Comparing Chaos and Complexity: The Quest For Knowledge

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Declaration

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

Abstract

The question of what it means to say one *knows* something, or has knowledge of something, triggered an epistemological study after the nature of knowledge and its acquisition. There are many different ways in which one can go about acquiring knowledge, many different frameworks that one can use to search after truth.

Because most real systems about which one could desire knowledge (organic, social, economic etc.) are non-linear, an understanding of non-linear systems is important for the process of acquiring knowledge. Knowledge exhibits the characteristics of a dynamic, adaptive system, and as such could be approached via a dynamic theory of adaptive systems. Therefore, chaos theory and complexity theory are two theoretical (non-linear) frameworks that can facilitate the knowledge acquisition process.

As a modernist instrument for acquiring knowledge, chaos theory provides one with deterministic rules that make mathematical understanding of non-linear phenomena a bit easier, but it is limited in that it can only provide one with certain knowledge up until the (system's) next bifurcation (i.e. when chaos sets in). After this, it is near impossible to predict what a chaotic system will do.

Complexity theory, as a postmodern tool for knowledge acquisition, gives one insight into the dynamic, self-organising nature of the non-linear systems around one. By analysing the global stability complex systems produce during punctuated equilibrium, one can learn much about how these systems adapt, evolve and survive.

Complexity and chaos, therefore, together can provide one with a useful framework for understanding the nature and workings of non-linear systems. However, it should be remembered that every observer of knowledge does so out of his/her own personal framework of beliefs, circumstances and history, and that knowledge therefore can never be 100 percent objective.

Knowledge and truth can never be entirely relative either, however, for this would mean that *all* knowledge (and thereby all opposing claims and statements) is equally correct or true. This is clearly not possible. What is possible, though, is the fulfilling and successful pursuit of knowledge for the sake of the journey of learning and understanding.

Abstrak

Die vraag na wat dit eintlik beteken om te sê mens *weet* iets, of dra kennis van iets, het na 'n epistemologiese soeke na die wese van kennis en die verwerwing daarvan toe gelei. Daar is baie maniere waarop mens kennis kan verwerf, baie verskillende raamwerke wat mens kan gebruik om te soek na waarheid.

Omdat die meeste wesenlike stelsels waarvan mens kennis sou wou verkry (organies, sosiaal, ekonomies ens.) nie-lineêr is, is 'n verstaan van nie-lineêre stelsels belangrik vir die kennisverwerwingsproses. Kennis vertoon die eienskappe van 'n dinamiese, aanpassende stelsel, en kan dus via 'n dinamiese teorie van aanpassende stelsels benader word. Daarom is chaosteorie en kompleksiteitsteorie twee teoretiese (nie-lineêre) raamwerke wat die proses van kennisverwerwing kan vergemaklik.

As 'n modernistiese instrument vir kennisverwerwing, verskaf chaosteorie deterministiese reëls wat die wiskundige verstaan van nie-lineêre verskynsels bietjie vergemaklik, maar dit is beperk deurdat dit net sekere kennis tot op die (stelsel se) volgende splitsing (d.w.s. waar chaos begin) verskaf. Hierna, word dit naas onmoontlik om te voorspel wat 'n chaotiese stelsel gaan doen.

Kompleksiteitsteorie, as 'n postmodernistiese gereedskap vir kennisverwerwing, gee mens insig in die dinamiese, selforganiserende aard van die nie-lineêre stelsels om mens. Deur die globale stabiliteit wat komplekse stelsels gedurende onderbreekte ewewig *("punctuated equilibrium")* toon te analiseer, kan mens baie leer van hoe hierdie stelsels aanpas, ontwikkel en oorleef.

Kompleksiteit en chaos, saam, kan mens dus van a nuttige raamwerk vir die verstaan van die wese en werkinge van nie-lineêre stelsels, voorsien. Daar moet egter onthou word dat elke waarnemer van kennis dit doen uit sy/haar persoonlike raamwerk van oortuiginge, omstandighede en geskiedenis, en dat kennis dus nooit 100 persent objektief kan wees nie.

Kennis en waarheid kan egter ook nooit heeltemaal relatief wees nie, want dit sou beteken dat *alle* kennis (en hiermee ook alle teenstrydige aansprake en stellings) gelyk korrek of waar is. Hierdie is duidelik onmoontlik. Wat wel moontlik is, is die vervullende en suksesvolle strewe na kennis ter wille van die reis van leer en verstaan.

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Dedication

This work is dedicated to all the hard-working children of God

who are trying to make a difference in this world.

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1.1 Proposed Title

Comparing Complexity and Chaos: The Quest For Knowledge

1.2 Background / Rationale

Humans as a species are known for their innate desire to know and understand things. Whilst this remains a generalisation, most people do desire at least a certain amount of understanding, even if it is only of certain specific phenomena.

For the everyday person on the street, most knowledge is learnt from those "in a position of authority". These "authorities" have this position because of their so-called expert knowledge of a specific subject or field. These kinds of authorities can be teachers, scientists, politicians or many other things. They have the authority because of something they *know.*

While students all over the world are at last being encouraged to question what authority figures tell them, and question the state of those figures' knowledge, many of us still come from the authoritarian/disciplinarian school of being told to be quiet and listen. The expert's word was considered the only knowledge on the subject (even if that expert was only in a book).

To question the status of someone's knowledge one must have some idea of how that knowledge was acquired. This involves an epistemological study of the nature of knowledge and its acquisition. Knowledge exhibits the characteristics of a dynamic, adaptive system, and as such could be approached via a dynamic theory of adaptive systems.

In an attempt to accomplish this mammoth task of trying to understand and model knowledge (at least partly), a framework approach was taken. Two possible frameworks for acquiring knowledge — namely chaos theory and complexity theory — were investigated, for a solid understanding of each, and then each was subjected to scrutiny as to whether it makes for a good knowledge framework or not. Chaos theory was considered as a modernist framework, and complexity theory as a postmodern framework; therefore, a detailed look at modernism and postmodernism and their respective problems was taken first.

Whilst complexity and chaos theory have had an increase in attention in recent years, they are still not completely understood. Many feel that complexity is just chaos masquerading as something ordered, and whilst this is not the belief of the author of this thesis, it is believed that the two phenomena require closer analysis.

Therefore, the aim of this thesis is to consider chaos and complexity theories as modernist and postmodernist frameworks for understanding the nature of knowledge, and consider their suitability for modelling the process of acquiring knowledge. Further, it is to determine what the best framework for acquiring knowledge is (if one exists), and how one can understand and implement it.

1.3 Preliminary Literature Review

Scientists have long since been motivated to discover and understand all kinds of phenomena, not merely for the sake of knowledge, but also for power. For with understanding comes prediction, and with prediction, control. Man (mostly) likes to be able to control his circumstances; therefore, the more we understand, the more power we have over our lives.

So what about those phenomena which defy conventional understanding? It would seem that the one who is capable of understanding such phenomena would hold a great amount of power over those who do not. This may have been one motivation for the pursuit of comprehension of complex phenomena, an undertaking that gave rise to what are now collectively called the complex sciences.

What does it mean for a phenomenon to be complex? Is complexity simply the opposite of simplicity? There is a certain amount of confusion over the definitions of "simple" and "complex" amongst users today. Possibly a few distinctions would be helpful here.

Firstly, complex is not the same as complicated. If one has a system with a number of intricate components for which one can give one complete description, then that system is merely *complicated*, such as with a computer. If, however, the interaction between the elements of the system, and between the system and its environment cause understanding of the system to be incomplete after an analysis of the elements, then the system is *complex*, as with the human brain [Cilliers, 1998: viii].

Nicholas Rescher illustrates this by saying "we [cannot]... arrive at a final and definitive account of the... structure of the world" [Rescher, 2000: 22]. Possibly surprising to note here, is that this is much the same as the postmodern view that one cannot find an overarching metanarrative to describe the world [Lyotard, 1984: xxiv]. This similarity will be considered in detail later in the thesis.

Secondly, complex is also not the same as chaotic. If a phenomenon (or a system) is really complex, it is not possible to describe it properly with a simple theory. Also, a complex system can display *chaotic* behaviour, and, as will be shown, *chaos* involves interaction between a relatively small number of elements, whereas in a *complex* system, there is always a large number of interacting elements [Cilliers, 1998: ix]. This means that a *complex* system will have a large number of interacting elements, and if it displays *chaos,* then this behaviour will be through the interaction of a relatively small number of those interacting elements.

So what can be considered complex? According to classical physicists, complex phenomena are those things that require complex descriptions, and so long as one has powerful enough tools to do so, describing complexity will not present a problem [Lewin, 1993: 11]. But more recently scientists have shown that this method of approaching complexity, or more specifically, a complex *system,* is not sufficient to encapsulate the whole complexity of the system. For, as will be shown, a complex system consists of many elements that interact dynamically with one another and with the environment, and it is from these reactions that the system's complexity arises. So, to describe the different elements of such a system would yield merely an understanding of the sum of the different components of the system, but the *complexity* of the system would remain aloof, as it were, for a complex system is not just the sum of its parts, it is much more.

And what about chaos? Some scientists have called this the "irregular side of nature" [Gleick, 1987: 3], and many have been reluctant to investigate it, or ignorant as to how to do so. As a result, human comprehension of the disorderly, discontinuous and spontaneous has been much lacking. Fortunately, many have now realised how important an understanding of these elements of phenomena can be to our ability to predict or control behaviour or future events.

The purpose of this thesis, then, is firstly to investigate the nature of human knowledge and the tools used to acquire it. This also involves attempting to understand what and how humans know, and to formulate (if possible) a solution for the best means to attain knowledge. And secondly, it is to gain a comprehensive understanding of chaos and complexity theories, and how they may fit into the modernism/postmodernism debate, as well as how they can assist in the quest for knowledge and understanding.

1.4 Research Problem

Investigate possible frameworks for acquiring knowledge (modernism, postmodernism, chaos theory and complexity theory), and find the best method for doing so, if one exists.

1.5 Research Hypothesis

To attain knowledge involves a new understanding of its nature, and a new (non-linear) approach to its acquisition.

Because most real systems about which one could desire knowledge (organic, social, economic etc.) are non-linear, an understanding of non-linear systems is important for the process of acquiring knowledge. And because one desires to acquire knowledge from such systems, the approach one takes to do so should represent the systems in some fundamental way. Knowledge displays the properties of a dynamic, adaptive system, and could therefore be approached by means of a theory of systems that model this behaviour. It is for this reason, then, that a non-linear approach to knowledge acquisition is necessary.

1.6 Chapter Outline

1.6.1 Modernism and Postmodernism

Firstly, modernism and postmodernism as theoretical frameworks are discussed, with reference to culture and society. Specific focus is given to how each of these approaches the knowledge acquisition process.

1.6.2 Chaos

Secondly, a detailed discussion of the phenomenon and science of chaos follows, with an introduction to dynamical systems. Why chaos can be considered to be a modernist knowledge framework, and how this framework can assist in the overall quest for knowledge, is examined.

1.6.3 Complexity

In the third chapter, complexity theory and complex systems are discussed. Why this theory can be deemed postmodern is considered, as well as how it can help in the process of acquiring knowledge. Finally, a comparison between complexity and chaos is made.

1.6.4 Conclusions

In the final chapter the previous three chapters are integrated, where the discussion focuses on what has been discovered and what one can learn from each of the theoretical frameworks considered in the previous chapters, concerning the epistemological pursuit of this thesis. Which of these frameworks provide one with the best background for acquiring knowledge; is it one, all or a combination? What has been learnt about knowledge and the possibility of its acquisition?

These questions are addressed in the final chapter, and a proposition is put forward (tentatively) as to how one should approach knowledge acquisition. Finally, the question of whether complexity is merely ordered chaos is also addressed.

Chapter 2 : Modernism and Postmodernism

2.1 Introduction

As humans, we have an innate desire to inquire after things; to find out what things are and how they work. This desire has taken human society — led by thinkers and scientists the world over — on a quest of discovery; a voyage to discover knowledge.

But what is the nature of human knowledge? And how is it that we come by this knowledge? What is necessary for beings like humans to understand the world in which they live?

There have been many different frameworks through the ages with which people have tried to explain or describe the world that they live in. Many have appeared to be fairly successful; or at least, they have seemed to concur with the empirical evidence at hand. Often, though, these seemingly accurate theories have come up short when new evidence has been unearthed. Does this mean that one must discard previous theories? Or simply adjust them?

Questions such as these, and their implications, make up the main focus of what is to follow. Therefore, it is important to first take a look at the phenomena of modernism and postmodernism, for both are vital for a further understanding of the problem of (satisfactorily) seeking knowledge.

Modernism and postmodernism both need to be understood as legitimate philosophical and intellectual frameworks. Without this understanding, one will struggle to truly grasp the implications of specific phenomena — especially complex phenomena such as chaos and complexity — and will not be able to participate in philosophical, academic or even general discourse on most contemporary subjects.

Therefore, this chapter takes a closer look at what modernism and postmodernism are, how they arose out of the modernist and postmodernist ages respectively, and how society and culture were structured during each of those times. Because knowledge of science, systems and networks becomes important when studying chaos and complexity, how modernism and postmodernism approach these subjects becomes important as well.

For the purposes of this thesis, it is essential to have a firm understanding of the two phenomena of modernism and postmodernism before one tackles chaos or complexity, for it will later be argued that chaos can be seen as an instance of modernism, and complexity as an instance of postmodernism. Therefore, both the good points and bad points of modernism and postmodernism are highlighted, remembering always, that on a journey of discovery such as this one, knowledge (of something specific) is not the ultimate goal; rather, an *understanding* of the *activity* of pursuing knowledge is and should be sought.

How then, can man understand the world he lives in? By understanding what it means to *know* something, and considering the suitability of the theoretical frameworks by which this can be done. Let us therefore firstly consider modernism.

2.2 Modernism

2.2.1 History

The modernist era was characterised by quite a dramatic change in human thinking. In the pre-modern era, man was an integral part of nature, he shared a natural connection with a divine or transcendent Nature that included and gave life to all living things [Trainor, 1998: 134]. Nature was the system in which all life shared a universe on equal grounds. Pre-modern man believed in absolute truth and the supernatural. They formed the basis for his worldview, the foundation for his reality as a *universe* [Fields, 1995: 5].

In the modernist era, instead of belief being founded in the mythical, as it had been in the pre-modern era, people began to place more and more belief in science. This happened because people began to realise that the myths most had organised their lives around were, for the most part, unprovable, and therefore could not be considered fact[1] (truth, reality); for fact implied *verifiability*.

For example, in the sixth century before Christ (most) people believed that the earth was flat. It was "fact" to them, because it *appeared* flat. And even when Pythagoras, (and later others such as Aristotle and Euclid), observed the curvature of the horizon, and concluded that the earth had to be spherical, it was some time before the theory became fully accepted [Russell, 1997: par. 5].

Philolaus, Pythagoras' student, took the first step towards proving that the earth is not the centre of the universe, a theory known as heliocentricity, although his version was still — for the most part — mystical [Plant, 2002: par. 2]. Later, Aristarchus of Samos, who lived in the third century B.C. and was also of the Pythagorean school, realised that the movements of all the celestial bodies could be explained if one assumed that the sun is the centre of the universe, and not the earth, but for a long time, heliocentricity was rejected by most people, even scientists [Plant, 2002: par. 3,4], for people were reluctant to relinquish their hold on their religion, or should it be the hold their religion/mythology had on them. For people believed what they could see, and what their (particular) mythology told them to believe.

Of course, the fact that the Ptolemic universe — the theory where the planets and the sun revolve around the *earth,* named after Claudius Ptolemy [Landry, 1998: par. 1] — fed man's ego by naming him as the centre of the universe did not do much for the promotion of heliocentricity either.

Many, many years later, however, in the sixteenth century, a Polish mathematician by the name of Nicolas Copernicus was studying Pythagorean mathematics when he

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[1] A *fact* is "a statement or assertion of verified information about something that is the case or has happened" [WordWeb dictionary]; a "truth verifiable from experience of observation" [McLeod, 1986: 301].

discovered a technical imperfection in the Ptolemic universe theory [Plant, 2002: par. 16]. He realised that the only way to fully and accurately explain the universe and the motions of the heavenly bodies was to place the sun at the centre of the universe [Plant, 2002: par. 16].

Even though Copernicus eventually published his findings, the "literally earth-shaking implications of the Copernican revolution did not begin to emerge until the work of Galileo and Kepler at the beginning of the 17th century" [Plant, 2002: par. 19; BBCi, 2002: par. 8]. Because of the radical change this revelation brought to science, it is considered by many scientists and laypeople alike to be the dawn of the modern age of science; a time of fact, when logical, rational and objective theories with universal applicability are sought after.

Modernity could be seen as a "critique of religion" [Milbank, 1992: 30], where, if a phenomenon (or theory) cannot be proved scientifically, then it is not considered true or even worthy of concern. What people believe (their particular mythology) is not necessarily the truth, or does not necessarily coincide with empirical evidence, and it was this realisation that made them turn to science.

But there has been much debate about the actual starting point for modernity, and not much consensus. Although most believe it to be somewhere around 1776, with the American Revolution, or 1789, with the French Revolution, there are those who take modernity's onset back as far as 1436, when Guttenberg first used moveable type, or forward to as late as 1895, with the publication of Freud's *Interpretation of Dreams* and the rise of modernism[2] in literature and the fine arts [Toulmin, 1990: 5].

Although it may be difficult to pinpoint exactly when modernity began, the shift in principles behind the culture of modernism is less difficult to see. On the whole, the movement from the pre-modern to the modern reflected a general shift from the practical to the theoretical [Toulmin, 1990: 34].

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[2] There is a semantic difference between the concepts of "modernity" and "modernism". *Modernity* refers to the specific historical period classified as "modern", whilst *modernism* refers to the typical *modern* culture of the time. The same distinction can be made for "postmodernity" and "postmodernism".

Modern theories — as opposed to those of for example the Renaissance humanists before them — need(ed) to be logical, rational, objective, and above all, universal. This was to ensure their scientific-ness, and to essentially secure truth. Whereas the Renaissance humanists concentrated on an oral means of communicating, modernists began to shift the emphasis of communication to the written, which meant that logic became more important than rhetoric. Pre-modernists focused on the particular, the local and the timely, for such was their world and their experience; but modernist theorists were more interested in the universal, the general and the timeless [Toulmin, 1990: 30-33]. Permanence and objectivity became sought-after standards, but with this came a much more theoretical approach to life, culture and science.

The permanent (and universal) theory that modernists are interested in is that theory that does not fold when time and/or circumstances change. It is the theory that is scientific, and therefore rational and objective; but more than that, it will hold true today, tomorrow, in ten years' time; here, on another continent, anywhere in the universe.

After being faced with the realities of life that Copernicus' revelation brought to the world, many scholars realised that if one did not know that some theory would hold at any time, in any place, then nothing could actually be said about that theory; or, conversely, *anything* could be said about it.

For example, if I were to say that water boils at one hundred degrees Celsius, but that this will only occur when *I* boil the water *now,* and not at *any* other time, then I am actually not saying anything true about the properties of water, for if water boils at one hundred degrees Celsius, it must do so at any time, and in any place. This theory (that water boils at one hundred degrees Celsius) must be *universal* for it to be true.

For the shapers of modern society — politicians, academics etc. — this "universally applicable rationality" was very important as a social structure, for it created the "unity and certainty of a worldview", which in turn led to the stable environment of a society who all thought and acted the same [Luhmann, 1998: 18, 20, 26]. And this *same* could then of course eventually be dictated by those in power.

2.2.2 Modernism in Philosophy

According to Deely, "classical modern philosophy began in the writings of Descartes", with the rise of Rationalism [Deely, 1994: 15]. Descartes called humans unique, rational beings, who should be true to their nature and search for the knowledge that would provide them with a secure foundation [Linn, 1996: 2].

In the pre-modern era, much of this search was focused on *being* — what is real and exists apart from us. But with modernists like Descartes, although the focus was still on being, it began to move away from that which *has* being, to what one (one's mind) does to *understand* being [Deely, 1994: 16].

> *... the key to knowledge... [lies] in rational reflection rather than in empirical observation [Scruton, 1981: 37].*

This shifted philosophical reflection towards rational discourse; hence Deely's (above) statement.

With this shift came the start of the attention given to method, common of all modern theoretical and/or scientific inquiry. It was Descartes that most actively pursued the "ideal" of method, because for him this would place philosophical argumentation on a par with the natural sciences (especially geometry) [Burnham & Fieser, 2001: par. 6, 10, 11], and would make conclusions drawn from such argumentation just as reasonable, certain and *scientific* as those from the empirical sciences.

He divided all things about which man can have knowledge into two groups: "... first, things which have existence; second; external truths which have no existence outside our thoughts..." [Kenny, 1993: 177]. These are the only things that humans can know about; therefore, the only knowledge man must strive towards is knowledge about these two things. Anything else is mere speculation and therefore it is irrational to claim to have knowledge (certainty) of it.

For Descartes, reason was the "foundation and guide for pursuing truth" [Burnham & Fieser, 2001: par. 10]. For without reason, man would never be able to attain the kind of conclusiveness he could with the natural sciences. And because of his strong background in mathematics [Burnham & Fieser, 2001: par. 6], Descartes saw reason as the tool to reaching scientific certainty in *any* discipline:

> *Reason is a universal instrument, which can be used in all kinds of situations [Morris, 1971: 178].*

Descartes believed that if one desired knowledge or truth, (on any subject), reason had to be the way one went about accomplishing this. Reasonable method would give any knowledge gained from any subject a scientific validity that other paths (to knowledge) could not provide.

Between 1619 and 1629 Descartes developed his theory of method, which was eventually published in a book entitled *Rules for the Direction of the Mind* [Burnham and Fieser, 2001: par. 6, 14]. The twenty-one rules contained in the book deal with the different aspects of his (new) method of inquiry [Descartes, 1985: 9-76], which utilised a deductive approach, and focused on using reason the right way [Descartes, 1960: 17; Burnham and Fieser, 2001: par. 14].

Later, Descartes condensed his twenty-one rules of *Rules for the Direction of the Mind* to a mere four [Descartes, 1968: 1], which he considered the most important and the most inclusive. These were later published in what is arguably his best-known work: *Discourse on the Method of Rightly Conducting One's Reason and Seeking the Truth in the Sciences (1637)* [Descartes, 1985: 109, 111]:

1. *Do not accept what one does not have "evident knowledge" for as truth, i.e. only accept what one cannot doubt [Descartes, 1960: 15].*
2. *Divide the problem one faces up into as many (simpler) parts as one can or needs to solve it better [Descartes, 1960: 15].*
3. *Think orderly about the problem: start with the simplest components (those about which one knows the most), presuppose some order between the components, and then proceed step by step up that*

order, towards "knowledge of the most complex" [Descartes, 1960: 15].

4. *Be sure to leave nothing out: be complete and comprehensive [Descartes, 1960: 15].*

According to S.V. Keeling, these four rules are based on three mental operations: intuition, deduction and enumeration. Together, they make up the faculty of human reason [Burnham & Fieser, 2001: par. 21]. Intuition means to directly glean what the simplest components of the problem ("subject matter") are [Burnham and Fieser, 2001: par. 21]. Deduction involves "inferring [the] necessary relations" between these components [Burnham and Fieser, 2001: par. 21]. And enumeration is the process of reviewing used when deductions have become so long as to possibly cause error [Burnham and Fieser, 2001: par. 21].

When one has discovered that (one's) old theories are not quite accurate any longer, Descartes suggests that one preferably begin methodically building them up from scratch, rather than attempt to renovate them over and over again — much like the old parts in a city [Burnham and Fieser, 2001: par. 15]. If one renovates too much, one may struggle to see what a particular (old) building was supposed to look like; also, it makes the building that much more unstable with each new renovation — rather like a patch job done on an old pair of jeans. But by starting from scratch, one is able to recognise and accept much new information, which could help to build new (and better) theories of knowledge:

> *And just as in tearing down a building we usually retain the debris to help build a new one, so in destroying all of my opinions which seemed to me ill-founded, I made many observations and acquired much experience which has since aided me in establishing more certain knowledge [Descartes, 1960: 22].*

Descartes' method of doubt, which led him to claim, *"cogito ergo sum";* or, 'I think, therefore I am', implies that certainty can only come from doubt. One must destroy all "knowledge" that cannot be definitively established, and start from a basis of that which can be unquestionably determined.

Modernism therefore "... seeks to reduce the burden of ... 'irrational' phenomena..." [Milbank, 1992: 31]. It is not rational to say that one has knowledge by means of one's tradition, belief or religion. These sources cannot supply certain knowledge. Modernism makes an attempt to show that these "knowledges" are based in error (or at least in an ignorant comprehension of how knowledge is acquired). Reason (as the ultimate weapon of modernism) fails when traditional, mythical 'knowledge' is claimed to be 'real knowledge'.

Modernist philosophers reacted in much the same way as other modern intellectuals when it came to the credibility and universality of their theories. They too realised that this scientific way of thinking (and investigating) led to greater intellectual certainty, and so a kind of "theory-centred style of philosophy" was born. When philosophical problems were posed or arose, solutions were then sought in timeless, universal terms. Descartes, Locke and Leibniz were all "theory-centred" (modern) philosophers [Toulmin, 1990: 9-10].

For philosophers and scientists alike, scientific method therefore became the ultimate theoretical (and practical) construct, for it is rational, sensible and stepwise, and produces a large amount of scientific surety when applied correctly.

