with no bias at all, –10 means extreme negative prejudice, and +10 means such positive prejudice that you can do no wrong. Now, suppose that you were treated with a prejudice of –2, or +5, or –8. What would that do to your performance at work?"

The relationship between prejudice and performance actually had to be put in a model once.[6] The study was for a firm that wanted to know how to do better at treating minority workers and how to move them up the corporate ladder. Everyone interviewed agreed that there certainly was a real connection between prejudice and performance. It was arbitrary what kind of scale to measure it by—it could have been 1 to 5 or 0 to 100—but it would have been much more unscientific to leave "prejudice" out of that study than to try to include it. When the workers in the company were asked to draw the relationship between their performance and prejudice, they came up with one of the most nonlinear relationships I've ever seen in a model.

Pretending that something doesn't exist if it's hard to quantify leads to faulty models. You've already seen the system trap that comes from setting goals around what is easily measured, rather than around what is important. So don't fall into that trap. Human beings have been endowed not only with the ability to count, but also with the ability to assess quality. Be a quality detector. Be a walking, noisy Geiger counter that registers the presence or absence of quality.

If something is ugly, say so. If it is tacky, inappropriate, out of proportion, unsustainable, morally degrading, ecologically impoverishing, or humanly demeaning, don't let it pass. Don't be stopped by the "if you can't

define it and measure it, I don't have to pay attention to it" ploy. No one can define or measure justice, democracy, security, freedom, truth, or love. No one can define or measure any value. But if no one speaks up for them, if systems aren't designed to produce them, if we don't speak about them and point toward their presence or absence, they will cease to exist.

Make Feedback Policies for Feedback Systems

President Jimmy Carter had an unusual ability to think in feedback terms and to make feedback policies. Unfortunately, he had a hard time explaining them to a press and public that didn't understand feedback.

He suggested, at a time when oil imports were soaring, that there be a tax on gasoline proportional to the fraction of U.S. oil consumption that had to be imported. If imports continued to rise, the tax would rise until it suppressed demand and brought forth substitutes and reduced imports. If imports fell to zero, the tax would fall to zero.

The tax never got passed.

Carter also was trying to deal with a flood of illegal immigrants from Mexico. He suggested that nothing could be done about that immigration as long as there was a great gap in opportunity and living standards between the United States and Mexico. Rather than spending money on border guards and barriers, he said, we should spend money helping to build the Mexican economy, and we should continue to do so until the immigration stopped.

That never happened either.

You can imagine why a dynamic, self-adjusting feedback system cannot be governed by a static, unbending policy. It's easier, more effective, and usually much cheaper to design policies that change depending on the state of the system. Especially where there are great uncertainties, the best policies not only contain feedback loops, but meta-feedback loops—loops that alter, correct, and expand loops. These are policies that design *learning* into the management process.

An example was the historic Montreal Protocol to protect the ozone layer of the stratosphere. In 1987, when that protocol was signed, there was no certainty about the danger to the ozone layer, about the rate at which it was degrading, or about the specific effect of different chemicals. The protocol

set targets for how fast the manufacture of the most damaging chemicals should be decreased. But it also required monitoring the situation and reconvening an international congress to change the phase-out schedule, if the damage to the ozone layer turned out to be more or less than expected. Just three years later, in 1990, the schedule had to be hurried forward and more chemicals added to it, because the damage was turning out to be much greater than was foreseen in 1987.

That was a feedback policy, structured for learning. We all hope that it worked in time.

Go for the Good of the Whole

Remember that hierarchies exist to serve the bottom layers, not the top. Don't maximize parts of systems or subsystems while ignoring the whole. Don't, as Kenneth Boulding once said, go to great trouble to optimize something that never should be done at all. Aim to enhance total systems properties, such as growth, stability, diversity, resilience, and sustainability—whether they are easily measured or not.

Listen to the Wisdom of the System

Aid and encourage the forces and structures that help the system run itself. Notice how many of those forces and structures are at the bottom of the hierarchy. Don't be an unthinking intervenor and destroy the system's own self-maintenance capacities. Before you charge in to make things better, pay attention to the value of what's already there.

A friend of mine, Nathan Gray, was once an aid worker in Guatemala. He told me of his frustration with agencies that would arrive with the intention of "creating jobs" and "increasing entrepreneurial abilities" and "attracting outside investors." They would walk right past the thriving local market, where small-scale business people of all kinds, from basket makers to vegetable growers to butchers to candy sellers, were displaying their entrepreneurial abilities in jobs they had created for themselves. Nathan spent his time talking to the people in the market, asking about their lives and businesses, learning what was in the way of those businesses expanding

and incomes rising. He concluded that what was needed was not outside investors, but inside ones. Small loans available at reasonable interest rates, and classes in literacy and accounting, would produce much more long-term good for the community than bringing in a factory or assembly plant from outside.

Locate Responsibility in the System

That's a guideline both for analysis and design. In analysis, it means looking for the ways the system creates its own behavior. Do pay attention to the triggering events, the outside influences that bring forth one kind of behavior from the system rather than another. Sometimes those outside events can be controlled (as in reducing the pathogens in drinking water to keep down incidences of infectious disease). But sometimes they can't. And sometimes blaming or trying to control the outside influence blinds one to the easier task of increasing responsibility within the system.

