Free Agency, Determinism, and Chaos Theory

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THE DOCTRINE OF FREE AGENCY, while not unique to Mormonism, is perhaps more central to Mormon doctrine than it is to that of any other church or philosophy. Doctrine and Covenants 93:29 tells us, "Man also was in the beginning with God. Intelligence, or the light of truth, was not created or made, neither indeed can be. All truth is independent in that sphere in which God has placed it, to act for itself, as all intelligence also; otherwise there is no existence." Section 58, verses 26-28, adds, "[I]t is not meet that I command in all things, for he that is compelled in all things is a slothful and not a wise servant; wherefore he receiveth no reward. . . . Verily I say, men should be anxiously engaged in a good cause and do many things of their own free will . . . for the power is in them, wherefore they are agents unto themselves."

On the concept of agency depends Mormonism's explanation of the nature of God, humankind, good and evil, and—since Mormons expect to be doing more than merely adoring God in the hereafter—the future of humanity and the universe.

While agency appears self-evident to the simple believer and the uninstructed, it is not so to most physicists, mathematicians, and philosophers. Indeed, the contrary doctrine of determinism has ruled the realm of science at least since the days of Simon Laplace, the renowned French polymath of the seventeenth century, who maintained that given the one-time location, direction, and speed of every particle in the universe he could calculate the future with perfect accuracy for all time.

While this was an overstatement of the possibilities in Laplace's time, it has certainly been the foundation of most science; and both physicists and chemists, not to mention economists and other social theorists, have devoted most of their efforts to trying to produce data giving a better and more precise fix on discrete elements of their fields of interest, with the idea of eventually combining this knowledge into an understanding of

the total phenomenon. Following his success in coming up with the Theory of Relativity, Albert Einstein spent the rest of his life trying to develop a *Unified Field Theory* which would bring into one grand whole our understanding of the so-called "weak force," "strong force," and the force of gravity—explaining the behavior of nature from quark to intergalactic scale events.

Indeed, throughout most of modern times scientists shared a set of intuitively-based beliefs about complexity: simple systems were expected to behave in simple ways. A pendulum or an electric circuit—as long as it could be reduced to a few perfectly understood, deterministic laws—would be stable and predictable in its long-term behavior. Complex behavior was believed to imply complex causes: a mechanical device, a wildlife population, a fluid flow, a biological system, the weather, the economy—systems which were visibly unstable must be governed by a multitude of independent components and/or subject to random external influences. And, it was further intuitively assumed, different types of systems behave differently.

In a heroic synthesis of this traditional perspective, contemporary French mathematician/philosopher Jacques Monod some twenty-five years ago published an attention-getting book called *Choice and Necessity* in which he popularized the view that while at the personal level phenomena might appear random and even self-directed, upon deeper insight every phenomenon, including human volition, was determined by preceding events.

Almost simultaneously with the publication of Monod's book, however, new findings were being made that cast an entirely new and unexpected light on the issue of determinism. American meteorologist Edward Lorenz, playing weather games on his new computer, discovered that simple systems of just three variables in fact became indeterministic after as few as three or four permutations. It seems that the most insignificant random variations or imperfections (which have come to be called "sensitive dependence"), instead of dampening out as one might expect, are rapidly multiplied, or "pumped up," during every stage of evolution, soon resulting in totally chaotic and hence unpredictable turbulence. This has come to be called *Chaos Theory.* The discovery of Chaos Theory was serendipitously accompanied by the development of Fractal Geometry, a method for describing and measuring the nonlinear forms of nature, which proved essential to the development and full understanding of *Chaos.*

The developments of these two new theories, *Chaos* and *Fractals*, over the past decade are placed by some with those of Relativity and Quantum Mechanics as the four greatest discoveries of the twentieth century. As a result of these new ways of thinking, all earlier suppositions about

simplicity and complexity, and of different systems behaving differently, have changed. Physicists, biologists, mathematicians, and astronomers now know, and social scientists are coming to understand, that simple systems give rise to complex behavior. Complex systems produce simple behavior. And, most significantly, the laws of complexity hold universally, independent of the organization of the constituent elements of various systems. How did this come about?

