The implications of Chaos Theory for understanding creation

Andrew Sibley

Chaos Theory may shape our understanding of biblical creation. An outline of the theological issues that arise will follow on from a historical sketch. Although, historically, some have considered the findings to be worrying for a proper appreciation of the creation, it does in fact lead to a deeper understanding of the power and wisdom of God. Regarding the theological aspects, it is necessary to consider whether Chaos Theory should apply to the pre-Fall world. Lastly, the paper discusses how Chaos Theory may also call into question secular dating methods, and shows that theories of self-organization, which are postulated in support of evolution, are inadequate.

Chaos Theory poses some challenges for the biblical creation position, and yet there have only been a few articles or papers in related publications;[1,2] there is more comment in secular literature.[3] This paper examines how Chaos Theory developed over time, and shows that it may actually enhance, not reduce, our understanding of the power and wisdom of the Creator. The theological aspect will also be considered, with a discussion about whether Chaos Theory should be applied to the pre-Fall world. The case is made that Chaos Theory calls into question the secular dating methods regarding prehistory. It is further highlighted how weak Chaos Theory is in offering evidence for theories of self-organisation.

It is relevant to note that there is a correlation between Chaos Theory and entropy; both seek to describe the observation that physical systems become more disordered over time, although they are not exactly the same. With entropy, scientists can state deterministically the start and end of a physical process; with Chaos Theory, while there is a degree of uncertainty over starting conditions, the end point is ultimately unpredictable. Entropy may deal with the properties of a substance (such as a gas) as a whole, while Chaos Theory describes changes occurring within part of the system. However, for the purposes of this discussion the principles inherent in Chaos Theory are considered to be a form of entropy.

What is Chaos Theory? An historical study

In the early modern period, many philosophers of science viewed the universe in the shadow of Greek thinking, especially within the framework of Aristotle's writing (the student of Plato). His assertions in *On the Heavens* held that the heavenly bodies were unblemished spheres, composed of aether, and traced out perfectly circular and deterministic orbits.[4] This was reflective of ideal shapes formed in the mind of a perfect designer. Thomas Aquinas later supported and adapted this view to make it fit with the doctrines of the Catholic Church.[5] The orbits of the planets were considered perfect, with the earth at the centre. This is often referred to as the geocentric or Ptolemaic system. But, despite this belief in perfect orbits, observational evidence showed that planets exhibit retrograde movement on occasions, which led to the *ad hoc* postulation of epicycles. This overall system was questioned by some medieval natural philosopher/clergymen such as Buridan and Oresme, who showed that the earth could be moving. Then the system was challenged outright by Copernicus and Galileo, who argued instead for a heliocentric view of the solar system. With the invention of the telescope, the presence of craters on the moon and the observation of sunspots also brought into question the perfection of the astronomical bodies.

Heliocentrism became widely accepted in later centuries, although a belief in the perfection of orbits was still widely held. (Galileo's contemporary Kepler showed that the orbits were closer to perfect *ellipses*.) This was exemplified by a dialogue between Gottfried Leibniz and Samuel Clarke in 1715/1716, where Clarke was essentially defending Isaac Newton's position.[6] Newton had proposed that, because of gravitational attraction and interaction between the planets and comets, the original order of the heavenly bodies given by 'the counsel of an intelligent being' had been disturbed. As such, the interaction between the bodies had led to a loss of order in the solar system, albeit measurable over 'many ages' (see below). This explanation, he argued, was preferable to the view that the order had arisen by laws of nature out of chaos and fate:[7]

> "And if he did so, it's unphilosophical to seek for any other Origin of the World, or to pretend that it might arise out of a Chaos by the mere Laws of Nature;

