Chapter 2 – From Mechanism to Inclusion: a discussion of selected literature on the philosophy of science and systems

2.1 Introduction

We all have a history of learning and experiences that affects the way we interpret the world. In research it is important to acknowledge this; it helps others to follow our reasoning if we explain how we got to where we are today. In this and the following three chapters I shall introduce the prior research and philosophies that have influenced my own ideas, so that the reader can recognise their precedents and follow my reasoning in the subsequent theoretical chapters of this thesis. In this chapter I shall discuss how we might have arrived at our contemporary views of the world, beginning with the development of classical orthodox models of thought, which are prevalent in modern scientific investigation. I shall then move on to discussing a number of other models that contrast with the classical worldview, including non-linear and "systems" approaches, holism, and a newly emerging viewpoint known as Inclusionality.

2.2 Classical modes of enquiry

The classical approach to enquiring about the world has long been dominant in Western society. This view originated in Ancient Greece, most notably in the writings of Aristotle. Aristotle believed that knowledge of the natural world should be based on what is *perceived* to exist there. He maintained that one could use the concrete and material evidence gathered by our *senses* as a start point, from which one could build an understanding of the world that is based on reasoning and logic. In subsequent years, Aristotle's rationale-based approach was discarded in favour of the church-led dogma that dominated the natural sciences during the Middle Ages. Centuries later however, the philosophers who were instrumental in the Scientific Revolution of the 16th and 17th Centuries returned to Aristotle's line of thought, and his evidence-based rationale became highly influential in their own philosophies. In fact it remains so in modern times, and even today we still sometimes refer to "Aristotelian logic", as it has played a fundamental role in how many think about the world.

The Scientific Revolution, which took place during the sixteenth and seventeenth centuries, was brought about by a succession of philosophers including Copernicus, Galileo, Bacon, Descartes and Newton. These giants of the philosophical world all contributed towards a line of thought that was to become the *mechanistic* worldview. This contrasted strongly with the prevailing view that had developed during the centuries that spanned the period between the Greek philosophers and the Scientific Revolution. During those “dark ages”, the Christian church dominated philosophical thought, and consequently, until the Scientific Revolution began in the sixteenth century, with the works of Copernicus, it was widely believed that the cosmos, and everything within it was created, maintained by, watched over and judged by an external Creator. Theology, philosophy and science were, at that stage, inextricably linked. Fundamental in this view was a geocentric model of the cosmos, where the Earth lay at the centre of the universe (placed there by God), orbited by all the other heavenly bodies (planets, stars and so on).

Copernicus however, was the first to suggest that the earth lay not at the centre of the universe, but that it was but one part of a system of planets that orbited the sun. At first this model was, predictably, shunned by the Christian church, which considered it to be heretical. Slowly however, as a result of work by philosophers such as Kepler and Galileo, and later Descartes and Newton, the model began to gain acceptance.

What was most significant about this newly emerging view of the cosmos was that it no longer demanded that God the creator be situated at the centre of the universe, controlling and causing action in all other areas. Rather, in the new scientific view, God was believed to be the creator of a *machine-like* system of parts that function together as a complex whole. God created the system and the laws by which it functioned, but his action was not necessarily required to explain the action of the system. Like a clockwork mechanism, once started, the cosmic machine would run of its own accord.

The French philosopher, Rene Descartes was a key instigator of this mechanistic view (Sagan, *et al* ,1997; Tarnas, 1991). Descartes began from the initial assumption that the only thing of which he could be certain was the existence of his own doubting mind. With this as a “first principle”, (the only one of which he could be certain to be true), he used a process of logic and reasoning to develop further philosophies about the nature of being. Principally, he developed a theory whereby all things in the world exist as either “*res cogitans*” (thought, spirit, experience and the like) or as “*res existans*” (material substance, matter, the physical world etc.). Descartes proposed that the only beings in the universe that embody “*res cogitans*” are God, and human beings (because we have consciousness). Descartes’ logic led him to assert therefore that all things that are neither God or human, are machine-like automata that function according to a set of pre-determined rules. Descartes believed that it was possible to deconstruct the “machine” and gain an understanding of the whole by examining the component parts.