Unfortunately, the modernist's devotion to reason and science caused him to turn reasonable method into a religion, resulting in precisely the same unscientific error that he had been arguing against (the lack of scientific credibility of religion) [Linn, 1996: 6]. Because modernists considered reason and science to be so important in the attempt to acquire knowledge or even 'truth', reason became the all-important faculty for truth. So reason was privileged above any other means of acquiring knowledge, and in doing so, modernists turned scientific method into a religion, with reason as its god [Montuori, 2004: par. 4].

2.2.3 Architecture

Modern scientists, sociologists and philosophers vied with each other to come up with the best "scientific" (or *true*) theories — whether historical, cultural or academic — to describe the nature of man and his progress. The pervading culture of general society (modern*ism*) began to reflect this shift towards the scientific, and this is best seen in the architecture of the time.

The modernist movement in architecture (and other fine arts) began around the 1890's, with the beginning of the so-called style of *"art nouveau"*, by the likes of Charles Rennie Mackintosh in Glasgow, and Otto Wagner and Josef Hoffmann in Vienna [Toulmin, 1990: 155]. Architects such as Mies van der Rohe and Walter Gropius began to create structures that were logical, anonymous, timeless and indistinguishable [Toulmin, 1990: 6; Cahoone, 1996: 13]. But above all, these buildings had to be functional and featureless; as architect Adolf Loos said: "any design should show us what the building is for" [Toulmin, 1990: 155].

A modern house, for example, could be seen as a large, rectangular block separated into smaller square or rectangular blocks, each with its specific function. Doors were situated in such a way that they provided an equally rapid exit from all rooms, and rooms such as kitchens or bathrooms were located as centrally as possible. Modernist structures are therefore designed to optimise functionality and resources, and they contain no specific, individual identifying marks; for the architects of the modern era, this epitomises the scientific character of modernism.

Modernism was not only seen in modern architecture, of course; all the art genres of modernity reflected the modern approach in some or other way. Painters such as Gustave Courbet and Claude Monet's realist and impressionist paintings [Cahoone, 1996: 13] respectively showed the modernist interest in the scientific and the structured, and in the music world, composers such as Arnold Schönberg and Alban Berg's use of atonality in musical works [Cahoone, 1996: 13] not only expressed pervading feelings of their war-affected time, but also illustrated the influence of modernism on the arts particularly well.

According to Bauman, modern art was a "desperate attempt to purify the work of the artist" [Bauman, 1992: viii]: words, colours, shapes and sounds were considered pollutants, and therefore the ultimate modernist painting became a blank canvas, the ultimate written piece an empty page, and the ultimate musical composition, silence [Bauman, 1992: viii].

2.2.4 Modernist Society

Modern societies are made up of three separate realms: technical-economic, political and cultural. Each of these realms had their own area of modern life to govern, and their own principles on which they did this.

The technical-economic realm worked on the principle of economising, or that old capitalist motto of maximisation of profit. This of course led to "specialisation and hierarchy" [Bell, 1976: 320], for if one's goal is to make as much money as possible, then business and life will tend to become organised along the lines of who has the knowledge and skills to get one that money, and who does not.

Thus businesses became bureaucracies, and people became things. As a part of the economic work force, one was forced to accept the fact that one was no longer an individual, but merely the walking, talking form of one's function. No matter how high up the economic hierarchy one found oneself, one still remained "the manager", "the lawyer" or "the cleaner". Needless to say, this gave people an immense feeling of isolation and general non-importance.

The second realm of modern society was the domain of the ruling or governing entities in that society, the political realm. In a democracy, this realm is (supposed to be) based on the principle of equality [Bell, 1976: 320], creating and preserving a culture of free and equal rights. It is the job of the modern government to regulate conflict, ensure the safety of its citizens, and protect the (equal) rights of all members of the society.

Unfortunately, this often means intervening in the economic and socio-cultural realms — to ensure the equal treatment of different peoples or cultural groups — which usually leads to frustration and ill feelings all around.

Although the ideal behind modern government still remains a noble one, most people have found that the modern political realm's application of this ideal considers some of its people to be 'more equal than others'.

The third and last realm of modern society is the cultural realm. As with all societies, it is here that culture, norms and traditions are established, but, unlike preceding cultures, the modern cultural realm is based on the principle of self [Bell, 1976: 320].

This is the idea of, 'what can this do for *me?'* Though most would not care to admit it, the majority of members of the modern society act only when they expect to profit in some way out of that action. People work because it will make them money, they give in to extra demands from their superiors because they believe it may earn them respect or a promotion. They help or give to charities because it makes them look or feel good.

Almost every instance of cultural interaction in the modern society reflects the expression or gratification of self, and it is in this way that the individual becomes the most important entity in modern society. Although it can hardly be called surprising, for the individual receives no recognition in either of the other spheres of modern life.

Is it really all that remarkable, then, as the self becomes what Daniel Bell terms the "touchstone of cultural judgement" [Bell, 1976: 322], that the cravings, urges and impact of the immediate experience, the *Now,* become all-important in modern society? The question to ask of this, however, is if this is our culture, what is to stop it becoming our reality? The impact of this immediate gratification of the self — if allowed to become the dominating social reality — could easily turn society into a culture of murder, lust, rape, perversion; in essence, a culture of inhumanity [examples: Bell, 1976: 322].

This emphasis on self, however, was not always a destructive thing. Most saw it as the Western ideal: autonomous man becoming self-determining. But to do this, man realised that, quite aside from immediate experience, he needed to increase his knowledge of himself, others and his surroundings.

It did not take the modernist political and social leaders long to realise, though, that with knowledge comes control, and so it was also not long before this led to a furious striving for autonomy. For if society has the knowledge, it must be able to determine its own values, customs and traditions without any outside interference or help [McGowan, 1991: 4]; it would be able to be an independent society, and the power to control that society would rest with those who had the knowledge to do so.

The trouble with such thinking is that it helps to establish hierarchies that lead to oppression. For whilst early modernists may have had such noble objectives as unity and national identity in mind, certain people that followed took this search for singleness and identity a bit far. Their obsession with unity caused them to disregard anything and any*one* that did not fit in with their idea of what was "right" or "ideal" [Cornell, 1992: 33], alienating and even discriminating against such *"other invasions"*.

The reasoning behind such prejudice is that "only unified, homogeneous entities... can act effectively" [McGowan, 1991: 20]; and there one has modern racism, sexism and other discriminatory practices. Hitler's systematic yet rapid elimination of the Jews in Germany is just one example of how the ideals of modernity went astray. He wished to "purge" the Germans of any "destabilising" link that could weaken the (in his mind) "ultimate race" through their 'otherness'.

For modernists, then, there is just one kind of social order: that which stems from the "science" of prediction and control that comes with knowledge and power. And, therefore, there is also only one valid view of the world: a grand narrative, one that reflects this (social) order, i.e. an ordered totality [Bauman, 1987: 3]. For it is only in the unification of the world under the universality of science that this world can exist. Science must be objective and universal, and the world must be based on this objectivity and universality, otherwise it would fall apart. And the only true way for us to live is to do likewise: to base our lives on the knowledge of the objective and the universal.

2.2.5 Knowledge and Reason?

Much of the scientific character of architectural structures mentioned above was achieved through technologisation, or the application of technology to everyday life, but whereas architecture was the functional application of the modernist "scientification", and technology was the means of accomplishing this, the underlying ideal behind it all was Reason: "inquiry based on the human faculty of grasping necessary connections" [Linn, 1996: 2].

Not just reason, but Reason with a capital **R**, because when modernists placed science in a preferenced position, they put reason on a pedestal: the pedestal of ultimate Dictator. For what could not be reasoned through, could not be proved, and was therefore rejected as being unscientific. And what *could* be reasoned, could be proved, and could therefore claim scientific status.

The modern man did not need the supernatural to guide him; reason and science alone could give him the answers he needed to understand the universe and structure the world.

Of course this knowledge of the scientific brought with it power — the power to dictate what is true and right and to thereby shape society — for when all believe the same, all think the same, and when all think the same, all act the same. This produces control for those controlling the knowledge. Anything not objectively verifiable should be rejected, for it "distort[s] knowledge and limit[s] effectivity of control" [Bauman, 1987: 3-4].

The modern view of knowledge, therefore, means "having the ability and the right to define and systematise reality, so as to judge it" [Brennan, 1995: 100]. It would appear, then, that the more knowledge one acquires, the greater one's control, and the bigger hand one can have in shaping society to a universal, one-minded entity. Or so say the modernists. A society of citizens who all think the same, act the same, and do not question the superior knowledge of their leaders —loyal, law-abiding citizens? Or robots?

National loyalty and patriotism, and civil obedience are good results of the above control of knowledge by modernists. But is this what happens when citizens are called to think and act the way their leaders prescribe, merely because they say so, even if those leaders have noble reasons for asking them to do so? It may be. But it may also possibly get out of hand, as has been seen at certain times in humanity's history. Does this control of knowledge, and ultimately of people, lead to progress and pride, or another possible holocaust?

Towards the beginning of the twentieth century, many people began to value modernism's prescribed, indistinguishable way of thinking less and less, and what with democracy aiming to protect the rights and views of the individual, more and more people began to look towards something less restrictive than modernism as they knew it.

So where did this leave society? The individual — as a product of mass production (where everything is made on a large scale, and each product looks exactly like the next) — sometimes became not much more than a puppet; powerless, on the end of the power-wielding modernist string. Whomever had the knowledge had the power to prescribe how people should be, and individuals who looked, acted or were even slightly different from the prescribed ideal were often rejected, alienated and discriminated against.

Many in power believed in the modernist "unity" ideal so much that they were willing to go to any lengths to ensure its preservation. Many horrendous practices continued to victimise people in a time of modernist "purification", not least of which apartheid and the Jewish holocaust. Allowing modernism *as it had become* to continue would eventually destroy all creativity, individuality and freedom, leaving only a world of robots. It had to change, or else be replaced by something else entirely.

And so, many individuals, in different places and in differing ways, began to move away from what they saw as the sameness, the functionality, the restrictiveness of modernism. Creativity and individualism began to be important again. This attitude, along with the realisation of modernism's limitations, paved the way for what came to be known as postmodernism.

This is not to say, however, that modernism has ended. Although many individuals feel that modernism is restrictive and needs to be adapted at least; on a practical level, much of the ideal of modernism still remains around the world today. There are still groups, peoples and even nations very much tied to the values of modernism, where modernism is still the dominant *modus operandi.* A good example of this is the nation of the United States of America.

2.3 Postmodernism

2.3.1 History

Before the term "postmodern" became relatively well known — towards the latter stages of the twentieth century — there were a number of scholars from various fields already using it, though their specific references differed quite widely.

German Rudolf Pannwitz, *à la* Nietzsche, described the nihilism of (early) twentieth century Western culture as *postmodern* in 1917 [Cahoone, 1996: 3]; Frederico de Onis, the Spanish literary critic, referred to the reaction against literary modernism in 1934 as *postmodern* [Cahoone, 1996: 3]; in 1939, the English theologian Bernard Iddings Bell called for a return to religion on account of "the failure of secular modernism", which he labelled *postmodern* [Cahoone, 1996: 3]; whilst at the same time, his countryman historian Arnold Toynbee termed the rise of mass society following World War One *postmodern* [Cahoone, 1996: 3].

In the 1950's and '60's, literary critics labelled reactions against aesthetic modernism *postmodern* [Cahoone, 1996: 3], and in the 1970's, architects (such as Robert Venturi)

[Toulmin, 1990: 6] also reacted against aesthetic modernism, building structures that were less functional, had much decoration and local colour, and were more aesthetically pleasing. This style became known as "postmodern".

There have been those, such as Jencks, who date the end of modernity (and hence the beginning of postmodernity) very specifically. Jencks claims that modernity crashed to its death at thirty-two minutes past three on the afternoon of July fifteen, 1972, when great slab blocks of the 1950's St. Louis Pruitt-Igoe Housing project were demolished [Huyssen, 1984: 359]. This building exemplified all that modernism had stood for — it was the functional, logical, optimal use of a small amount of space, so that as many people as possible could live in the small, boxlike apartments — so for people like Jencks, its demolition was symbolic of modernism's fall, and the progression to something new (and by implication, better).

Although the exact date (again, if there was one) of the beginning of the postmodernist era is uncertain, there was a definite, noticeable shift in the mood or ideas of late modernist scholars.

After the second world war, artists began to attack the institution of Art, with its strict, rigid, functionalistic ideas, and tried to include more integration of colours and shapes into their works as well as their lives [Huyssen, 1984: 363].

A new technological optimism began to emerge, as post-industrial society enthused over new media: television, video and the computer [Huyssen, 1984: 363].

A culture of validation began to take form: in everyday life, individuals previously classed as "outside" of the institutionalist norm were validated, affirmed and generally accepted [Huyssen, 1984: 363]. No longer was the modernist mass culture the norm, but rather a culture of multiplicity and diversity began to develop, in which tolerance and acknowledgment played a vital role.

As people eventually realised that the tension between tradition and innovation could no longer be ignored, and the discontinuity between the conservation and renewal of the social order no longer disregarded, new frontiers were sought in attempts to expand the views and organisation of society, as well as the boundaries of knowledge [Huyssen, 1984: 363, 371].

2.3.2 *Postmodernism in Philosophy*

In the 1980's, when philosophers began to call the French poststructuralist movement of the 1960's — which denied the possibility of objective knowledge and the unity of the human self [Cahoone, 1996: 2,3] — *postmodern*, postmodernism as a philosophical position and a cultural movement, began to gain acceptance. 1980's philosophers, who were uneasy about modern rationalism, utopianism and foundationism, declared society "post"-modern, and called for movement against and away from modernist focuses.

The modern faith in human reason, which, through rational science, leads to objective truth, was one of the first problems for postmodernists.

Is it really possible for a subjective being (such as a human) to objectively observe anything at all [Rüsen, 1994: 188; Brennan, 1995: 100]? One's eyes can certainly deceive one, for the world appears flat when it is in fact spherical, and it is also possible for science to fail; for the most careful experiment to yield incorrect, inaccurate or even impossible results. Is knowledge at *all* possible in the light of human subjectivity? For many theorists, therefore, it seems unlikely that truly objective truth can be gained.

By the end of the twentieth century, "postmodern" had become a buzzword; people were throwing the term about as a sign of social progress, and applying it to everything from micro-machines to relationships. Postmodern philosophy, however, came to be recognised by these five, somewhat reactive (to modernism), themes [Cahoone, 1996: 14]:

2.3.2.1 Representation and construction:

There is nothing that is immediately present to one; all is dependent on one's interpretation thereof. Unlike the modernists, who privilege presence, postmodernists focus on representation: how humans represent phenomena and occurrences to one another through signs and concepts; and construction: the products that they make from these representations [Cahoone, 1996: 14].

2.3.2.2 *Phenomena:*

It is not (as modernists claim) possible to see "beyond" a phenomenon to its origin or foundation. There is therefore nothing "deeper" than the phenomenon itself. It is not possible to return to, recapture, or even represent the origins of phenomena; indeed, this is not necessary, for all that one needs to understand a phenomenon is the phenomenon itself [Cahoone, 1996: 14].

2.3.2.3 *Plurality:*

The world is pluralistic and indeterminate. Everything in it is constituted by relations to other things. Therefore nothing is simple, obvious or totally present to us, and analysing it will only yield part of the whole, part of the truth [Cahoone, 1996: 4, 15].

This theme is like the parable of six blind men who all encountered an elephant. One touched its trunk and said it was a snake. Another touched its side and said it must be a wall. A third felt the tail and said it was a rope, and a fourth felt the leg and said it must be a tree. The fifth man touched the elephant's ear and claimed the thing they were encountering to be a fan, and the last man, when touching the elephant's tusk, argued that it had to be a spear [example: Cahoone, 1996: 12].

What these men did not know was that they were all touching different parts of a very large animal. Each of them was in a sense right, for their particular part. But what this story illustrates is the postmodern theme of plurality: any one part cannot be the whole elephant; any one part of modernity cannot claim to be the whole [Montuori, 2004: 5]. That is where the modernists went wrong.

An analysis of any one part of history, any one instance, any one phenomenon cannot yield the whole truth. The world is plural, and so must philosophy be.

2.3.2.4 *Immanence of norms:*

The norms we live by today are not transcendent, they are subjective products of the processes they govern [Cahoone, 1996: 15]. Is it just, for example, to kill a man? Immediately one answers, "No, of course not, that is why there are laws against such things!" Is the norm of justice not then transcendent, above all processes and circumstances of justice, the same at all times and in all places? It may appear so. But killing a man may become just when he is terminally ill, if one believes in euthanasia, or if he is a convicted, dangerous criminal, if one believes in the death penalty. And so the lofty norm of Justice falls from its transcendental, societal pedestal, where it should never have been put in the first place. Norms are immanent: dependent on the circumstances and people involved, and not transcendent.

2.3.2.5 *Constitutive otherness:*

That which modernism marginalised, excluded, cast aside — i.e. "the other" — in postmodernism is privileged, made the centre and studied for the knowledge it can provide [Cahoone, 1996: 16]. For what modernism privileged, what it considered important, could only be constituted through *not being the other* [Derrida, in Cornell, 1992: 70].

For example, what is presence but a lack of absence, and what is a system other than what is *not outside* its boundaries? If one could not define a system in terms of what may not be inside its boundary walls, there would be no system. This modernist process of excluding or repressing that which is seen as secondary and unimportant, is therefore self-undermining, for without the "other" there could be no primary, "important" phenomena [Cahoone, 1996: 16].

For postmodern philosophers, it is important to realise that there is not just one point of view in any given circumstance. The meaning anyone ascribes to any situation is based on their interpretation of the factors governing that situation, and is also affected by their environment, background and relation to the situation [Johannessen et. al., 2002: 16]. Plurality is important [Aronovitch, 1995: 322], just as remembering that certain rules may needed to be amended at times, to fit the circumstance.

This does not mean that nothing can be scientific anymore. It merely means that our definition of science needs to be redefined. Scientific method can no longer remain the objective, universal, observable method of modernism, governed by a modern analytic reason.

Nature is inherently disorderly [Fields, 1995: 5], not orderly as the modernists claimed. Therefore, uniform scientific method cannot apply to the study of nature or of man. Rather, a new kind of method for studying science is needed, one in which reason becomes a synthesis of modernism's analytic reason and pre-modernism's myths; a synthetic, aesthetic, dynamic reason [Gier, 2000: par. 8].

An example of this kind of reason is found in virtue. Virtue is a unity of fact (modernism), value (pre-modernism) and beauty (pre- or postmodernism) [Gier, 2000: par. 8].

Postmodernists see the world as fragmented, changing, discontinuous [Beck, 1993: 5]. Because it is constantly changing, and because people are also dynamic, changing beings, reality becomes in part a human creation. People mould their reality according to their needs, and out of their perspective, culture, background etc. There can never be one complete, specific, all-encompassing description of nature, the world, reality, life... or anything at all.

Thus, postmodern philosophers are suspicious of traditional or conventional conceptions of truth, reason and objectivity, and see the world as contingent, ungrounded, diverse and unstable. Whereas modernism tried to formulate "ultimate grounds of explanation", grand narratives which "legitimate all other discourse" [Eagleton, 1996: vii; Lyotard, 1984: xxiv; Montuori, 2004: par. 3], postmodernism does not need or want such 'meta'-

narratives. It is, as Lyotard said, "incredulity towards metanarratives" [Lyotard, 1984: xxiv].

The postmodern philosopher does not wish to unify all knowledge; rather, he desires a large variety of discourses (local narratives) all existing together, because for him, each describes something legitimate and worth knowing in itself, and the *process* of acquiring knowledge is more important than the knowledge itself [Brennan, 1995: 100]. Postmodernism, therefore, has to do with a "radically altered view of knowledge" [Brennan, 1995: 100].

It is also not important to know the origin of phenomena, for though context is important to the postmodernist, it is the context in which one observes the phenomenon *now* that matters. One can in any case never claim to know the origin of some thing, for it has passed; one was not present at that origin. It is also not necessary to legitimate other discourses, for they justify themselves within their own contexts.

2.3.3 Media

Postmodernism as a theoretical framework has many applications in everyday life. There are many ways and many places in life today where one can actually *see* postmodernism at work — in art, in the ethos of acceptance and tolerance propagated by some groups or governments, in the importance given to marginalised groups, in the plurality and disjunction of fused cultures in society — and, not least of all, in today's media. Every person living today is affected by postmodern media in some or other significant way. One cannot get away from it. Should this fact threaten us, or excite us? Is today's media good or bad?

Although the respective pros and cons of postmodern media make up an important ethical debate, how one judges the impact of the media is not as important as acknowledging the change it has brought to our lives and our world [Schirmacher, 2000: par. 1]. Most people today would be unable to live without the media in some kind of form, though they would probably be reluctant to admit it.

Think for example, though, of September 11, 2001. A great majority of people worldwide would not have known about this tragedy had it not been for the media, and would certainly not have been able to follow the developments that ensued. Things happen so fast today that man relies on the media to keep him up to date and informed, even though he may not be present to what is happening, or much influenced by it.

One's life could therefore be much simpler, and much slower if there were no media. Instead, one is thrown about from one story to the next, trying to comprehend and react to each before the next one comes, and brings with it new names, new events and new emotions to observe, experience and sort out.

So what can postmodernism offer one in one's quest for knowledge? It is a way of looking at, and describing, the world we live in. One could view the world out of a modernist perspective, and one would then see it as a uniform, scientific phenomenon, to be understood rationally and reasonably. The modernist seeks to understand the world he/she lives in as objectively as possible; and this is done by formal scientific inquiry.

For the postmodernist, the view is a bit different. He/she does not necessarily seek to *understand* the world, but rather to *experience* it. The postmodernist realises that the world is not uniform, and experiences of it will not be universal. Therefore, how one views the world is much more of a subjective experience, rather than based on objective discovery. Each person will represent the world based on his/her experiences, and each of these representations is valid for the context in which it operates. There is no all-encompassing, over-arching view of what the world is.

A demand, therefore, for absolute certainty or truth of how the world is, completely devoid of any subjective influencing factors, is not only unwarranted, it is unreasonable. Absolute certainty (in this way) does not exist, and science therefore is not universal in that the explanations it offers are not universally valid. Indeed, this is the reason for scientific progress, for if scientists always accepted that any explanation science produced was universal, there would be no need for further inquiry.

French philosopher Jean Baudrillard referred to postmodern man as "living in an era of rapid and constant change brought about by the electronic media" [Frisch, par. 4]. As an example of this postmodern media, consider television. What does television today convey to the general public? Does it, as Heath and Skinner claim, relay reality as it happens, without selection, control or mediation; a real transmission of the real world, as sociologists Kroker and Cook maintain [Media Ethics..., par. 5, 9]?

Or does television — and media in general — feed its viewer an artificial reality tainted by whatever subjectivity is present at the time; a *simulation* which subtly forces him to buy into the deception placed before him [Media Ethics..., par. 37]? There are some who think the latter.

McLuhan, for example, describes television as a "subtle, maleficent, elusive twisting of meaning" [Media Ethics..., par. 41], and Baudrillard considers postmodern television to be the "final stage before culture disappears into the control of the image" [Media Ethics..., par. 5]. The media image then becomes the substitute for reality; television transforms real into *hyperreal,* an intensification of reality, a simulation that is more real than the real itself [Media Ethics..., par. 32, 49].

It may be easier to accept this simulation if one realises that the *act* of simulating is not a new phenomenon. Western culture at least has gone through many of what Gane terms "phases of cultures of accumulation" [Gane, 1991: 94].

During the Renaissance, nature competed with what was seen as fake or *simulated* nature. In the Industrial era, the natural and the mass-produced product vied for the consumer's attention, and in post-Industrial time, people must distinguish between what is real and what is hyperreality [Gane, 1991: 94].

Most of us would like to claim that the media portrays reality as it actually is, but as there are always people involved in observing, experiencing, editing and presenting it, it is relatively near impossible for media to depict a completely objective reality. As Eco said, any person's perception of things is always already affected by his/her background and emotions towards that which he/she perceives, which could lead to distorted or even false knowledge [Media Ethics..., par. 35]. Therefore, media news is shaped by the world it attempts to convey, and the viewing public has no control over the amount of valid truth it receives from these representations [Media Ethics..., par. 6, 10].

According to Baudrillard, this simulation of reality that the viewer is given begins with what he terms an "implosion of meaning". This occurs when the distinction between active and passive becomes blurred [Frisch, par. 15]. No longer does man experience reality first-hand, and decide for himself the validity of the truth portrayed before him; now, he is no longer present to the truth, and the media becomes free to present as "truth" whatever pleases the camera and producer. In doing so, the unsuspecting viewer is made a "passive machine" [Media Ethics..., par. 5, 49], accepting and believing that which is put before him/her, whilst "technology... obscures... real and false, and merges fantasy [and] reality" [Frisch, par. 4].

The distinction between the simulation and reality, the copy and the original, is gone. The viewer assimilates the simulation into his/her life usually without even knowing it, and before long, what he/she wants is the simulation, and not the real [Media Ethics..., par. 38, 40].

Many people would call this brainwashing, indoctrination, manipulation or at least distortion of the truth. But, as Baudrillard realised, simulation does not hide the truth, it is the truth that hides the fact that there *is no truth* [Taylor, 1992: 19; Media Ethics..., par. 30]. There is no depth, no perspective to Truth [Gane, 1991: 102]. Reality, and hence truth, is what one makes of it. Or in this case, what the media makes of it.

But, as most people are not completely gullible, they would most likely recognise the media image as an inaccurate simulation if they just thought about it long enough. Media's answer to this problem, says Deleuze, is repetition. Repetition is extremely important for the media to retain a sense of the real [Media Ethics..., par. 49]. If it did not at least *appear* to resemble reality, no one would buy into it, and the media (the postmodern media at least) would die out.