"Intrinsic responsibility" means that the system is designed to send feedback about the consequences of decision making directly and quickly and compellingly to the decision makers. Because the pilot of a plane rides in the front of the plane, that pilot is intrinsically responsible. He or she will experience directly the consequences of his or her decisions.

Dartmouth College reduced intrinsic responsibility when it took thermostats out of individual offices and classrooms and put temperature-control decisions under the guidance of a central computer. That was done as an energy-saving measure. My observation from a low level in the hierarchy was that the main consequence was greater oscillations in room temperature. When my office got overheated, instead of turning down the thermostat, I had to call an office across campus, which got around to making corrections over a period of hours or days, and which often overcorrected, setting up the need for another phone call. One way of making that system more, rather than less, responsible might have been to let professors keep control of their own thermostats and charge them directly for the amount of energy they use, thereby privatizing a commons!

Designing a system for intrinsic responsibility could mean, for example, requiring all towns or companies that emit wastewater into a stream to place their intake pipes *downstream* from their outflow pipe. It could mean

that neither insurance companies nor public funds should pay for medical costs resulting from smoking or from accidents in which a motorcycle rider didn't wear a helmet or a car rider didn't fasten the seat belt. It could mean Congress would no longer be allowed to legislate rules from which it exempts itself. (There are many rules from which Congress has exempted itself, including affirmative action hiring requirements and the necessity of preparing environmental impact statements.) A great deal of responsibility was lost when rulers who declared war were no longer expected to lead the troops into battle. Warfare became even more irresponsible when it became possible to push a button and cause tremendous damage at such a distance that the person pushing the button never even sees the damage.

Garrett Hardin has suggested that people who want to prevent other people from having an abortion are not practicing intrinsic responsibility, unless they are personally willing to bring up the resulting child![7]

These few examples are enough to get you thinking about how little our current culture has come to look for responsibility within the system that generates an action, and how poorly we design systems to experience the consequences of their actions.

Stay Humble—Stay a Learner

Systems thinking has taught me to trust my intuition more and my figuring-out rationality less, to lean on both as much as I can, but still to be prepared for surprises. Working with systems, on the computer, in nature, among people, in organizations, constantly reminds me of how incomplete my mental models are, how complex the world is, and how much I don't know.

The thing to do, when you don't know, is not to bluff and not to freeze, but to learn. The way you learn is by experiment—or, as Buckminster Fuller put it, by trial and error, error, error. In a world of complex systems, it is not appropriate to charge forward with rigid, undeviating directives. "Stay the course" is only a good idea if you're sure you're on course. Pretending you're in control even when you aren't is a recipe not only for mistakes, but for not learning from mistakes. What's appropriate when you're learning is small steps, constant monitoring, and a willingness to change course as you find out more about where it's leading.

That's hard. It means making mistakes and, worse, admitting them. It means what psychologist Don Michael calls "error-embracing." It takes a lot of courage to embrace your errors.

> Neither we ourselves, nor our associates, nor the publics that need to be involved . . . can learn what is going on and might go on if we act as if we really had the facts, were really certain about all the issues, knew exactly what the outcomes should/could be, and were really certain that we were attaining the most preferred outcomes. Moreover, when addressing complex social issues, acting as if we knew what we were doing simply decreases our credibility. . . . Distrust of institutions and authority figures is increasing. The very act of acknowledging uncertainty could help greatly to reverse this worsening trend.[8]

> Error-embracing is the condition for learning. It means seeking and using—and sharing—information about what went wrong with what you expected or hoped would go right. Both error embracing and living with high levels of uncertainty emphasize our personal as well as societal vulnerability. Typically we hide our vulnerabilities from ourselves as well as from others. But . . . to be the kind of person who truly accepts his responsibility . . . requires knowledge of and access to self far beyond that possessed by most people in this society.[9]

Celebrate Complexity

Let's face it, the universe is messy. It is nonlinear, turbulent, and dynamic. It spends its time in transient behavior on its way to somewhere else, not in mathematically neat equilibria. It self-organizes and evolves. It creates diversity *and* uniformity. That's what makes the world interesting, that's what makes it beautiful, and that's what makes it work.

There's something within the human mind that is attracted to straight lines and not curves, to whole numbers and not fractions, to uniformity and not diversity, and to certainties and not mystery. But there is something else within us that has the opposite set of tendencies, since we ourselves evolved

out of and are shaped by and structured as complex feedback systems. Only a part of us, a part that has emerged recently, designs buildings as boxes with uncompromising straight lines and flat surfaces. Another part of us recognizes instinctively that nature designs in fractals, with intriguing detail on every scale from the microscopic to the macroscopic. That part of us makes Gothic cathedrals and Persian carpets, symphonies and novels, Mardi Gras costumes and artificial intelligence programs, all with embellishments almost as complex as the ones we find in the world around us.

