Thinking Outside Newton's Box

Metaphors for Grassroots Development

by Patrick Breslin

That which is overdesigned, too highly specific, anticipates outcome; the anticipation of outcome guarantees, if not failure, the absence of grace.
— William Gibson, All Tomorrow's Parties

Newton's genius

Into a world of mystery and confusion, Isaac Newton in 1686 introduced a mathematical order that not only explained the movements of the heavens but gave humankind a framework, and a set of assumptions for thinking about almost everything else. Before Newton, people approached the universe with magic and religion and gazed in wonder at the impenetrable dance of the planets. Astronomers from the Egyptians on mapped the sky's gyrations and scrambled to accommodate them in their inadequate theories. Then Newton devised the gravitational theory, the laws of motion and the differential calculus to track them, and suddenly the orbits of the planets arranged themselves in predictable paths.

Based on Newton's work, Edmond Halley soon was able to correctly foretell the reappearance of the comet now named for him. A century later, scientists derived from Newton's laws alone the existence of the undiscovered planet Neptune and pinpointed (with a bit of mathematical luck) its location in the firmament. So stupendous was Newton's achievement that it provided succeeding generations a mechanistic metaphor for the universe as well as an exalted expectation of what science should be. It sanctified scientific reductionism — analyzing systems by breaking them into their constituent parts for study. These intellectual tools reduced nature to linear processes that could be mapped and measured, and their power led to the greatest advances in scientific discovery in human history. No wonder then that they would be applied to all fields of human activity.

Which was a problem

Since Newton, most Western thinking about human society has followed the linear and mechanical assumptions of his physics. Newton bequeathed a paradigm, the mental framework that defines the problems and the tools with which scientists work. And paradigms are enormously powerful. They ripple through the consciousness of an era and decide or influence not only scientific inquiry but everything else, from style to literature to economic, social and political organization. They frame the way we see things, the questions we ask, what we leave out. They provide our metaphors.

Given the pervasive influence of Newton's paradigm, it was only natural that when attention turned, for a variety of reasons in the 1950s, to the problems of poverty in the poor countries, those problems, and assumptions about how to solve them, were understood within a linear framework. This way of thinking was reinforced by the success of the Marshall Plan — the first great experiment in fostering economic development. After World War II, the United States pumped large amounts of capital into the shattered economies of Western Europe, and in a few short years those economies were getting back on their feet. But the conditions were specific to Western Europe, which, unlike most of Latin America, Asia and Africa, had already been a largely industrialized region before the war. Equally important, Europeans decided how the aid would be used. Because these facts were later overlooked, the seemingly linear and mechanistic success of the Marshall Plan still seduces development thinkers and policy-makers, and to this day every new effort at development is rhetorically wrapped in its mantle.

But 50 years of efforts to bring about rapid social and economic development among the world's poor has left us, early in a new century, in frustration and near paralysis. The large infusions of capital that quickly financed reconstruction in post-war Europe simply dissipated in Third World seas of poverty. The promises of development too often went unfulfilled. Too many ambitious plans went awry. The absolute numbers of the poor have soared, the world's cities are strangling, virgin forests have been razed. Despite such disasters, development planners continue to set out goals, plan and implement projects, and await the results. Though they seldom appear as expected, faith in the linear model continues.

Could it be that in development work, as in so much else in modern life, our assumptions, at the deepest level, were wrong? Could it be, as former Czech president Vaclav Havel suggested, that "the relationship to the world that modern science fostered and shaped ... fails to connect with the most intrinsic nature of reality and with natural human experience"?

For more than 30 years, the Inter-American Foundation has been supporting development in a decidedly nonlinear way. We call our approach grassroots development to emphasize that the projects we fund are conceived and managed by local people trying to solve their own community's problems, not by outsiders who decide that what is needed is family planning or education or hydroelectric dams or health care or farm-to-market roads or any of the other magic-bullet ideas that have surfaced and sunk in the last half century. At IAF, with some exceptions, we have limited ourselves to responding to the projects proposed to us. Our representatives in the field may question or challenge those proposals, even suggest revisions. But they don't write them. We receive hundreds of proposals from all over Latin America and the Caribbean every year, and, with our limited funds, support a few dozen of the ones we think most innovative and most promising. This contrary approach to development was shaped not by an intellectual paradigm, but by experience. Central to the Foundation's formative years were individuals who had spent a lot of time on the ground in the region as Peace Corps volunteers and staff, missionaries or businessmen from retail companies who boosted sales by knowing their customers.