That is why advertising is so important to the media industry. Advertisements not only provide a glimpse of reality "as it should be", causing the viewer to immediately want whatever is advertised, but with constant repetition comes conditioning to believe that what is advertised is real. Also, the more the media bombards one with the same "reality" over and over again, the less time one has to truly consider the merits of what it claims.

One of the main effects of media's "representations" of reality in television, film, advertising etc. is the obscuring of the boundary between public and private. The media is everywhere, and therefore what was once private, becomes public.

Take for example the *paparazzi* photographers who constantly invade the privacy of celebrities in the hope of getting a good picture to sell to the media. The media then prints the picture (because the public wants to see it, of course), and it is the public who get to invade the private lives of those celebrities.

On the other hand, the media plays just as important a role in causing the public to become private. When there is a war taking place somewhere in the world, or some terrible event such as September 11th occurs, the media is always there to bring these public horrors right into one's living room, whether one wants it there or not.

Baudrillard calls this interchanging of the public and private an "obscenity" [Media Ethics..., par. 25], and it is not all that surprising why. No one is safe anymore; life becomes television, and television becomes life [Media Ethics..., par. 31].

An interesting example of this is the reality-television show *Big Brother*. For the housemates, whatever privacy they thought they had, or would have, is completely gone. Television makes their whole lives public to the entire country, and as far as the public is concerned, they (the public) have to contend with the invasion of the antics of the housemates into their homes, possibly even for twenty-four hours a day. The housemates' lives become television, and this television becomes part of the lives of the general public.

How does the media accomplish all of this? According to Schirmacher, there are four rules of the media game. The first, and most important, is to keep the focus on the self [Media Ethics..., par. 11]. The media screams, *"take care of yourself!"* and this is advocated especially by its advertising. All advertisements are aimed at the self, aimed at make one's life better. *"Use this miracle cream"*; *"eat this new cereal"*; *"buy this type of shampoo"*... all these imply that if one buys that specific product, one will look better, feel better, be more popular, more successful and more important.

Besides advertising the necessity of looking after oneself, the media also challenges the viewer to create his/her own life [Media Ethics..., par. 12] — for example with camcorders, which can record and edit events in one's life exactly as one wants, for future use; with answering machines, on which one can place a message specifically formulated to create a certain impression of oneself; and with films, the greatest freedom to truly create life and reality as one desires — but at the drop of a hat the authority of the media can take over. An important world event, an international sports meet, a national arts festival; all will find the media's time, space and money given over to these events.

Why does this happen? The simple answer is money. It is the ultimate goal of the media industry — just like any other business — to make money, and whatever it takes to make people watch, this is what it will concentrate on. The working rule of thumb *"if it doesn't look good, nobody will buy it, and you will be out of a job"* can be considered the media's motto, and *every* instance of media proffered to the public has to abide by this law; news, wars, world events included [Media Ethics..., par. 13].

Rule number two defines performance as the moment of truth [Media Ethics..., par. 13]. The media metaphors of speech, print and television especially define this (postmodern) world. Through Baudrillard's *hyperreality,* the simulation of an extra-real reality, one becomes involved in what Eco called "the pleasure of imitation" [Media Ethics..., par. 13].

Though one may not always be aware of it, one becomes conditioned to the simulation presented to one, and eventually, the simulation becomes better than the reality. One desires to imitate the simulation, not reality. Therefore, the media must present that simulation in such a way that the viewer does not recognise it as a simulation, and desires to become like it.

The third rule of the media game concerns style. Style is the medium of action, and the media "seduces by style alone" [Media Ethics..., par. 14]. Style is that which produces action on the part of the viewer, for without it, he/she would be bored, uninterested, and completely apathetic towards the media and its proponents. How boring the media is to the viewer becomes the only deciding factor in whether or not he/she accepts its simulatory performance, and desires to partake of its illusion.

Therefore, it is by style alone that the viewer is convinced that he/she wishes to act. Television becomes tele-*action* [Media Ethics..., par. 14], and style persuades the viewer that the media is not making a machine or robot out of him/her, but merely making him/her more "with it", more intelligent, more creative, happier, and ultimately, more in control of his/her own life.

The fourth and final rule of the media game states: "mediation is the flow of media" [Media Ethics..., par. 14]. This means that media can only be truly authentic as a mediator. Much of the three previous rules has focused on what is important from the side of the media; what must be done to make it work. This final rule is concerned with how media can contribute in a real and positive way to the lives of its viewers.

The media not only gives one access to events, places and emotions otherwise beyond one's reach, but it also connects one to its inherent process.

With the media as a mediator, two worlds are connected in one instant: the past and the present, the present and the future, the known and the unknown, the accessible and the inaccessible, the possible and the impossible, the real and the simulation. The symbolic exchange of the real for the hyperreal is controlled by the media's "hierarchised systems" — systems that manipulate the movement of signs. The media is "power through control over exchanges" [Gane, 1991: 94].

2.3.4 Postmodernist Society / Culture

Every society in the world has a different way of structuring, running and ordering its people and their culture, though these could be divided into a limited number of groups, such as democracy, socialism, communism etc. Societies and cultures have also changed over time, and each one could be said to have had its good points and bad points, just as each society today can be considered good in some ways, and bad in others.

Pre-modern and modern societies share a culture of hard labour, power struggles, oppression and exploitation. In traditional societies, much emphasis was placed on family, community and tradition, but there was not a lot of individual freedom, and the people were often very poor, both materially and socially [Eagleton, 1996: 107]. There was a general "lack of self-critical awareness" because of the prescription through myths and traditions, and this social collectiveness emphasised by the community [Degenaar, 1993: 53].

In the later modern societies, human equality, universal rights and "free individual development" became very important, but as people fought to gain independence and wealth, and to rise up the corporate ladder, relationships deteriorated, until they were neither significant, caring nor meaningful [Eagleton, 1996: 107].

With the rise of postmodernism, some people began to realise that freedom, equality and wealth were all very well, but what has happened to brotherhood? Men worked themselves almost to death to "move up in the world", and gain all they desired, only to find that this did not (as they had expected) make them happy. Kinship, community and something to believe in had made pre-modern societies strong in a way modern people could not understand, and this is only now beginning to dawn on many of them.

Not that all modern ideals are bad; on the contrary, some are very lofty; they can just not be all there is to life. It would appear then, that the postmodern view of culture calls for (in a sense) a limited change: change that incorporates the best of all preceding attempts at organising society and culture; change that brings the best out of man, both individually and corporately.

2.3.5 Relativism

And so, to some, postmodernism represents an escape from, or a break with, theology, metaphysics, racism and domination [Cahoone, 1996:1], whilst for others it is an endeavour to do away with western civilisation; and for still others, merely a collection of vague writers talking about nothing [Cahoone, 1996: 1].

These, of course, are not the only views of what postmodernism is — it can encompass all that is good in opposition to the negativity of modernism, all that is bad in a drastic attempt to move away from modernism's mistakes, or any combination of the two — but the mere presence of such differing views indicates that postmodernism cannot be boxed; no grand narrative can be written on what postmodernism is or should be.

Some might accuse postmodernism of *relativism*, arguing that this (above) point is exactly an indication of just how relativistic postmodernism actually is. Relativism is "...the thesis that the natural world and such evidence as we have about that world do little or nothing to constrain our beliefs" [Laudan, 1990: viii], and according to the *Internet Encyclopaedia of Philosophy,* proponents of relativism usually purport that "all points of view are equally valid" [Westacott, 2001: par. 1], and what any one person or group of people think or believe is relative to their specific framework or standpoint.

So, (according to German Georg Simmel), nature, history and all other 'truth descriptions' gain meaning only in the light of one's own particular perspective [Avey, 1954: 228]. In other words, truth independent of one's point of view does not exist [Kirk, 1999: 10, 11]; it cannot be "out there" as Richard Rorty said, independent of one's mind [Kirk, 1999: 11].

There have been many descriptions of relativism, by people for and against it, but probably the most famous or most encompassing description was given by the Greek philosopher Protagorus: "Man is the measure of all things: of what is, that it is, and of what is not, that it is not" [Kirk, 1999: 37]. In other words, man decides what is to be truth and what is not. Whether this is a valid description of how things are or not, remains to be seen.

For relativism to work, three major points have to be understood. Firstly, the *character* of relativism is what is known as *alethic,* which means to do with the nature of truth [Margolis, 1991: 3]. So relativism is a theory or framework by which one could try to understand what truth is.

Secondly, the *conditions* under which relativism works are known as "favourable épistèmic [knowledge] conditions" [Margolis, 1991: 3]. To create these conditions, one must assume that man can (is able to) grasp (the) truth about the world.

And thirdly, a limit must (from the start) be placed on the theory of relativism: one must also assume that reality is inherently unchanging, otherwise it would be almost impossible to know anything about it. This is known as the *ontic* [being] *constraint* of relativism.

The above three aspects of the theory of relativism — the alethic character, the épistèmic consideration and the ontic constraint — encompass the most important issues of the theory, and together are known as the *archic canon* of relativism [Margolis, 1991: 3].

If truth really is relative, and all points of view equally valid, as relativists claim, then it makes sense that there would be a large number of differing types of relativism, each as 'valid' as the next, for no one theory (of relativism) could claim to be 'more correct' than the next. Of the types of relativism discussed below, all arose from either a strong connection with, or a strong rejection of, the archic canon.

2.3.5.1 *Cultural relativism:*

Cultural relativism, as it is called, is derived from contextualising the archic canon. Proponents of this type of relativism believe that because people perceive things differently from within their differing cultural frameworks, it is not correct to claim a universal truth or absolute, for truth will differ for each person because no two people's cultural and sociological backgrounds are the same [Margolis, 1991: 14]. If two or more people happen to agree on some truth, cultural relativists claim that this is only because they have reached agreement out of some common interest or for some common goal.

Truth, therefore, becomes merely "a product of short-term localised consensus belief" [Norris, 1997: 1]. If, for example, two people believe that the earth is round, then they have merely both decided that it is best for themselves to believe supposed photographs from supposed scientific authorities.

2.3.5.2 Strong sociological form of cultural relativism:

There is also a stronger form of cultural relativism, put forward by Gaston Bachelard, known as the strong sociological form of cultural relativism. Bachelard claims that "scientific truth... [is] just the... title bestowed on those language games (or metaphors) that best fit in with the beliefs, social policy interests, or ideological self-images of the age" [Norris, 1997: 26].

This also implies that those in authority have the power to decide what these "self-images of the age" are, and therefore to decide what "scientific truth" is, although it is unclear whether Bachelard intended this form of relativism to have this effect or not.

2.3.5.3 Least form of relativism (LF):

This type of relativism also has a connection with the archic canon, in that it abandons what is known as the principle of excluded middle, or (in formal logic) the law of bivalence. Certain concepts that do not make sense without an understanding of their opposites — such as 'up' and 'down' — form a "conceptual polarity" (with their opposites) [Honderich, 1995: 691], and are known as bipolar oppositions. In the law of bivalence, bipolar oppositions are applied to truth-values, such as 'true' and 'false', where there can be no other option between the polar opposites. Therefore, something is either true or it is false; there is no third option, no *middle* way. This is known as the law of *excluded middle* [Honderich, 1995: 257; Margolis, 1991: 18].

In the least form of relativism, (LF), this law is done away with, making room for many-polared truth-values. Something need not be merely 'true' or 'false', it can be 'true for me', 'true at such-and-such a time' etc.

2.3.5.4 Protagoreanism:

Protagoreanism, after the Greek philosopher Protagorus, integrates the least form of relativism, which abandons the principle of excluded middle, with a strong rejection of the archic canon [Margolis, 1991: 18].

2.3.5.5 Subjectivism:

The subjectivist claims, "whatever seems to me to be true is true, and whatever seems to you to be true is true" [Kirk, 1999: 37]. But this is impossible, for if what is true for one person is the opposite of what is true for another person, contradiction occurs.

For example: I believe that the earth is round. Someone else believes that it is flat. It seems round to me; therefore, according to subjectivism, it is round. But it seems flat to the other person, and therefore must be flat, according to subjectivism. This is a contradiction. The world cannot be both round and flat. Logically, there cannot be contradictions.

Protagorus' answer to this problem was what he termed "true-for-me" relativism. This is simply: there is "no such thing as truth full-stop; ...only truth for people at times" [Kirk, 1999: 38]. So the earth is not necessarily round or flat, its roundness or flatness is not truth *per se,* because this does not exist; rather, the statement 'the earth is round' is true *for me,* or for *most educated people,* etc.

But if one is to attempt to take Protagorean "true-for-me" relativism seriously, one comes across a glitch in this theory. If the statements 'it is true for X that the earth is round' and 'it is true for Y that the earth is not round' are both true, then it appears that there is disagreement over facts (about the earth). For if it was merely what each person *believed* about the existence and shape of the earth, then the matter would merely be one of differing tastes.

The disagreement over facts implies a distinct *realist* attitude towards the existence and shape of the earth; i.e. they do not depend merely on what one *believes* of them. Therefore, what is true *is* independent of what one believes [Kirk, 1999: 41-43], and Protagorus' "no truth per se" falls flat, along with his type of relativism.

2.3.5.6 *Strong and weak relativism:*

Lastly, it is important to distinguish between strong and weak relativism. The underlying relativistic scepticism at what 'evidence' can do for what one believes to be true remains the focus, but the intensity of that scepticism differs. Weak relativism maintains that evidence can *sometimes* not allow or help one to choose between certain opposing theories, whilst strong relativism purports that evidence can *never* allow or help one to choose between *any* pair of opposing theories [Laudan, 1990: 55-56].

In the light of the journey of knowledge on which we have embarked, what does relativism entail for attempts at describing the world? The modernist social order, that of prediction and control, falls away with postmodernism; for none can say their order is the correct or best kind of order. Order is not *a priori,* and there are therefore an infinite number of models of order to choose from [Bauman, 1987:4]. No one is more 'right' than any other one.

If truth is governed by what one believes, and what one believes depends on a specific frame of reference, who gets to supply that frame of reference used to describe the world? If the answer, generally, is humans, then this would imply that humans share a common frame of reference, and the base of relativism collapses.

If it is a government, society or group that provides this frame of reference, then not only is the ordinary man's truth being prescribed for him, but the agenda of the group is bound to affect its view of how the world is and what truth should be.

If, however, every individual is to decide for him-/herself what the world is like, then it stands to reason that there would be any number of conflicting views of the world, for the way one sees the world depends on one's experience of it, and conflicting experiences would lead to conflicting representations of the world [Ayer, 1982: 3, 251].

As Protagorus said in the fifth century B.C: "... [our] opinions... are always personal and ... based upon... [our] immediate sense perceptions" [Avey, 1954: 18]. Therefore, how one represents the world is based on one's experiences of the world, and those experiences are based on one's (individual) perceptions of it.

It may seem logical, then, to ask how one decides which one is accurate, but the question is misguided. None of these representations of the world could be accurate, for, in the end, they remain *representations* [Ayer, 1982: 251]. And to return for a moment to the archic canon; *if* man can glean the truth about the world, and *if* that world is and remains unchanging, then to say that "truth" means only that which is true for a certain perspective is preposterous! For if one can know the truth about the world, and it is unchanging, then surely one has arrived at some kind of knowledge which is true irrespective of one's framework or point of view.

It appears, then, that relativism has 'shot itself in the foot', so to speak, right at the beginning of its attempt to legitimise itself [Margolis, 1991: 3].

Relativists do not believe in absolute truth (or any absolutes for that matter), and consider reality to be contingent and immanent [Saugstad, 2001: 2,3]. For, (as Ferdinand C.S. Schiller said), man can only ever form an opinion (on something); nothing is ever absolute or final, for the perspective of the experiencer of truth affects his/her view thereof [Avey, 1954: 244].

The problem with this view is that if everything really is just a 'matter of opinion' (which is of course based on one's frame of reference) then all views *are* really equally valid, and *nothing* is preferable to anything else [Laudan, 1990: 162-163]. *"To rape is always good"* then becomes just as true and valid a statement as *"rape is wrong"*, for example; and the realist's view that *"relativism is false"* is just as true as the relativist's insistence that *"relativism is right"* [Westacott, 2001: par. 1].

Also, the relativism defence statement *"there is no absolute truth"* is surely an absolute in itself [Avey, 1954: 242]; and the statement *"persons exist independently of what anyone may think"* is true no matter whether anyone believes it or not. But if the relativist refuses to take this (above) statement as truth, then he considers himself the only intelligent being there is, and falls into solipsism [Kirk, 1999: 44].

So whilst it may be a noble ideal to never privilege one particular viewpoint above another, clearly, the above problem illustrates that not all contradictory viewpoints can be equally valid, and when one insists on no absolutes, one finds oneself committing precisely the error of absolutes one wishes to eliminate.

For a matter of interest, is it really possible to live without absolutes? If knowledge is truly dependent on one's perspective [Saugstad, 2001: 2], what happens to morality? Man will be able to act as unethically as he desires, and simply blame it on his viewpoint! A world without some form of control or guidelines that work in many situations tends towards anarchy, and although man is free to change them when they no longer work, it is still vital that they be in place whilst they do work.

And although many of these guidelines may be specific to a particular context, is it not possible that there are at least some that may be applicable everywhere? Whether or not there are remains to be seen, and may also be subject to individual opinion, but the *possibility* that some absolutes do exist, still remains.

It is unlikely, therefore, that philosophy (be it postmodernism or something else) can do without some kind of universal principles or absolutes [Morawski, 1992: 54]. This would be to destroy itself, its people and the world.

So how, then, does a postmodernist choose what is best for any particular circumstance? By evaluating the possibilities against criteria set up for that particular circumstance. One cannot evaluate what lies outside the boundaries of the tradition or framework

[Cornell, 1992: 70] in which one is; therefore, only the specific tradition or case is important and relevant at that time.

In this way relativists are *similar* to postmodernists. Both do not believe in "universal exceptionless truths" (absolutes) [Margolis, 1991: 20, 195], and both believe that meaning is in some way determined by interpretation. But postmodernism is *not* relativism. It is merely context-specific. This does not mean that "anything goes". It means that each individual case or phenomenon must be judged on its own merits, the merits of its particular context.

But if relativism *is* true, what is to become of the notion of scientific development? Is it progress or merely change? If one is directed to such an extent by one's cultural, sociological and physical environment, how can one ever be sure of any kind of objectivity?

According to the relativist, one cannot. Science is not absolutely objective; it is "a social and human activity" [Laudan, 1990: 147]. Lakatos said: "The direction of science is determined primarily by human creative imagination and not by the universe of facts which surround us" [Laudan, 1990: 55; footnote 6]. This, however, only indicates that science progresses through creative imagination, not that there are no objective "facts" at all. In fact, Lakatos may even have been supporting the notion of objective facts actually existing. Whichever way, science cannot claim to be absolutely objective, or there wouldn't be any disagreement, change or progress in science at all.

It is possible, however, to claim that science is "quasi-objective" on many matters, and there is much that it can teach us, as long as the human subjectivity of it is also acknowledged, and recognising that it is not absolute.

Philosophical postmodernism (as a discipline) does not embody any single point of view [Beck, 1993: par. 7]. There are many different types of postmodernism, and, as indicated above, many different views on what postmodernism is. The postmodernism endorsed by this author is one that liberates society from some of the constrictions of modernism, whilst still retaining *some* form of stability and organisation (for the sake of civil peace); and that promotes acceptance, diversity and creativity whilst still emphasising knowledge and progress. It is a "wake up call" for every person living today, to respect and accept all others, but not to give in to the pressure of conforming or the self-satisfaction of complacency.

2.4 Conclusion:

So modernism was (is) a systematic and reasonable way of thinking [Degenaar, 1993: 53]: a foundation of linear, temporal and progressive logic — governed by that all-human faculty of Reason — that replaced traditional mystical thinking. Modernist science is rational, empirical and technological, with a focus on uniform, purposeful and universal progress [Gane, 1991: 92].

This is reflected in the functionality of modernist architecture. Man has become self-aware, and what is seen as true knowledge is that which can be verified empirically, and reasoned rationally. Modernism also affected society and culture, making it more autonomous, democratic and also dehumanising. As people became 'things' they began to rebel, and search for new ways of creating individual meaning.

Postmodernism, therefore, initially arose out of a frustration towards the dehumanising effect of modernism. A tradition of plurality and tolerance fosters a culture of individual creativity, where otherness is celebrated, and cultural freedom is developed [Degenaar, 1993: 53]. Relationships become all-important; be it one's relationship with friends, family, the community, work, the system or society as a whole. Man recognises and acknowledges the "complexity of things", and realises that reason is not "all-supreme" [Degenaar, 1993: 53].

A fragmented and subjective logic produces a science of hyperreality; a simulation governed by synthetic, aesthetic, dynamic reason. Knowledge in a postmodern world is not that which can be verified or studied; rather, it is whatever the simulator says it is.

Much of what one regards as true one accepts merely because one read it in a magazine or encyclopaedia, or saw it in the media. The simulator's simulation has become more important than what really is true.

But what does *"modern"* actually mean? For consumers, and especially those who market and sell to consumers, to be modern means merely to be new. It is *"le dernier cri"*, or the latest thing [Toulmin, 1990: 5; Eagleton, 2000: 83]. It could, therefore, be possible that modernism never really died out, never really passed. Did postmodernism ever actually *replace* modernism? Modernism and postmodernism are connected. Modernism can also be seen as complex, as changing with each discipline and context [Taylor, 1992: 12].

It could be that man is now in an era where modernism and postmodernism are both present, and both influence the way society and the individual run their lives.

Is this then how it should be? Should society nowadays be built around a culture that incorporates the best of the modern, postmodern and even pre-modern worlds, whilst striving to eliminate the mistakes of these eras?

Perhaps.

But is this the way contemporary society is moving? It does not appear so. The liberty and autonomy given to man (through modernism) to realise "human realities, goals and desires" [Milbank, 1992: 30] was (ideally) intended to bring freedom, rationality and progress. And the loosening of modernity's restrictive bonds was at least partially supposed to breed creativity, independence and free thinking.

Unfortunately it seems that most people's idea of a postmodern world involves more control, more freedom (for themselves) and more taking. Essentially, more ME. And if each person is his or her own God, society is in for a titanic battle for ultimate control of the world.

There are many that believe that the postmodern condition is merely a collection of many fragmented discourses where anything goes, for where the individual is central, each could claim (the most) importance to their local discourse, and no one could challenge or oppose the claim of the next.

It may be possible to see postmodernism as a free-for-all if one views the postmodern individual as its most important component. But this is not entirely correct. It is not the individual that is important, but the relationship. The relationship he/she has with other individuals, the system, his/her work, environment, him-/herself. Focus on the relationship and it is impossible for "anything to go", for relationship implies consideration.

Also, in the postmodern society, one is always involved in some kind of network. One discourse is always linked to many others, which are dynamic and interacting all the time. Each individual is part of this network, part of many different patterns of thought and action. Never isolated, never static. Always richer.

In the chapters to follow, how modernism and postmodernism relate to two major phenomena — chaos and complexity — will be investigated. Whether or not these two phenomena can be called modern or postmodern is an important feature of the comparative nature of this thesis, hence the discussion of modernism and postmodernism above.

Therefore, it now becomes necessary to take the next step on the road of intense and exciting discovery. The world of *chaos* is the next stepping stone on our quest towards knowledge and understanding.

Chapter 3 : Chaos

3.1 Introduction

Most people desire at least some form of order in their lives. If there is none, they (often) create it [Back, 1997: 50]. Indeed, it would not be possible for a society to exist — where people must coexist — if there were not at least some rules governing behaviour.

A society can be seen as an example of an adaptive system. These systems can display different types of behaviour, such as order, complexity and chaos. Chaos theory examines the surprising behaviour some systems display when they reach certain points. All of these (above) types of behaviour displayed by adaptive systems are important when one considers the process of acquiring knowledge. Because knowledge is also a type of dynamic system, one must understand the different behaviours dynamic systems can produce, in order to understand how man acquires knowledge. One must be aware that dynamic systems can display distinctly different behaviours.

At times, though, it becomes difficult to distinguish between certain behaviours or distinctions, such as random and pattern, limits and delimits, inside or outside of boundaries. It was (is) a predominant characteristic of modernism that strove to keep these distinctions separate. But many people are becoming increasingly aware of the fact that it is not always possible, nor desirable, to keep these 'opposites' separate.

Sometimes, a phenomenon can be both of two different opposites, depending on the perspective of the observer. For example, the detail of cloud formations may seem random when viewed up close, but if one sees them from a distant position (such as the ground), one can often perceive them as forming distinct patterns.

The above distinction — random vs. pattern — can at times be reversed, or even dissolved entirely. It is therefore not always necessary for these distinctions to be mutually exclusive; sometimes they may exist together, simultaneously. Cloud patterns can be both random and patterned, depending on one's viewpoint. It is important to realise that many phenomena cannot simply be defined, categorised or labelled and then put away in a 'box' of similar things. Many phenomena fit into multiple 'boxes' and should not be regarded as merely an instance of 'this or that'.

Similarly, chaos cannot be put in a box, cannot be limited in that way. If one tries to understand it in such a way, one will surely fail, for "where chaos begins, classical science stops" [Gleick, 1987: 3].

There are many examples of systems with chaotic characteristics around us constantly: the weather, the behaviour of cars on a highway, hurricane patterns on radar, the swirls of a mountain stream, uncontrollable patterns of rising smoke, stresses that lead to war, and so on [examples Gleick, 1987: 5; and Devaney, 1990: 151]. That is why an understanding of chaos and how it works can be so important for so many different fields of study.