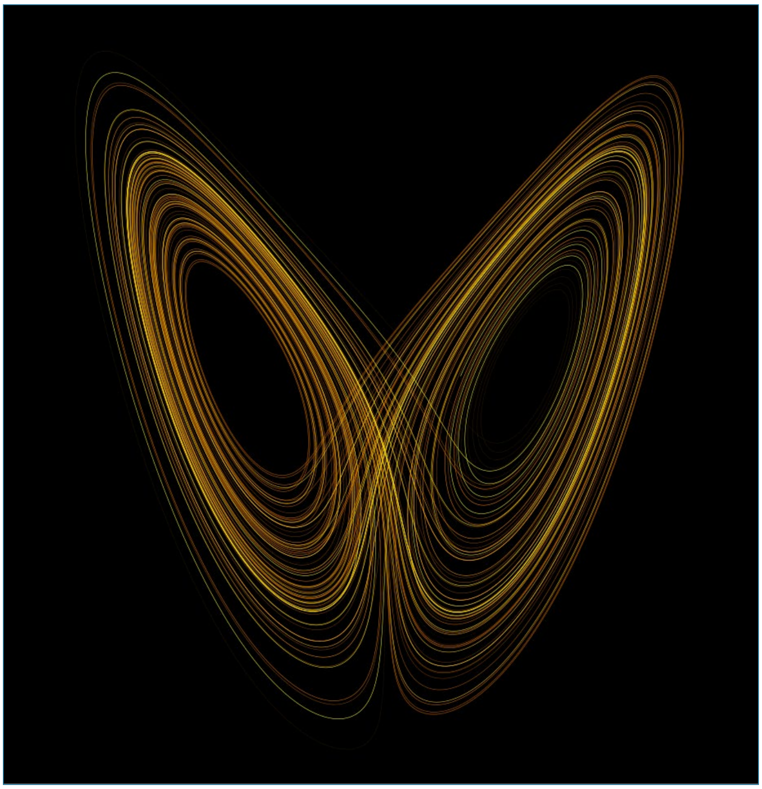

Figure 1. The Lorenz attractor, a well-known exemplar of Chaos Theory, sometimes called a butterfly diagram

though being once form'd, it may continue by those Laws for many Ages. For while Comets move in very excentrick Orbs in all manner of Positions, blind Fate could never make all the Planets move one and the same way in Orbs concentrick, some inconsiderable Irregularities excepted which may have risen from the mutual Actions of Comets and Planets upon one another, and which will be apt to increase, till this System wants a Reformation. Such a wonderful Uniformity in the Planetary System must be allowed the Effect of Choice."[8]

Newton was here anticipating the later description of Chaos Theory, although thinking that periodic interventions, or divine *Reformations*, would be sometimes necessary to restore that order; that is, allowing God freedom to work within the system to maintain order. But in response, Leibniz proposed that the universe was set up with laws in such a way that it could run continually without the intervention of God—anything else, he believed, would diminish the Creator. He wrote:

"In my view, the world always contains the same force and energy, which changes only by passing from one material thing to another in accordance with the laws of nature and the beautiful order pre-established. And I hold that when God works miracles, he does it not to meet the needs of nature but the needs of grace. Anyone who thinks differently must have a very mean notion of the wisdom and power of God."[9]

Newton's close acquaintance, Samuel Clarke, responded in a letter of 26 November 1715. He pointed out that God is necessarily at work in sustaining the creation in its ongoing operation, and that it is misguided to consider the cosmos as a perfect clock or machine. That position would essentially exclude God from the world, and lead to deism and atheism. He wrote:

"… as well as assembling things into structures, he is himself the author and continual preserver of their basic forces or powers of motion. … The idea that the world is a great machine that goes on without intervention by God, like a clock ticking along without help from a clockmaker—that's the idea of *materialism* and *fate*. Under cover of declaring God to be a *supra-mundane intelligence*, it aims to exclude providence and God's government from the world [emphases in original]."[9]

Clarke elaborated further (in a letter of 10 January 1716) that the present laws of motion, and any amendments, are all part of God's design from the beginning.[9] However, this subtlety was lost on many scientists. With ongoing overconfidence in the explanatory power of science, continuing well into the 19th century, Pierre-Simon Laplace still argued along deterministic lines. He commented that if the starting conditions were known, then it would be possible to predict the future perfectly.[7] But the solar system is, in reality, more complex than this. While Newton's Theory of Gravity could predict the movement of a two-body orbiting system deterministically, such as the sun and Earth, or Earth and the moon, the equations of motion become increasingly unresolvable when a third body is added (for example, sun–Earth–moon). This three-body problem was discussed by the French mathematician Henri Poincaré in 1887.