Over roughly the same 30 years, new scientific questions and approaches were appearing, and generating new metaphors for how the world works. Many of those metaphors seem intuitively closer to what the Inter-American Foundation has learned about development than does Newton's clockwork universe. The rest of this essay explores the place of metaphor in development thinking, using examples from classical science and from more recent inquiries into chaos and complexity. If we want to move past the graveyard of failed development efforts, questioning our metaphors is a good first step. For as economist Brian Arthur points out, "an awful lot of policy-making has to do with finding the appropriate metaphor. Conversely, bad policy-making almost always involves finding inappropriate metaphors." (Waldrop: 334)

Sand in the gears

Newton's laws and methods established science's fundamental paradigm for 250 years. But even Newton's gears had some sand in them. From the outset, it was clear that the laws didn't completely explain the solar system. Newton himself confessed frustration at his inability to calculate the moon's orbit. Also, as more observations of the planets were made, the mathematics to account for them became increasingly complicated, and they didn't always work. An intractable problem in calculating Mercury's orbit wasn't solved until Einstein's general theory of relativity in 1917. (Peterson: 94)

Further complications appeared as physicists probed not only the reaches of the solar system but the less and less analogous inner space of the atom, a probe that led to quantum mechanics, a more accurate while more indeterminate (everything about quantum mechanics seems paradoxical) alternative to classical Newtonian mechanics. Quantum mechanics studies the behavior of atoms and the particles that make them up. And studying this behavior has its own, non-Newtonian, implications. Classical science assumes an objective observer whose act of measurement does not affect the thing being measured. But since quantum mechanics measures something as small as an electron within an atom, by bouncing another electron off it, measurement obviously changes something. This led Werner Heisenberg to formulate the Uncertainty Principle: you can't know everything about an atomic particle precisely. If you measure its position, you change its velocity. If you measure velocity, you change position. You must always be uncertain about something. Instead of certainty, you have probabilities.

Other baffling aspects to measurement in quantum mechanics thicken the uncertainty. One is whether quantum particles are particles, or waves — the only two ways energy is transmitted. It turns out that they leap to be whatever you measure for. Use a wave detector and electrons behave like a wave; use a particle detector and they behave like particles. "What we see is what we look for." (Zohar: 44)

The new concepts seemed to mirror much of the confusion and uncertainty of modern human society, and indeed some of them passed into popular speech — "quantum leaps," for example, or "it's all relative." But because they deal with phenomena esoteric to daily human experiences, like behavior near the speed of light, they did not fundamentally alter the common, linear view of the world. The Newtonian paradigm has not been junked. As physicist Murray Gell-Mann, who won the Nobel Prize for predicting the existence of the subatomic quark, points out, "Newtonian versus Einsteinian mechanics of the solar system [is still used] far more often than its more accurate and sophisticated successor." (Gell-Mann: 87) The earth still spins in a Newtonian orbit and development agencies, like everyone else, continue to expect predictable outcomes to actions.

The edge of chaos

In the last three decades, a new scientific focus on studies of chaos and complexity has emerged. It has generated both enthusiasm and skepticism from scientists and popularizers of scientific concepts. Even though this body of scientific inquiry is still in its infancy, it has already spun off a swarm of attractive metaphors.