It may one day be possible to predict future behaviour more accurately than is now possible, by better understanding the behaviours of the systems involved. If sociologists can understand why cars on a highway behave in a particular way, they may be able to prevent accidents. And if the stresses that eventually lead to war can be fully understood, (understanding) chaos may actually prevent wars in the future.

However, because of the nature of chaos and chaotic behaviour, it is important to remember that it is not possible to predict the behaviour of a system displaying chaos entirely. Chaos theory shows that it is only possible to predict this behaviour up until a certain point, after which the number of possible states of behaviour become too great.

How is it possible that simple laws can explain complex behaviour? The phenomenon of chaos sheds some light on this question. Chaos is also merely a framework, a way of viewing the world we live in. In attempting to understand chaos, one can equip oneself better for the greater task of understanding knowledge itself. If chaos can provide one with a workable background for understanding the nature of knowledge and what it means to have it, then one is one step closer to finding out just what human knowledge is.

The discussion begins with a look at the rise of chaos from a historical point of view — it usually helps one's understanding of a new subject if one can see a timeline of its development — and then progresses to introductory remarks about chaos: what it is and what is necessary for its existence. After the basics are understood, one can move on to the in-depth science pertaining to the phenomenon of chaos and its applications.

After studying the science and concepts of chaos, one can judge for oneself the strength of this theory as a context for obtaining and understanding knowledge. Whether or not one is more equipped to "understand" after studying chaos remains to be seen.

But first, one must become acquainted with chaos.

3.2 History

Most of the investigation into the phenomenon of chaos has been fairly recent, although scientists have been paving the way towards its discovery for a number of centuries.

When Newton and Leibniz developed calculus in the middle of the seventeenth century [Guastello, 1995: 11], they unwittingly placed (mathematical) scientific investigation on a path headed for chaos, for with the tools of calculus, mathematicians were able to address most problems — until they came to prediction.

They discovered that calculus (and with it conventional mathematics) helped for only certain problems of prediction, and did not appear to work for others at all. Without knowing it, they had come up to the borders of chaos.

In ancient Greek philosophy there was a theory (or a belief) that all events — everything that happens — are effects of a chain of earlier events. Around 1500 this came to science as the theory of *determinism* [Mendelson & Blumenthal, 2000: par. 2]. Cause and effect rules became one of the most important principles of science.

Sir Isaac Newton's laws were deterministic, and therefore able to predict quite accurately the behaviour of (deterministic) systems. His laws were based on the belief that everything that happened would be based wholly on what happened just before [Mendelson & Blumenthal, 2000: par. 2].

Determinism was an important scientific theory, because it showed how events could be causally linked together. Every link (cause to effect) in the chain is solid [Honderich, 1995: 194], and every choice, result and action is the inevitable effect of earlier causes [McLeod, 1986: 232]. This means that all choices are already determined, and should be able to be predicted.

So, if a system is deterministic, it means that if the initial conditions (values describing the system at a certain time [Korsch & Jodl, 1994: 303]) of that system are known, then its future states can be predicted with relatively high accuracy. In other words, if one knows the precise conditions that were present at the beginning of some system's behaviour, then future behaviour of that system can be calculated accurately [Schuster, 1995: 1; Mullin, 1993: xi].

In the early nineteenth century, Laplace's belief that the movement of all physical bodies could be expressed by equations [Guastello, 1995: 11] reintroduced determinism as a strong scientific movement.

In the late nineteenth and early twentieth centuries, French physicist and mathematician, Jules Henri Poincaré, was working on a problem called the three-body problem of astrophysics: how to determine an object's path when it is influenced by three gravitational forces (its own and that of two other objects or bodies in proximity) [Murzi, 2001: par. 6]. These three objects form a system, because a change in any one of them affects the other two. The system is also deterministic, because the initial positions and velocities (speeds) of the objects can be calculated[3] [Murzi, 2001: par. 6].

Poincaré discovered that, in some instances, a minutely small change in the initial position of one of the objects could lead to a hugely different later state than was predicted (without the small change). He called this phenomenon *chaotic determinism* [Murzi, 2001: par 6].

A physicist by the name of Ludwig Boltzmann used the phrase *"molecular chaos"* as a physical term over one hundred years ago [Bai-lin, 1997: 133]. This was most probably the first time the word "chaos" was used to describe something non-regular, yet ordered. By the turn of the twentieth century, physics was very close to discovering chaos, because of scientists investigating problems such as the three-body problem of astrophysics, turbulence, and solar system stability [Bai-lin, 1997: 133]; all of which could not be satisfactorily explained by mere determinism alone.

In 1961, a meteorologist by the name of Edward Lorenz was working on the problem of weather prediction. He had a computer that used three equations to model what the weather (theoretically) might do [Chaos Theory, 2002: par. 2], and printed sequences of numbers as output. One day, Lorenz wished to see a certain sequence again. He entered the applicable number off the printout into the computer — 0.506 — and left for an hour.

When he returned, he found that the sequence had diverged from the path of the original [Chaos Theory, 2002: par. 3,4], growing more and more different, until after some time, it was almost impossible to see the similarities between the new sequence and the original.

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[3] And the law of gravity is constant. Both these conditions must be met for the system to be deterministic.

In the computer's memory, the numbers were stored to six decimal places, but to save space, Lorenz only had the computer print the first three decimal places. The actual number of the original sequence was 0.506127 [Chaos Theory, 2002: par. 4], a mere one hundred and twenty-seven millionths more than what Lorenz typed in for the new sequence. He had expected the sequences to at least run very similarly — as most scientists would have. Accuracy of three decimal places — thousandths of a unit — is almost impossible to measure, and so surely the fourth, fifth and sixth decimal places couldn't have more than a minuscule effect on the result [Chaos Theory, 2002: par. 5].

What Lorenz discovered is one of the most important properties of chaos: very small changes in the initial states of a system can have huge effects on its future states.

This came to be called the butterfly effect [Chaos Theory, 2002: par. 6]. Initial differences such as Lorenz discovered are often so small that they can be compared atmospherically to the flapping of a butterfly's wings [Chaos Theory, 2002: par. 6]. Given enough time, this difference could actually change the atmosphere, and eventually cause a huge atmospheric disruption — such as a tornado — that wouldn't ordinarily have happened, elsewhere in the world [Ian Stewart, quoted in Chaos Theory, 2002: par. 7].

It is, of course, also possible that the energy of the butterfly's wings could dissipate and have no effect on the atmosphere whatsoever (or some effect between nothing and a tornado). This is a mark of chaos: it is not possible to know accurately what effect could occur.

In scientific terms, this feature of chaos is known as *sensitive dependence on initial conditions* [Cohen & Stewart, 1994: 191]. If one could know the initial state of a phenomenon *precisely,* then one could predict its future state entirely [Campbell & Mayer-Kress, 1997: 23]. Prediction implies that one can know the future with *the same certainty* as knowing the present [Saperstein, 1997: 103].

Prediction has been the problem facing many scientists in a wide range of fields, from meteorology to medicine, ecology, engineering and even behavioural science, for many years. For a long time it was believed that if one could measure initial states with a relative degree of accuracy, one would get relatively accurate results, i.e. one could predict future states with relatively high accuracy.

This was believed because scientists were working mainly with linear systems, where the response to any change in a system is proportional to the size of that change [Korsch & Jodl, 1994: 304]. In other words, if one were, for example, following a simple recipe for biscuits, and one doubled the amount of ingredients, then one would get double the number of biscuits at the end (all other things constant).

This principle works fairly well for all linear systems, and even some (weak) non-linear ones, and the results scientists achieved substantiated this belief. A small difference between the starting conditions of two experiments caused only a minor difference in their outcomes [Campbell & Mayer-Kress, 1997: 23], and it was believed that these initial differences were negligible.

By the 1970's there was much more scientific inquiry into instances of disorder and irregularity worldwide than there had been previously. Look out of a window, and try to find any straight line that is not man-made. Most naturally occurring structures are inherently non-linear, yet most descriptions or representations of these things tend to be with straight lines [Guastello, 1995: i].

This may be because linearity is much easier to deal with. But non-linearity gives a much more accurate description of most phenomena [Guastello, 1995: 3], and when scientists discovered this, and began investigating non-linearity, they began to discover order developing in many areas previously seen as merely randomly chaotic (i.e. *no* order whatsoever, totally random): the human heart, gypsy moth populations, stock price data, paths of lightening, clusters of stars, turbulence and many more [examples Gleick, 1987: 3-4].

They then began to investigate (stronger) non-linear systems — and the seemingly random phenomena some of them produced — more closely, but it was some time still before the world's scientists realised the implications of the butterfly effect. For prediction of more non-linear phenomena it meant that the initial states of such systems would have to be taken into account, and would have to be known with *infinite* precision. One would have to be infinitely certain of the initial conditions governing the system; only then could one expect a valid and accurate prediction. This is, however, not possible, as no instrument can measure with infinite accuracy, no person can measure a current state with an infinite degree of accuracy, and no mind can comprehend infinite certainty.

Take the following example of mathematical chaos: π = 22/7 or 3.1415978... and apply this working rule: "chop off everything before the decimal point and multiply by ten" [Cohen & Stewart, 1994: 191-192]. This will illustrate the necessity for precision.

If one takes π to be 3.14159, after applying the rule five times, one will have: 1.4159, then 4.159, 1.59, 5.9 and finally 9. If π is taken as 3.141597 (one more decimal place), one would get: 1.41597, 4.1597, 1.597, 5.97, 9.7 and finally 7 (after six applications). And if π is made one decimal longer, 3.1415978, then the following series is reached: 1.415978, 4.15978, 1.5978, 5.978, 9.78, 7.8 and 8.

Each of the above instances differs by only one decimal place, but each gives a completely different answer: 9, 7 and 8. This means that no matter how many decimals one takes, one will eventually be able to come to a different answer. This tiny change in the initial conditions of this mathematical system (π) means that one would have to specify π up to infinite decimals, to be sure of getting an accurate answer.

This is why prediction (amongst other things) has been so limited in the past, and why meteorologists' proficiency at weather prediction reaches only as far as a few days. This is an important philosophical consideration of chaos [Ruelle, 1997: 99]: it means that without infinite precision in initial conditions, (long-term) prediction evades our grasp.

Edward Lorenz, in 1961, had discovered the principle of sensitive dependence on initial conditions — the most important feature of chaos [Sakai, 2001: 2] — quite by accident, and in so doing, (perhaps unwittingly) opened the doors to the uncovering of the most recent of the great scientific discoveries: the phenomenon of chaos.

3.3 What is Chaos?

When one hears the word "chaos", one usually thinks of the dictionary definition of chaos, something indicating *"complete disorder", "utter confusion"* [McLeod, 1986: 141; Glass, 1997: 220; OED, 1989: par. 8 *"chaos"*], or *total randomness,* because that is what is conventionally understood by the word. This is, however, not what the science of chaos refers to.

Chaos is not disordered, nor is it entirely random either. It is therefore not surprising that there has been much confusion about the nature of chaos, and also why many scientists are wary of using the word "chaos", preferring terms such as *"non-linear dynamical systems theory"* (NDS) [Guastello, 1995: 3]; *"non-periodic, deterministic flow"* [Kendall et. al., 1997: 198]; or *irregular, deterministic, complex phenomena* [Mayer-Kress, 1995: par. 1].

The term "chaos" was first used to describe phenomena that appeared to scientists to be totally random, without order, i.e. *chaotic.* Only later, once technology had improved sufficiently to allow non-linear systems to be observed and analysed properly, did scientists realise that what they had been calling "chaos" was in fact not chaotic at all; rather, it was highly complex behaviour that stuck to certain deterministic rules. But because the movement of chaotic systems is "complicated and irregular" [Ruelle, 1997: 99], it is not surprising that scientists viewed it as strange, disordered, and... chaotic.

So what is this complex phenomenon called chaos? Simply put, chaos is the "behaviour of a system which is governed by deterministic laws but is so unpredictable as to appear random, owing to its extreme sensitivity to changes in parameters" (initial conditions) [OED, 1989: par. 19 (under heading *chaos*)].

Chaos is the "science of the global nature of systems" [Gleick, 1987: 5]. A system can be anything involving two or more elements that interact with one another, and having a clearly defined boundary (governing what is inside or outside the system).

Take again, for example, the three-body problem of astrophysics: how to determine an object's path when influenced by three gravitational forces (its own and that of two other objects or bodies in proximity) [Murzi, 2001: par. 6]. These three bodies can be seen to form a system, for they interact with one another — i.e. changes in one body have effects in the others — and the system's boundary can be defined (meaning merely that it is possible to know what is inside this system, and what is outside it).

Chaos occurs in *dynamical systems*. The elements of a *dynamical* system must not only interact with one another, they must also be interdependent with one another [Stroup, 1997: 126-127]. This is because of the second important factor of dynamical systems. They must be able to adapt to changes in the environment. A dynamical system has what is known as the capacity to self-organise. If some kind of external stress from the environment causes change in the system, the system has the capability to reorganise itself and its elements so that it can adapt to the external change. This involves not only returning to some sort of stable state, but also incorporating the effects of the change so as to "learn" from them.

For chaos to occur, the system must display four key factors: sensitivity to initial conditions, non-linearity, self-organisation and iteration. The first three of these have already been discussed. If a system is sensitive to initial conditions, very small changes in these initial conditions can increase exponentially, resulting in tremendous, drastically disproportionate effects [Sakai, 2001: 2].

For a system to be non-linear, initial changes must cause disproportionate results [Elliott & Kiel, 1997: 66], often surfacing as discontinuous, sudden changes in the system's behaviour [Gleick, 1987: 8]. This is of course included in the first factor, as a system cannot be sensitive to initial conditions unless it is non-linear [Mullin, 1993: x; Korsch & Jodl, 1994: 300].

Non-linearity of a system implies non-periodicity [Gleick, 1987: 22; Glass, 1997: 220]. This just means that the behaviour of the system in not regular or recurrent [Mendelson & Blumenthal, 2000: par. 5]. In other words, it does not repeat exactly the same behaviour after a certain amount of time.

To illustrate what periodic means, take the above-mentioned working rule for mathematical chaos and apply it to: 1.2121212... From the second application onwards, the results oscillate between 1.21212... and 2.1212. This kind of oscillation means the system is periodic [Cohen & Stewart, 1994: 192].

Any non-periodic system — such as weather, animal populations or epidemics [examples Gleick, 1987: 19-22] — can lead to unpredictability. For weather, for example, relatively accurate prediction is only possible up to a few days. After that, the "uncertainties [of the butterfly effect] multiply" [Gleick, 1987: 20-21], and prediction becomes impossible.

Yet through the seeming randomness of weather, there runs a fine line of structure and order. This is characteristic of chaotic systems, and is what makes them so difficult, yet intriguing, to study. Systems that appear random, yet have a definite structure [Ueda, 1997: 325; Sakai, 2001: 2; Korsch & Jodl, 1994: 300; Mullin, 1993: x-xi], but still remain constantly one step ahead of man's best attempts to understand and predict them.

The capacity of a system to self-organise and adapt to environmental changes is a very important factor of a dynamical system; for a system to be able to learn from the environment and adapt accordingly [Lee, 1997: 20] makes it a much more robust system, and therefore this is the most difficult part of dynamical systems to understand and recreate.

The fourth and final criterion for dynamical systems is iteration, or feedback. This is when some part of the system (which could be called output) loops back to be used again (as input) [Stroup, 1997: 126-127]. In other words, at some point, the system produces some information that is then *fed back* and used at some other point in the system. This is the same as what is known in mathematical terms as recursion. Certain future states of the dynamical system depend on earlier (or *an* earlier) state or states [Eve, Horsfall & Lee, 1997: xxix].

Self-organisation of a dynamical system can also be defined as a "natural process whereby feedback loops within a complex system give rise to non-linear behaviour" [Guastello, 1995: 12]. And this non-linear behaviour is known as chaos. It is therefore often difficult to know precisely which dynamical systems will lead to chaos [Eve, Horsfall & Lee, 1997: xxix].

3.4 The Science of Chaos

Now that the basics of chaos theory have been covered, it is time to progress to the substance of the subject. This section is much more technical, and though it may be complicated at times, a detailed knowledge of chaos theory is necessary for an understanding of what this phenomenon chaos is and how it works. For to acquire adequate knowledge of a subject, one must study it in detail.

After Edward Lorenz discovered the principle of sensitive dependence on initial conditions, he started looking for other non-linear systems that might display the same sort of chaotic or deviatory behaviour [Chaos Theory, 2002: par. 10]. He decided to investigate fluid turbulence, by stripping convection equations down until they were unrealistically simple, and he discovered that convection could lead to chaotic behaviour at high enough temperatures [Gleick, 1987: 25].

Convection

When fluid (for example, water) in a box with a smooth bottom is heated from below, the hot water will attempt to move to the top (because heat rises), but the fluid's viscosity will keep it at rest. The system is stable, at thermodynamic equilibrium; this means to stay in the same steady state, and if some external disturbance forces a change in the system, it will eventually return to that state of equilibrium [Gleick, 1987: 26].

If the heat is turned up, the fluid will expand as it becomes hotter, and therefore become less dense, which will make it lighter. When light enough to overcome viscosity, the hot fluid will begin to rise. A convection roll (which resembles a cylinder) will start to form: hot fluid rising on the one side and cooler fluid sinking on the other (see figure 3.1 (a)). This is known as the process of convection [Gleick, 1987: 26]. There will most likely be more than one convection roll at a time in the box.

When the heat is turned up even more, the rolls start to wobble. As the hot fluid rises along the roll, it comes into contact with the cooler fluid, and starts to lose heat. If the roll is turning fast enough, the hot fluid will not have cooled down sufficiently when it starts to move down the other side of the roll, and so it will start to push back up against the hot fluid coming up behind it. This causes the instability that makes the wobble in the convection roll (see 3.1 (b)).

At even higher temperatures, this flow becomes chaotic (turbulent) [Gleick, 1987: 26]. This simple example of fluid turbulence, through convection, became the most universal example of chaos [Turcotte, 1997: 3].

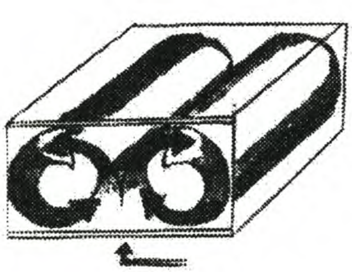

Figure 3.1 (a): Convection roll

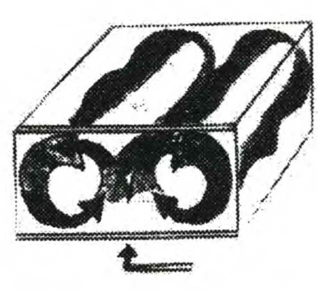

Figure 3.1 (b): Chaotic flow

Lorenz's stripped down equations did not exactly model real convection properly, they were too simplistic, but there was a real-life system that the equations did model: the

Lorenzian waterwheel [Gleick, 1987: 26, 29]. This is a waterwheel with buckets that are open at the top and have holes in the bottom.

Waterwheel

Water pours in at the top at an even rate. If the flow is slow, the top bucket never has a chance to fill up because the water runs out too fast. If the top bucket does not fill up, it will not become heavy enough to overcome friction, and the waterwheel will remain stationary [Gleick, 1987: 27].

If the flow is faster, the top bucket will start to fill up, and its weight will cause the wheel to start turning. As each bucket is filled, its weight will keep the wheel moving (in the same direction), with full, heavy buckets moving down the one side, getting emptier and emptier, and lighter, emptying buckets moving up the other side. The waterwheel will settle into this steady state (equilibrium) (see figure 3.2 (a)) [Gleick, 1987: 27].

But if the flow is increased further, the non-linearity in the system starts to have an effect. The buckets do not have enough time to fill up properly if the wheel is turning too fast, so they are not heavy enough to keep the wheel's momentum going. Buckets can also start up the other side before they have emptied enough. Their weight then will cause the waterwheel to stop turning, and change direction (see figure 3.2 (b)).

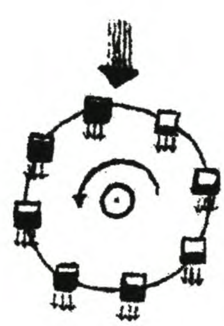

Figure 3.2 (a): Lorenzian waterwheel (equilibrium)

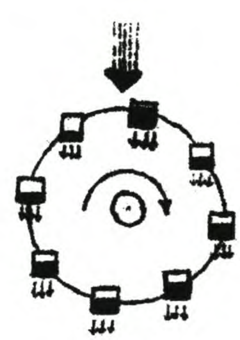

Figure 3.2 (b): Chaotic spin

Lorenz discovered that, over long periods of time, the waterwheel would change direction many times, not staying at a steady rate, but also not repeating itself predictably [Gleick, 1987: 27].

It appeared to Lorenz that his stripped down equations had led to completely random behaviour, but when he plotted them on a graph, he noticed that it was not entirely random. The motion of the waterwheel always stayed on the same double spiral, never intersecting its own path, but also staying within certain limits. The behaviour of the waterwheel was therefore definitely ordered, (not totally random), but it was a new kind of order, not a steady state (of motion towards a single point), nor periodic repetitiveness [Chaos Theory, 2002: par. 12; Gleick, 1987: 30-31].

Lorenz called this graphic representation (of the new kind of "orderedness") the "Lorenz attractor" (see figure 3.8).

3.4.1 Attractors and Repellors

The behaviour of a system involving chaos is greatly influenced by the attractors and repellors that exist in its space. An attractor, according to Korsch and Jodl (1994), is "a geometric object in phase space towards which [a system's] trajectories converge" — given enough time [Korsch & Jodl, 1994: 299].

There are four main types of attractors; however, only the first three (which concern discrete systems) will be discussed here. The fourth type of attractor concerns continuous systems, is quasi-periodic and leads to what is known as a toroidal attractor.

3.4.1.1 Fixed-point attractor:

When a system's behaviour or motion tends towards a steady state or constant value [Guastello, 1995: 13], that value is known as a fixed-point attractor. This can be either a radial type (which attracts all trajectories towards the centre), or a spiral type (where the system's trajectories spiral inwards towards the fixed point) [Guastello, 1995: 13; Gleick, 1987].

If, for example, one held a rubber tube such as the inner tube of a bicycle motionless with a ball bearing on the inside, the ball bearing would be at rest at the lowest part of the tube. Should one move the tube, however, the ball bearing will always eventually come back to rest at that lowest point of the tube (see figure 3.3). On paper, all the ball bearing's trajectories would tend towards that lowest point — an attracting fixed point of the radial type (see figure 3.4).

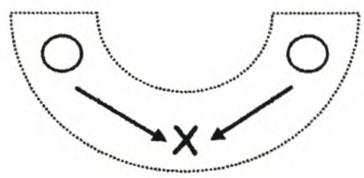

Figure 3.3: Motion of a ball bearing in an inner tube [example Mullin, 1993: xi-xii]

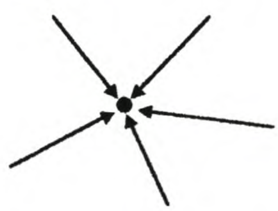

Figure 3.4: A fixed-point radial attractor

Another example of a fixed-point attractor is the motion of a pendulum [Gleick, 1987]. A pendulum appears to repeat the same motion over and over again: one side to another, and then back again. But although this motion appears periodic, the pendulum does not follow exactly the same path each time. Because of friction, its speed will be a little less each time, and the distance it travels will also be a bit less each time.

If one plots the motion of the pendulum (as it swings back and forth) on a graph, each point representing the pendulum's distance travelled and velocity (speed) at a particular time; as it starts to move (position A, see figure 3.5), its velocity is zero, and its position is maximum distance (to the left of the rest position, where the distance is zero).

At position B, the distance is zero (rest), and the pendulum's velocity is now at a maximum (because gravity has pulled the pendulum ball down as far as possible). The pendulum's momentum then keeps it going up (against gravity) until position C, where its distance is again maximum (to the right of rest), and it slows down to a velocity of zero (gravity is winning). Here it turns around and moves back through position B to position A.

The pendulum's motion from C to A will only mirror that of its motion from A to C if there is no friction at all. In a real case, friction causes the pendulum to lose a bit of velocity and distance at each section of its motion, and so the trajectory is a spiral (not a circle), where all motion tends towards the stable state of no motion at all — a spiral type fixed-point attractor (see figure 3.6).

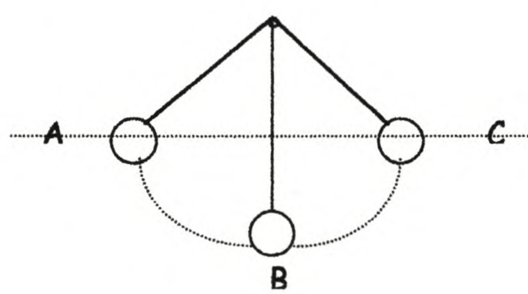

Figure 3.5: Motion of a pendulum [example Gleick, 1987]

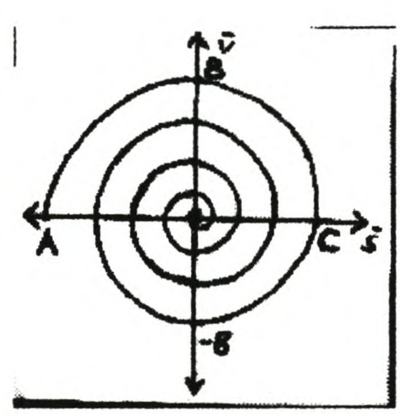

Figure 3.6: A fixed-point spiral attractor

Fixed point attractors are very predictable, and are hardly ever found in human systems [Fitzgerald & Eijnatten, 2002: 412].

