Places to Intervene in a System
By Donella H. Meadows (*Whole Earth* Winter 1997

Folks who do systems analysis have a great belief in "leverage points." These are places within a complex system (a corporation, an economy, a living body, a city, an ecosystem) where a small shift in one thing can produce big changes in everything.

The systems community has a lot of lore about leverage points. Those of us who were trained by the great Jay Forrester at MIT have absorbed one of his favorite stories. "People know intuitively where leverage points are. Time after time I've done an analysis of a company, and I've figured out a leverage point. Then I've gone to the company and discovered that everyone is pushing it **in the wrong direction** !"

The classic example of that backward intuition was Forrester's first world model. Asked by the Club of Rome to show how major global problems—poverty and hunger, environmental destruction, resource depletion, urban deterioration, unemployment—are related and how they might be solved, Forrester came out with a clear leverage point: Growth. Both population and economic growth. Growth has costs—among which are poverty and hunger, environmental destruction—the whole list of problems we are trying to solve with growth!

The world's leaders are correctly fixated on economic growth as the answer to virtually all problems, but they're pushing with all their might in the wrong direction.

Counterintuitive. That's Forrester's word to describe complex systems. The systems analysts I know have come up with no quick or easy formulas for finding leverage points. Our counterintuitions aren't that well developed. Give us a few months or years and we'll model the system and figure it out. We know from bitter experience that when we do discover the system's leverage points, hardly anybody will believe us.

Very frustrating. So one day I was sitting in a meeting about the new global trade regime, NAFTA and GATT and the World Trade Organization. The more I listened, the more I began to simmer inside. "This is a HUGE NEW SYSTEM people are inventing!" I said to myself. "They haven't the slightest idea how it will behave," myself said back to me. "It's cranking the system in the wrong direction—growth, growth at any price!! And the control measures these nice folks are talking about—small parameter adjustments, weak negative feedback loops—are PUNY!"

Suddenly, without quite knowing what was happening, I got up, marched to the flip chart, tossed over a clean page, and wrote: " **Places to Intervene in a System** ," followed by nine items:

9. Numbers (subsidies, taxes, standards).
8. Material stocks and flows.
7. Regulating negative feedback loops.
6. Driving positive feedback loops.
5. Information flows.
4. The rules of the system (incentives, punishment, constraints).
3. The power of self-organization.
2. The goals of the system.
1. The mindset or paradigm out of which the goals, rules, feedback structure arise.

Everyone in the meeting blinked in surprise, including me. "That's brilliant!" someone breathed. "Huh?" said someone else.

I realized that I had a lot of explaining to do.

In a minute I'll go through the list, translate the jargon, give examples and exceptions. First I want to place the list in a context of humility. What bubbled up in me that day was distilled from decades of rigorous analysis of many different kinds of systems done by many smart people. But complex systems are, well, complex. It's dangerous to generalize about them. What you are about to read is not a recipe for finding leverage points. Rather it's an invitation to think more broadly about system change.

That's why leverage points are not intuitive.

9. Numbers.

Numbers ("parameters" in systems jargon) determine how much of a discrepancy turns which faucet how fast. Maybe the faucet turns hard, so it takes a while to get the water flowing. Maybe the drain is blocked and can allow only a small flow, no matter how open it is. Maybe the faucet can deliver with the force of a fire hose. These considerations are a matter of numbers, some of which are physically locked in, but most of which are popular intervention points.

Consider the national debt. It's a negative bathtub, a money hole. The rate at which it sinks is the annual deficit. Tax income makes it rise, government expenditures make it fall. Congress and the president argue endlessly about the many parameters that open and close tax faucets and spending drains. Since those faucets and drains are connected to the voters, these are politically charged parameters. But, despite all the fireworks, and no matter which party is in charge, the money hole goes on sinking, just at different rates.

The amount of land we set aside for conservation. The minimum wage. How much we spend on AIDS research or Stealth bombers. The service charge the bank extracts from your account. All these are numbers, adjustments to faucets. So, by the way, is firing people and getting new ones. Putting different hands on the faucets may change the rate at which they turn, but if they're the same old faucets, plumbed into the same system, turned according to the same information and rules and goals, the system isn't going to change much. Bill Clinton is different from George Bush, but not all that different.

Numbers are last on my list of leverage points. Diddling with details, arranging the deck chairs on the *Titanic*. Probably ninety-five percent of our attention goes to numbers, but there's not a lot of power in them.

