Toward a Theology of Chaos: 
The New Scientific Paradigm 
and Some Implications for Ministry

By

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Abstract:
Scientific paradigms influence people’s approach to and understanding of faith and its relevance. The paradigm shift in science begun in the 1960s and accelerated in the 1980s has broad implications for theology and ministry. A brief, non-technical introduction to chaos theory and its related principles is offered.

Glory be to God for dappled things—
    For skies of couple-colour as a brinded cow;
    For rose-moles all in stipple upon trout that swim;
Fresh-firecoal chestnut-falls; finches’ wings;
    Landscape plotted and pieced—fold, fallow, and plough;
    And ill-tried des, their gear and tackle and trim.

All things counter, original, spare, strange;
    Whatever is fickle, freckled (who knows how?)
    With swift, slow; sweet, sour; adazzle, dim;
He fathers-forth whose beauty is past change:

Praise

him.

Gerard Manley Hopkins

“As far as the laws of mathematics refer to reality, they are not certain; and as far as they are certain, they do not refer to reality.”

Albert Einstein

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Introduction

Our society is in the process of revolutionary changes, changes that will affect every aspect of life on this planet. Over the last several decades, the pace of change and diversification has accelerated, in some areas accelerating so quickly that even experts have trouble keeping up with their areas of expertise. Yet our increasingly complex world is increasingly interconnected. More and more societal problems seem so inextricably and dynamically entwined with other problems that a new level of thinking and problem-solving is called for. Many of the institutions around us, including the church, seem out of synch with emerging ways of living, working, thinking and relating.

Though the need for the Gospel and the Church to be relevant has never been greater, many churches seem unable to adapt to the changing times. Overwhelmed and fearful, these churches continue doing things as they always have and wonder why they are not working. Part of the sense of fear and inundation stems from not knowing from where these new structures and ways of ministry will come and an inability to visualize these new structures and ways. Where will these new structures and ways come from? What will they look like?

One source for these new structures and ways is what some call the "new sciences," and others "chaos theory." The new ways of scientific inquiry have broad implications for theology and ministry. This article will briefly explore the importance of paradigms, outline some ideas from chaos theory and develop some of its implications for theology and ministry. Given the sheer volume and complexity of each area touched on this article, these thoughts must per force serve as only a springboard for further study and development.

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2 As one will discover from the description below, the term “chaos” is not entirely satisfactory for in fact, “chaos theory” describes the underlying patterns and self-organizational tendencies that seem to rise out of chaos. The term was first used by James Yorke in his paper, “Period Three Implies Chaos,” American Mathematical Monthly, 82(1975), pp. 985–92. As Butz notes in “Chaos Theory: Philosophically Old, Scientifically New,” Counseling & Values, 39:2(Jan 1995), pp. 84+, “How scientists experienced apparent randomness seems to be an important key to this topic, in that when they are able to analyze what appears to be random they find an underlying order...Grotstein (1990) had this to say: ‘It is my belief that emotional turbulence constitutes chaos but is experienced as randomness (p. 274)’ Therefore, it seems that much of the power of this theory arises from its ability to use the term chaos in describing the psychological experience of encountering material that is outside the bounds of an ‘order’ that one is accustomed to.” This article provides the widest ranging history of the ideas of chaos (as newly defined) from several different cultural millieus.
Of Paradigms and Paradigm Shifts

Beginning perhaps most notably with Copernicus and Galileo, science and theology have had an unusual relationship, each influencing how the other approaches and understands its discipline, yet neither entirely comfortable in the other’s presence. Despite their differences in perspective and method, however, science and theology both seek to understand reality and make predictions about reality for the future.

One of the areas of mutual influence is in the area of “paradigms.” In his seminal work, *The Structure of Scientific Revolutions*, Thomas Kuhn defines a paradigm as “an accepted model or pattern...In a science...a paradigm is...an object for further articulation and specification under new or more stringent conditions.” In more common usage, “paradigm” has come to mean a particular framework for thinking or worldview. Stephen Covey suggests that a paradigm is like a map. A map is not the territory, but explains how to negotiate the territory. As long as the map helps us negotiate the territory, we use it. If what we experience from reality and what we understand from the map are incongruous, then the map’s usefulness becomes problematic. Indeed, if enough incongruities exist between the map and reality, we may opt to get a new map entirely.