It was, however, Isaac Newton who managed to distil and unite the newly emerging mechanistic worldviews of these various philosophers into a physical model that would transform Western science (Tarnas, 1991). Newton developed three fundamental physical laws (inertia, force and equal reaction), along with his theory of universal gravitation, which explained and exposed the mechanisms by which a heliocentric (sun centred) cosmic model would work, as well as a great many other natural phenomena.

So, as a result of the work of these various pioneering philosophers, the Scientific Revolution took place, and the mechanistic worldview was born. The birth of this view was to be a pivotal point in the development of Western science. The Cartesian/Newtonian view of the world as a giant machine has permeated through history to become fundamental to the way that most scientific research is carried out today. Today, most scientists implement a mechanistic view in the form of a methodology, where systems of any sort are considered to be constructed from “parts”. In this methodology, physical and living systems alike are disassembled, to their “component parts”, before being described and investigated. The knowledge gained in this piecemeal manner is then reassembled, to build a picture of the whole system. This approach is known as *reductionism*. The reductionist approach, whereby systems are deconstructed to smaller and smaller components in order to gain an understanding of the whole system, has become deeply embedded in the way analytical research is conducted today.

One area where one might suppose the mechanistic view not to have become so dominant is in the life sciences, where because one is dealing with living organic systems, it might be thought that some other paradigm, such an organic model, as opposed to a mechanistic one, would be favoured. But paradoxically, the conventional approach to biological science is often *highly* reductionist. This stems again from the powerful influence of Descartes and Newton, who sought to explain nature in terms of mechanism. In biological laboratory science the approach is often highly reductionist. For biological lab work, the conventional approach is to extract an organism, let us suppose it's a plant, from its natural living environment, and place in a sterile and "controlled" laboratory, where all aspects other than those that are being examined are controlled or accounted for. Ostensibly this is done to simplify the investigation, so that only one part of the complex ecosystem that the plant normally inhabits need be examined, i.e. the plant itself. Often the focus of interest is at a level lower than the whole organism. So, to further study the functioning of the plant, it is broken down, to leaves, flowers, roots etc. and each part investigated separately. Scientists have even developed techniques that allow them to culture parts of an organism after they have been removed from the system, as in plant cell culture, where parts of a plant can be kept alive in a Petri dish, through the addition of nutrients, hormones etc., and the exclusion of microbes such as bacteria, that would otherwise cause the cells to decay. The principle is that many different researchers may work on different aspects of plant structure and function, and that the findings they all individually make can be pieced back together to create an understanding of the plant as a whole.

The connection of the parts that have been studied using a reductionist approach usually involves a search for sequences and cause-and-effect relationships. A system that has been analysed reductively is often characterised by the exposition of linear relationships between elements, and by hierarchies. Hierarchies within a system are significant, as they engender a structure where some elements of the system take precedence over others. Hierarchies, whether real or imposed, suggest that parts of a system are more *powerful* than others.

A key goal of reductionism and classical analysis is to produce an understanding of systems that permits their behaviour to be *predicted*. Once behaviour of a system can be predicted, and cause-and-effect relationships within it are understood, one has the potential to exert control over it and to have influence over its future behaviour.

The apparent advantage of the reductionist approach is that it breaks complex problems down into manageable parts, and there is no question that Western reductionist science has told us a great deal about the world in which we live, as well as giving us many tools with which we can control it. Western science, and its reductionist methodology have given us breakthrough technologies, such as antibiotics, medicines and so on. It has at the very least given us a place from which to start our investigations, allowing us to build our knowledge of the world around us piece by piece, working from the simple to the complex.