Not that parameters aren't important—they can be, especially in the short term and to the individual who's standing directly in the flow. But they RARELY CHANGE BEHAVIOR. If the system is chronically stagnant, parameter changes rarely kick-start it. If it's wildly variable, they don't usually stabilize it. If it's growing out of control, they don't brake it.

Whatever cap we put on campaign contributions, it doesn't clean up politics. The Feds fiddling with the interest rate haven't made business cycles go away. (We always forget that during upturns, and are shocked, shocked by the downturns.) Spending more on police doesn't make crime go away.

However, there are critical exceptions. Numbers become leverage points when they go into ranges that kick off one of the items higher on this list. Interest rates or birth rates control the gains around positive feedback loops. System goals are parameters that can make big differences. Sometimes a system gets onto a chaotic edge, where the tiniest change in a number can drive it from order to what appears to be wild disorder.

Probably the most common kind of critical number is the length of delay in a feedback loop. Remember that bathtub on the fourth floor I mentioned, with the water heater in the basement? I actually experienced one of those once, in an old hotel in London. It wasn't even a bathtub with buffering capacity; it was a shower. The water temperature took at least a minute to respond to my faucet twists. Guess what my shower was like. Right, oscillations from hot to cold and back to hot, punctuated with expletives. Delays in negative feedback loops cause oscillations. If you're trying to adjust a system state to your goal, but you only receive delayed information about what the system state is, you will overshoot and undershoot.

Same if your information is timely, but your response isn't. For example, it takes several years to build an electric power plant, and then that plant lasts, say, thirty years. Those delays make it impossible to build exactly the right number of plants to supply a rapidly changing demand. Even with immense effort at forecasting, almost every electricity industry in the world experiences long oscillations between overcapacity and undercapacity. A system just can't respond to short-term changes when it has long-term delays. That's why a massive central-planning system, such as the Soviet Union or General Motors, necessarily functions poorly.

A delay in a feedback process is critical RELATIVE TO RATES OF CHANGE (growth, fluctuation, decay) IN THE SYSTEM STATE THAT THE FEEDBACK LOOP IS TRYING TO CONTROL. Delays that are too short cause overreaction, oscillations amplified by the jumpiness of the response. Delays that are too long cause damped, sustained, or exploding oscillations, depending on how much too long. At the extreme they cause chaos. Delays in a system with a threshold, a danger point, a range past which irreversible damage can occur, cause overshoot and collapse.

Delay length would be a high leverage point, except for the fact that delays are not often easily changeable. Things take as long as they take. You can't do a lot about the construction time of a major piece of capital, or the maturation time of a child, or the growth rate of a forest. It's usually easier to slow down the change rate (positive feedback loops, higher on this list), so feedback delays won't cause so much trouble. Critical numbers are not nearly as common as people seem to think they are. Most systems have evolved or are designed to stay out of sensitive parameter ranges. Mostly, the numbers are not worth the sweat put into them.

8. Material stocks and flows.
The plumbing structure, the stocks and flows and their physical arrangement, can have an enormous effect on how a system operates.

When the Hungarian road system was laid out so all traffic from one side of the nation to the other had to pass through central Budapest, that determined a lot about air pollution and commuting delays that are not easily fixed by pollution control devices, traffic lights, or speed limits. The only way to fix a system that is laid out wrong is to rebuild it, if you can.

Often you can't, because physical building is a slow and expensive kind of change. Some stock-and-flow structures are just plain unchangeable.

The baby-boom swell in the US population first caused pressure on the elementary school system, then high schools and colleges, then jobs and housing, and now we're looking forward to supporting its retirement. Not much to do about it, because five-year-olds become six-year-olds, and sixty-four-year-olds become sixty-five-year-olds predictably and unstoppably. The same can be said for the lifetime of destructive CFC molecules in the ozone layer, for the rate at which contaminants get washed out of aquifers, for the fact that an inefficient car fleet takes ten to twenty years to turn over.

The possible exceptional leverage point here is in the size of stocks, or buffers. Consider a huge bathtub with slow in and outflows. Now think about a small one with fast flows. That's the difference between a lake and a river. You hear about catastrophic river floods much more often than catastrophic lake floods, because stocks that are big, relative to their flows, are more stable than small ones. A big, stabilizing stock is a buffer.