Putting an old map aside to accept and develop a new one is called a “paradigm shift,” changing the entire framework for viewing and interacting with the world.

Making a paradigm shift is not an easy process. Changing paradigms is energy intensive, so most people and communities avoid it as long as they can. Further, people spend much of their lives adding to their understanding of the world based on a particular paradigm and so are personally invested in using the paradigm. In order to change paradigms, not only is future structure revised, but one’s understandings of self and past are as well. Thus a paradigm shift happens when a person or community reaches a crisis point, when the old paradigm encounters a dead end and a new paradigm promises a way out. Only when a state of crisis forces communities and individuals to do so will they dedicate their time and energy to making a new map and shifting paradigms.

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3 Most sources refer to “science and religion,” but I am more concerned here with how science relates to how people think about God (theology) and apply that to their whole lives (faith) rather than with only the outward, pietistic expressions of faith (i.e., “religion”).


5 P. 23. Ironically, Kuhn’s book caused a revolution not only in regard to the history of science, but also for public understanding of the concept of “paradigm” and “paradigm-shift.” His discussion (in Chapter XIII) of theology in relation to these theories is intriguing.


7 Kuhn, pp. 23–4.

8 Kuhn, pp. 66–76. See also M. Scott Peck’s *The Road Less Traveled*(NY: Simon & Schuster, 1978) for a non-technical explanation of the psychological aspects of paradigm shifts.
Influence of Paradigms in Science and Theology

Every paradigm explains some things well and carries far-reaching implications. Newton’s theories, for example, offered some fascinating insights into the way the world works and put the final touches on the paradigm shift begun by Copernicus and continued by Galileo. Newton’s laws of inertia and causality explain many situations and interactions. His math, calculus, is the foundation for all mechanical physics. The Newtonian paradigm viewed the world through a mechanistic lens and encouraged a clockwork model: the universe was like a machine, a collection of equations (“laws”) which could be used to predict the behavior of objects. If you had a large problem you could, as with a machine, break it down into smaller equations and by solving these smaller problems, eventually solve the large problem. Thus, an acceptable practice was to make close approximations in calculations with large numbers, on the assumption that small perturbations essentially were inconsequential to the final outcome.9

The pinnacle of this thinking is reflected in Simon Pierre Laplace’s *Philosophical Essays on Probabilities*:

An intellect which at any given moment knew all the forces that animate Nature and the mutual positions of the beings that comprise it, if this intellect were vast enough to submit its data to analysis, could condense into a single formula the movement of the greatest bodies of the universe and that of the lightest atom: for such an intellect nothing could be uncertain; and the future just like the past would be present before its eyes.10

Indeed, one of the driving forces behind the invention of computers was that it might approach Laplace’s “vast intellect” and enable scientists to predict (even control) the weather.11 Newtonian-based theology approached issues of faith from this same mechanistic or causal viewpoint. Theologians tended to think of Creation in terms of the making of a machine.12 Newtonian-based theology pushed toward breaking down faith into component experiences to make them more easily understood.13 In biblical study, the tendency toward Newtonian reductionism is seen in the textual criticism that analyzes

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12Francis Oakley, p. 433.

13The Puritans were famous for these efforts, and some evangelicals continue with them to this day. For an analysis of Puritan thought on this, see Conrad Cherry’s *The Theology of Jonathan Edwards: A Reappraisal* (Gloucester, MA: Peter Smith, 1972), pp. 62–7.
each word or phrase of an author’s work to determine whether a particular textual element was part of the original or a later redaction.

But the Newtonian paradigm—as many problems as it solves, as many tools as it provides for understanding the universe—has reached a sticking point. Some of the problems scientists face in the real world are so complex as to be completely intractable to the linear, reductionistic techniques of science as we all learned it. The promise of the old paradigm was that

Through reason, man[sic] would discover the “laws of nature.” If man could just know enough and apply that knowledge, things would get better.... What is melting into the air is an old paradigm: a faith, really, that explained the way the world works. One of the things undermining that faith now is the scholarly emergence of chaos theory, which holds that many complex phenomena are inherently unpredictable.14

What is chaos theory and where did it come from? Can it improve on the old paradigm and if so, how? How might theologians, pastors and society benefit from the painstaking process of changing paradigms?