This reductionist approach, however, make some significant assumptions. The first of these is that the world *can* be broken down into smaller manageable-sized parts, and that the things we learn about these isolated parts will actually relate to the whole systems from which they originate. The second is that it that is *possible* to make clear distinctions between the different parts of a system, and that one could take an imaginary pair of scissors and “cut out” the object of interest so that it can be separated from its environment. This view has been referred to as “discretism” (Rayner, 1998). In a discretist approach, objects and phenomena of interest are *defined* so that they may be identified independently from their surroundings.

The discretist view also has some important philosophical implications, and could be said to require a number of “leaps of faith” to be able to work in the real world. At a fundamental level, discretism assumes that any entity within a system *can* be defined independently from its context, and that it is *possible* to conceptualise any part of a system as an independent entity. This appears easy to do when dealing with say, berries on a blackberry bush – we can pick the berries and hold each one individually in our hands. But in many systems parts cannot be so readily distinguished, such as a “seat” on a long gym bench, or the branches on a tree. In these examples it is much harder to distinguish where one seat ends and the other begins, or where trunk turns into branch.

So, one of the repercussions of a discretist approach is that boundaries in the system of study are required to be precise. This can either be achieved through identifying physical structures – as in the blackberries (the berries are apparently distinct from the bush, as they can be “picked off”), or through imposition, which is what one would have to do to define a “seat” on the bench.

In a discretist paradigm it is thought to be possible to separate anything from anything else; to pick out “A” from “that which is not A”. This polarised view should be familiar to those who have studied Western philosophy, as it is sometimes known as the “Law of the Excluded Middle”, it reflects the Aristotle’s “two value logic” and the Cartesian concept of “Dualism” (Haste, 2000). Dualism separates entities in a bipolar fashion. As I mentioned earlier, Descartes proposed that the workings of the mind could be separated from the body, effectively creating a clear distinction between that which is “thought”, and that which is “substance” (Tarnas, 1991). Dualistic thinking is one of the dominant features of the classical worldview. This mode of thought encourages us to make clear distinctions between one thing and another, be it subject and object, observer and observed, content and context, self and other, male and female (Haste, 1993), and inner and outer (Rayner,1997). These bipolar distinctions have directed the paths of Western thought, promoting a focus on clear *categories* of being, and a steering away from that which is “fuzzy”, without boundary, or ambiguous (Haste, 2000). As a result of dualistic thinking and approaches, which have been particularly influential in Western *science*, the predominant scientific viewpoint is one that values clear definitions, and seeks to clear up ambiguity or lack of clarity. That which is “between”, a “best fit” or an “uncertainty” is less valued.

2.3 Systems theory, chaos and complexity

The Cartesian/Newtonian worldview has not gone unchallenged. At sporadic intervals since it was first developed, alternatives to the dominant mechanistic worldview have appeared. For example, during the late eighteenth and nineteenth centuries the Romantic movement, which was pioneered by authors, painters, and other artists of the day, shifted the balance of favour away from the mechanistic paradigm (Capra, 1996). During that time, the influential philosopher Immanuel Kant (1724-1804) argued that the processes of scientific enquiry can only provide insights that are mechanistic, but that organisms are not like machines, and that they exist as self-reproducing, self-organizing wholes (Capra, 1996; Kauffman, 1995). Later in the nineteenth century however, the mechanistic view regained its dominant hold, spurred on by the development of microscope technology that lead to significant advances in biological science (Capra, 1996). It was during this era that modern cell biology and microbiology were born, which of course was driven a significant step further by the work of Louis Pasteur (1822-1895), who discovered the first antibiotics.

Early in the twentieth century there was a further shift away from Classical Analysis toward what we now refer to as the "holistic" movement. The development of the quantum theory of physics during the 1920s and 30s revolutionised the world of physics and mathematics. Quantum theory represented a radical shift from classical Newtonian physics and analytical reductionism. Unlike the Newtonian view, which considers matter to be completely solid, according to quantum theory, at a subatomic level matter exists as a pattern of *probabilities* (Capra, 1996; Penrose, 1999). This revelation threw Classical Analysis, with its reliance on the Cartesian distinction between the substantial and the insubstantial, into turmoil. A bevy of physicists and mathematicians, including Planck, Bohr, Heisenberg and of course later Einstein (Penrose, 1999) published work related to quantum mechanics that remains influential today.