The stabilizing power of buffers is why you keep money in the bank rather than living from the flow of change through your pocket. It's why stores hold inventory instead of calling for new stock just as customers carry the old stock out the door. It's why we need to maintain more than the minimum breeding population of an endangered species. Soils in the eastern US are more sensitive to acid rain than soils in the west, because they haven't got big buffers of calcium to neutralize acid. You can often stabilize a system by increasing the capacity of a buffer. But if a buffer is too big, the system gets inflexible. It reacts too slowly. Businesses invented just-in-time inventories, because occasional vulnerability to fluctuations or screw-ups is cheaper than certain, constant inventory costs—and because small-to-vanishing inventories allow more flexible response to shifting demand.

There's leverage, sometimes magical, in changing the size of buffers. But buffers are usually physical entities, not easy to change.

The acid absorption capacity of eastern soils is not a leverage point for alleviating acid rain damage. The storage capacity of a dam is literally cast in concrete. Physical structure is crucial in a system, but the leverage point is in proper design in the first place. After the structure is built, the leverage is in understanding its limitations and bottlenecks and refraining from fluctutions or expansions that strain its capacity.

7. Regulating negative feedback loops.
Now we're beginning to move from the physical part of the system to the information and control parts, where more leverage can be found. Nature evolves negative feedback loops and humans invent them to keep system states within safe bounds.

A thermostat loop is the classic example. Its purpose is to keep the system state called "room temperature" fairly constant at a desired level. Any negative feedback loop needs a goal (the thermostat setting), a monitoring and signaling device to detect excursions from the goal (the thermostat), and a response mechanism (the furnace and/or air conditioner, fans, heat pipes, fuel, etc.).
A complex system usually has numerous negative feedback loops it can bring into play, so it can self-correct under different conditions and impacts. Some of those loops may be inactive much of the time—like the emergency cooling system in a nuclear power plant, or your ability to sweat or shiver to maintain your body temperature. One of the big mistakes we make is to strip away these emergency response mechanisms because they aren't often used and they appear to be costly. In the short term we see no effect from doing this. In the long term, we narrow the range of conditions over which the system

can survive.

One of the most heartbreaking ways we do this is in encroaching on the habitats of endangered species. Another is in encroaching on our own time for rest, recreation, socialization, and meditation.

The "strength" of a negative loop—its ability to keep its appointed stock at or near its goal—depends on the combination of all its parameters and links—the accuracy and rapidity of monitoring, the quickness and power of response, the directness and size of corrective flows.

There can be leverage points here. Take markets, for example, the negative feedback systems that are all but worshiped by economists—and they can indeed be marvels of self-correction, as prices vary to keep supply and demand in balance. The more the price—the central signal to both producers and consumers—is kept clear, unambiguous, timely, and truthful, the more smoothly markets will operate. Prices that reflect full costs will tell consumers how much they can actually afford and will reward efficient producers. Companies and governments are fatally attracted to the price leverage point, of course, all of them pushing in the wrong direction with subsidies, fixes, externalities, taxes, and other forms of confusion. The REAL leverage here is to keep them from doing it. Hence anti-trust laws, truth-in-advertising laws, attempts to internalize costs (such as pollution taxes), the removal of perverse subsidies, and other ways of leveling market playing fields.

The strength of a negative feedback loop is important RELATIVE TO THE IMPACT IT IS DESIGNED TO CORRECT. If the impact increases in strength, the feedbacks have to be strengthened too.

A thermostat system may work fine on a cold winter day—but open all the windows and its corrective power will fail. Democracy worked better before the advent of the brainwashing power of centralized mass communications. Traditional controls on fishing were sufficient until radar spotting and drift nets and other technologies made it possible for a few actors to wipe out the fish. The power of big industry calls for the power of big government to hold it in check; a global economy makes necessary a global government.

Here are some other examples of strengthening negative feedback controls to improve a system's self-correcting abilities: preventive medicine, exercise, and good nutrition to bolster the body's ability to fight disease, integrated pest management to encourage natural predators of crop pests, the Freedom of Information Act to reduce government secrecy, protection for whistle blowers, impact fees, pollution taxes, and performance bonds to recapture the externalized public costs of private benefits.

6. Driving positive feedback loops.
A positive feedback loop is self-reinforcing. The more it works, the more it gains power to work some more.