3.4.1.2 Limit-cycle attractor:

The second type of attractor is known as a limit cycle. This is an attractor that keeps an object in orbit around its centre [Guastello, 1995: 14]. To return to the ball bearing and tube example; if one were to place the tube (with the ball bearing inside) in the centre of a level turntable that is turning at a constant speed, the ball bearing inside the tube would follow a fixed route around the middle of the turntable. If one were to draw this route on paper, it would resemble an ellipse around the centre-point of the turntable (see figure 3.7). This (route) is known as a limit cycle.

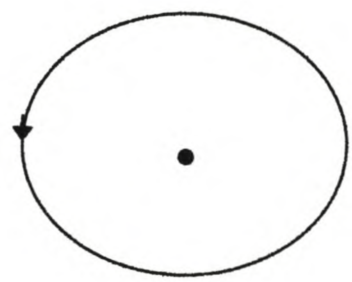

Figure 3.7: A limit cycle attractor [example Mullin, 1993: x-xi]

3.4.1.3 Strange or chaotic attractor:

The third kind of attractor is called a strange or chaotic attractor. This is "a complex geometric object in phase space towards which chaotic trajectories move" after sufficient time [Korsch & Jodl, 1994: 306]. These trajectories never repeat themselves, but are definitely ordered, and do stay within certain limits [Guastello, 1995: 16-17; Mullin, 1993: xii]. Strange attractors are highly unpredictable [Fitzgerald & Eijnatten, 2002: 412], can be generated by simple, deterministic equations, and display the butterfly effect.

The term "strange attractor" was first used by Ruelle and Takens around 1971 during their work on turbulence. There are many different kinds of strange attractors, (see figures 3.9, 3.10 & 3.11); the above-mentioned Lorenz attractor is just one of them. The Lorenz attractor displays infinite complexity, and the two different wings represent different directions of spin (crossover from one side to the other; see figure 3.8) [Gleick, 1987: 31].

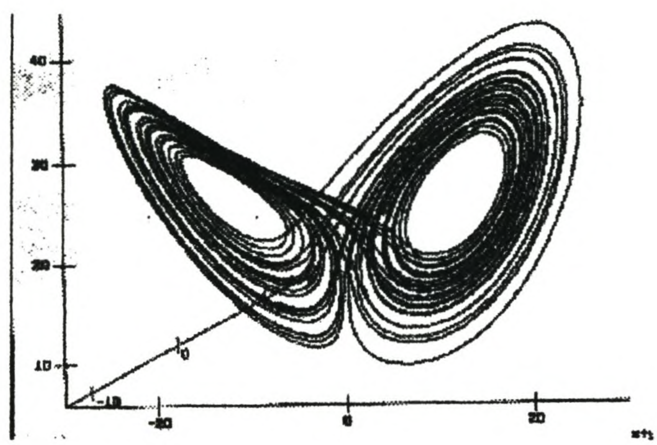

Figure 3.8: The Lorenz attractor

Figure 3.9: The Japanese (Ueda) attractor

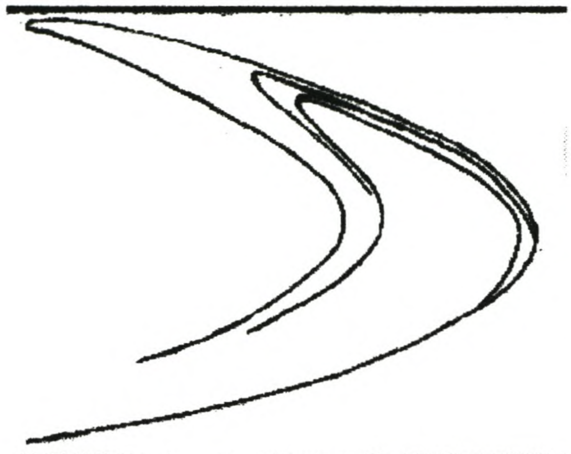

Figure 3.10: The Henon attractor

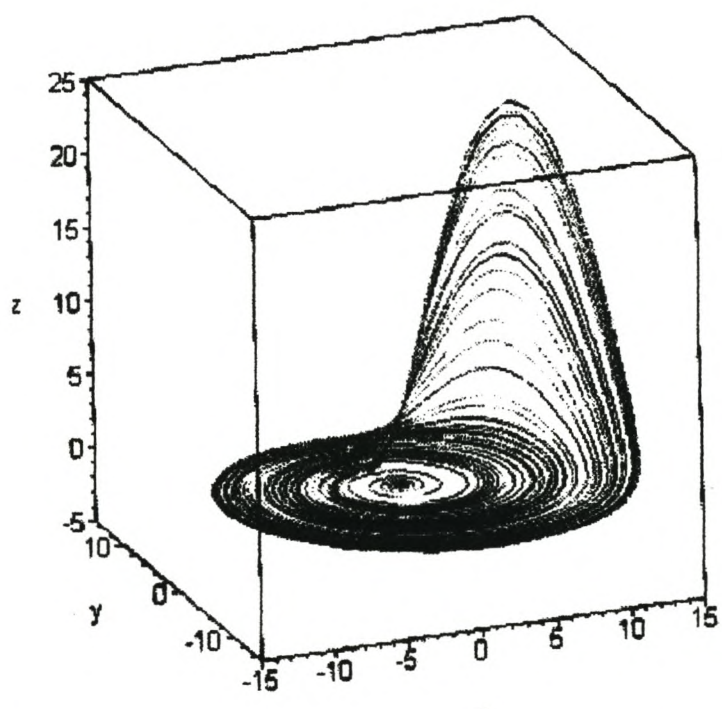

Figure 3.11: The Rossler attractor

The opposite of an attractor is called a repellor, and its range of influence is known as a separatrix. An attractor's range of influence is called a basin [Guastello, 1995: 13, 15].

It is possible for dynamical systems to have both attractor and repellors points, and some points can have both attractor and repellors properties, such as saddle points (see figure 3.12).

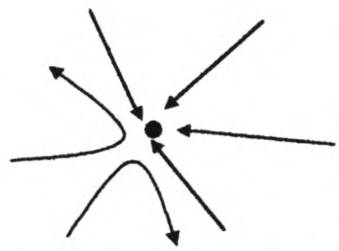

Figure 3.12: Saddle point

Systems can be classified as stable or unstable. Systems that are stable are unlikely to change. Stable means that they have low ***entropy***, or the rate at which information about a variable (of the system)'s predictability is lost, is low [Guastello, 1995: 22, 56].

Examples of stable systems include fixed-point attractors, limit cycles and chaotic attractors (as a whole). Unstable systems lead to change, which often causes unpredictable or non-repeatable results [Guastello, 1995: 22; Korsch & Jodl, 1994: 303].

Unstable systems (such as repellors, saddles and chaotic attractors (on a local level)) have high entropy. This means that it becomes increasingly difficult to predict what any one element of the system might do, and therefore more and more difficult to know what the system as a whole might do.

3.4.2 Bifurcation

In dynamical systems, the same kind of behaviour does not need to be present at all times — the elements of a system can display different behaviour at different times — especially if the system is unstable. If a system is unstable, it can reach what is known as a *bifurcation point:* a critical point beyond which "bifurcation" takes place.

Bifurcation is when a system's elements follow a common path (up to the bifurcation point), but then diverge into two or more directions [Guastello, 1995: 25, 26]. Bifurcation points are qualitative changes in dynamical behaviour. There are four types of bifurcation.

3.4.2.1 Subtle:

Subtle bifurcation is where one type of attractor or repellor turns into another. For example, a weak limit cycle can turn into a spiral repellor when agitated, or a point attractor can become a repellor[4] [Guastello, 1995: 25].

Another way in which subtle bifurcation can take place is when the system has regions or areas (called *terrains)* in phase-space occupied by both attractor basins and repellor separatrices, such as in catastrophe theory. This theory investigates those extraordinary areas in a dynamical system that lead to discontinuity and abrupt changes. Catastrophe theory is a model for the conditions under which these abrupt changes take place [Back, 1997: 48].

3.4.2.2 Period doubling:

The second type of bifurcation is where a limit cycle suddenly changes into a cycle of twice the period [Korsch & Jodl, 1994: 304]. A period is "the time taken to complete one cycle of a regularly recurring phenomenon" [McLeod, 1986: 627]; i.e. *periodically*. Beyond the critical point, where this occurs, the motion becomes chaotic.

3.4.2.3 Catastrophic:

The third type of bifurcation is called catastrophic bifurcation. This occurs when terrains that have different kinds of attractors and repellors (or combinations thereof) suddenly change dramatically. For example, in a terrain that contains a repellor and a saddle, a limit cycle can suddenly appear "out of the blue". This is known as a *"blue sky catastrophe"* [Guastello, 1995: 46-47].

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[4] This is known as the "Hopf bifurcation".

3.4.2.4 Explosive:

The last bifurcation type is known as explosive bifurcation. Terrains containing multiple attractors or repellors (or combinations thereof) change because of a variable in the system that is altered, and cause collisions that lead to explosive changes in the terrain.

A collision between a limit cycle and a repellor creates a point attractor; this is known as the *"annihilation dynamic"*. Collision between attractors in a terrain with a saddle, repellor and fixed-point attractor causes the saddle and the fixed-point attractor to disappear, and a limit cycle to form around the repellor — this is called the *"blue loop annihilation"* [Guastello, 1995: 46-47].

It is also possible for a system to change from one sort of behaviour to another. A system can go from periodic behaviour to chaos without going through increased bifurcation and period doubling [Guastello, 1995: 28]. Therefore, a dynamical system displaying chaos does not need to be restricted to one type of bifurcation, just as it need not be limited to one kind of attractor or repellor either.

3.4.3 Fractals

Dynamical systems demonstrating chaos will at some point display the characteristics that cause fractal structures. These structures are mathematical constructs caused by self-similarity.

As a physicist and mathematician, Poincaré at some time studied the distribution of stable and unstable points in phase-space. This distribution is so chaotic that he did not try to graph it. It was only when Benoit Mandelbrot, a mathematician working for IBM, began studying the phenomenon of self-similarity a century later that Poincaré's insights were developed [Murzi, 2001: par. 7]. Self-similarity is displayed when a system has within itself an exact replica of itself — magnify a part of it to a certain scale, and what is magnified is an exact replica of the whole [Korsch & Jodl, 1994: 305; Chaos Theory, 2002: par. 20, 29]. Mandelbrot discovered chaos in the fluctuation of cotton prices, and his Mandelbrot set[5] is probably the most famous of chaos images (see figure 3.13).

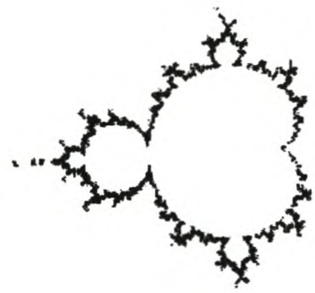


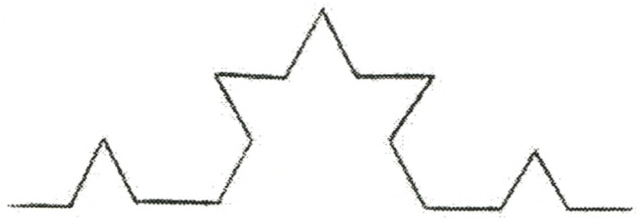
Figure 3.13: Mandelbrot set

A mathematician, Helge von Koch, used self-similarity to capture the problem of determining the length of a coastline. No matter how much one magnifies a coastline, one will always miss those bays that would be visible if one magnified it more. Von Koch used a structure known as the Koch curve to represent the coastline: in the middle of a straight line an equilateral triangle is placed (first iteration; see figure 3.14 (a)), and then to each side another such triangle is added (second iteration; see figure 3.14 (b)).

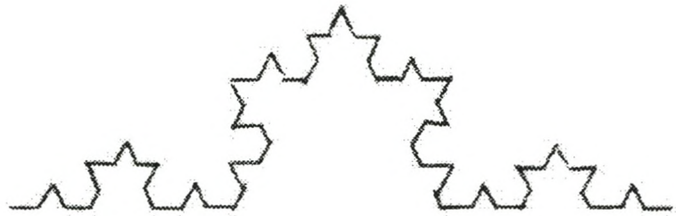
This is repeated over and over, and the resulting structure is a Koch curve (see figure 3.14 (c and d)). This structure represented an image of a coastline, and magnification of any part of the curve looked precisely like the whole — the Koch curve is therefore self-similar [Chaos Theory, 2002: 23-24]. Also, curves like the Koch curve have infinite perimeters, yet still have finite areas.

Figure 3.14 (a): The Koch curve (first iteration)

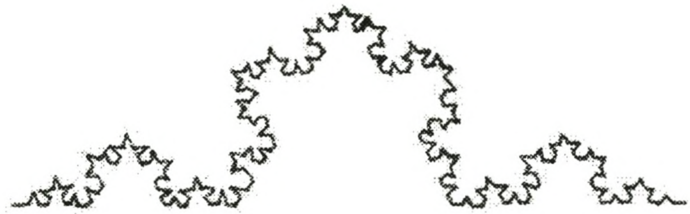
[5] Mandelbrot set: self-similar chaotic behaviour from a very simple equation ($z=z^2+c$).



<u>Figure 3.14 (b):</u> The Koch curve (second iteration)



<u>Figure 3.14 (c):</u> The Koch curve (third iteration)



<u>Figure 3.14 (d):</u> The Koch curve (fourth iteration)

The Koch curve is also a *fractal,* an object that has fractional dimensionality (a dimension that is a non-integer, i.e. a fraction) [Korsch & Jodl, 1994: 302; Guastello, 1995: 29]. The Koch curve is not smooth like a line or a curve, which have dimensions of

1, but it does not really have an area like a square either, which has a dimension of 2, so the dimension of the Koch curve is between the two; 1.26 in this case [Guastello, 1995: 25].

The Mandelbrot set is also fractal; so is the Lorenz attractor. Because of the infinitely repeating self-similarity of strange attractors, they have been called "complex mathematical figure[s] containing infinitely repeating detail in both... fine and gross structure" (see for example the Julia set, figure 3.15) [Eve, Horsfall & Lee, 1997: xxx].

Poincaré's distribution of stable and unstable points was also fractal, which is why he could not graph it at the time. It was too complex. With modern computers, it has become much easier to study fractals, and an understanding of how fractals function is critical to the pursuit of knowledge about chaos.

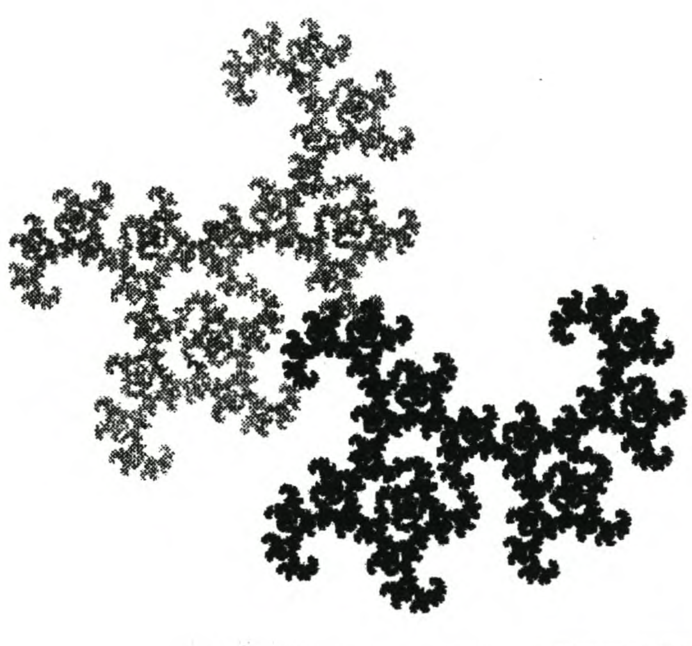


Figure 3.15: The Julia set

Fractals are everywhere. One can see them in the ocean currents; in the flow of blood through blood vessels; in tree branch structures... the list is endless. Chaos has "inescapably become part of modern science" [Chaos Theory, 2002: par. 36]. Although these fractal structures have been present for many years, man has only just begun to learn how to see and understand them.

A scientist by the name of Feigenbaum discovered the scaling factor for the bifurcations in the equation for population growth. The bifurcations occurred at a constant scaling of 4.669 [Chaos Theory, 2002: par. 27]. This meant that the scale at which the equation was self-similar was 4.669. So, if one magnified the diagramme of the population growth equation 4.669 times, one would find an exact replica of the whole diagramme.

Feigenbaum also discovered that other chaotic equations all displayed self-similarity at exactly the same scaling rate — 4.669. This was a very important discovery. It meant that something about chaotic equations was universal, something about chaos could be fully analysed and understood because it was following a simple, mathematical rule. The first steps towards really understanding what chaos is and how it works were being made. Chaos is not only *not* randomness, it also obeys mathematical rules.

Conversely, certain simple mathematical rules can cause highly complex or chaotic behaviour. One of the most common examples of this is called the *logistic function*[6]. This function appears simple and even linear, but when solved electronically, it can result in chaotic behaviour after a certain number of iterations.

Fractal structures are not only found hiding in mathematical equations. They can be seen everywhere. The structure of the veins on a fern (see figure 3.16), stock market data graphs, the beat of the human heart, and even the intricate structure of the brain are all fractals [examples Chaos Theory, 2002: par. 30, 32]. They are all self-similar, and they all display chaotic patterns.

Chaotic systems also often display what is known as *emergence*. This is what surfaces out of the system once chaos has entered, though often only after bifurcation. A

[6] The logistic function: $X_{t+1}=kX_t-kX_t^2$ (see Morçöl, 2002: 159-162 for discussion).

"complex adaptive system... give[s] rise dynamically to emergent phenomena..." [Smith, 1997: 55].

Figure 3.16: Fern fractal

Many examples of emergence can be seen every day. Certain chemicals appear in different colours at different times. Sulphur, for example, may be yellow, orange, red or purple, depending on how the atoms interact with the light. The wavelengths of the light determine the colour, so the colour is not inherent in the chemical's atoms, but emergent [Cohen & Stewart, 1994: 232].

Also, out of the complex deoxyribonucleic acid (DNA) system, through the right chemistry, emerges life. Stuart Kauffman describes this emergence aptly:

> *Life... is an emergent phenomenon arising as the molecular diversity of a prebiotic chemical system increases beyond a threshold of complexity [edge of chaos[7]]... [L]ife is not located in the property of any single molecule... but in the collective emergent properties of the whole they create... [T]he collective system does possess a stunning property not possessed by any of its parts. It is able to reproduce itself and evolve... [it] is alive [Kauffman, 1995: 24].*

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[7] Edge of chaos: see section 3.5.

These emergent phenomena are not, however, merely the sum of the parts or processes of the system [Smith, 1997: 55]. If one takes a look at the phenomenon of chaos as a whole, one can see that *simplicity* emerges from chaos when order is brought to a seemingly random system [Cohen & Stewart, 1994: 232]. Chaos plus order does not equal simplicity, hence Henry Adams' statement: *"chaos often breeds life, when order breeds habit"* [Mendelson & Blumenthal, 2000: par. 3]. Emergent phenomena are entirely new phenomena on their own. This is known as collapsing chaos [Cohen & Stewart, 1994: 232].

3.5 Chaos and Modernism

When Feigenbaum discovered the self-similar rate of chaotic equations (4.669), he inadvertently proved that chaos could be seen as a modernist phenomenon, at least in one particular way.

Chaos theory is "a symbolic representation of the world... a dynamic [theory] that captures movement and change" [Eve, Horsfall & Lee, 1997: xxxi]. Chaos is scientific, deterministic and mathematical. It follows universal rules, and can be rationally analysed using reasonable application of mathematical laws. Once these laws are understood, chaos can lead to significant progress in many different fields [Lee, 1997: 16].

Because of the deterministic nature of chaos, it also has strong statistical regularities, such as average, standard deviation and correlation [Kendall et. al, 1997: 198; Cohen & Stewart, 1994: 233]. This can also be seen as a modernist feature, for with regularity comes prediction, and with prediction, control. For modernists, the determining of facts (science) must take place objectively, so that regularities observed can lead to the formulation of laws that can function as universal standards. To gain knowledge of this world requires some sort of certainty, be it Descartes' observation that he definitively exists, or the regularities born from chaotic systems following deterministic rules.

For the modernist, reason and logic lead to (certain) knowledge. For the chaotic theorist, knowledge is gleaned from an understanding of how the simple can give birth to the complex, and how "random" activity can cause dynamic order. Once one understands this about chaotic systems — something that was not possible until recent technological developments — one can learn something about the nature of these systems, and about the phenomena they affect.

Modernism is also concerned with order. Order that is rational, universal and controlled by whomever supposedly has the knowledge and authority to do so. It is therefore very important for modernist political figures to have the knowledge to create a social order that can be run on functional, egalitarian principles (for what is equality other than universal rights)?

Being too focused on progressive, liberal mastery of one's world, though, may cause one to miss the individual, the different, the purposeful that may be present and may contribute in a valuable way to the process of knowledge accumulation. It may also cause one to alienate or even discriminate against the "other", who is just as important and just as useful as the one who fits into the "box of reasonable existence".

Modernists revel in the autonomy and stability of the self. The self becomes the agent of increasing knowledge, and therefore the instrument for the will to power. By increasing one's knowledge one can increase one's power over those who do not have that knowledge.

In chaos theory it is not the self that becomes the instrument of power, but the system. Understanding how a system is able to evolve, adapt and self-organise, and how it can creatively produce behaviour not inherent in its individual elements, is vital for gaining power. For if one has this understanding, one has knowledge that can be used to, for example, give a dynamic business a competitive edge over other businesses.

There are many such applications for chaos and chaos theory. In 1991 Peters applied chaos to his non-linear market dynamics theory. In the time series analysis of "specific commodities and broader market indices" there are limit cycles and chaotic attractors

[Guastello, 1995: 296]. Chaos occurs because of those events that were unexpected, and affect the 'normal' price (distribution) curve. A market crash is not chaos; it is merely a drop from one basin to the next [Guastello, 1995: 296-297]. Peters observed that chaos could cause creativity: if a system (such as a company or organisation) could respond and adapt to the sudden and unusual changes that chaos causes in its environment, then it is being creative, and chaos has essentially led to creativity.

With chaos, dualism becomes unimportant. Something does not necessarily need to be an instance of this or that; it can be either, it can be both, it can be neither, or a range of other things [Turner, 1997: xxiv]. In this way chaos theory departs from modernism, for modernism upholds polar opposites such as outer vs. inner (for example what is inside or outside a system's boundaries), subject vs. object, fact vs. value, science vs. religion, theory vs. practice.

Systems can also be at the edge of chaos (see section 4.3.1.4). These systems are mostly living systems that move in and out of chaos through self-organisation [Guastello, 1995: 52]. For example, consider contemporary evolution theory: natural selection within highly diverse populations. The numbers (of the populations) or the distributions of the genes border on chaos [Guastello, 1995: 52]. The genetic structure of the population is self-organised. This ensures the stability of the population. If the populations are stable, they become unstable when disrupted by the environment. The non-linear, self-organising nature of the system, however, ensures that it can learn from the disruption, adapt itself for future prediction, and reorganise into a new kind of stability. Thus making it highly dynamic.

3.6 Conclusion

So, chaos is not a new phenomenon, it is merely a new discovery. Chaos does not mean random, disordered, disorganised; i.e. *chaotic,* in the traditional sense of the word. Rather, chaos implies order, determinism, even regularity. Chaos, as has been shown, is not truly entirely random: self-similarity provides chaotic systems (systems displaying deterministic chaos) with a certain inherent order to their structure. Because these systems follow deterministic, universal, mathematical rules, they are scientific, ordered and, essentially, modernistic.

What can an understanding of chaos as a phenomenon and a science tell one about knowledge in itself? Knowledge of phenomena specifically, and the universe in general, can be greatly improved by an accurate understanding of chaos. Especially now that man has been given a greater access to the intricacies of nature, through chaos, and to the extraordinary self-organisation of fractals. One can learn much from studying these natural phenomena. If the self-organisation and adaptation of such dynamical, natural systems can be understood, then it can be applied in many different ways to everyday life.

Chaos, and an understanding of its nature, has become one of the phenomena that link many disciplines and areas of investigation. As James Gleick says:

> *Chaos breaks across the lines that separate scientific disciplines. Because it is a science of the global nature of systems, it has brought together thinkers from fields that had been widely separated* [Gleick, 1987: 5].

It may seem that chaos is quite removed from much of life and society, other than physics (specifically) and science in general. But because of this broad spectrum of influence, chaos is actually much more powerful and can be a much greater tool than was originally envisaged. If, for example, a system (such as a company or organisation) is aware of the critical (bifurcation) points that arise in its development, and it can respond and adapt to the sudden and unusual change that causes chaos, then it can be called creative, and chaos has caused creativity. It is then also less likely to succumb to failure caused by unexpected change.

Unfortunately, this sounds much simpler than it actually is. Nearly all the tools of chaos and complexity fail to offer much insight into real systems. This could be because (even small) differences between reality and the model created by the tool get magnified and can grow into huge differences, so that the model in the end fails to represent reality at all.

This said, understanding the complex science of non-linear systems can provide much needed knowledge, facilitate dynamic prediction and ultimately, foster success in a similar, everyday, human system. It is therefore vital that scientists continue the endeavour to do just this.