The Development of Chaos Theory

Mathematics and physics have long been acquainted with what are known as *attractors*. An *attractor* is, viewed from one perspective at least, nothing more than a stable state or boundary. A *point attractor* can be thought of as the condition of rest towards which every pendulum tends, a plumb bob reacting to gravity. And the decorative case of the grandfather clock can be thought of as a *limit attractor,* restricting the pendulum from swinging past a certain established limit.

Edward Lorenz, playing with chaotic weather systems on his new computer, discovered what has come to be called the *Lorenz attractor*—an entirely new, unexpected, and puzzling form of attractor. While the system remains chaotic, in the sense that the movement of a wave, cloud formation, or other phenomenon never returns to precisely the same position as it was before and cannot therefore be predicted with accuracy, Lorenz found that *chaos* seems to settle down into more or less regular swings between the *point attractor* and the *limiting attractor.* When graphed, the result looks like two doughnuts mashed into each other with the swings of the graph passing alternatively from one to the other, taking on the appearance of a pair of pebble eyeglasses reflecting not-quite concentric rings of light.

Because it was published in meteorological journals, Lorenz's work was slow to come to the attention of physicists and mathematicians. But attention did come, and others have extended his study.

A biologist, Robert May, tinkering with Lorenz equations, soon discovered another remarkable inherent characteristic. Raising the parameters drastically beyond any imagined by Lorenz, May found a series of bifurcations appeared as the boundary was approached, oscillating between high and low values, then oscillating again between further bifurcations as higher values were approached. The bifurcations came faster and faster—4, 8, 16, 32 . . . Then, beyond a certain point, periodic bifurcation abruptly gave way to chaos, fluctuations that never settle down at all. James Yorke, a mathematician, analyzing the data with mathematical rigor, established that in any regular cycle of period three, the system will produce cycles of every other length as well as completely chaotic cycles.

This was so contrary to intuition that it hit the scientific community like a shock. These findings have had startling applications in biology, medicine, economics, astronomy, and many other disciplines. The finding of bifurcation in every process casts especially interesting light on the Mormon doctrine "That there must needs be an opposition in all things. If not so . . . [there is no existence]" (2 Ne. 2:11).

An Application of Chaos Theory to Astronomy

In astronomy *Chaos Theory* has given remarkable new insights into the analysis of *globular clusters,* the huge star groups akin to the Milky Way which make up most of the universe. Dynamically speaking, a globular cluster is a many-body problem. The two–body system is fairly easy to solve: Newton solved it completely. The earth and the moon, for example, each travel in a perfect ellipse around the system's joint center of gravity. The three-body system, however, is worse than hard. It is often incalculable. Orbits can be tracked for a time, but the uncertainties soon swamp the calculations.

Spaceship Earth: Free Flying Planets?

We have customarily considered the solar system to be stable, and certainly it appears so in the short term. But with the new knowledge of *Chaos Theory* astronomers now realize that there is no way of knowing for sure that some planetary orbits might not become more and more eccentric with the passage of time and the operations of Chaos Theory until one or another planet flies off from the system forever. On a grander scale, much of the universe consists of stable binary star systems. But when a third star encounters a binary, one of the three tends to get a sharp energy kick and not infrequently reaches escape velocity. This has been observed, though astronomers have not as yet confirmed the presence of planets in other star systems to confirm the possibility of "free flying planets" (though the existence of planets in other star systems is intuitively compelling and the existence of one near the neighboring star Vega has recently been preliminarily reported).