The more people catch the flu, the more they infect other people. The more babies are born, the more people grow up to have babies. The more money you have in the bank, the more interest you earn, the more money you have in the bank. The more the soil erodes, the less vegetation it can support, the fewer roots and leaves to soften rain and runoff, the more soil erodes. The more high-energy neutrons in the critical mass, the more they knock into nuclei and generate more.

Positive feedback loops drive growth, explosion, erosion, and collapse in systems. A system with an unchecked positive loop ultimately will destroy itself. That's why there are so few of them.

Usually a negative loop kicks in sooner or later. The epidemic runs out of infectable people—or people take increasingly strong steps to avoid being infected. The death rate rises to equal the birth rate—or people see the consequences of unchecked population growth and have fewer babies. The soil erodes away to bedrock, and after a million years the bedrock crumbles into new soil—or people put up check dams and plant trees.

In those examples, the first outcome is what happens if the positive loop runs its course, the second is what happens if there's an intervention to reduce its power.

Reducing the gain around a positive loop—slowing the growth—is usually a more powerful leverage point in systems than strengthening negative loops, and much preferable to letting the positive loop run.

Population and economic growth rates in the world model are leverage points, because slowing them gives the many negative loops, through technology and markets and other forms of adaptation, time to function. It's the same as slowing the car when you're driving too fast, rather than calling for more responsive brakes or technical advances in steering.

The most interesting behavior that rapidly turning positive loops can trigger is chaos. This wild, unpredictable, unreplicable, and yet bounded behavior happens when a system starts changing much, much faster than its negative loops can react to it.

For example, if you keep raising the capital growth rate in the world model, eventually you get to a point where one tiny increase more will shift the economy from exponential growth to oscillation. Another nudge upward gives the oscillation a double beat. And just the tiniest further nudge sends it into chaos.

I don't expect the world economy to turn chaotic any time soon (not for that reason, anyway). That behavior occurs only in unrealistic parameter ranges, equivalent to doubling the size of the economy within a year. Real-world systems do turn chaotic, however, if something in them can grow or decline very fast. Fast-replicating bacteria or insect populations, very infectious epidemics, wild speculative bubbles in money systems, neutron fluxes in the guts of nuclear power plants. These systems are hard to control, and control must involve slowing down the positive feedbacks.

In more ordinary systems, look for leverage points around birth rates, interest rates, erosion rates, "success to the successful" loops, any place where the more you have of something, the more you have the possibility of having more.

5. Information flows.
There was this subdivision of identical houses, the story goes, except that the electric meter in some of the houses was installed in the basement and in others it was installed in the front hall, where the residents could see it constantly, going round faster or slower as they used more or less electricity. Electricity consumption was 30 percent lower in the houses where the meter was in the front hall.

Systems-heads love that story because it's an example of a high leverage point in the information structure of the system. It's not a parameter adjustment, not a strengthening or weakening of an existing loop. It's a NEW LOOP, delivering feedback to a place where it wasn't going before.

In 1986 the US government required that every factory releasing hazardous air pollutants report those emissions publicly. Suddenly everyone could find out precisely what was coming out of the smokestacks in town. There was no law against those emissions, no fines, no determination of "safe" levels, just information. But by 1990 emissions dropped 40 percent. One chemical company that found itself on the Top Ten Polluters list reduced its emissions by 90 percent, just to "get off that list."

Missing feedback is a common cause of system malfunction. Adding or rerouting information can be a powerful intervention, usually easier and cheaper than rebuilding physical structure.

The tragedy of the commons that is exhausting the world's commercial fisheries occurs because there is no feedback from the state of the fish population to the decision to invest in fishing vessels. (Contrary to economic opinion, the price of fish doesn't provide that feedback. As the fish get more scarce and hence more expensive, it becomes all the more profitable to go out and catch them. That's a perverse feedback, a positive loop that leads to collapse.)

It's important that the missing feedback be restored to the right place and in compelling form. It's not enough to inform all the users of an aquifer that the groundwater level is dropping. That could trigger a race to the bottom. It would be more effective to set a water price that rises steeply as the pumping rate exceeds the recharge rate.

Suppose taxpayers got to specify on their return forms what government services their tax payments must be spent on. (Radical democracy!) Suppose any town or company that puts a water intake pipe in a river had to put it immediately DOWNSTREAM from its own outflow pipe. Suppose any public or private official who made the decision to invest in a nuclear power plant got the waste from that plant stored on his/her lawn.