Chaos studies focus on nonlinear systems, those in which components cannot act independently, in which the actions of one affect the rest through a web of connections. The phenomenon at the heart of the study of chaos is that in nonlinear systems, small changes in initial conditions can produce vastly divergent outcomes. Such systems are not inherently stable, and in them change can come with alarming abruptness. The example most often cited is the "butterfly effect" first discovered by Ed Lorenz, a meteorologist from the Massachusetts Institute of Technology working in the early 1960s on computer models of the atmosphere. In a time of optimism that science would eventually be able to predict and then control the weather, Lorenz's computer suddenly revealed how an infinitesimal change in initial conditions could produce vastly different results. A butterfly flapping its wings in Indonesia today, for example, could jiggle the atmosphere so as to cause a snowstorm in Chicago next week. Weather systems, while controlled by deterministic laws, are dramatically unstable. "As a result, they allow minuscule changes at one location to percolate through the system so as to bring about major effects somewhere else." (Casti: 90)

Linear thinking leads us to assume that systems are stable and change is gradual. "Intuition and common sense say that small, gradual changes in causes give rise to small, gradual changes in effects. This fundamental principle underlies what's technically termed structural stability, a crucial property built in to most of the mathematical descriptions of natural phenomena we've inherited from classical physics ... [T]o a great extent, classical physics is the physics of structurally stable systems . . . But not all phenomena of earthly concern are structurally stable. Nor are they continuous . . . [There are] processes in which a small change in the input . . . can lead to a big change in the final result." (Casti: 44-45)

There's stable behavior, like the solar system, and there's pure random behavior, like rolling dice. "What we're finding," says physicist William L. Ditto, "is that most of nature does something in between."

(Schwartz) Once scientists started thinking about chaos, they found it everywhere: in water going through a tube, currents in a mountain stream, a cascading pile of sand, the shape of storm clouds, the emergence and extinction of species in the geological record, the rise and fall of ancient civilizations, the New York Stock Exchange. Most systems display regular behavior up to a limit. Water from a faucet drips regularly, until you change the flow slightly. Then it becomes chaotic. Pour sand on a pile and you get a nice symmetrical cone. Keep pouring it and you get sudden avalanches. There's a place called the edge of chaos, and when a system approaches it, the behavior can quickly change in unpredictable ways.

In development, we see the butterfly effect played out again and again in projects IAF has funded. The phenomenon led IAF staff to design a system for describing the results of projects that encompasses unforeseen outcomes and multiplier effects. We report on the tangible results of each project, but we also try to track intangible results: how the confidence derived from successfully addressing one problem motivates a grassroots organization to address a more complex issue, for example, or how differences can be resolved when a community focuses on a common goal. We also look at how a project meant to address a specific problem in a community can be the catalyst for broader changes affecting many more people. An example from Colombia illustrates the point. In 1983, IAF awarded a grant to help a research group in Bogotá begin a program of legal services for female domestic workers, many of whom had unresolved disputes with employers. Over the next few years, the interest generated by that initiative began to have cascading effects in Colombian society. Additional legal work, the formation of mutual support groups among the workers, public forums and growing media attention, and the emergence of similar groups in other Colombian cities eventually led to a national law, passed in 1988, making social security and health benefits mandatory for all domestic workers and day laborers across the country.

Order for free

As chaos studies challenged the idea that change is always gradual and predictable, so the notion of complexity challenges the reductionist idea that things are best understood by dividing them into their smaller components. With growing urgency, many scientists have come to believe that the reductionist approach, and the ever-more compartmentalized structure of modern science it produced, was nearing a dead end. The more science learned, it seemed, the less it had to say about many of the world's most complex problems. In 1956, cybernetics pioneer W. Ross Ashby pointed to a divide in science. "For two centuries it has been exploring systems that are either intrinsically simple or that are capable of being analyzed into simple components." But the reductionist method, he said, "is often fundamentally impossible in the complex systems." (quoted in Casti: 172)

Scientific attention began to shift from the pursuit of ever smaller particles to questions about their relationships and how the systems they made up worked. George Cowan, a leading nuclear weapons researcher at Los Alamos, was convinced that science needed a new direction. In 1984, he, Murray Gell-Mann and other prominent scientists, set up the Santa Fe Institute, now one of several research institutions in the U.S., Europe and Japan dedicated to the study of complexity. The most striking thing about that study is how widely it ranges. Complexity science sees underlying similarities in subjects as apparently diverse as the rise and fall of civilizations both ancient and modern, the human immune system, the origins of life, evolution, the brain, ecology, genes, flocking birds, the stock market and the world economy.