Chaos and modernism are similar frameworks for seeking knowledge in many ways, but they are not identical. One important difference is that modernism upholds dualisms, as the distinction between two opposing elements is important for creating or distinguishing universal phenomena. In chaos theory, however, dualisms are not important; boundaries are less rigid if not unnecessary. It is not possible to fully understand a dynamic system if one does not understand at least something of the environment that system functions in. The line between inside and outside the system becomes fuzzy, the internal and external fused.

A modernist approach to understanding is one that is based on reason and logic. These scientific faculties are the keys to unlocking the secrets of knowledge. Discovering the universal regularities that exist in nature leads to progress, and progress leads to a more functional and ordered society. Only life that is well organised, efficient, disciplined and in its rightful place has the right to be present in a modernist world, and only such life will be successful.

Modernism can also be seen as a somewhat restrictive framework for knowledge. If only what is scientific, empirical and objective can be called true knowledge, then it becomes almost impossible to ever obtain such knowledge. Most observation is tainted by the observer, most theories tainted at least in some way by the purporter. It is not possible for man to be completely objective, for he can never escape his background or his experiences.

Chaos theory may be seen as less restrictive when it comes to its use for acquiring knowledge. Although chaotic systems still adhere to universal, mathematical laws, there is much freedom in what these systems can accomplish. The behaviour of deterministic systems can be predicted, but with chaotic systems this prediction is only up until the next critical point. One cannot know when or where this point will occur, nor can one predict the path the system's behaviour will follow when chaos does set in, but one can predict *that* it will occur.

The occurrence of emergence — a wholly non-linear phenomenon — also implies slightly more creative possibilities than one finds with purely deterministic (modernist) systems. It is not possible to understand or explain the behaviour of a dynamic non-linear system by studying or analysing its individual components. There is something new that emerges out of the interaction of these elements — new in the sense that it was not contained in the system's individual elements — something that can lead to new knowledge and understanding.

There is much work left to be done in the field of chaos study [Chaos Theory, 2002, par. 36], but a keen interest in its possible applications, and a humble respect for its greatness, should ensure that man takes great care to learn as much from chaos as is humanly possible.

As a framework for knowledge acquisition, chaos has its advantages and its disadvantages. But it remains somewhat limited in that the rules that govern its behaviour do not change, and the system is 'condemned' to follow these rules, whether they are in its best interest or not. For a somewhat less rigid knowledge framework, let us consider complexity.

Chapter 4 : Complexity

4.1 Introduction

Most systems around us are complex. One can see complexity in so many different systems: societal structures, social behaviour, mental illness, education, climate, a human cell, the evolution process, certain molecules such as sugar, a vortex, culture... etc. The list is endless. These systems surround people every day, and yet are often misunderstood.

Complexity theory, like chaos theory, can be seen as a framework out of which one interprets information, and acquires knowledge. Because it is one of the non-linear sciences, it is able to afford one insight into the workings of non-linear systems, on a much deeper level than linear methods can. And because so many everyday systems are non-linear, it is vital that one first understands non-linearity and how systems display it.

The desire to understand the nature of our knowledge is crucial for an investigation into the phenomenon of complexity [Cilliers, 2000: 32], and a sound understanding of complexity may help one to fathom the depths of the nature of knowledge. Complexity theory helps one understand non-linearity, and provides one with some perception of how it is possible that systems can give rise to entirely new phenomena or behaviour that have little to do with the elements in the system individually.

This chapter discusses what complexity is, how and why it arose, and what one can learn from it. Firstly, the history of complexity theory and complex systems is reviewed. It is necessary to know how and why a phenomenon such as this came about, in order to understand the impact it can have.

Complex systems are then examined; first defining the terms, characteristics, and states involved; then investigating how these systems deal with change and influence society.

Hereafter, some types of complexity are considered, and then complexity theory is considered as an example of a postmodernist theory. The similarities and differences between complexity and postmodernism are highlighted, and then complexity theory's contribution to the quest for the nature of knowledge and truth is considered.

As a theory for understanding dynamic and evolving systems, complexity theory does much to enlighten one's comprehension and appreciation of the complexity that surrounds people every day. But one can only evaluate it as a framework for knowledge once one knows just what complexity theory and complex systems are about. That is what will be discussed below.

4.2 History

The development of the complex sciences and complexity theory has been relatively recent; however, pioneering scientists have been working on the ideas that led to this development since a surprisingly early time.

A philosopher by the name of Lewes was already working on a phenomenon he termed 'emergence' in the nineteenth century [Morrison, 2002: 6]., and in 1926 Heisenberg's uncertainty principle, plus his work with Schrödinger and Dirac, led to the discovery that "some phenomena are probabilistic" [Rihani, 2002: 6].

During the 1930's, Souter, a New Zealand economist, and Hodgson, his English counterpart, were both working on 'emergence' and 'unpredictability'. At around the same time, a biologist by the name of Von Bertalanffy was tackling the problem of 'open systems' [Morrison, 2002: 6]. In the 1940's he developed what came to be called

General Systems Theory: a group of ideas that could be used in many different fields [Flood & Carson, 1988: 2].

This theory eventually became a metadiscipline; it was interdisciplinary, not multidisciplinary [Flood & Carson, 1988: 16]. By using the ideas of the General Systems Theory in an integrated way, physicists studying mechanics and astronomy, and biologists studying zoology and botany, were able to work together in a new direction that became known as biophysics. Similarly, sociologists, who studied cultures and institutions, and psychologists, who studied groups and individuals, together paved the way towards what is now called social psychology [Flood & Carson, 1988: 6].

Throughout the 1950's and '60's, many different scientists were working on the problems of emergence, unpredictability and open systems, such as Allport, Polyani and Katz and Kahn [Morrison, 2002: 6, 7], whilst towards the latter stages of the previous century, more and more scientists from many different disciplines focused their attention on the lesser-known problems of non-linearity and systems theory.

During the era when modernist approaches were most prevalent, most scientists dealt with the issue of complexity from an analytical point of view. The complex was broken down into simple parts, which were then each analysed individually. This is known as *reductionism*[8], and is also what was propounded by Descartes in his *Rules for the Direction of the Mind* (see section 2.1.2).

The reductionist claims that the "... universe can be reduced to an understanding of its smaller parts" [Mihata, 1997: 34]. The whole is equal to the sum of the parts; therefore, one can understand something in its totality by studying its individual parts [Rihani, 2002: 66].

There are two major problems with this view; however, both of which only became a problem for scientists when they started working with more non-linear phenomena (see sections 3.1 and 3.2). The first of these problems is that reductionism cannot account for the times when the individual parts of a whole, through their interaction, result in

[8] For a more detailed discussion and critique of this method, see Cilliers, 1993: 4; Urry, 2003: 13.

something entirely new, something that could not be predicted through an analysis of the individual parts [Cilliers, 1993: 4-5]. This phenomenon is known as *emergence* (see section 4.2.1 (ix)).

The second difficulty with the reductionist approach to complexity is that it implies that all sciences can eventually be reduced to physics (for this is where "smaller parts" are studied), making the human and social sciences redundant [Mihata, 1997: 34]. But fortunately scientists have become increasingly aware of the importance of these "non-scientific" sciences, and what an understanding of the phenomena they cover could imply.

Studying the social sciences is vital for an understanding of social behaviour. Understanding the factors that affect social interaction — such as social expectations, laws, raw materials, technology, fiscal policies, competition etc. [Marion, 1999: 64] — can help one appreciate why social beings act in certain ways. This could lead to a greater understanding of phenomena such as crime (through sociology and politics), mental illness (psychology) and disease (biology / medicine)[examples: Cilliers, 1993: 21].

4.3 Complexity and Complex Systems

There have been many so-called sub-sciences that have influenced the rise of the thinking that led to complexity theory. These include gestalt psychology, field theory, sociometry, information theory, game theory, fuzzy sets, catastrophe theory and chaos [Back, 1997: 39]. Although it is not always certain which of complexity theory or chaos theory developed first.

One can classify the non-linear sciences in terms of one goal: an interdisciplinary study of systems that produce disproportionate and unexpected change [Elliott & Kiel, 1997: 66]. Or, as Kelly and Allison assert: that "set of interdisciplinary studies that share the idea that all things tend to self-organise into systems" [Kelly & Allison, 1998: 5]. This is a relatively descriptive definition, as it includes the notion of 'self-organisation' (see section 4.2.2 (v)), but it is rather general as it claims that *all* things must tend towards this kind of behaviour.

Therefore, a slightly looser, working definition of the complex sciences is needed. This could be something such as: the complex sciences are a set of interdisciplinary sciences that study the behaviour of complex systems and their implications, which includes mathematics, physics, biology, chemistry, chaos theory, cybernetics, synergetics and non-linear dynamics [Kelly & Allison, 1998: 5].

It is also important to note that the concepts "simple", "complicated" and "complex" are rather more intricate than they seem. This is part of what makes complexity science difficult to define. Something may appear complex, or complicated, yet actually be simple, or vice versa. A snowflake appears very simple, but on closer inspection, it is seen to have a very complicated structure. On the other hand, a combustion engine appears extremely complex, but is actually a relatively simple mechanism [examples: Cilliers, 1993: 6].

4.3.1 Characteristics of Complex Systems

The theory of complexity purported by each of the complex disciplines may differ in some ways, but all have certain features in common. Firstly, "complexity... seeks to establish pattern similarity" [Urry, 2003: 121] in many different complex systems. A system includes two or more interacting elements (i.e. changes in one have an effect on the others) [Jervis, 1997: 6], and having defined boundaries (governing what is inside or outside the system) (see section 3.2).

4.3.1.1 Interaction:

A *complex* system involves a high number of interacting components. The behaviour of a complex system is defined by the "rich interaction" of the individual components or elements of the system [Rihani, 2002: 7; Urry, 2003: 80; Mihata, 1997: 31; Cilliers, 1993: 7; 2000: 24]. This means that each element interacts with many others — some directly and some indirectly through the path of others — and is why some (such as Gell-Mann) have defined complexity as "... a function of the number of interactions between elements in a system" [Elliott & Kiel, 1997: 66].

4.3.1.2 Dynamic:

Such a system must also be dynamic (see section 3.2). Dynamic means that it changes over time; therefore, a dynamical system is "... a set of highly interdependent variables evolving over time" [Stroup, 1997: 126; Jervis, 1997: 17]. To evolve, a complex system must firstly survive, then learn from change and its environment, and lastly adapt to these changes [Rihani, 2002: 8, 83; Cilliers, 2000: 24].

4.3.1.3 Non-linear:

The interaction between the individual elements of these kinds of systems gives rise to behaviour that cannot be mapped linearly [Smith, 1997: 55; Cilliers, 1993: 8]. This means that linearity does not explain the behaviour correctly or sufficiently. Because the elements in a dynamical system can evolve, linear descriptions are merely too limited to capture their behaviour accurately.

Change in one of the elements of a dynamic system could lead to many possible effects across the system [Urry, 2003: 24]. This means that even the smallest change to the initial conditions of a system can lead to hugely disproportionate results [Kelly & Allison, 1998: 12]. Causes do not necessarily lead to effects, and some effects may have a huge influence on the outcome or the behaviour of the system, whilst others may have none. A particular cause may also have more than one effect [Rihani, 2002: 7, 68].

Non-linearity is the "ontological principle" [Byrne, 1998: 15] of complexity, because it has to do with the very *nature* of complex systems. These systems are inherently non-linear, and it is through the non-linear interaction of the elements in these systems that their complexities arise [Cilliers, 2000: 24].

This implies that it is near impossible to predict the complex behaviour of the elements in a complex system [Marion, 1999: 5] (see section 4.2.4).

4.3.1.4 <u>*Open:*</u>

Complex systems are known as open systems. An open system is one in "... which the boundaries permit interaction with their environment" [Kelly & Allison, 1998: 12]. In other words, complex systems interact and communicate with their environment [Cilliers, 2000: 24].

Take for example a human cell. It has interacting components, and clearly defined boundaries. It is therefore a system. Nutrients and information can enter the system from the outside (rest of the body), and waste and information can exit the system to the environment (outside) [example: Kelly & Allison, 1998: 12].

In this way, a complex system interacts with its environment across its boundaries. It becomes "embedded" in its environment [Stroup, 1997: 132], and is dependent on it. This interaction is very vital for the survival and evolution of a complex system [Marion, 1999: 81; Luhmann, 2000: 36]. It must co-exist with its environment, and mutually influence it [Morrison, 2002: 5].

Complex systems can not only take up nutrients and information, they can also take up and use energy from the environment, and they can also give off disorder to the environment [Byrne, 1998: 30]. This is known as *dissipation.* Energy is dissipated spontaneously through the relationships between the components of the system [Kelly & Allison, 1998: 4]. The behaviour of the system can therefore change the environment it acts in. For example, during the evolution process, plants and animals adapt to their environment, and make it more hospitable to some and less to others [example: Jervis, 1997: 48].

Closed systems do not allow interaction with the environment. They cannot change or evolve, and are therefore destined to reach some form of equilibrium (see section 3.3). This static state is death for the complex system, which much interact and evolve to survive. Complex systems, therefore, exist far from equilibrium[9] [Cilliers, 1993: 8-9; Rihani, 2002: 70].

4.3.1.5 Self-organisation:

A complex system must be able to adapt to changes in the environment. If some form of perturbation (secondary influence) acts on the system, causing it to change somehow, it can reorganise itself to adapt to the change (see section 3.2). This is known as *self-organisation* [Urry, 2003: 98; Morrison, 2002: 7]. Self-organisation also means learning from the perturbation, and evolving [Byrne, 1998: 30; Kelly & Allison, 1998: 7]. These systems are therefore sometimes also known as complex adaptive systems [Rihani, 2002: 7].

According to Kelly and Allison, *all* living and social systems are self-organising, because they dissipate energy, materials and information from the environment [Kelly & Allison, 1998: 4]. While it may be too early to claim such generalisation, it is true that each of these systems is unique in that they interact with a specific environment at a specific time [Kelly & Allison, 1998: 4].

Also, each living and social system — indeed, each complex system — has a unique history that constantly affects how it develops and evolves [Cilliers, 1993: 9]. Self-organising systems are able to make an imprint of something from the environment, and use it later, much as a baby chick's first picture of its mother becomes imprinted in its memory [Marion, 1999: 71]. This is known as *mapping*. Because the system is constantly learning from the change occurring around and to it, naturally, what has happened in its history can teach it how to respond to change in the future better.

Self-organisation, therefore, merely means that the system can return itself to overall stability after change, without any external help [Rihani, 2002: 104;

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[9] Far from equilibrium: also sometimes called *edge of chaos* (section 3.5), see for example Kauffman, 1995.

Marion, 1999: 7; Lee, 1997: 21]. In this way, a complex system can develop structure out of what was not structured [Cilliers, 1993: 20]. If the original stability (structure) of the system becomes unstructured because of environmental perturbation, the self-organising system is able to reorganise itself to form a new, evolved structure.

This is not a new concept, though. Even the philosopher Emmanuel Kant referred to organisms as dynamic and self-organising, almost 200 years ago [Marion, 1999: 45]. Self-organisation is one of the most important features of complex systems [Price, 1997: 10; Mihata, 1997: 31], for without it, they would not be able to adapt or evolve.

4.3.1.6 Representation:

The ability of a complex system to self-evolve from within is known as auto-catalysis [Morrison, 2002: 15]. To do this, complex systems must be able to acquire, store and later use information about the environment; i.e., a system must *represent* information that is important to it [Cilliers, 1993: 18].

4.3.1.7 Autopoietic:

Another feature displayed by complex systems is autopoiesis [Price, 1997: 10; Luhmann, 2000: 38]. An autopoietic system is "a self-organising system that creates its own boundaries and preserves and renews itself over time" [Kelly & Allison, 1998: 28]. This creation and renewal process involves three actions. Firstly, the system is self-bounding [Kelly & Allison, 1998: 28; Morrison, 2002: 15], i.e. creating its own boundaries (as to what is inside or outside the system) [Wolfe, 2000: 180].

Secondly, the system is self-regenerating [Kelly & Allison, 1998: 28; Morrison, 2002: 15], which means that it can adapt to its environment and use the environment's resources to its advantage. And thirdly, it is self-perpetuating [Kelly & Allison, 1998: 28; Morrison, 2002: 15]; this implies that the system maintains and renews itself.

4.3.1.8 Feedback:

One of the most vital properties of a complex system is feedback [Elliott & Kiel, 1997: 66] (see section 3.2). This is the "action of feeding or reporting back to the originator of an action the results of that action" [Kelly & Allison, 1998: 14], similar to a customer response to a new product.

A feedback *loop* is "a series of actions, each of which builds on the results of the prior action and loops back in a circle to affect the original state" [Kelly & Allison, 1998: 14; Marion, 1999: xii] (see figure 4.1). There are many such feedback loops in a complex system, and they can be direct or indirect [Cilliers, 2000: 24]. Feedback produces global (or overall systemic) patterns through recursion [Kelly & Allison, 1998: 5] (see section 3.2). "Simple... rules [are] applied [sequentially] over and over again to the latest results" [Kelly & Allison, 1998: 5][10].

All this means is that at some time part of a complex system produced as output is fed back into the system again to be used as input. This is why even minute differences at the beginning of a recursion can lead to huge deviations later on, because the differences accumulate [Kelly & Allison, 1998: 5] (see the *butterfly effect*, section 3.1). Change in one element or part of a complex system can cause change in another, which then affects the original [Jervis, 1997: 125].

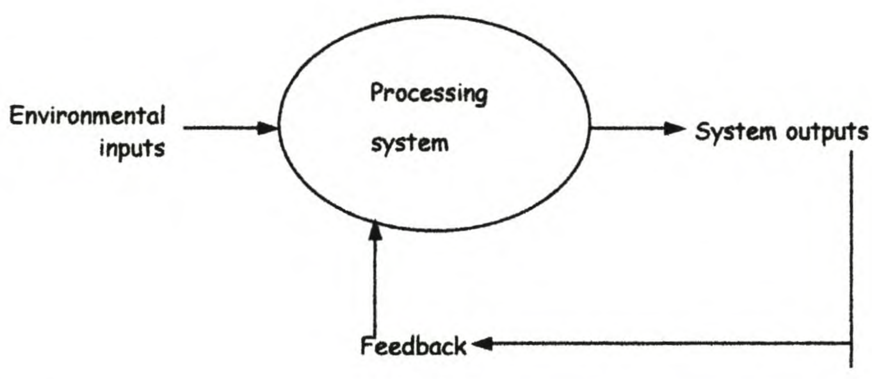

Figure 4.1: Generic open systems theory model (illustrating feedback) [Marion, 1999: 64]

[10] See also Anderson, 1999: 218.

There are two types of feedback: positive or amplifying, and negative or balancing. Positive (amplifying) feedback is when change in one direction causes more change in the same direction [Jervis, 1997: 125]. This reinforces the original state, and leads to growth. For example, when purchases lead to an increase in the stock market and this in turn leads to more purchases, which lead to an increase in the stock market etc. etc. [Kelly & Allison, 1998: 14].

Negative (balancing) feedback is when change in one direction causes counteractive change in the opposite direction. This changes the direction of the original state, and leads to stability and organisation [Kelly & Allison, 1998: 14; Jervis, 1997: 125].

Mostly complex systems use positive feedback, as negative feedback tends to result in equilibrium (or death). Feedback is very important for the active and efficient functioning of a complex system [Urry, 2003: 98], although it should not be taken as rigidly correct all the time, for it can lead to some strange anomalies.

For example, consider this sequence of feedback: *peace leads to war* and *war leads to peace.* Take the term "peace" as arbitrary starting point: *peace* leads to *plenty, plenty* leads to *pride, pride* leads to *quarrel, quarrel* leads to *war.* So peace has led to war! Or take "war" as a starting point: *war* leads to *spoilage, spoilage* leads to *poverty, poverty* leads to *patience, patience* leads to *peace* [example: Jervis, 1997: 127]. Now war in turn has led to peace! It is almost possible to force any concept to lead to any other, if feedback is applied in this (above) way. But, used in the right way, it remains a vital force for any complex system.

4.3.1.9 <u>*Emergence:*</u>

Approaching complexity using modernism's analytical method became a problem when dealing with complex systems because of the phenomenon of emergence [Cilliers, 1993: 4-5; Clewley, 2004: sec. 2.1]. The complexity displayed by such a system as a whole does not reside within the individual elements of that system. The complexity arises from the dynamic interaction between the elements [Cornell, 1992: 33]. Each element interacts with many others in the system, but responds only to information received locally [Cilliers, 1993: 9], i.e. from its immediate neighbouring elements. In this way, each element can affect a large number of other elements (indirectly), through a series of interactions. In other words, the *connectivity* (between the elements) is relatively high.

Through this dynamic interaction, "characteristics not inherent within the individual elements" [Urry, 2003: 13] can emerge spontaneously. These are known as *emergent properties*. Something new that emerges from the interaction between the elements [Mihata, 1997: 31]. These can be behaviours, qualities or patterns. For example, the flavour of sugar is not inherent in the carbon, hydrogen or oxygen atoms that make up the sugar molecule [example: Urry, 2003: 25].

Emergent properties transcend the individual elements of a complex system in that their complexity cannot be understood by analysing the components in the system independently [Cilliers, 2000: 24]. What is true for a particular element in a dynamic system is not necessarily true for the system as a whole. The system is usually not equal to merely the sum of its parts [Urry, 2003: 24; Marion, 1999: 29; Smith, 1997: 55]. This is known as *non-deducibility*. One cannot deduce emergent properties from the properties of individual elements, and one cannot deduce general laws from the rules governing individual elements [Mihata, 1997: 33]. Emergent results are different to and more powerful than those that could possibly be produced by the elements individually [Kelly & Allison, 1998: 4].

This is why complexity theory is not a reductionist theory. Because of emergence, it is not possible to reduce a system to the sum of its parts [Byrne, 1998: 14]. Complexity is instead a *holistic* theory [Byrne, 1998: 35; Marion, 1999: 64, 81; Morrison, 2002: 7, 9, 12]: to understand the complex systems, one must look at the system as a whole [Cilliers, 1993: 17]; how the elements interact to form new properties, how feedback steers the system's behaviour in a specific direction, and how the system learns from and interacts with its environment to adapt and evolve.

Complexity theory highlights the boundaries of the reductionist approach concerning complex systems. This does not mean, however, that reductionism is entirely useless; it may still provide useful understanding of certain aspects of complex systems.

4.3.2 States of Complex Systems

Complex systems must move though a number of different states to survive. How many states depends on the number of individual elements in the system [Rihani, 2002: 78]. For a system with N number of elements, each which have only two possible states (such as "on" and "off"), then the number of states the system can move through is equal to 2^N. For example, if there are three elements in a system, i.e. N=3, then there are 2^3 — i.e. eight — states. If N=10, then there are 2^{10} — i.e. 1024 states; and if N=12, there are 2^{12} — i.e. 4096 — states.

If, however, each element in the system can have one of m possible states (not merely two), then an N element system will have m^N states.

It is important for an evolving system to scroll through the right number of states. If it has too many states, it will develop into completely random (totally chaotic) motion. If, however, it has too few states, it will lapse into total order, equilibrium and certain death [Rihani, 2002: 80].

A completely chaotic state has an infinite number of states, none of which are the same. The system displays no regularities, and its components have very high connectivity. The opposite extreme, equilibrium or ordered state, is when the system becomes frozen into fixed activity. The components display very low connectivity.

Organised complexity is what most evolving, adaptive complex systems display. This can be seen as between organised simplicity (equilibrium) and random chaotic behaviour

[Marion, 1999: 71]. These types of systems have a large number of similar, but not identical, states, which are defined by the limits of the particular attractor basin in play at the time (see section 3.3.1), and they also have (relatively) high connectivity levels. [Rihani, 2002: 8, 78-79, 84].

To illustrate these different states, consider water running into a bath with a plughole. If the tap is closed and the plughole open, there will be order. Nothing flows in and nothing flows out. Equilibrium settles in. If one opens the tap widely, the water flow will eventually become wild and turbulent. It will splash around and it will not be possible to predict which drops will splash around in the bath, and which will go down the plughole; neither will it be possible to predict *when* these drops go down the plughole. This is chaos. But if the water flows at an even rate out of the tap, a kind of vortex (whirlpool) is formed. The water flows evenly from the tap, in the bath around the plughole, and out of the plughole. This pattern will remain for as long as the flow rate is kept even. This is known as *self-organised complexity* [example: Rihani, 2002: 7].

A complex system can move quickly from one state to another. Mostly, these systems follow a path known as *punctuated equilibrium.* This means that the system displays overall global stability — it is "dynamically stable" [Marion, 1999: 59] — punctuated by large instances of disturbance (or perturbations) [Rihani, 2002: 80]. These disturbances are most often caused by what are known as *gateway events;* events that lead to the rise of new developments, such as the internal combustion engine that heralded the start of the industrial revolution, or the personal computer, that launched the information age [examples: Rihani, 2002: 87].

Gateway events affect the system's homeostasis, or its tendency to maintain equilibrium. If the perturbations are dramatic, the system can either return to the original homeostasis (equilibrium), or it can move on to a new homeostasis (adaptation) [Marion, 1999: 59].

4.3.3 The Incompressibility of Complex Systems

Many people, if not most, desire to reduce that which is complex in their world, to something simpler, or easier to understand. This is an ancient desire [Taylor, 2001: 137], and one of the reasons for the development of and sustained belief in reductionism. This does not, however, imply that reductionism is equal to simplification; reductionism is rather a particular type of simplification. Any attempt one makes to model phenomena is in essence simplification; even if it is a complex systems approach.