There is a systematic tendency on the part of human beings to avoid accountability for their own decisions. That's why there are so many missing feedback loops—and why this kind of leverage point is so often popular with the masses, unpopular with the powers that be, and effective, if you can get the powers that be to permit it to happen or go around them and make it happen anyway.

4. The rules of the system (incentives, punishments, constraints).
The rules of the system define its scope, boundaries, degrees of freedom. Thou shalt not kill. Everyone has the right of free speech. Contracts are to be honored. The president serves four-year terms and cannot serve more than two of them. Nine people on a team, you have to touch every base, three strikes and you're out. If you get caught robbing a bank, you go to jail.

Mikhail Gorbachev came to power in the USSR and opened information flows (glasnost) and changed the economic rules (perestroika), and look what happened.

Constitutions are strong social rules. Physical laws such as the second law of thermodynamics are absolute rules, if we understand them correctly. Laws, punishments, incentives, and informal social agreements are progressively weaker rules.

To demonstrate the power of rules, I ask my students to imagine different ones for a college. Suppose the students graded the teachers. Suppose you come to college when you want to learn something, and you leave when you've learned it. Suppose professors were hired according to their ability to solve real-world problems, rather than to publish academic papers. Suppose a class got graded as a group, instead of as individuals.

Rules change behavior. Power over rules is real power.

That's why lobbyists congregate when Congress writes laws, and why the Supreme Court, which interprets and delineates the Constitution—the rules for writing the rules—has even more power than Congress.

If you want to understand the deepest malfunctions of systems, pay attention to the rules, and to who has power over them.

That's why my systems intuition was sending off alarm bells as the new world trade system was explained to me. It is a system with rules designed by corporations, run by corporations, for the benefit of corporations. Its rules exclude almost any feedback from other sectors of society. Most of its meetings are closed to the press (no information, no feedback). It forces nations into positive loops, competing with each other to weaken environmental and social safeguards in order to attract corporate investment. It's a recipe for unleashing "success to the succesful" loops.

3. The power of self-organization.
The most stunning thing living systems can do is to change themselves utterly by creating whole new structures and behaviors. In biological systems that power is called evolution. In human economies it's called technical advance or social revolution. In systems lingo it's called self-organization.

Self-organization means changing any aspect of a system lower on this list—adding or deleting new physical structure, adding or deleting negative or positive loops or information flows or rules. The ability to self-organize is the strongest form of system resilience, the ability to survive change by changing.

The human immune system can develop responses to (some kinds of) insults it has never before encountered. The human brain can take in new information and pop out completely new thoughts.

Self-organization seems so wondrous that we tend to regard it as mysterious, miraculous. Economists often model technology as literal manna from heaven—coming from nowhere, costing nothing, increasing the productivity of an economy by some steady percent each year. For centuries people have regarded the spectacular variety of nature with the same awe. Only a divine creator could bring forth such a creation.

In fact the divine creator does not have to produce miracles. He, she, or it just has to write clever RULES FOR SELF-ORGANIZATION. These rules govern how, where, and what the system can add onto or subtract from itself under what conditions.

Self-organizing computer models demonstrate that delightful, mind-boggling patterns can evolve from simple evolutionary algorithms. (That need not mean that real-world algorithms are simple, only that they can be.) The genetic code that is the basis of all biological evolution contains just four letters, combined into words of three letters each. That code, and the rules for replicating and rearranging it, has spewed out an unimaginable variety of creatures.

Self-organization is basically a matter of evolutionary raw material—a stock of information from which to select possible patterns—and a means for testing them. For biological evolution the raw material is DNA, one source of variety is spontaneous mutation, and the testing mechanism is something like punctuated Darwinian selection. For technology the raw material is the body of understanding science has accumulated. The source of variety is human creativity (whatever THAT is) and the selection mechanism is whatever the market will reward or whatever governments and foundations will fund or whatever tickles the fancy of crazy inventors.

When you understand the power of self-organization, you begin to understand why biologists worship biodiversity even more than economists worship technology. The wildly varied stock of DNA, evolved and accumulated over billions of years, is the source of evolutionary potential, just as science libraries and labs and scientists are the source of technological potential. Allowing species to go extinct is a systems crime, just as randomly eliminating all copies of particular science journals, or particular kinds of scientists, would be.