One way to state the fascination of complex systems is the commonplace observation that they are more than the sum of their parts. As Gell-Mann points out, "The basic components — atoms, molecules, cells — are each simple enough, but as they interact with one another, new properties emerge." (Berreby) So, such systems are not only complex, they are also adaptive. They have the ability to change. They process information, learn, adapt and self-organize. For scientists, busy the past few centuries calculating exact balances of mass and energy, understanding those "emerging" properties requires a new approach, not refinement of traditional methods. Scientists typically get at these emergent properties by computer simulation of one kind or another. They use computers to model the basic biological mechanisms of evolution and life itself. (Waldrop: 198) Cellular automata — grids of cells that can be programmed by simple rules that govern how they react to their neighbors — are a popular tool. The behavior of many birds swooping through the sky, flowing around obstacles, never crashing into one another but always maintaining the flock, can be modeled in this way. Scientists can watch the interactions and see how patterns and structures emerge. They see emerging order and self-organization. And they look at the outside world, at biology, at evolution, and see similar patterns.

Stuart Kauffman, a theoretical biologist who has long puzzled over this, says there is a "marked preference of complex systems to spontaneously organize themselves into persistent patterns of activity that work." (quoted in Casti: 267) The complex dynamics of the system itself, the richness of the interactions, seem to spontaneously produce patterns of stability and organization. (Waldrop: 11) Kauffman calls it "order for free."

IAF's experience confirms the phenomenon of emerging patterns and emerging order. One of our main intellectual resources is the flow of proposals into our office each year. As we sift through them, a picture emerges of the changes going on at the grassroots in Latin America and the Caribbean. Although it sometimes takes us a while to perceive it, the opportunity to sift all those ideas often gives us an early glimpse of the future. An example from the 1980s is the burgeoning number of proposals from farmers' groups who wanted support for environmental protection. Most development experts, in linear, reductionist fashion, thought of environmental protection and agricultural production as two separate concerns. Often, they saw farmers clearing land for crops as an environmental threat. But we were receiving proposals from farmers who wanted to increase their production, who wanted better access to markets and who also wanted to preserve the natural environment around their fields. They had made the connection between protection of the forested slopes above them — often in national parks or reserves — and the water they needed for their crops. They recognized that new farming techniques (frequently traditional practices resurrected) were necessary to keep their land from sliding downhill or being leached of nutrients. They wanted natural pesticides rather than expensive chemical poisons.

Before long, it dawned on us that we were funding projects in several countries that simultaneously targeted better livelihoods and biodiversity. Environmental agencies started sending their staff to learn from these projects how the two goals could be blended. The view that a machete-wielding farmer was only a threat to the environment began to change to a view of the farmer, in the right supportive circumstances, as a steward of his surroundings.

A more recent example from Mexico illustrates how responding to proposals rather than planning projects can keep a development agency ahead of the curve. APOYO (Fundación para la Productividad en el Campo) is a Mexican NGO with long experience providing technical support to small-scale farmers in some of the poorest parts of the countryside. Some four or five years ago, the APOYO staff noticed they were running out of clients because most of the young farmers in the communities they served had migrated north looking for wages they could send home to their families. APOYO approached IAF with a new proposal: to encourage linkages between the hometown associations of the migrants in the United States and the communities they'd left behind. Migrants have since provided a wide range of services to their hometowns, not only in Mexico but also in El Salvador, Haiti and the Dominican Republic. The phenomenon was the subject of the first major conference on remittances and development, held in 2001 and sponsored by the IAF, the World Bank and the Washington Office of the United Nations Economic Commission for Latin America and the Caribbean. Now, IAF is discussing co-funding development projects in Latin American communities with hometown associations of migrants from those communities working in the U.S.