Complexity however, as seen above, is holistic; i.e. it cannot be reduced to simpler parts, because of the phenomenon of emergence. Because it is possible for new and distinct phenomena to emergence out of the dynamic interaction of the elements of a complex system, such systems produce complexities not found in their constituent parts.

Because the interactions in complex systems are non-linear, no group of interactions could be represented by a group smaller than itself [Cilliers, 2000: 27-28; 2001: 3; Cornell, 1992: 70]. This is known as *irreducibility*, or *incompressibility*. Complex systems cannot be reduced to the individual elements of the system; nor can the complex behaviour displayed by such systems be reduced to the behaviour of any one or more of its elements. The *complexity* displayed by these systems cannot be *compressed* any further.

If one were to reduce a system to something simpler, inevitably one would have to leave something out. If it were a deterministic or linear system, what was left out would not present much of a problem, as it would either be unimportant, or contained in the reduced version of the system. The problem with complex systems, however, is that one can never predict exactly what the status of that which is left out could be [Cilliers, 2001: 3]. A seemingly inconsequential variation could, as Lorenz discovered, in the long run cause an enormous difference; something that is unimportant now could become highly important later.

Consequently, it may often be difficult to deal with and understand complex systems, because the complexity involves the whole system; one cannot just "leave things out." This should not, however, dampen one's desire to learn as much as one can from and about these extraordinary systems and the behaviours they display. It is also not always necessary for one to have a perfect model or representation of a complex system to understand something about it. One can still acquire useful knowledge from imperfect representations of complex systems. And as much as possible must be learnt from them, so that we may be another step closer to the understanding of knowledge.

4.3.4 Change

The status of a system depends on the state of the variables (elements) and how that state came to be (see section 4.2.2). Sometimes changing a variable does not change the result (or resulting behaviour). Often at least two variables must be modified to affect the change [Jervis, 1997: 38]. This is because of an effect known as hysteresis,[11] which causes a delay in the result produced by the changing variable.

The type of change displayed by the system depends of course on what kind of system it is. A simple, deterministic or linear system will display linear, proportional change that is ordered and predictable. This kind of system culminates in one solution or result [Byrne, 1998: 22, 26].

On the other hand, a purely random system has an infinite number of possible changes, which cannot be predicted because of the non-linearity and randomness inherent in the system. These kinds of systems can produce infinite solutions [Byrne, 1998: 26].

A system displaying self-organised complexity has a range of change *between* one and infinity. It can go through any number of non-linear changes, and will produce many solutions (but a finite number) [Byrne, 1998: 22, 26]. It should be remembered, however, that complex systems can also display other kinds of behaviour: linearity and chaos, for example, and that it is not these *qualitatively different* [Cilliers, 2000: 24] behaviours that cannot be predicted — it is possible to know what types of behaviours a

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11 *Hysteresis* is "the lag in a variable property of a system with respect to the effect producing it as this effect varies" [McLeod, 1986: 417].

complex system could produce — rather, it is which behaviour will be displayed at which point in time that is not predictable.

Change in a system can be internal or external. Internally, change can occur as a result of interaction between the elements, and externally, between the system and its environment [Byrne, 1998: 30, 31]. Change can also be complementary — where one side of the change (exchange) gets stronger, and the other weaker by the same amount — or symmetrical — where both sides of the exchange get stronger or more hostile at the same time [Jervis, 1997: 126]. It is also possible for a system to display change that is a combination of complementary and symmetrical, and likely that it will display a combination of internal and external change.

Change is necessary in any system that wishes to survive and evolve. This is because of the increasing pressure and uncertainty placed on it because much of its future is undetermined. The environments in which these evolving systems operate tend to function at a relatively rapid pace, causing many changes, and many of the old methods of coping with these changes used in these systems no longer suffice [Kelly & Allison, 1998: 7].

4.3.5 Prediction

To be able to say that one has acquired knowledge about something is an enormous accomplishment. Most people desire knowledge so that they may be able to control some aspect of their circumstances in some way. Much of this control comes with prediction. If one really could predict the weather properly, with great accuracy, as far in advance as one wished, not only could one be sure of for example not organising an outdoor function when it rains, but one might even be able to save lives, by predicting such disaster events as hurricanes well in advance.

Prediction and control can do man a lot of good if used properly, but first we must attempt to understand the world around us, before we attempt to control it. This understanding is now increasingly focused on complex systems, as so many systems one comes into contact with today are complex. If a system abides by rules, then one can control that system. Once the rules are known, the system's behaviour can be predicted, and once the behaviour can be predicted, the system can be manipulated to one's benefit [Byrne, 1998: 19, 41].

This attempt at understanding and prediction, however, is more difficult than it seems. Because emergent properties cannot be predicted, complex systems do not lead to inevitable or expected results [Urry, 2003: 24; Rihani, 2002: 68]. In the linear paradigm, where systems were at most weakly non-linear, prediction was possible because, once the universal, deterministic rules governing the system were known, its (future) behaviour could be determined based on previous behaviour [Rihani, 2002: 66] (see section 3.1).

But with complex systems this kind of deterministic prediction is only possible in theory. In practice, it means that infinite precision and accuracy is necessary to predict the behaviour a complex system will display [Rihani, 2002: 89] (see section 3.1). It may not be possible to make the kind of quantitative predictions that will determine precisely what a complex system will do, but it is possible to make relatively accurate qualitative predictions as to what possible behaviours the system could display.

One cannot predict the system's overall behaviour from the individual behaviours of the elements in the system (see section 4.2.1 (ix)). For example, two individual medicines (individual elements) that are helpful, when taken separately, for two different ailments can be potentially fatal if taken together (unpredictable emergent result: fatality) [example: Jervis, 1997: 39]. The interconnectedness of the elements within a complex system means that if one changes one aspect or variable in the system it could trigger a whole series of unanticipated other changes [Jervis, 1997: 61].

Take as an example of this the shutting down of abortion clinics in the 1980's in the U.S.A. The belief was that if there were fewer clinics, there would be fewer abortions. Unfortunately, as officials later found out, this transpired to be not the case, as the abortion clinics also provided "birth control supplies", so the prevalence of abortions actually increased, due to lack of these supplies [example: Jervis, 1997: 61].

This does not mean that prediction in complex systems is completely impossible, merely that is more difficult than in linear systems. Short-term prediction is possible because a stable relationship between the interacting elements in a system emerges over the short-term. The overall stability between radical change caused by environmental perturbations means that, with the local data displayed during times of stability, one can gather enough information for short-term prediction [Marion, 1999: 149].

There has also recently been one other small success in the prediction of complex systems. The kind of manipulation mentioned above is not (yet?) possible with these kinds of systems; however, minor manipulation is possible. At critical points of change (bifurcation points — see section 3.3.2), when a system must 'decide' which path to follow, one can introduce some small external disturbance to the system, to force it to go down the more suitable (or desirable) path, and thereby bring overall stability [Byrne, 1998: 41]. This method is, however, rather limited in its use thus far.

Complex systems are much more complex than they may at first seem. Although prediction is important, it must be realised that with our (limited) present understanding of these systems, long-term prediction is not yet possible. It may never be entirely possible even if we do have a thorough and complete understanding of how complex systems function. No wonder Saperstein called complexity theory that "... set of deterministic theories that do not necessarily lead to long-term prediction" [Saperstein, 1997: 105].

4.3.6 Society and Complex Systems

Most social systems can be seen as complex systems because they must adapt and evolve to survive, and because there exists a high level of interconnectedness between their elements [Marion, 1999: 41, 100; Lee, 1997: 20]. Social systems are "adaptive [systems]... [that] carry information about their environment and their past" [Marion, 1999: 23]. A social system's history is important for its learning and adaptation; so is its interaction with its environment.

Organisms, which can be social or organic systems, "... [result] from a self-organising, self-generating dynamic" [Goodwin, 1994: 197]. They are complex systems, self-organising, dynamic and autopoietic (see section 4.2.1). Nature, as an organism (or organic system), is not static and unchanging. It is constantly "active and creative" [Urry, 2003: 13]; rebuilding and renewing itself each day, whilst also learning what it takes to survive, and adapting itself accordingly.

Culture is a complex phenomenon, and the players in a cultural system are complex individuals. It is often difficult to predict how they will interact, and what complex reactions change will trigger (see section 4.2.4).

Cultures have "coherent patterns of human thought" [Kelly & Allison, 1998: 25], which specify how cultural rules and customs should be reproduced. These are known as *memes,* and function in much the same way as genes. Just as genes carry the blueprint to reproduce life, memes carry the blueprint to reproduce culture [Kelly & Allison, 1998: 27]. These memes can be general (such as national laws) or more specific (such as the vision inherent in a business strategy), and could be seen as deterministic rules governing the behaviour of these complex systems in times of punctuated equilibrium (see section 4.2.2).

Societies are self-referential — they can talk about themselves (or at least, the people inside the societies can talk about them) — and they can communicate with or about their environments. Societies are also autopoietic [Luhmann, 2000: 36,38]. They make their own boundaries, they regenerate themselves when necessary, and they are self-perpetuating. Without the people (as their individual elements), these systems would not be able to survive, adapt or evolve.

Societal habits are "behaviour patterns supported by amplifying feedback loops" [Kelly & Allison, 1998: 121]. "Organisational boundaries are formed by patterns of communication and learning behaviour" [Kelly & Allison, 1998: 186]. Societies therefore display feedback and learning as well.

Societies and other social systems function as complex systems. In 1970, the most costly and prized global trade goods were simple products such as clothes, paper, yarn, meat and coffee [examples: Urry, 2003: 31]. By 1995, however, almost two-thirds of trade commodities worldwide were complex products and processes, such as electronic components, cyber-architecture and socio-technical systems [examples: Urry, 2003: 31]. With the dawn of the information age, social systems and their accompanying endeavours such as trade have become even more complex; the products have changed and the interactions have changed.

This is important for the understanding of the behaviour of these systems and their individual elements. Predicting their behaviour can become very necessary, and this will only be possible once one fully understands how complex systems work.

4.3.7 Types of Complexity

Complexity (therefore) is displayed in "... systems that have large numbers of internal elements that interact locally and non-linearly to produce stable, but evolving, global patterns" [Rihani, 2002: 6; Urry, 2003: 138]. This means that one can only predict the global (overall) pattern, not the individual, local interactions [Rihani, 2002: 105]. Order — as this pattern — emerges naturally out of the dynamic, unpredictable (or chaotic) interaction of the elements [Marion, 1999: xii; Rihani, 2002: 89].

A complex adaptive system is one "in which interactions give rise dynamically to emergent phenomena that are resilient in the face of perturbations" [Smith, 1997: 55; Urry, 2003: 7]. The environment agitates the system through gateway events (see section 4.2.2), and the system responds by learning from them, adapting, and returning itself to overall global stability.

There can also be different types of complexity. Algorithmic complexity concerns the level of complexity displayed by the system. With this kind of complexity, the length of the message needed to describe a system determines its complexity level [Rihani, 2002:

88; Elliott & Kiel, 1997: 66; Cilliers, 1993: 16]. Generally, the most common levels are ordered (equilibrium), chaotic and organised complexity (see section 4.2.2).

According to Cohen and Stewart, "complexity at any given level is a consequence of the operation of relatively simple rules one level lower down" [Cohen & Stewart, 1994: 219]. If this were so, however, this would mean that the complexity of any given level could be reduced to simplicity on another level. This reductionist view is just what complexity theorists are against, because this reduction does not account for the emergence of entirely new phenomena. One can only solve complex problems with complex descriptions or solutions [Cilliers, 1993: 5, 16]; although not all problems concerning complex systems are necessarily complex.

Computational complexity is the "... amount of time... necessary to compute the description of the system" [Elliott & Kiel, 1997: 66]. Many instances of complex systems can be seen in everyday life: society structures, culture, organisation, education, climate, economies etc. [examples (some): Marion, 1999: 25], and the computational complexity differs for each of these. This kind of complexity also depends on the frame chosen to represent the system (see section 4.4).

Complexity can also be either active or passive. Active complexity arises from complex systems that can adapt, evolve and self-organise, such as organic systems [Cilliers, 1993: 7]. This kind of complexity is "fluid, flexible and adaptable" [Kelly & Allison, 1998: 83]. Passive complexity is the fixed, structural complexity displayed by such complex systems as the Mandelbrot set (see section 3.3.3) [Cilliers, 1993: 7].

4.3.8 Increasing Levels of Complexity

The figure below indicates the path of how both chaos theory and complexity theory lead to increasing levels of complexity.

Chaos theory is an example of a theory of simplicity, because it is based on deterministic equations, and follows certain specific mathematical laws (see figure 4.2).

This does not mean chaos is simple, neither does it imply simple, predictable results. As seen above, chaos theory leads one towards ever-increasing complexity and unpredictability, because of the inherent non-linearities in a chaotic system.

On the other hand, complexity theory is an example of a theory of complexity, because complex systems are incompressible (see figure 4.2). Due to the dynamic interactions of the components of a complex system, the complexity of that system increases with the emergence of unique properties and/or behaviour.

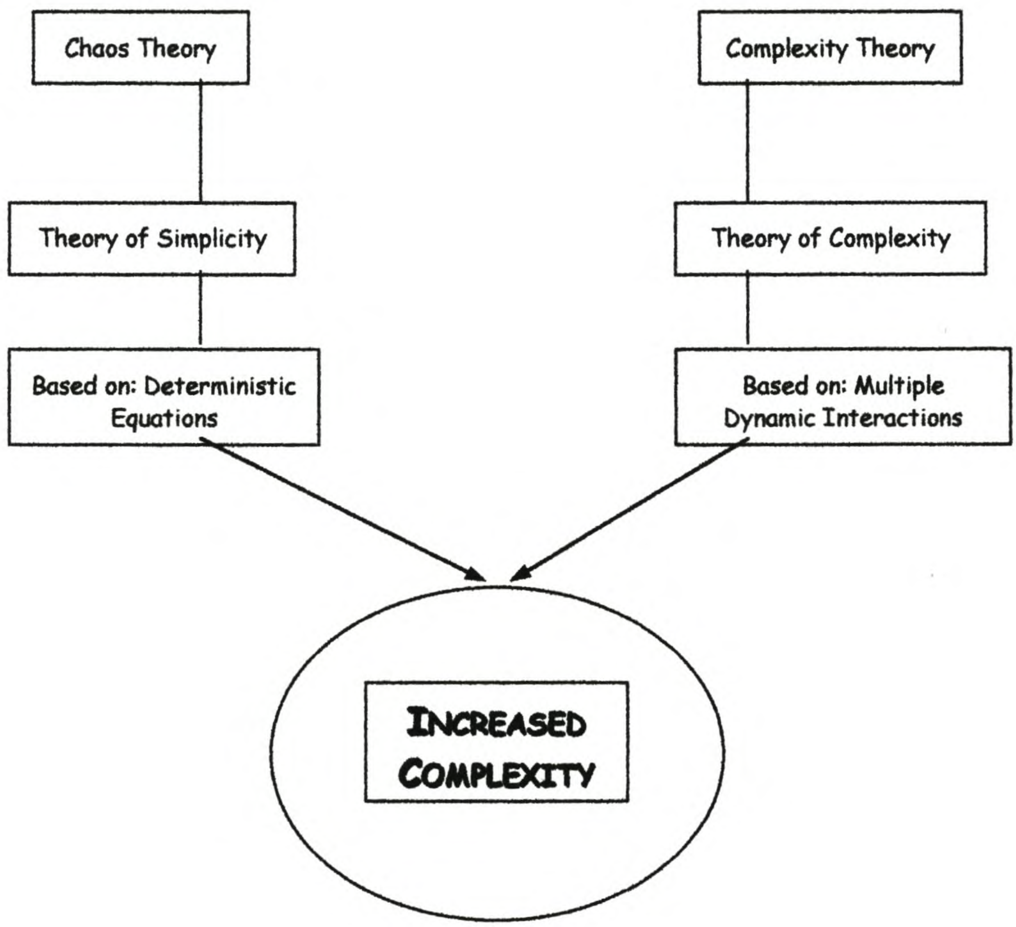

Figure 4.2: Schematic showing how chaos theory and complexity both lead to increased complexity [Elliott & Kiel, 1997: 67]

So even though chaos and complexity theories are different types of theories, they both can lead to increased levels of complexity. This is why (the phenomenon) complexity emerges from a combination of chaos (locally) and order (globally) [Rihani, 2002: 70], and why it has been called a "hybrid state... between stability and chaos" [Marion, 1999: 23]; the "domain between linearly determined order and indeterminate chaos" [Byrne, 1998: 1].

The (above) example of a vortex is descriptive of this kind of hybrid state (see section 4.2.2). If something is not completely ordered, this does not mean that it is unordered, i.e. total random chaos [Byrne, 1998: 16]. Complexity incorporates both.

Both chaos and stability are important for dynamic, evolving systems. Stability is important for memory and mapping, and chaos forces the system to adapt and breeds creativity [Marion, 1999: 73]. Self-organising complexity takes place at the edge of chaos; it is "bounded instability" [Kelly & Allison, 1998: 4, 30]. This means that the instability caused by perturbations is limited; the system will always eventually go back to some form of stability, usually after learning and evolution has taken place.

4.4 Complexity and Postmodernism

One of the biggest problems facing modernists attempting to understand complex systems in an analytic (modernistic) way is prediction. Because of the butterfly effect, and the phenomenon of emergence, it is clear that prediction in complex systems *is* a problem [Ruelle, 1991: 48] (see section 4.2.4). Prediction cannot occur linearly as with linear, deterministic systems, and neither can one attempt to understanding complex systems in a linear way [Price, 1997: 9]. A different method of understanding — one that models the complexity of such systems — is necessary. Complexity theory shares this scepticism of linear methods of understanding with postmodernism.

Because of this difficulty with prediction, it is clear that no universal or "unifying" description of a complex system can actually exist [Luhmann, 2000: 39]. Each one is unique, and through the interaction of each one's elements, unique phenomena emerge.

There can also, as noted by Löfgren, be many different descriptions of one particular complex system, because there are many different facets to an evolving system, and many different functions. Take society for example. If one looks at a society from a perspective of freedom, one could define it as conservative, liberal etc. From an equality point of view, a society could be socialist, communist or democratic. And if one describes a society based on its level of organisation, it could be an institution, culture or government [examples: Luhmann, 2000: 39].

The scope of the system one decides on depends on the level of detail one requires. The observer (of the system) picks a "distance" from the system based on what it will be used for. This is known as *framing* [Cilliers, 1993: 8; Cornell, 1992: 70]. The above society distinctions get increasingly larger as the frame is enlarged. In other words, the observer of society as a system moves further and further away from the system in order to see it on a more general (less specific) level.

The freedom perspective focuses on the elements — the people — in the system: how much freedom do they have? Move slightly further away and one can see the society at an equality level: can the society in general be classified as socialist, communist or democratic? To view the society on an organisational level, one must move further away again, so as to see the society as a whole as an institution, culture or government.

So, there are many different levels and many different views of complex systems. The level depends on the frame one chooses. Also any interpretation or description one gives of a complex system would be from within the framework of one's environment and history. Such descriptions are therefore always contingent to the person and circumstance involved. Complexity theory and postmodernism therefore share a rejection of metanarrative descriptions: all-encompassing, universal descriptions of phenomena (see section 2.2.2); these are not only undesired, but virtually impossible.

Is it therefore possible that there are some rules *not* contingent to the person or circumstance that could guide the evaluation of such knowledge (descriptions)? Chaos theory has provided some: the self-similarity rate of bifurcations, for example. But these universal rules do not do enough to capture the complexity of complex systems (as seen above).

But, whereas postmodernism is completely against universals of any kind (these cannot exist because reality is subjective and contingent), complexity theory only coincides up to a rejection of metanarrative descriptions. For complexity theorists, there can be universals. These are the global properties complex systems produce through the local interaction between elements [Price, 1999: 13].

Complex systems are constantly learning, adapting and evolving (see section 4.2.1 (ii)). It is important for these systems; otherwise they will stagnate and die. This is because they are dynamic systems.

Postmodernism is a dynamic theory that focuses on change, diversity and the privileging of the "other" (see sections 2.1.4 & 2.2.2). Diversity involves not only acknowledging others and their viewpoints, but also considering them to be at least as equally valid as your own. With postmodernism, the marginalised "other" minority becomes central or is made the norm, and the previous majority or "accepted" now becomes less important.

Complexity theory can also be seen as a postmodernist theory because it is against domination of any kind (see section 2.2.5) [Byrne, 1998: 44-45]; be it one person over another, society over the individual [Marion, 1999: 304], the accepted over the unaccepted, or merely one concept over another. Like postmodernism, complexity theory is concerned with the local context of a phenomenon [Byrne, 1998: 47, 51]; in this case, complex systems: the time and context in which it takes place, its history and memory, and the individual elements and their interaction.

The disproportions between cause and effect displayed by complex systems (because of their inherent non-linearities) can also be seen as parallel to the discontinuity characteristic of postmodernism [Urry, 2003: 7, 24; Marion, 1999: 6].

Previously, physics scholars coped with complexity by means of equilibrium thermodynamics. The initial conditions of the system are left out, energy is dissipated and disorder is the focus point [Prigogine & Stengers, 1984: 129]. Unpredictability arises when particles interact with random resonance states related to the amount of potential energy in the particles [Marion, 1999: 148]. This, in addition to the butterfly effect, causes indeterminacy in a physical system, and therefore uncertainty is a natural part of non-linear systems, and one should not try to make it more certain.

The problem with this approach is that it does not bring one any closer to understanding how complex systems work. Non-linear systems may display disorder, but only during times of upheaval brought about by perturbations or gateway events. Thereafter, they return to punctuated equilibrium, maintaining global stability after evolution.

Some of the complexity that emerges from complex systems may also be missed with this approach. Without a focus on the interaction between the elements of a complex system it is not possible to fully understand them. Equilibrium thermodynamics is also limited mainly to physical systems, most of which are chaotic, not complex.

Complex systems derive meaning from their interaction. Meaning is a *process* of interaction, which is "dialectical" because it involves interaction inside and outside of the system, and historical because it involves history (see section 4.2.1 (v)) [Cilliers, 1993: 29].

When this interaction is observed, however, it becomes dependent on the observer: his/her frame of reference, environment, history etc. It is never possible to observe completely objectively; all knowledge is therefore in some way actually just a representation of the truth. This is also a postmodernist idea. Knowledge is a representation (at least in part) of the truth, as viewed by the observer (see section 2.2.5).

This does not mean that truth or all knowledge is relative. Merely that man may not be able to acquire completely objective knowledge, and often knowledge needs to be context-specific.

4.5 Conclusion

The theory of complexity, therefore, is one that focuses on understanding complex systems, and how the interaction of elements in such systems can cause entirely new phenomena to emerge.

Complex systems differ widely, but they all display the same important characteristics. All complex systems have large numbers of interacting elements. These elements interact dynamically and with non-linearity. Complex systems are open; i.e. they interact with the environment, and can self-organise to maintain global stability. And to be able to adapt and evolve, complex systems must represent the information that is important to them.

Complex systems are also known as autopoietic systems, which means that they are self-bounding, self-generating and self-perpetuating. They create and maintain themselves. They also use feedback (mainly positive) to produce global patterns, and display emergent properties as a result of the dynamic interaction between the system's elements (see section 4.2.1).

Dynamic systems go through a certain number (m^N) of states, which must be the right number for the type of system to survive. These states can be randomly chaotic, ordered equilibrium, or organised complexity. Evolving complex systems usually display organised complexity, where there are a large number of similar, unidentical states. They also have relatively high connectivity levels.

Complex systems function through punctuated equilibrium, when periods of disturbance caused by gateway events break up the stability in the system. After these events, complex systems learn, adapt and evolve, organising themselves into a new states of temporary stability.

Change is very necessary for complex systems. Because they are dynamic and evolving, they need to change to learn and adapt. This change can be external or internal, and complementary or symmetrical. These systems can go through any number of non-linear changes (between one and infinity), which cannot be predicted.

Dynamic systems also display non-linear or disproportionate effects. Causes do not necessarily lead to expected effects, and a particular cause can have one, many or no effects at all.

Predicting the behaviour of complex systems is difficult, because the dynamic interaction of the elements leads to emergent behaviour not inherent in the behaviour of the individual elements [Fitzgerald & van Eijnatten, 2002: 416]. Long-term prediction is only possible in theory; in practice, it would mean that one could measure initial conditions with infinite accuracy. Short-term prediction, however, is possible because of the stable relationships between the elements, and the global patterns complex systems produce during times of stability (between gateway events) [Cornell, 1992: 70].

Social systems can be seen as complex systems because of their high interconnectedness levels, and because they must adapt and evolve to survive. The history of a social system is also important, and these kinds of systems are open, as they interact with and through their environment. Societies are self-referential and autopoietic, and display amplifying feedback.

There are different types of complexity. These can be algorithmic or computational, active or passive, and average complexity increases.

Although chaos theory is similar to complexity theory, it is still based on deterministic rules. There are certain things about complex systems that chaos theory cannot explain adequately: the "life" factors, such as memory, adaptation and learning. Complexity is also more stable than chaos as it maintains global stability through punctuated equilibrium.

Complexity (as displayed in complex systems) is best seen as a hybrid of order and chaos, between equilibrium and randomness. Complex systems need both order and chaos to function, evolve and ultimately survive.