The same could be said of human cultures, which are the store of behavioral repertoires accumulated over not billions, but hundreds of thousands of years. They are a stock out of which social evolution can arise. Unfortunately, people appreciate the evolutionary potential of cultures even less than they understand the potential of every genetic variation in ground squirrels. I guess that's because one aspect of almost every culture is a belief in the utter superiority of that culture.

Any system, biological, economic, or social, that scorns experimentation and wipes out the raw material of innovation is doomed over the long term on this highly variable planet.

The intervention point here is obvious but unpopular. Encouraging diversity means losing control. Let a thousand flowers bloom and ANYTHING could happen!

Who wants that?

2. The goals of the system.
Right there, the push for control, is an example of why the goal of a system is even more of a leverage point than the self-organizing ability of a system.

If the goal is to bring more and more of the world under the control of one central planning system (the empire of Genghis Khan, the world of Islam, the People's Republic of China, Wal-Mart, Disney), then everything further down the list, even self-organizing behavior, will be pressured or weakened to conform to that goal.

That's why I can't get into arguments about whether genetic engineering is a good or a bad thing. Like all technologies, it depends upon who is wielding it, with what goal. The only thing one can say is that if corporations wield it for the purpose of generating marketable products, that is a very different goal, a different direction for evolution than anything the planet has seen so far.

There is a hierarchy of goals in systems. Most negative feedback loops have their own goals—to keep the bath water at the right level, to keep the room temperature comfortable, to keep inventories stocked at sufficient levels. They are small leverage points. The big leverage points are the goals of entire systems.

People within systems don't often recognize what whole-system goal they are serving. To make profits, most corporations would say, but that's just a rule, a necessary condition to stay in the game. What is the point of the game? To grow, to increase market share, to bring the world (customers, suppliers, regulators) more under the control of the corporation, so that its operations become ever more shielded from uncertainty. That's the goal of a cancer cell too and of every living population. It's only a bad one when it isn't countered by higher-level negative feedback loops with goals of keeping the system in balance. The goal of keeping the market competitive has to trump the goal of each corporation to eliminate its competitors. The goal of keeping populations in balance and evolving has to trump the goal of each population to commandeer all resources into its own metabolism.

I said a while back that changing the players in a system is a low-level intervention, as long as the players fit into the same old system. The exception to that rule is at the top, if a single player can change the system's goal.

I have watched in wonder as—only very occasionally—a new leader in an organization, from Dartmouth College to Nazi Germany, comes in, enunciates a new goal, and single-handedly changes the behavior of hundreds or thousands or millions of perfectly rational people.

That's what Ronald Reagan did. Not long before he came to office, a president could say, "Ask not what government can do for you, ask what you can do for the government," and no one even laughed. Reagan said the goal is not to get the people to help the government and not to get government to help the people, but to get the government off our backs. One can argue, and I would, that larger system changes let him get away with that. But the thoroughness with which behavior in the US and even the world has been changed since Reagan is testimony to the high leverage of articulating, repeating, standing for, insisting upon new system goals.

1. The mindset or paradigm out of which the system arises.
Another of Jay Forrester's systems sayings goes: It doesn't matter how the tax law of a country is written. There is a shared idea in the minds of the society about what a "fair" distribution of the tax load is. Whatever the rules say, by fair means or foul, by complications, cheating, exemptions or deductions, by constant sniping at the rules, the actual distribution of taxes will push right up against the accepted idea of "fairness."

The shared idea in the minds of society, the great unstated assumptions—unstated because unnecessary to state; everyone knows them—constitute that society's deepest set of beliefs about how the world works. There is a difference between nouns and verbs. People who are paid less are worth less. Growth is good. Nature is a stock of resources to be converted to human purposes. Evolution stopped with the emergence of *Homo sapiens* . One can "own" land. Those are just a few of the paradigmatic assumptions of our culture, all of which utterly dumbfound people of other cultures.

Paradigms are the sources of systems. From them come goals, information flows, feedbacks, stocks, flows.

The ancient Egyptians built pyramids because they believed in an afterlife. We build skyscrapers, because we believe that space in downtown cities is enormously valuable. (Except for blighted spaces, often near the skyscrapers, which we believe are worthless.) Whether it was Copernicus and Kepler showing that the earth is not the center of the universe, or Einstein hypothesizing that matter and energy are interchangeable, or Adam Smith postulating that the selfish actions of individual players in markets wonderfully accumulate to the common good.

People who manage to intervene in systems at the level of paradigm hit a leverage point that totally transforms systems.