The implications of new metaphors

Chaos and complexity are new sciences, full of intriguing ideas and enveloped in the buzz of excitement that goes with new ventures. They haven't produced a scientific paradigm, as Newton's physics did over three centuries ago, but they have already spun off a rich assortment of metaphors, many of which seem intuitively right for the issues that development theorists and practitioners encounter. At this stage, new metaphors may be the most valuable contributions of the new sciences to development thinking. A good starting point in the search for appropriate development metaphors is the basic distinction between linear and nonlinear systems. Simple, linear systems behave predictably. If we drop a stone it falls at a measurable speed. Nonlinear processes generate surprises, like the weather system can when a butterfly revs up. Sadly, attempts to solve the problems of poverty at home or abroad have generated more surprises than successes. All too often, major resources and good intentions go into the system, but what comes out is frighteningly far from expectations.

To use the language of the new sciences, a development project is an intervention in nonlinear and complex adaptive systems. When it has been planned with linear methods and expectations, chaos theory suggests what can happen. A development project fueled with lots of money, mapped in great detail and driven by experts can represent a very significant change in "initial conditions." As things get rolling on the ground, what actually happens often begins to diverge from expectations and as results feed back the divergence widens, sometimes catastrophically. Low-cost housing projects give rise to slums worse than the housing they replaced. New freeways give rise to unprecedented traffic jams. (Casti: 271 ff.) A development plan meant to ease population pressures by opening up agricultural land with a road ends up destroying vast swaths of rain forest, exhausting the soil and leaving the very people it was meant to help in even more desperate poverty.

Several years ago, I stood on the shores of a man-made lake in the central mountains of Honduras, the country assigned the role of electricity producer in a massive development scheme for Central America. Several huge dams were built to produce power for Honduras' cities and leave enough for sale to its neighbors. Workers were recruited from poor rural areas, roads were cut through virgin forest, the concrete walls went up and the turbines were installed. But when construction ended, so did the jobs. With nowhere to go, many of the workers stayed to begin farming on the steep slopes above the reservoirs. That quickly led to erosion, and by the time I saw them, enough silt had already slid into the reservoirs to literally create islands, tree were growing on the islands, electric production was down, and Honduras was suffering periodic power blackouts. Additional investments of tens of millions of dollars were eventually needed to start restoring vegetation to the slopes.

Similar examples are common in the last half century of development assistance. Over and over, ambitious development schemes are planned with impressive internal coherence, and then imposed from the top down on a complex human system. But because "it's effectively impossible to cover every conceivable situation, top-down systems are forever running into combinations of events they don't know how to handle . . . and they all too often grind to a halt in a dither of indecision." (Waldrop: 279) The problem is in trying to deal with poverty by the reductionist approach of breaking it into its components. At various times, development planners believed that building the physical infrastructure of roads, bridges and harbors was the key to development, or that education was or urban housing or modernizing agriculture or micro-enterprise. It's not that any of these are wrong. What is wrong is assuming that you can change one factor in a complex situation and then predict the outcome.

What would a nonlinear development model look like? Metaphors from chaos and complexity studies suggest that it would look very much like what we call grassroots, participatory, bottom-up development. There is an almost eerie fit between the way we talk about grassroots development and the way scientists talk about the evolution of complex systems: "Instead of being designed from the top down, the way a human engineer would do it, living systems always seem to emerge from the bottom up, from a population of much simpler systems." (Waldrop: 278). And listen to a scientist describing how to mimic lifelike behavior on a computer: "[S]imulate populations of simple units instead of one big complex unit. Use local control instead of global control. Let the behavior emerge from the bottom up, instead of being specified from the top down. And while you're at it, focus on ongoing behavior instead of the final result . . . [L]iving systems never really settle down."

The responsive grassroots development approach sees in human communities the same capacity for self-organization that scientists see in all complex adaptive systems. Accordingly, it relies more on the capacity of poor people to understand their own problems and craft their own solutions — often in dialogue with local technicians — than it relies on projects designed from the outside. It emphasizes the uniqueness of each project. It looks for success, as much, if not more, in intangible outcomes like increased human capabilities as it does in quantitative project results. It recognizes that complex systems are adaptive, and it seeks to strengthen adaptiveness so that it can be carried forward to the next development challenge.