**Introduction to Chaos Theory**

The essence of chaos theory is the interpenetration of determinacy and randomness, order and chaos. Order gives rise to chaos, and chaos in turn admits surprising degrees of order. A simple, orderly, deterministic process can generate complex, unpredictable results. At another level, however, random process admits remarkable order.15

Chaos theory has five primary characteristics: sensitive dependence on initial conditions, self-similarity across scales, global patterns to local randomness, self-organization from unpredictability, and universal application to dynamic systems.

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The Butterfly Effect

In 1961, Edward Lorenz, a meteorologist at MIT, was running computer simulations of weather on an early computer. Using a set of three “natural laws” (equations) that described dynamic relationships between pressure, temperature, and windspeed, Lorenz built a deterministic “world.” At one point, Lorenz wanted to recreate a particularly interesting run. He entered in a set of starting conditions from his printout and started the weather running again. To his surprise, the second run almost immediately began to diverge from the first, and after a short time, became completely different. (See Figure 1) In examining the data more closely, Lorenz discovered that the numbers he had entered as initial conditions for the second run had been one decimal place shorter than those produced by the first run. Yet the small difference had led to enormous changes in the system. Lorenz had witnessed what came to be known as “the butterfly effect.”

The butterfly effect derives its name from the way in which dynamic systems are sensitive to small changes in the initial conditions. In weather systems, for example, a butterfly flapping its wings in the Andes might set into motion a cascading chain of events that could cause flooding in Bangladesh. This effect is reflected in the rhyme:

“For want of a nail the shoe was lost
for want of a shoe the horse was lost
for want of horse the rider was lost
for want of a rider the battle was lost
for want of a battle the kingdom was lost!”

A small change can have exponential consequences! Lorenz’s experience with his deterministic weather model ran counter to the Newtonian-Laplacian assumptions about reality.

Self-Similarity Across Scales

Another primary characteristic of systems displaying chaotic behavior is that they are self-similar across scales. Benoit Mandelbrot, a mathematician with IBM, looked at systems as diverse as flooding in the Nile, cotton market reports, British cartography, and transmission noise in telephone lines. He discovered that if one looked at some systems, behavior at a macroscopic level was very similar to that at a microscopic level. One question Mandelbrot asked was “How long is the coastline of Britain?” The answer is that it depends on the ruler you use. If you measure the coastline in kilometers, you will get one answer. If you measure the coastline in meters, you will get another answer, longer than the first. If you measure the coastline in centimeters, you will get yet another answer, longer again than the second. Yet the total area of Britain will never exceed that of the circle drawn around it. “Mandelbrot found that as the scale of measurement becomes smaller, the measured length of a coastline rises without limit, bays and peninsulas revealing ever—smaller subbays and subpeninsulas—at least down to atomic scales...” Strangely, if one were to view a coastline from a satellite and then from a plane and then from a ladder, one would notice a similarity in the coastline’s roughness. (See Figure 2) This self-similarity across scales holds true most of the time with many natural objects and phenomena, everything from clouds and lightning to market reports and plant formation. An object’s “degree of roughness” is what Mandelbrot called its “fractal dimension.” The new branch of mathematics he founded is called “fractal geometry.”