Complexity theory can be called a postmodern theory because it shares many of postmodernism's characteristics. It is a dynamic, non-proportionate theory, focuses on the dynamic, changing nature of systems, and how they display emergence and disproportionate effects. Postmodernism is also a dynamic theory; it acknowledges change, diversity and the importance of the "other". Disproportion, or discontinuity, is a key element of postmodernist systems.

Both complexity theory and postmodernism reject the idea of metanarratives; there can be no universal, all-encompassing descriptions, although complexity does deviate from postmodernism by accepting that there can be universals: the complex phenomena that emerge from the dynamic interaction between stable elements of a complex system.

During the modernist era (polar) opposites were also considered important (see section 3.4). It was vital for structure and stability to have these dualisms clearly defined and opposed. Complexity theory is very much against this type of distinction, for in complex systems this kind of boundary is transgressed [Urry, 2003: 96; Rasche & Wolfe, 2000: 17]. One of more important of these distinctions was between order and chaos, stability and change; as shown above, these two exist together (see section 4.3).

Postmodernism and complexity theory also have in common the idea that knowledge is contingent upon the circumstance and observer involved. Observing the "truth" affects the observer, whilst the observer's environment and history affects his/her perception of the truth. Truth is not, however, completely relativistic. It may just not be possible for man to observe or portray truth absolutely objectively.

How, then, can complexity theory help one to understand the nature of knowledge better? Complexity theory focuses one's attention on the fact that truth is tainted by the observer, and gives one a much better understanding of how most systems function. An understanding of complexity and non-linear systems is important, because linearity and the analytical method of understanding are just not adequate enough. To acquire knowledge one needs to understand complex, non-linear systems, for knowledge displays the same attributes as these types of systems. It is therefore necessary for an understanding of the knowledge acquisition process that one understands non-linear theories such as complexity theory. Complexity theory provides one with a much better comprehension of the world as it really is.

More work is also needed on complex systems for our understanding of them and the phenomena they produce to increase. If one is to be able to understand and model the process of knowledge acquisition, complex, adaptive systems must be studied in greater detail.

In an attempt to discover the nature of knowledge and truth, we have discussed chaos theory as a modernist approach, and complexity theory as a postmodernist approach to understanding knowledge. Now it is time to seek a solution.

Chapter 5 : Conclusions

5.1 Introduction

The purpose of this thesis was to discover something about the nature of human knowledge, and attempt to propose what could be considered a useful and adequate method of acquiring it, if possible.

How much of what one accepts to be true knowledge is actually an accurate representation of how things really are? What does it mean to say one has knowledge; of something specific or in general?

In attempting to answer these questions, chaos and complexity theories were considered as instances of modernist and postmodernist knowledge frameworks respectively. Firstly modernism and postmodernism were explored, and then chaos and complexity were each considered separately.

All that remains is for them to be considered together.

5.2 Comparing Complexity and Chaos

The science of complexity can be seen as the general theory encompassing the non-linear sciences. Chaos theory is a sub-branch of this complexity science [Lewin, 1993: 12]; one of the non-linear sciences, which studies how deterministic systems displaying non-linearity can produce chaotic results, and how to understand them. Complexity theory is another sub-branch of the non-linear sciences, focusing on dynamic, evolving complex systems, and what is necessary to understand them.

Scholars disagree on the exact specifications of these (above) sub-disciplines, and exactly where they fit into the overall framework of complex sciences. Some even consider complexity theory and chaos theory to be one and the same; however, although these theories *may* (in some cases) essentially deal with the same thing (i.e. the complex behaviours displayed by complex systems), the qualitative behaviours displayed by these systems can be very different.

Because it is important to have a firm understanding of the subject matter when one claims to have knowledge of something, each of chapters two, three and four began with an in-depth study of the relevant topic. Considering that all knowledge is interpreted using a framework that involves certain assumptions, backgrounds and environments, two specific frameworks for acquiring knowledge were considered in this text. Both chaos theory and complexity theory are relatively new knowledge frameworks that have arisen because of the realisation that certain older methods are no longer adequate enough to ensure valid and accurate knowledge representation.

5.2.1 Chaos and Modernism

Chaotic systems are not random, they follow rules, display order through self-similarity, and are well-organised, functional systems. They can adapt and may even cause creativity at critical bifurcation points. It is these bifurcation points, however, that lead to the misconception that these systems are entirely random (i.e. no order at all).

Systems that display chaos reach certain critical points where the behaviour of the system must follow one of two distinct paths. The conditions present within the system at the point of bifurcation determine which path will be taken. After this point it becomes impossible to tell which way the system will go, and how it will behave. Its motion becomes chaotic, always unpredictable, yet always within the boundaries of the system. It is therefore possible to predict the behaviour of a chaotic system only up to bifurcation; after that, the only prediction possible is to say that it will stay within the limits prescribed by the attractors in that particular basin.

Chaos theory was considered as an instance of knowledge acquisition from within a modernist framework. This is because chaotic systems follow deterministic, universal rules; which, if understood, could lead to prediction and control. Chaos theory "... makes strong claims about the universal behaviour of complexity" (the phenomenon) [Gleick, 1987: 5]. As seen above, however, these rules only afford (quantitative) prediction up until bifurcation; it would take infinite precision and accuracy to (quantitatively) predict chaotic movement thereafter (although theoretically, it is possible). One can, however, predict what qualitative movements will occur; in other words, one can know *what* possible behaviours the system could display, but not *when* they would be displayed.

A modernist framework for understanding demands a certain amount of certainty, for certainty brings understanding (through its universal nature), which in turn leads to knowledge, prediction, control, and ultimately, success. For modernism, this is accomplished through the *self* (one's own person), which through its own intellect searches for and discovers knowledge. This provides the self with the power that comes from control over knowledge; an inherent desire for all human beings.

With chaos, this process is accomplished through the system. The system becomes the medium through which knowledge is acquired; the system is the will to power — through control over knowledge. If one can know what the system will do, one can predict its behaviour; if one can predict its behaviour, one can gain control over the system. This control brings with it power.

There are, however, some ways in which chaos theory diverges from a modernist framework of knowledge. Chaos is against dualisms, whilst modernism strongly upholds them. In chaotic systems, boundaries and oppositions do not need to be as rigid, as they can be moved, transgressed or even inverted. Also, chaotic systems do not allow for modernist reductionism, because the phenomenon of emergence (present in both chaotic and complex systems) means that these systems cannot be reduced to the sum of their individual parts.

Modernism as a framework for the acquisition of true and valid knowledge is much restrictive. To gain the kind of certainty modernism desires requires that all knowledge must be completely objective; otherwise it cannot be considered true or valid. But this is not possible, as all knowledge is a representation of the truth, tainted by the background and environment of the person/s involved. Knowledge is affected by the purporter, and the observation process is influenced by the observer [Rasche & Wolfe, 2000: 21].

Chaos is a less restrictive modernist theory, as it allows for prediction only up to bifurcation; after that, no one can be certain what the system will do. A chaotic system does, however, still have to follow all the deterministic rules that govern it.

5.2.2 Complexity and Postmodernism

Complexity theory investigates complex systems, those systems that have a large number of interacting, highly interconnected elements, and the phenomena and behaviour they produce. Complex systems are open to their environment; indeed they create, define and sustain their own boundaries. They are also fully able to maintain themselves, by learning to adapt and evolve for survival.

Complex systems produce emergent phenomena — phenomena or behaviour not inherent in the individual elements of the system — through the interaction between the elements. These phenomena cannot be predicted because of the non-linear nature of the interactions between the elements.

Through the process of feedback complex systems display self-organised complexity. This means that they learn and adapt through punctuated equilibrium, incorporating order and chaos. Gateway events cause large disruptions in the system, from which it learns, evolves and reorganises itself into a temporary pattern of global stability.

It is these patterns that emerge out of disorder that make temporary prediction of complex systems possible. During the times of stability between gateway events, the elements in a complex system exhibit stable relationships. These can be understood and used to predict what the system will do — until the next gateway event. Hereafter, the system will have evolved, and new stable relationships will have formed.

Complexity theory was considered as an example of postmodern knowledge acquisition. For complex systems change is important. It fosters the adaptation and evolution process. Postmodernism also considers change to be important. Without it, life, society and development stagnates. And because social systems can be considered complex, it is important to understand complexity so that one can understand social behaviour better.

Postmodernism considers the individual to be important. No one person should be privileged above another. The previously hated "other" now becomes at least as valid and important as the "norm" had been. Diversity and life are to be celebrated, not condemned, and dualisms can no longer be enforced, for they undermine one another.

Complexity theory also considers the "life" qualities of a system to be important: memory, adaptation, learning. Without these, the system cannot survive. Dualistic distinctions between polar opposites no longer exist, because a dynamic, non-linear system dissolves them. Chaos and order, stability and change exist together within the system, maintained through punctuated equilibrium.

5.2.3 Complexity, Postmodernism and Relativism

The theories of relativism and postmodernism share a number of commonalities. Both reject the ideas of metanarratives, and absolutes. Because knowledge is dependent on the perspective of the viewer — all descriptions are interpretations based on the viewer's circumstances and framework — all knowledge remains a representation of the truth. Every person's representation will then differ according to their own framework, circumstances and history, so there can never be a universal, all-encompassing description of the universe or of any phenomenon for that matter, because this would imply that every person has the same perspective, the same circumstances and the same history, at the same time.

There can be no metanarratives to describe complex systems either, as this means that a unified description of all types of complex systems and complexities exists, that is the same for all people at all times. This is not possible, not only because the complexity of complex systems is too diverse and unpredictable to lump together under one common description, but also because once again no two people will view complex systems and their arising complexities in the same way, at the same time. This is also a postmodern quality.

There can also never be any absolute truth, because this would mean that it is the same at all times, in all places, and for all people. But this is not possible, because knowledge is contingent upon the multi-perspectivity of its observers. Meaning is derived from interpretation: the interpretation of knowledge in the specific context, through the specific person's framework. This is something well-known to modernist scientists, for science progresses on the basis that one does *not* have absolute truth.

How, then, does one recognise and "... acknowledge the contingency of all description and interpretation" [Rasche & Wolfe, 2000: 9], without falling into relativism? As seen in chapter two, relativism involves a belief that *everything* (every statement, every fact, every bit of knowledge) is relative to the point of view of the person involved. This belief is not rationally grounded, as it contradicts itself in many ways; not least of which the point that *any* statement therefore has as much validity and truth as any other. So the statement: *'relativism is false'* must be as true as the statement *'relativism is true'*. There is clearly something wrong with a theory that tends towards a contradiction such as this; unless one does not consider the standards of logic necessary for a theory's validity.

This said, most theories have something wrong with them, or at least parts that may be less obvious than others; this does not, however, mean that one should ignore every possible contribution those theories could make to man's understanding of the world in general and phenomena in particular.

Also seen in chapter two, Protagorus' answer to this problem, "true-for-me" relativism, which implies that there is no truth "out there" per se, involves a realist disagreement over facts. If this was not so, "true-for-me" relativism would merely be differences in opinion, and would not pose a problem for the relative claims of knowledge.

This disagreement implies a realist attitude towards the phenomenon in question. *'The world is round'*, and *'the world is flat'* both imply that there is a phenomenon ('world') to which they refer, that exists independently of how one perceives it. The 'world', therefore, must exist "out there" a priori; and truth, then, does exist independently of one's point of view, although the *interpretation* thereof remains just that: an interpretation.

The archic canon (see section 2.3.5) also requires further attention. Is it necessarily true? The alethic character of relativism means that it is a theory by which one can understand truth. This implies that relativism is *only* a theory, one of many ways in which truth can be understood. If relativism is to be accepted as true, then this statement (that relativism is only one theory of many) can be viewed from two different angles.

The first side is that it is only true if accepted from a certain point of view, or for certain people. Relativism is a theory of truth or knowledge adhered to by some people, just as realism or scepticism is followed by others. This fits in with relativism's claim that all points of view are equally valid, and no truth exists independently of one's perspective.

The other side of the view that relativism is only a theory presents a bit more of a problem, however. If truth can be understood (which must be possible if relativism is a theory by which one can do so), then this means that there is something to be understood. Does this not imply that 'truth' exists independently of how one goes about understanding it? For if one can take any approach valid for one (from within one's own perspective) to understand knowledge and truth, then it follows that this knowledge and truth must exist for one to be able to understand it, especially from any point of view.

By saying that knowledge and truth exists independently of how one views it does not, however, mean that truth necessarily has a physical existence, that it can be observed as an 'object'. Knowledge and truth are inherent parts of other objects or phenomena, and do not necessarily have a 'real' existence of their own. What is meant is that truth or knowledge about some other real object can be gained, because truth is still independent of the view one takes towards it.

For example, *'the earth is round*[12]*'* is a statement that appears true (based on the latest available 'evidence') regardless of the perspective one has towards it or of the phenomenon in question, the earth. The earth is the object that has real existence, but the truth of the statement about it, *'the earth is round'*, still (appears) true nevertheless.

Also, the ontic constraint of the archic canon — that the world or reality is unchanging — must surely imply that this is true regardless of the perspective one has of it. If the world is unchanging, how can one's perspective of it change it? Yet relativists must accept this constraint as prerequisite for their theory to work. And as far as absolutes go, *'the world is unchanging'* is definitely an absolute; if one denies this, then one denies the prerequisite of the ontic constraint, and, essentially, one denies relativism.

There are other such instances of absolute truths that relativists claim (whether consciously or sub-consciously), such as: *'there can be no absolutes'*, which put their theory in jeopardy. If all claims or points of view truly are relative, then such statements as these cannot exist (or can at least not be considered true or valid).

The strong sociological form of cultural relativism (see section 2.3.5.2) presents one with more of a moral authoritative problem, rather than an epistemological or ontic one. If what Bachelard claims is true, that scientific truth is merely what fits in best with the social policies of that time, then whoever is in charge of those policies gets to decide what is scientific truth and what is not. Should this be allowed? How can one know if the person deciding these 'truths' knows or even cares what the actual state of reality is? If knowledge is merely a representation of truth in part, how can anyone be qualified to prescribe for others what truth should be?

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[12] Round: the earth is in fact spherical, but *round* is used here for continuity with previous examples.

This does not, however, mean that all knowledge is entirely relative, merely that our *interpretation* thereof is contingent on our point of view. This means that it is not possible to gain an entirely objective account of knowledge, because any human account will always involve not only human error based on prejudice or misunderstanding, but also misrepresentation because of personal background, beliefs and environment. Even if the observer of knowledge is able to be completely objective, there will always be some aspects he/she will focus on that others would not, and some aspects left out: our history and our beliefs make us see things in a certain way.

It is therefore always necessary to remember that whatever knowledge is acquired (from within a framework) should be interpreted from within that same framework. And that one person's point of view is not necessarily any better or worse than another's. This suggests that one should take certain notions — such as 'objectivity', for example — with a certain pinch of salt. Scientists often strive for objectivity, knowing full well that it is a near impossible goal [Cornell, 1992: 70]. Perhaps these terms should be redefined to include that inevitable element of human subjectivism.

5.3 The Quest for Knowledge:

Four years into the 21st century man could be considered to be at his most advanced concerning knowledge of the world in which he lives. It is logical to expect that this kind of progress would be reflected in the way people run their lives, interact with one another, and live in conjunction with the environment. But this is not so. Why is it that man has all this knowledge, and yet still lives as if he were the only living thing on this planet?

It may be merely that human beings are essentially selfish — or at least ignorant — and that the furthering of science to gain knowledge is simply to make our own life better. This is possible. But what is also possible is that much of what is considered human knowledge is actually not only incomplete truth, but maybe even be distorted or simply false versions of the truth.

The intended purpose of the complex sciences varies from person to person, and it is possible to see how a person's expectations could lead him/her to concentrate research in a specific direction:

> *Non-linear science['s]... aim is to provide the concepts and the techniques necessary for a unified description of the particular... class of phenomena whereby simple deterministic systems give rise to complex behaviours... [Nicolis, 1995: xiii].*

Unified implies a universal, metanarrative description of non-linear systems. This attempt at forcing modernist descriptive processes on complexity is limited. There can be no metanarrative to describe non-linearity (see section 4.4). But if one expected the non-linear sciences to function in a modernist way, and provide answers to modernist questions, then one would consider the above attempt worthwhile; indeed, one would most likely focus only on that which (could) accomplish this.

Considering the above frameworks: modernist chaos and postmodern complexity; what does it all mean for the quest for knowledge? As already discussed, knowledge can never be entirely objective. Also, a linear approach to understanding is very limited, and will mostly not bring one knowledge of the world around one. As most social and organic systems are non-linear, it is with theories that allow for non-linearity that one must approach understanding of them.

Both chaos and complexity have something important to give to the non-linear approach to understanding. Chaos provides one with the knowledge that simple rules can cause chaotic behaviour, and prediction is very limited. Complexity presents one with the birth of entirely new phenomena not inherent in the individual components, and awakens one to the intelligent behaviour of the system. Both theories involve a combination of order and stability, and it is through this organised complexity that a non-linear approach to understanding should be attempted.

From chaos theory come the modernist universal rules that make mathematical understanding of non-linear, complex or chaotic systems easier. And through complexity theory one can gain insight into the postmodern dynamic, self-organising nature of everyday systems. As it is knowledge we desire, and knowledge could be seen as a dynamic, complex system, then "knowledge, as organised information may also be interpreted as complexity" [Jantsch, 1980: 218].

The global stability that complex systems present through stable element relations between gateway events in punctuated equilibrium also provides man with a way of understanding what happens when self-organising systems have adapted and evolved. This can help us understand much about these kinds of systems.

For an example of how chaos and complexity, modernism and postmodernism can and should work together to assist one with the process of knowledge acquisition, consider again the general theory of systems (see section 4.2).

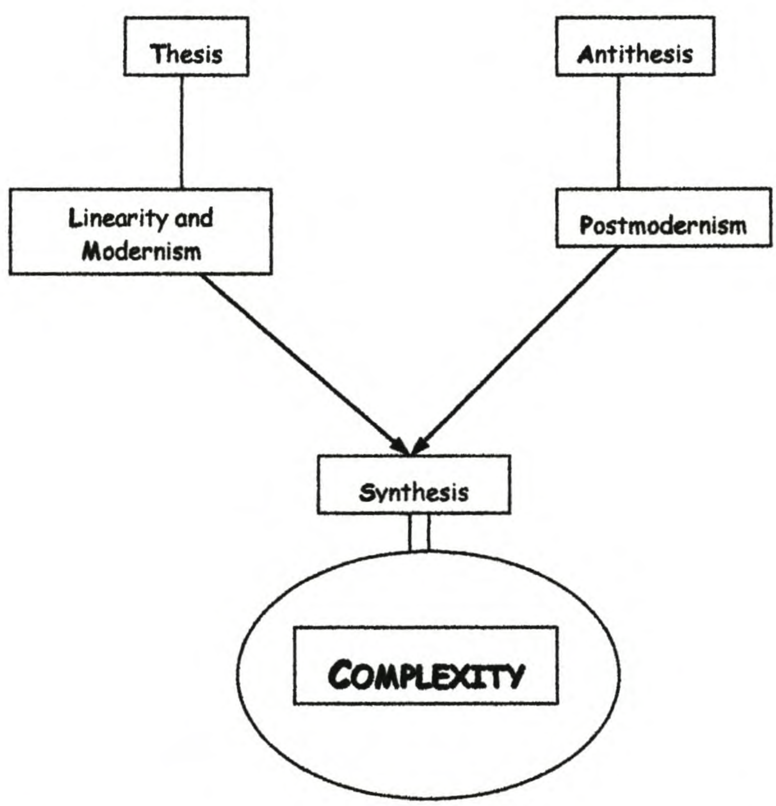
Systems theory is a pragmatic theory; it acknowledges that knowledge is contingent [Rasche & Wolfe, 2000: 16]. This implies that one should be greatly committed to epistemology: search for the best means of acquiring knowledge. It does not mean one should disregard it simply because it cannot be 100 percent objective. Knowledge and truth can still be real, still be applicable.

Systems theory wishes to describe all systems. However noble this may be, it is most likely that a metanarrative of systems does not exist, for it is not possible to describe linear, non-linear, self-organising and chaotic systems together (in the same way).

Systems theory is, however, a theory of knowledge that explains human behaviour better than many theories — such as modernism — because most social systems are complex — and chaos theory — because it addresses many different kinds of non-linear systems. It is against dualisms, and for plurality (or multi-perspectivity), which means that it could be called a postmodern theory [Rasche & Wolfe, 2000: 17, 21].

Systems theory is against the "Modernist and Enlightenment strategy... of reducing complexity via social consensus" [Rasche & Wolfe, 2000: 21]. Reductionism is much limited in supplying useful knowledge about complex systems (because of the phenomenon of emergence). It is also important to ask why one should desire to simplify complex systems (or phenomena) merely because some (or all) people do not understand the complexity displayed by such systems (or phenomena). The human desire to understand should not cause one to allow the complexity and "life" of complex systems to be lost or weakened in an attempt to make it more understandable.

It is not always possible for man to understand certain things. Many such things become clearer only later, when humans have in a sense 'caught up' with the complexities of such phenomena. It does, however, seem possible to bridge the gap between linearity and postmodernism. If linearity and modernism (i.e. the analytical approach) are considered the thesis of studying systems, and postmodernism is the antithesis, then complexity could be considered a synthesis (see figure 5.1).



<u>Figure 5.1:</u> Schematic of complexity as the synthesis of reductionism and postmodernism [Adapted from: Byrne, 1998: 44]

The resulting epistemological framework, with which one can best observe, discover and interpret knowledge and truth, then, is a non-linear, dynamic theory that incorporates modernism and postmodernism, and the best of chaos theory and complexity theory. This framework should mimic complex system behaviour as much as possible, to be able to gain appropriate insight into the workings of everyday systems, and to account for the incompressibility of such systems.

A knowledge framework remains just that: a framework. Though it may seem that this means one can interpret knowledge and truth from within any framework, from any point of view, this is not entirely so. If the frame of reference one uses to study life and behaviour around one is not flexible, dynamic and willing to change, grow or even be rejected if no longer applicable, then one will be limited in the knowledge one acquires through this framework.

One more question on the road to knowledge remains: is complexity merely ordered chaos? This has been suggested by some authors and scientists, and while they do not claim that chaos and complexity are one and the same thing, they maintain that complexity is merely the result achieved when chaos becomes ordered.

Out of the discussion of the previous three chapters it is clear that chaos and complexity are not the same. What is also clear is that chaos and complexity are two different behaviour states displayed by non-linear systems. The third of these states is ordered equilibrium. A dynamic system can display any of these states, at any time. Only truly linear, ordered states exist at equilibrium all the time. To be in a constant state of equilibrium means death for the complex system (as seen in chapter 4), because it has no chance to adapt and evolve.

Chaotic systems display order only at certain times. This is before the next bifurcation, when the system settles into a routine of undetermined regularity. Complex systems maintain order only for a short time: between gateway events. Then their elements are in stable relationships; but only until the next disturbance, after which they learn, adapt and evolve.

So to say that complexity is merely ordered chaos is not only incorrect, it demonstrates a complete misunderstanding of what complexity and chaos really are. Chaos cannot become "ordered", and complexity is not just chaos that has been "smoothed out" and become regular. Complexity is a whole new experience on its own, and with the birthing of emergent phenomena, complexity can never merely arise from chaos that has "been ordered".

5.4 Conclusion

Some authors, such as Urry, consider chaos and complexity to be one and the same phenomenon [Urry, 2003: 17]. Others view complexity theory merely as a branch of chaos theory [Marion, 1999: xii].

Although complexity and chaos theories appear very similar, as they both deal with dynamic systems, and both describe increased levels of complexity (see figure 4.2), chaos theory is still based on simple, deterministic rules. Because of this, it cannot describe the complexity generated by the multiple dynamic interactions of complex systems adequately [Elliott & Kiel, 1997: 67].

If one attempts to analyse social systems using chaos theory, one will miss most of the "life" displayed by these systems: their adaptation, reproduction and evolution [Marion, 1999: 6]. Chaos theory cannot explain the social phenomena of consciousness, memory and identity [Marion, 1999: 7]. One needs a richer sort of explanation.

Complex systems are also more stable than chaotic systems [Marion, 1999: 7]. Chaotic systems have little memory because information is lost due to the butterfly effect [Marion, 1999: 73].

The study of chaos theory should not, however, be discontinued. Chaos theory has opened the door to understanding and gaining knowledge of a whole range of previously unassailable topics. A non-linear understanding of knowledge would perhaps not have been possible, or at least very limited, had it not been for the emergence of chaos theory. Also, chaos focuses our attention on the fact that the simple and the complex are not always causally or proportionally related. The modernistic universal rules that appear in systems displaying chaotic behaviour further promote understanding in a non-linear way.

Complexity theory also provides one with insight into the new phenomena that emerge out of the interaction of complex systems. The postmodern, self-organising nature of those systems around one can provide much knowledge necessary to facilitate the process of understanding.

The studying of the complex sciences, therefore, should:

> *... be seen not as aiming at a new 'synthetic theory' of complexity of any kind, but as a cross-disciplinary field of research and meeting place for dialogue between specialised groups of people such as biologists, physicists, philosophers, mathematicians, computer scientists, and, last but not least, science writers [Emmeche, 1997: 43].*

These types of systems have shown us that prediction is possible, only that it is limited. They have also shown us that it is possible to acquire knowledge of phenomena previously considered too complex, or too random, to understand.

These facts alone should be enough to encourage us to persevere on the road of discovery. Armed now with an integrated modern and postmodern, chaotic and complex, ordered and non-ordered, systematic non-linear theory of understanding, the fulfilling and successful pursuit of knowledge for the sake of the journey of learning and understanding is made possible. Towards this we should strive.

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