The resolution to the problem involved the prediction of the movements and positions of the three bodies in very small time steps. This entailed running the equations iteratively through a lengthy modelling process; that is, recalculating the solution many times, with the new data applied at each new step.[10] This process can be applied to the prediction of the movement of asteroids, and to weather forecasting. But, in reality, it is far too laborious even for a room full of mathematicians; Lewis Fry Richardson had imagined just this scenario.[11] Instead it requires the data-crunching power of super computers.

Edward Lorenz was one of the first to conduct meteorological experiments with computerized simulations in the 1950s and 1960s, essentially using an early numerical weather prediction (NWP) model that utilized non-linear differential equations:

$$dx/dt = -\sigma x + \sigma y;$$
$$dy/dt = rx - y + xz;$$
$$dz/dt = xy - bz.$$

Modern weather forecasting models work along similar lines, involving fairly simple equations, but very powerful computers. The NWP computer models work with nonlinear differential equations and divide the weather system three-dimensionally into small grid boxes. Then they are run forwards in time with short time steps.

In his work, Lorenz observed that solutions may vary considerably over time due to tiny differences in starting conditions. During one experiment he stopped the program half-way through, and then started it again from that mid-point, utilizing the most recent data displayed by the computer. The outcome was markedly different than expected. He later discovered that, although the computer had displayed the numbers to 3 decimal places, internally the system was working to 6 decimal places. Evidently, large differences had come from small changes, even at the level of the rounding of numbers in the computer. The findings were referred to as Deterministic Nonperiodic Flow in the paper.[12]

The implication is that very tiny initial variations can cause large differences over time because of the compounding of errors. As well as the problem of rounding of numbers in the computer, in reality there is also uncertainty in the initial observations. The well-known analogy that Lorenz developed referred to the flapping of a butterfly's wings: "Does the flap of a butterfly's wings in Brazil set off a tornado in Texas?"[13]—although originally it involved the flapping of the wings of a seagull.

> "One meteorologist remarked that if the theory were correct, one flap of a seagull's wings would be enough to alter the course of the weather forever. The controversy has not yet been settled, but the most recent evidence seems to favor the seagulls."[14]

This particular analogy is probably not feasible because of dampening in the atmosphere, but it does highlight how very small initial differences can cause more significant divergence later in time. Errors are compounded as the model runs forwards. In the physical world, this tendency towards greater randomness and disorder is a form of entropy. To deal with this level of uncertainty, meteorological NWP models are run multiple times, referred to as *Ensemble Modelling*. This allows for the probability of different outcomes to be calculated. One tool for assessing the confidence of a particular ensemble is the use of a measure called *Shannon Entropy*.[15] It provides a measure of the amount of useful information in the forecast model output over time, set against climatology. As you would expect, the useable information in the model decreases with time.

While Chaos Theory leads to diverging outcomes in this way, there are also attractors that limit the divergence; in both mathematical models, and in physical reality (figure 1). These attractors lead to *fractals*, where beautiful patterns may emerge on the edge of apparent chaos (figure 2). Weather systems follow similar patterns, where, for example, tropical cyclones (figure 3) or mid-latitude depressions are limited by the hydrodynamic and thermodynamic equations of the atmosphere, and geographical features.

Within chaotic systems there is a combination of deterministic equations that plays out through chaotic motion and complex physical interactions, together with limiting attractors. Despite varying starting parameters, the same equations normally produce a series of outcomes through the iterative process that are increasingly concentrated around a specific set of parameter values; this is referred to as the 'attractor'. This combination often leads to beautiful structures in nature, such as weather systems, the rings of Saturn, and arguably galaxies.[16]

> "Big whirls have little whirls that feed on their velocity, and little whirls have lesser whirls and so on to viscosity."[17]

The reality of these features in creation leads to a greater appreciation of the wisdom and intelligence of the Creator; more so than the purely mechanical, or clockwork view of the universe. However, the term Chaos Theory is perhaps a misnomer. Perhaps complexity theory might be more appropriate as the outcomes of modelling such systems are unpredictable.