How would development change under the influence of post-Newtonian scientific metaphors? The change from linear, mechanistic metaphors would be quite radical. If we stopped thinking of development as a linear process, one of the first things to disappear would be the illusion of control inherent in projects designed from the top down. The littered landscape of development fiascos in the past half century demonstrates how little control project designers and managers actually have had, but the illusion continues. Control is power, and metaphors drawn from studies of chaos and complexity suggest that power must be ceded and dispersed downwards to permit adaptive behavior and the emergence of new patterns.

With control would go the idea of predictability. The demand for predictability unrealistically forces complex processes into the framework of simple models. That distortion is at the root of development failures. With different metaphors, development projects would no longer be thought of as analogous to laboratory experiments. Goals would be clear, but the focus would be much broader than the scorecard or checklist marking their attainment. It would expand to encompass what happens on the way to the goals, and would accommodate the reality that as a complex system evolves and adapts, goals too can change.

This means, of course, that the field of project evaluation would change, as would the definition of success. Evaluation would become less a measurement of progress toward externally set goals and more of a feedback mechanism into a human group's evolution. We would still have numbers, but we would pay more attention to stories. In the place of control and predictability, there would be more observation, more listening. Development workers would necessarily spend more time out of their offices and move closer to the grassroots. Rather than function as project designers and managers, they would have a more modest, but much more exciting role, something like Waldrop's example (331-334) of whitewater guides who watch the currents, eddies and hydraulics, observing and occasionally sticking an oar in when it may do some good. Becoming observers, development workers might wind up doing longer tours of duty in the same place. Now, many development workers move around too much. They plan a project, and by the time it's up and running, or down and out, they're gone to another assignment. "They never see their mistakes," the head of one Honduran NGO told me.

Not all development workers would necessarily welcome the change in role. Comparing scientific work in complexity compared to classical science, economist Brian Arthur told Waldrop (334), "I think there's a personality that goes with this kind of thing. It's people who like process and pattern, as opposed to people who are comfortable with stasis and order." Projects would be smaller — remember the butterfly's wing — and much more numerous. Gell-Mann (356), pointing out that large-scale projects often create environmental damage while hardly helping poor people at all, noted that "the same people can often be aided very effectively through large numbers of small efforts, applied locally, as for example in the practice known as microlending." The individuality and uniqueness of projects would be recognized.

The idea of replicability would be rethought. In linear thinking, a successful project becomes a model to be applied elsewhere. Prevailing metaphors encourage an assumption identified by Gow (381) "that project conditions are generally similar, irrespective of the differing contexts." Metaphors from complexity would shift attention to what is truly replicable about development projects: an approach that encourages local creativity and initiative, that emphasizes process over results and that lets projects evolve in the interplay between the participants, their experiences and their reflections. Development workers, instead of making decisions about what is replicable, would become facilitators, enabling representatives of other communities to visit and see first hand what in the successful project they would wish to replicate.

Such an approach might diminish, if not eliminate, one of the uglier aspects of development work — the tendency to blame failed development efforts on the "target population's" supposedly inferior culture. In typical linear thinking, development workers design a project and set about implementing it. When the local people fail to carry out their assigned roles, the frustrated expert blames their defective culture. Grassroots experience, on the other hand, teaches that often it is precisely the values of the local culture that drive successful projects. Of course, moving resources to a nonlinear development model would not mean the end of government-to-government, or international bank-to-government, foreign assistance. Just as the Newtonian model still effectively answers many scientific questions, so the linear relationship in development aid is often appropriate. Vaccination campaigns are an obvious example.

The trick is to broaden our range of metaphors about development and to know which are appropriate to a given situation. And if we want people to truly participate in development efforts that they will carry on after the foreign assistance ends, then butterflies and self-organizing flocks of birds should be among our common metaphors.

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The publications below were among the first popular introductions to chaos, complexity and modern science.

Gleick's Chaos is the basic primer, and Waldrop's very readable book introduces the early ideas on complexity coming out of the Santa Fe Institute. Gell-Mann's work carries some of his scientific insights into discussions of development issues. For a more recent discussion of the shortcomings of scientific approaches from physics and chemistry when applied to what he calls "historical sciences," see the epilogue to Jared Diamond's Guns, Germs, and Steel, The Fate of Human Societies, W.W. Norton & Co., New York, 1999.

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