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16Gleick, op. cit., pp. 11–18.
17ibid, p. 23.
18ibid, p. 96
19Parts of Mandelbrot’s manifesto, The Fractal Geometry of Nature (NY: W.H. Freeman and Company, 1983), are amazingly accessible and worth reading, if only to catch his aesthetic approach to mathematics.
The shapes derived from fractal geometry carried a delicate beauty that brought an important aesthetic appeal to chaos theory and hailed a possible reunification of mathematics and art.\textsuperscript{20}

**Global Patterns to Local Randomness**

A third primary characteristic of chaos theory is that what appears to be unpredictable at one level reveals pattern at another level. When Lorenz plotted the points from his equations (see “The Butterfly Effect” above), entering the resulting conditions from one calculation as the initial conditions for the next calculation, he discovered that they followed a rough pattern (See Figure 3) that never repeated and never crossed itself; it was an infinite line in a finite space, i.e., it had a fractal dimension. This line is bound by what is called a “strange attractor,” a pattern that serves as the system’s graphic “magnet,” constraining the options of the system. If there are blank areas, that means that for that system, that area is out of bounds. Without question, one reason strange attractors were not discovered before is that computers—especially desktop computers—with graphic display were not generally available to do the thousands (even millions) of calculations necessary to make a strange attractor apparent. With dynamic systems, what appears to be chaotic behavior when viewed at one level often resolves into structure at a more global level.

**Self-Organization from Apparent Unpredictability**

The fourth primary characteristic of deterministic chaos (chaos with a pattern) is self-organization from apparent unpredictability. Robert May, a biologist from Princeton University was working with a simple equation for the behavior of populations expressed by \( x_{next} = rx(1-x) \), where \( x \) is the rate of growth for one year, \( x_{next} \) is the rate of growth for the next year, and \( r \) is a constant that measures the likelihood a population will “boom or bust.” (Note: this equation uses an iterative process, just like Lorenz used for creating his strange attractor.) For low values of \( r \), the equation behaves as expected, converging on a steady rate of growth. As \( r \) increases, at a certain point (about 3) the rate of growth oscillates between two numbers. Push the system harder by increasing \( r \), and the system begins to oscillate between four numbers, even harder and it oscillates between eight, etc. When this system is drawn graphically (see Figure 4), as \( r \) reaches 3 the line splits (bifurcates) into two, as it rises further it splits into four, then eight and so on. Continue drive the system harder and it becomes completely unpredictable; it has gone to chaos. But if you continue to increase \( r \) and drive the system even harder, windows of organization appear at odd intervals. (See Figures 5 and 6) In chaos theory, these windows are “self-organized” and “self-organization” is a hallmark of dynamic systems.\textsuperscript{21}

**Universal Application to Non-linear, Dynamic Systems**

The fifth primary characteristic of chaos theory is its universal application to all non-linear, dynamic systems. Where Newtonian theory is linear, based on relatively simple equations, chaos theory is non-linear, based on problems that until the 1970s scientists and mathematicians had proved (with rare exceptions) could not be solved because the variables were too dynamically related, e.g., like Lorenz’ factors for pressure, temperature and windspeed. In August of 1975, Mitchell Feigenbaum of the Los Alamos National Laboratory was working with a simple non-linear equation, mapping it much as Lorenz and May had when he noticed bifurcations “not just coming faster and faster, but they were coming faster and faster at a constant rate” i.e., geometric (exponential) convergence. “Feigenbaum knew what he had.

\textsuperscript{20}Mandelbrot writes”...fractal geometry reveals that some of the most austerely formal chapters of mathematics had a hidden face: a world of pure plastic beauty unsuspected till now.” (p. 4.) See also Gleick, pp. 215–240.

\textsuperscript{21}James Yorke analyzed this behavior with mathematical rigor in his “Period Three Implies Chaos” paper. He proved that in any one-dimensional system, if a regular cycle of period three ever appears, then the same system will also display regular cycles of every other length, as well as completely chaotic cycles.” Gleick, p. 73.
because geometric convergence meant that something in this equation was *scaling*, and he knew that scaling was important...Some regularity lay beneath the turbulent surface of the equation...”\(^{22}\) When he tried a different non-linear equation he got the same number...to ten decimal places! The regularity turned out to be what is now known as Feigenbaum’s number, 4.692016090.

Now this may not seem like much until you realize that this constant and the math that went with it applies with mathematical precision to systems as divergent as heart disease and information theory, snowflakes and the Dow Jones, water turbulence and electrical circuits. Feigenbaum’s work meant that scientists could not only produce aesthetically pleasing graphics, but describe real world systems.