The narrative of secular science is that God has been removed from the scene as science has advanced. The rejection of geocentricism and a greater understanding of the complexity of the world leads to a deeper understanding of the power and wisdom of the Creator.

Chaos Theory and the pre-Fall world—the biblical text

While we can see chaotic forces at work in the present world, we may also think about the implications of this theory for the pre-Fall world. We are informed in Scripture that the creation was 'very good' (Gen. 1:31), and a place where Adam and Eve could potentially live forever. How could chaotic forces be at work in such an environment? It may also be asked whether the meaning of 'very good' in

Image: Farry / Wikimedia (Public Domain; CC0 1.0)

Figure 2. The Barnsley Fern. A fractal named after the mathematician Michael Barnsley; described in his book *Fractals Everywhere* (Academic Press, Boston MA, 1993). It was produced to resemble the fern black spleenwort, *Asplenium adiantum-nigrum*.

Genesis 1:31 implies perfection (good: *ṭôḇ* טֹוב; very: *mə'ōḏ* מְאֹד). In the context of the passage the creation was stated to be 'good' on six occasions (Gen. 1: 4, 10, 12, 18, 21, 25), and 'very good' only on the seventh time, after the creation was *complete*.

Some notable Christians over the years have interpreted 'very good' to mean perfection; including, for example, Henry Morris, who believed that the Second Law of Thermodynamics began at the Fall,[18] and John Calvin. Calvin, in his *Commentary on Genesis*, also uses the word 'perfection' when discussing the meaning of this verse. The English translation accurately captures the Latin:

> "But now, after the workmanship of the world was complete in all its parts, and had received, if I may so speak, the last finishing touch, he pronounces it perfectly good [Latin: *perfectè bonum*]; that we may know that there is in the symmetry of God's works the highest perfection [Latin: *perfectionem*], to which nothing can be added."[19]

Danny Faulkner and Lee Anderson have both argued that 'very good' implies completeness, but that this does not necessarily imply a view of perfection which goes beyond the concept of goodness.[20–22] This view, they argue, allows room for the Second Law of Thermodynamics to be in operation, albeit in some rather limited way. For Faulkner, this includes such possibilities as crystals not requiring perfect internal structures. Sarfati broadly concurred regarding entropy, and proposed that God, through His sustaining power, was able to counteract the effect of the Second Law of Thermodynamics prior to the Fall, even while entropy was a reality in some limited form.[23] Examples of such entropy include the digestion of food, respiration, and the radiant heat transfer from the sun to Earth. Clearly these are ongoing and necessary processes in the pre-Fall world. The implication is that God was necessarily sustaining the created system in perpetuity; just as the shoes of the Israelites in the wilderness did not wear out.[23]

The idea of physical perfection is also based upon the Aristotelian view of the planetary bodies possessing unblemished characteristics in terms of ideal shape and orbital plains, although for Aristotle the earth and planets were made of different material (earth and aether). The creation account does seem to describe a place where there were flowing rivers, which implies hills and mountains; thus, this would not qualify as perfect in terms of a Greek view of the heavenly bodies, but would qualify as 'very good' in terms of fulfilling God's plan.

The Greek Old Testament (Septuagint) translates 'very good' as καλὰ λίαν (*kalá lían*), implying an intrinsic benevolence in the created order. The word καλός (*kalos*) is used in the New Testament to mean that something is directed towards its end goal (Matt. 12:33; Rom. 7:16); or it is used in terms of being moral or honourable, or acting in line with righteousness (Gal. 4:18). The divine statement 'very good' then implies that creation was complete, a sacred place, and ethically in line with the will of God. The Hebrew meaning is that of original goodness and completeness, not Aristotelian perfection.