We can, and some of us do, celebrate and encourage self-organization, disorder, variety, and diversity. Some of us even make a moral code of doing so, as Aldo Leopold did with his land ethic: "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise."[10]

Expand Time Horizons

One of the worst ideas humanity ever had was the interest rate, which led to the further ideas of payback periods and discount rates, all of which provide a rational, quantitative excuse for ignoring the long term.

The official time horizon of industrial society doesn't extend beyond what will happen after the next election or beyond the payback period of current investments. The time horizon of most families still extends farther than that—through the lifetimes of children or grandchildren. Many Native American cultures actively spoke of and considered in their decisions the effects on the seventh generation to come. The longer the operant time horizon, the better the chances for survival. As Kenneth Boulding wrote:

> There is a great deal of historical evidence to suggest that a society which loses its identity with posterity and which loses its positive image of the future loses also its capacity to deal with present problems, and soon falls apart. . . . There has always been something rather refreshing in the view that we should live like the birds, and perhaps posterity is for the birds in more senses than one; so perhaps we should all . . . go out and pollute something cheerfully. As an old taker of thought for the morrow, however, I cannot quite accept this solution. . . .[11]

In a strict systems sense, there is no long-term, short-term distinction. Phenomena at different time-scales are nested within each other. Actions taken now have some immediate effects and some that radiate out for decades to come. We experience now the consequences of actions set in motion yesterday and decades ago and centuries ago. The couplings between very fast processes and very slow ones are sometimes strong, sometimes weak. When the slow ones dominate, nothing seems to be happening; when the fast ones take over, things happen with breathtaking speed. Systems are always coupling and uncoupling the large and the small, the fast and the slow.

When you're walking along a tricky, curving, unknown, surprising, obstacle-strewn path, you'd be a fool to keep your head down and look just at the next step in front of you. You'd be equally a fool just to peer far ahead and never notice what's immediately under your feet. You need to be watching both the short and the long term—the whole system.

Defy the Disciplines

In spite of what you majored in, or what the textbooks say, or what you think you're an expert at, follow a system wherever it leads. It will be sure to lead across traditional disciplinary lines. To understand that system, you will have to be able to learn from—while not being limited by—economists and chemists and psychologists and theologians. You will have to penetrate their jargons, integrate what they tell you, recognize what they can honestly see through their particular lenses, and discard the distortions that come from the narrowness and incompleteness of their lenses. They won't make it easy for you.

Seeing systems whole requires more than being "interdisciplinary," if that word means, as it usually does, putting together people from different disciplines and letting them talk past each other. Interdisciplinary communication works only if there is a real problem to be solved, and if the representatives from the various disciplines are more committed to solving the problem than to being academically correct. They will have to go into learning mode. They will have to admit ignorance and be willing to be taught, by each other and by the system.

It can be done. It's very exciting when it happens.

Expand the Boundary of Caring

Living successfully in a world of complex systems means expanding not only time horizons and thought horizons; above all, it means expanding the horizons of caring. There are moral reasons for doing that, of course. And if moral arguments are not sufficient, then systems thinking provides the practical reasons to back up the moral ones. The real system is interconnected. No part of the human race is separate either from other human beings or from the global ecosystem. It will not be possible in this integrated world for your heart to succeed if your lungs fail, or for your company to succeed if your workers fail, or for the rich in Los Angeles to succeed if the poor in Los Angeles fail, or for Europe to succeed if Africa fails, or for the global economy to succeed if the global environment fails.

As with everything else about systems, most people already know about the interconnections that make moral and practical rules turn out to be the same rules. They just have to bring themselves to believe that which they know.

Don't Erode the Goal of Goodness

The most damaging example of the systems archetype called "drift to low performance" is the process by which modern industrial culture has eroded the goal of morality. The workings of the trap have been classic, and awful to behold.

Examples of bad human behavior are held up, magnified by the media, affirmed by the culture, as typical. This is just what you would expect. After all, we're only human. The far more numerous examples of human goodness are barely noticed. They are "not news." They are exceptions. Must have been a saint. Can't expect everyone to behave like that.

And so expectations are lowered. The gap between desired behavior and actual behavior narrows. Fewer actions are taken to affirm and instill ideals. The public discourse is full of cynicism. Public leaders are visibly, unrepentantly amoral or immoral and are not held to account. Idealism is ridiculed. Statements of moral belief are suspect. It is much easier to talk about hate in public than to talk about love. The literary critic and naturalist Joseph Wood Krutch put it this way:

> Thus though man has never before been so complacent about what he *has*, or so confident of his ability to *do* whatever he sets his mind upon, it is at the same time true that he never before accepted so low an estimate of what *he is*. That same scientific method which enabled him to create his wealth and to unleash the power he wields has, he believes, enabled biology and psychology to explain him away—or at least to explain away whatever used to seem unique or even in any way mysterious. . . . Truly he is, for all his wealth and power, poor in spirit.[12]

We know what to do about drift to low performance. Don't weigh the bad news more heavily than the good. And keep standards absolute.

Systems thinking can only tell us to do that. It can't do it. We're back to the gap between understanding and implementation. Systems thinking by itself cannot bridge that gap, but it can lead us to the edge of what analysis can do and then point beyond—to what can and must be done by the human spirit.