The primary characteristics of chaos theory described above are ubiquitous—in the whorls in our coffee, the dripping of a faucet, the piling of clouds, the spread of measles, the static in phone lines, and the beat of a heart.\(^{23}\) The elegance and power of chaos theory has allowed scientists to ask and find answers to messy, real life problems—not just the simplified, linear problems solvable through the Newtonian paradigm.

### Some Theological Implications

The Christian astronomer, Robert Jastrow described a scene where “The scientist has scaled the mountains of ignorance; he is about to conquer the highest peak; as he pulls himself over the final rock, he is greeted by a band of theologians who have been sitting there for centuries.”\(^{24}\) Jastrow’s keen insight here reminds us that theology and especially ministry do not have the luxury of avoiding unsolvable questions. Theologians and pastors often face urgent needs or events that do not fit any linear understanding of the universe.\(^{25}\) Moreover, because theologians and ministers often deal with intuitions, symbols and myth, experience often leads them to understand chaotic behavior on a practical level ahead of the theoretical basis is available. Nevertheless, applying chaos theory to theological and pastoral concerns yields some intriguing implications.

#### Prayer and Process

Sensitive dependence on initial conditions underscores prayer as a critical tool for people of faith. If so much of reality rests like a pencil on its tip with a hairsbreadth difference changing the course of history, then prayer may be much more effective in altering reality than we may have imagined. All prayer has to do is alter, however slightly, a situation and exponential change can result!

In a similar vein, the butterfly effect reinforces the importance of a process-orientation toward ministry. If slight variance in initial conditions can have large effects, then someone starting a ministry (for example) should pay special attention to making the process a good one. This also explains why congregations that begin in conflict have a hard time avoiding conflict in the future. The small tensions inherent in the initial conditions often raise pronounced difficulties even after years of ministry.

#### Pre-destination and Free Will

Chaos theory has some fascinating and helpful implications for the issues of pre-destination and free will. As Lorenz’ experiment proves, humans have a practical limit to the amount of control they can exert on a system. Even if one does everything right, in both laying the foundation and in approaching the process, one still cannot control the outcome. Christian faith offers some important insights here. When

\(^{22}\)Ibid, p. 172.

\(^{23}\)Researchers made an interesting discovery in relation to heart disease: a little chaos is necessary for the stability of the heart. Indeed, often chaotic stimulation restores normal function to a chaotically beating heart! See ibid, pp 280–293


\(^{25}\)Kuhn, op. cit., p. 165.
the secular world may be tempted to throw up its hands and ask, “Why bother?” Christian theologians might shrug and say, “What else is new?” A basic premise of reformed theology is that in the final analysis, humans are not in control anyway—only God is! While the Laplacian grail cannot be touched by human hands, God’s omniscience allows knowledge of infinite points with infinite precision. As Laplace correctly puts it, “for such an intellect nothing could be uncertain; and the future just like the past would be present before its eyes.”

26See note 8 above.
This would seem to make free will an impossibility, and yet, the metaphors of strange attractors and scaling suggest a way around the dilemma: Of what value is human choice in a determined system?27 The strange attractor and scaling aspects of chaos theory suggest that while one cannot predict with certainty what a person will decide on a particular matter, one can say that the global pattern (salvation history) will be the same. Our path then is freely determined, but while decisions may perturb the path somewhat, the boundaries of the attractor are stable. As Stewart put it so aptly (playing on Einstein’s famous words in regards to quantum physics, “God doesn’t play dice”), “If God played dice...He’d win!”28 This only serves to remind us that

From a Christian perspective, such an encounter with the limits inherent in the nature of the physical realm should remind man of the fundamental distinction between an infinite Creator and a finite and limited creation, including man. The new discoveries give man further reason to adopt a stance of “epistemic humility” in the face of a complex and unpredictable world.29

Doyne Farmer, of Los Alamos National Laboratory, concludes, “On a philosophical level, it struck me as an operational way to define free will, in a way that allowed you to reconcile free will with determinism. The system is deterministic, but you can’t say what it’s going to do next.”30