The Apostle Paul also provides a commentary on the Genesis passage in Romans 8, particularly in terms of shedding light on the Fall, as recorded in Genesis 3.[24] Romans 8:19–21 reads as follows:

> "For the creation waits with eager longing for the revealing of the sons of God. For the creation was subjected to futility, not willingly, but because of him who subjected it, in hope that the creation itself will be set free from its bondage to corruption and obtain the freedom of the glory of the children of God."

The two words of interest here are 'futility' (or *vanity* in the KJV), and 'corruption' (NIV has *decay*). In the Greek they are defined as follows:

> Futility = *mataiotēti*, ματαιότητι. It implies an emptying or loss of something spiritual in the creation, so that it is not currently fulfilling its original purpose.
>
> Corruption = *phthoras*, φθορᾶς. The word is used here to imply that something has fallen to a lesser state, in this case in terms of contrasting the fallen physical world with a more spiritual standard. Decay or corruption then convey a fairly clear meaning, but in the context of the wider passage *phthoras* has a clear spiritual implication.

The context in Romans 8 is that the created world has been bound over by God's decree to a lesser, more carnal and corrupted, state, with the loss or emptying of something spiritual as a result of the Fall. Even so, the Fall had physical consequences, including death for Adam and his offspring; for example, God said:

> "Cursed is the ground because of you … . By the sweat of your face you shall eat bread, till you return to the ground, for out of it you were taken; for you are dust, and to dust you shall return" (Gen. 3:17, 19).

It was a spiritual Fall that (through the consequent Divine curse) led to decay, corruption, and physical death. Biblical creationists need to remember the spiritual loss when discussing the effects of the Fall, and not just think of the pre-Fall world in physical terms. God's presence was more strongly felt in the pre-Fall world, with His sustaining power holding all things together against the effect of the ever-present entropy. Christ is still upholding all things by His powerful Word, but it is now subject to the Curse (Heb. 1:3; Col. 1:17).

Chaos Theory and the pre-Fall world—theology and science

This discussion has noted the reality of entropy in limited form in the pre-Fall world, but what of Chaos Theory? For example, how should we describe the movement of weather systems and planetary bodies in such a 'very good' setting? The creation account describes the creation of the moon, planets, stars, flowing rivers, seas, and an atmosphere where birds fly. Birds generate lift by flapping their wings and generating mini-vortices, as do fish with their fins as they swim in the rivers and sea.

When we think about the mathematical laws and dynamics of such systems, we need to consider the three-body problem, which leads to Chaos Theory as the more accurate modelling approach. It is hard to imagine the pre-Fall world as a place where chaotic systems (i.e. complex, unpredictable systems) were not present, if we assume it is right to apply similar physical laws and mathematics to such a place/time.

Even so, we can see Adam and Eve living in a protected space in the Garden of Eden. We are told in Gen. 3:22 (compare Gen. 2:17) that they would have lived for ever had they not eaten the forbidden fruit, of the Tree of the Knowledge of Good and Evil. Despite the presence of chaotic systems, we may assume that it was a place where, for example, the weather was universally benign, and where asteroids did not impact the earth—it was a place protected by the providence of God.[25]

Faulkner has argued for the chaotic asteroid bombardment and cratering of the moon on Day 4 of the Creation Week,[26] although we see that various vegetation was already created on Day 3 (Genesis 1:11–13). This suggests the earth was already a protected planet. Although moon cratering on Day 4 is possible within the context of the meaning of *very good*, another solution is that the cratering occurred at the time of the Flood.[27] We are faced with the dilemma of modelling a world where Chaos Theory may apply, but at the same time is protected from the worst outcomes of chaotic motion. There is a solution to this problem, when it is recognized that diverging outcomes are dependent upon very small differences in starting conditions.