This new knowledge also casts interesting light on a teaching attributed to the prophet Joseph Smith. Numerous early members of the church report the prophet as having taught that the earth did not originate in its present orbit around the sun, and that in "the restoration of all things" it would return to its original orbit around *Kolob.* This teaching may have been based on Isaiah 13:13-14, "Therefore I will shake the heavens, and the earth shall remove out of her place . . . in the day of his fierce anger. And it shall be as the chased roe." Some have viewed this as con-

trary to common sense and astronomical science. Might it just be, however, that the prophet (who claimed he was merely reporting the astronomy of Abraham—and Isaiah?—which had been revealed to them by God) had a deeper insight into the physics of nature than the scientists of his day, or, until the last six or eight years, of our day?

A Powerful New Constant Inherent in All Natural Events

The next inspiration in the evolution of *Chaos Theory* came to a young New York mathematician named Mitchell Feigenbaum working with a hand calculator. Noting the doublings of May's bifurcations, Feigenbaum began writing down the parameter values that governed each period doubling. Doing this by hand instead of on a high speed computer gave him time to reflect. And in a flash of insight he realized that he could guess the next period. As a mathematician, he understood that this must be because there was a scaling pattern in the equation. On his hand calculator he worked out the rate of convergence to be 4.669. Later, on a more powerful computer, the exact ratio proved to be 4.6692016090.

This proved to be a constant holding true for every physical system upon which it has been tried. And it has been tried on pendulums, rolling streams, electronic oscillators, and dozens of other systems each of which moves beyond initial quasi-stability into chaos. To be sure, the equations for fluids and certain other complex systems proved highly challenging. But the point of Feigenbaum's constant is that such equations are irrelevant. When order emerges, it is insignificant what the original equation was. Quadratic or trigometric, the results are the same. Feigenbaum had found a new way to calculate complex nonlinear problems.

Attention is now focussing on some of the strange things that occur on the boundaries as events transition from one level of the Feigenbaum constant to the next. As viewed on the computer screen, strange bubbles and quasi-orderly chaotic conditions begin to appear (could this eventually prove to have a bearing on the newly-discovered bubble configuration of the observed universe?). A definitive border condition existing in nature is absolute zero. And some are beginning to wonder whether the extraordinary behavior of superconductive electricity as the boundary of absolute zero is approached may not be due to an as yet undiscovered aspect of *Chaos Theory.* If so, the science fiction concepts of translocation of matter and anti-gravity may prove to be as valid intuitive leaps as that of Plato's concept of Inherent Form (see discussion below).

Order from Chaos

A French astronomer, Michel Henon, employing Feigenbaum's con-

stant to plot carefully the orbits of stellar galaxies on a time scale of some 200 million years discovered something equally interesting. Orbits proved to be not completely regular. An orbit as it passed a particular point would on successive rounds pass through points a few inches to the right, then another, more to the right and up a little. After hundreds of thousands of orbits the points formed at first an egg-shaped curve, which later twisted into figure eights, then separate loops, eventually taking the form of a three dimensional torus, which proved to be the limit attractor of the system.

Any two consecutive orbits are randomly far apart, like any two points initially close together in a turbulent flow. The points appear so arbitrarily, however, that it is initially impossible to discern that they are forming a shape or to guess where the next point will appear—other than it will be somewhere on the attractor—at least until thousands of them form a "cloud" outlining it.

At higher levels orbits become so unstable that points again fragment into apparent chaos, only to re-emerge once more in a new order as the new points move unpredictably, but always within the three-dimensional torus form outlining the next limit attractor. Here, too, one senses the remarkable relationship of this new scientific knowledge to the ancient revealed doctrine, recorded in Moses 3:5, that there are limits to each kingdom even within the limitlessness of space and being. While we have agency as an inherent aspect of Being, this agency is bounded by the kingdom or *estate* in which we find ourselves, just as with the Henon indeterminacy between the boundaries of Feigenbaum's torus attractor.