Salvation of Scales

Chaos theory also suggests that the grand scale of salvation is reflected on the smallest scale. We know instinctively that this is true, indeed we see it all the time: the Exodus event reflected in the life of a young person who shakes an addiction, the crucifixion in a frail old woman in Calcutta who continually put the needs of the poor ahead of her own, Pentecost in the enthusiasm of people who catch God’s vision as it is made real through them. This carries at least two further implications:

1. Small events may require dramatic action. Under some circumstances, pastors may need to react more strongly to a small act of dominance, misunderstanding or abuse than the situation seems to warrant. If a pastor lets a situation like this “ride,” they may be asking for difficulties completely out of proportion to the initial infraction. The key is keeping the cascade of events from beginning. On the positive side, if a person does a small thing well, dramatic praise or appreciation may start a positive cascade of events with unforeseen and large positive results.

2. The principles which the Bible presents are applicable across scales. The key to Jesus’ approach to life31 is one which applies as well for congregations, denominations, and the Church Universal. No matter the scale, if an entity willingly subordinates its will to God’s, then “resurrection” is sure, though the path to it is not certain.

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27Some might argue that it is not our place to debate God’s will with our Creator (cf. Romans 9:19–24), and yet the mystery of why humans have a sense of choice and understand questions of morality remains. A full-discussion of this topic, so pervasive to human nature, is not possible here.

28Ian Stewart, op.cit., p. 303. Leslie D. Weatherhead in The Will of God, describes three aspects of the will of God: intentional (how God intends things to be), circumstantial (how God works through situations that are not as God intended them to be), and ultimate (how God’s will wins out in the end and cannot be thwarted.


30Quoted in Gleick, p. 251.

31As expressed in the Garden of Gethsemane: “Nevertheless, not as I will but as you will.”
Thus, the symbols, myths and stories of our faith, as finite expressions of the infinite, are vital tools for approaching life on all scales.

The Complexity Spiral: Coping with Uncertainty

One of the more frightening implications of chaos theory is that it describes how our society is moving right now. Chaos theory implies that much about life is uncertain, yet humans crave stability. Merry attributes a large portion of the current levels of anxiety and stress to the growing uncertainty in our society. Over the last hundred and fifty years, accelerating technological advancement has driven the interwoven system of our society harder and harder. Society has reached several bifurcations when utter disintegration was possible and avoided. Our inter-relatedness (i.e., the connections between people, organizations and communities) and diversity (e.g., different family structures that have been prevalent in the last few decades) have increased the complexity in our society (and in individual lives). In recent years, Merry contends, we have begun to see chaotic behavior in society as the old paradigm with its industrial structure of society reaches a collection of crisis points. If Merry is correct, we will enter a period of chaos as we drive our societal system harder and harder. Only after we pour a great deal of energy (human and capital) into the system will society transform itself and arrive at a new paradigm.

Such a forecast means the church will have important, perhaps critical, roles to play in society, including:

- comforting and counseling for individuals overcome by the anxiety and stress of the increasingly uncertain age,
- training people with the skills they need to cope in society,
- transforming society by visibly demonstrating a hope- and power-filled alternative to other, less desirable paths with which society may flirt,
- paying closer attention to people’s needs, including making the Gospel relevant in the contexts of people’s everyday lives, and
- demonstrating a desire to change more flexibly as opportunities arise to share the Good News to a wider and increasingly unchurched.

Conclusion:

Einstein once noted that “The significant problems we face cannot be solved at the same level of thinking we were at when we created them.” As individuals and as a society, we will continue to struggle with and even flounder in the increasing chaos of our world unless we can arrive at new ways of thinking about and approaching our problems and challenges. As the level of complexity in society increases, gathered people of faith could play a decisive role in a number of areas. The prospects of chaos theory as a model and its set of metaphors certainly offer excellent insights and useful envisioning as we try to understand what God is doing in the world and how we might better follow God’s lead.

32Taken from the title of Uri Merry’s Coping with Uncertainty: Insights from the New Sciences of Chaos, Self-Organization, and Complexity (Westport, CT: Praeger, 1995).
33ibid, pp. 121ff.
34ibid, pp. 81ff
Bibliography

Butz, Michael R. “Chaos Theory: Philosophically, Old, Scientifically New.” Counseling & Values, 39:2, pp. 84+.