Within the divine action debate, we are faced with two extreme positions: either a clockwork universe that supports a deistic view of the world, or a place where God must actively determine every change, even at the level of quantum mechanics. In the latter, God becomes a sort of cosmic juggler. However, we may note that the universe runs according to laws, spoken into existence by God at creation, and sustained by His Word. Matter irresistibly follows those rules, and yet God also can countermand or add to those laws. Chaos Theory allows for God to actively intervene in creation, even in minimal ways.

The fact that very small, imperceptible changes in starting conditions can have observable outcomes, often very different ones, implies that God could actively adjust the created system in order to bring about a desired benevolent outcome—even in ways that are not scientifically discernible. This possibility of divine action in creation, in ways that could not be detected by science, has, for example, been discussed by John Polkinghorne.[28] From this, it is possible to accept the reality of Chaos Theory in the universe before the Fall, while accepting that it is a world that is also upheld and protected by the sustaining power and goodness of God.

The existence of chaotic systems, considered in isolation, does not necessarily imply decay, but it does illuminate the wisdom of the Creator, and the wonder and beauty of creation. The unpredictability of the world also makes it both more interesting and challenging, and directs the believer towards a life of prayer and faith. Essentially, Chaos

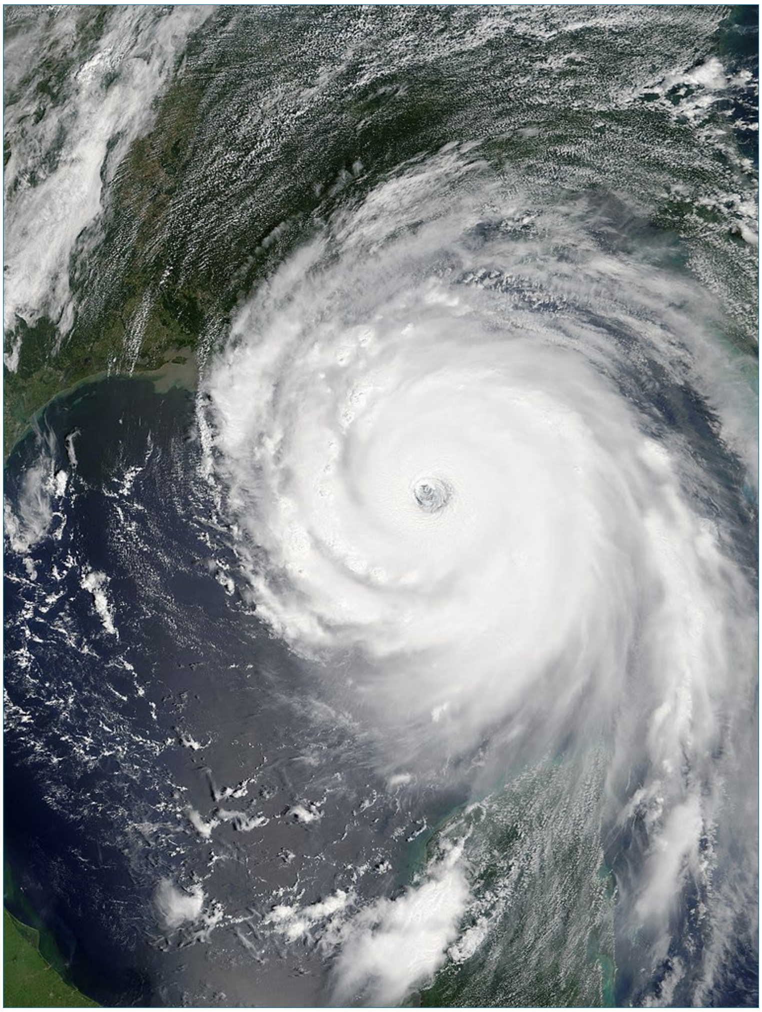

Image: NASA / Wikimedia (Public Domain)

Figure 3. Hurricane Katrina, 28 August 2005

Theory is an empirical construct to describe the complexity of physical processes. Modelling chaotic systems, such as the movements of weather systems or asteroids, involves complex mathematics. This can be illustrated with beautiful diagrams from more simple mathematical equations (figure 1).