The Application of Fractal Analysis to Chaos Theory: Platonic Form in Nature

It was Michael Barnsley, observing that most objects in nature had a *fractal*—i.e., irregular—form, who first began applying fractal analysis to such forms. Barnsley found that with relatively few rules he could decode such shapes and reproduce them on a small desktop computer. He concluded that nature was playing its own version of the chaos game. Because of his interest in ferns, he played with fern shapes. Convinced that the genetic code for ferns must be reasonably simple because of the limits of the genetic coding system, he decided there were limits to the way in which a fern could grow. He found that while the spots of light on his computer screen moved with apparent randomness—as had the blips which formed the *limit attractor* torus of Michel Henon—the blips always remained within the bounds forming the fern shape in the phosphorescence of the computer screen. In short (back to Jacques Monod), there

really is no fundamental randomness in nature. The appearance of total chance is an illusion. The shapes of the objects of nature depend on deep *fractal algorithms* existing in nature and brought into reality by time and the constructive forces of *chaos*, as modified by *sensitive dependence*—what we earlier described as the apparently insignificant perturbations affecting an initial state which are quickly magnified at every stage of a flow or process, eventuating—for a time at least—in the dissolution of regularity into chaos.

Was Plato's proposition that "pure forms" exist in nature independent of matter an intuitive leap of understanding? Is it right to think that elaborate Mandelbrot sets existed in nature waiting to be unveiled even before they were discovered? Could this be what is meant when the Lord says in Moses 3:5 that "All things were before created; but spiritually were they created and made. . . before [they] grew"?

Joseph Ford sums up contemporary thought on chaos, agency, and determinism, saying, "Evolution is chaos with feedback." The universe is randomness and dissipation, but it appears randomness with direction can produce surprising complexity. And dissipation is an agent of order. Chaoticists have come to speak of the "Butterfly Effect"—the concept that minuscule perturbations in the atmosphere caused by the movement of a butterfly's wings in China can within a few days by the "pumping up effect" of Chaos Theory result in a tornado in Kansas.

Think what God, or his human agents acting on his revealed wisdom, can do with complete knowledge of the laws of nature in causing deliberate, if apparently initially insignificant, perturbations (the introduction of deliberate *sensitive dependence*) in nature, resulting in widespread, even galactic, effects at future (and not necessarily remote) periods of time. Moving planets from their orbits, creating new solar systems, peopling new worlds. "God plays dice with the universe," is Ford's answer to Albert Einstein's famous question. "But they're loaded dice. And the main job of science is to find out by what rules they were loaded and how we can use them for our own ends."

A Concluding Thought

Chaos Theory has for the first time since Laplace and the scientific revolution of the modern age provided mathematical and logical underpinning for the concept of non-determinacy, or free agency, if agency is peculiarly bounded by the limiting attractors of each successive sphere of predictability (i.e., within its relevant "Kingdom" or "realm").

This may, for some, provide insight into the apparent contradiction between the scriptural assertion that God knows every thought and wish of the human mind, that "not a sparrow falls without his knowledge,"

and the equally compelling assertion that he will "lead, guide, direct aright, bless with wisdom, love and light; in nameless ways be good and kind, but never force the human mind."

For some there has perhaps also been an apparent conflict between God's gift of free agency and his warning that "In nothing doth man offend God . . . save those who confess not His hand in all things . . ." (D&C 5:91). Some thoughtful Latter-day Saints, recognizing that God himself works within the laws of nature, which include this strange, semi-controlled randomness, have come to think of Mormonism as *Deistic Existentialism.* That is, things are as they are and we must accept them as such, but with the presence of an omniscient deity many things can be accomplished which in current circumstances appear to us miraculous. Yet, as Brigham Young once said, "Even God cannot produce a five–year–old horse in five minutes."

In Mormon theology God is himself bounded by the laws of nature—though, living in an entirely different estate (dimension of time/space?), his boundaries are different from those of humankind. Surely someday we will understand these apparent contradictions just as we are now coming to see some of the alternating relationships between order and chaos, between the regularity of the Feigenbaum constant and the total unpredictability of the next individual point in Henon's torus or Barnsley's emerging fractal fern.