Chaos Theory, evolution, and Shannon Entropy

There are two ways that Chaos Theory interacts with evolutionary science: 1) the search for theories of self-organization in biology, and 2) the effect of *Shannon Entropy* on the modelling of history, especially prehistory.

There are various ideas around self-organization in evolutionary science, including those that connect Chaos Theory with a belief in emergent order on the edge of chaos, such as fractals. This has been discussed by, for example, Stuart Kauffman.[29] Yet Kauffman doubts that evolutionary science can make much headway in describing the outcomes scientifically; and is not even able to "finitely prestate the configuration space of a biosphere" .[30] Although Chaos Theory plays a part in this uncertainty, there are other factors that come into effect. He writes:

> "So the biosphere, it seems, in its persistent evolution, is doing something literally incalculable, nonalgorithmic, and outside our capacity to predict, not due to quantum uncertainty alone, nor deterministic chaos alone, but for a different, equally, or profound reason [*sic*]: Emergence and persistent creativity in the physical universe is real."[30]

He recognizes that there is difficulty in determining biological processes through scientific algorithms because of the way in which open, non-equilibrium, thermodynamic systems operate. Such systems function like universal Turing machines, where it is not possible to prestate the organization of the system in terms of its "configuration space, variables, laws, initial and boundary conditions"—it follows, he thinks, that a general law for all open thermodynamic systems cannot exist.[31] Despite this doubt, some scientists have proposed the existence of a fourth law of thermodynamics for non-equilibrium systems in terms of the 'steepest entropy ascent'.[32]

Kauffman, however, refers to his investigations as 'serious protoscience', and suggests that evolutionary science is forced to rely upon artistic narratives, not just science; "Biospheres demand their Shakespeares as well as their Newtons", he proposed.[33] There are good reasons to think that emergent order on the edge of chaos does not offer much help to evolutionary science, especially when it is not possible to prestate the starting conditions.

Shannon Entropy and modelling the past

In trying to model dynamical, physical processes, Chaos Theory also leads to the problem of decreasing information in the outcome; referred to as *Shannon Entropy.*[15] It is usually applied to future predictions in meteorological ensemble modelling processes. As the ensemble, with multiple model runs, progresses forwards in time, beyond about 5 to 7 days, it becomes increasingly hard to find usable information in the forecast against a background of normal climatology. However, it is proposed that this problem also applies to modelling the past. This was also discussed by Price and Carter, who refer to it as the 'Malcolm Effect', from *Jurassic Park*.[2,34] As we seek to determine history or prehistory, we are faced with a decreasing amount of usable information the further back in time we go. Dating methods, for example, rely upon untestable assumptions regarding prehistory, and calibration errors apply to data collected over short time intervals, which are then extrapolated into the distant past. Creation scientists have often pointed out uncertainties inherent in radiometric dating methods.[35]

Summary

In terms of evolution, Chaos Theory need not be a problem for biblical creation, and instead enhances our appreciation of the power and wisdom of the Designer. The divine agent is free and able to interact with creation, even in ways that are scientifically undetectable.

Chaos Theory does pose a problem for explaining the increasing complexity of life, and involves the reliance upon narratives as opposed to pure science. It also highlights that piecing together the past, as prehistory, is hindered by random events, and changing variables in ways that are unpredictable. Thus, categorical statements about the past by naturalistic scientists are unsustainable.

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Andrew Sibley *is a Chartered Meteorologist, based in the UK, and has published a number of papers in the field. He has a B.Sc. (Hons) and completed an M.Sc. in Environmental Decision Making in 2003 with the Open University. He also has an M.Phil. in theology from Exeter University (UK); his dissertation was* Intelligent Design: Scientific and Theological Perspectives. *He is the author of several books, including* Restoring the Ethics of Creation and Cracking the Darwin Code: Exploring the non-scientific foundations of deep-time and evolution. *Already a frequent contributor to CMI's publications, he joined CMI-UK/Europe as an associate speaker and writer in February 2021.*