The physics-led advances in quantum mechanics opened a path that led researchers in other sciences toward new non-classical approaches, particularly in biology, but also in the social sciences and psychology. For example, a number of psychologists in the 1920s began to develop a view of human psychology that involved pattern-recognition, and concerned “wholes”, rather than parts, resulting in a field of psychology known as Gestalt theory (Greenfield, 1995). Gestalt theory states that the way living beings perceive the world around them is not as a series of isolated elements, but as integrated patterns that give rise to meaningful wholes. The work of the Gestalt psychologists had significant influence on other researchers. It was instrumental in the development of Social Network Theory (which will be discussed in detail in Chapter 7 of this thesis), and also led directly to the rise of systems thinking, and systems theory.

2.3.1 Systems theory and cybernetics

Systems theory is a term coined by Bertalanffy in the 1940s (Bertalanffy, 1968), it deals with whole systems, rather than their disassembled parts. By contrast, the focus in systems theory is on the *interactions* within and between parts of a system, and on the interactions between a system and its environment. Context is therefore given some recognition in systems theory. Bertalanffy believed that there are general “systems” principles that apply to many different kinds of system, be they biological, physical, chemical etc. To study a system using systems theory was intended to bring these general principles to light. Some of the principles that Bertalanffy identified as “systems concepts” include the way that systems deal with inputs and outputs through processes, and how information can be viewed as a currency of communication.

One of the key points raised by Bertalanffy was the difference between *closed* and *open* systems. Closed systems are isolated from their environment; they have no inputs or output exchanges with anything outside of their boundaries. The boundaries of a closed system are completely impermeable, and as such they define the extent of the system’s reach. Until the development of systems theory, most of physics dealt only with closed systems. Thermodynamics specifically states that its laws only apply to a system that is closed.

A closed system will tend to move towards greater order; to increase its *entropy* until a maximum level whereupon a state of *equilibrium* is reached. In a closed system this equilibrium state is achieved, and maintained, without the input of further energy than the system already contains. Upon reaching a state of equilibrium, however, the system is effectively "fixed" and unable to perform any "work" (Bertalanffy, 1968).

In the living world however, no system is closed; living systems have permeable boundaries, and are engaged in constant dynamic exchanges with their environments. According to Bertalanffy, living systems tend toward a "steady state", which is a state of *dynamic* equilibrium. An open system that is maintaining itself at a steady state is apparently in equilibrium, yet it is not actually in a state of true physical, chemical or energetic equilibrium. Rather, it is maintained dynamically in a non-equilibrium state, at a point that is not the level of maximum entropy were the system to be made closed. In order to maintain this state of dynamic equilibrium, an open system requires energy input. The benefit however, is that an open system is capable of performing "work" (Bertalanffy, 1968).

At around the same time that Bertalanffy was working on systems theory, a group of mathematicians, neuroscientists, social scientists and engineers began work on a novel system model that became known as c*ybernetics*. The word cybernetics is derived from the Greek term *kybernetes*, which means "steersman". Cybernetics has been defined as the "science of control and communication in the animal and the machine" (Wiener, 1948). During the 1940s, this initially diffuse group of researchers organized a series of now famous meetings known as the Macy Conferences, which were held in New York City. In these meetings, this group of researchers, who included Gregory Bateson (a biologist/ecologist), Margaret Mead (a social scientist) and Norbert Wiener (a mathematician), collaboratively developed the theoretical framework of cybernetics. Central to cybernetic theory are the concepts of *feedback*, and *feedback loops*. The principle is that in any autonomous system, processes are controlled and self-regulated by causal cycles, where the outputs of processes are connected together in cycles, with the output of each process becoming the input for the next. The nature of the connection between each process determines whether it is a *positive* or *negative* feedback relationship. This is illustrated in Figure 2.1.

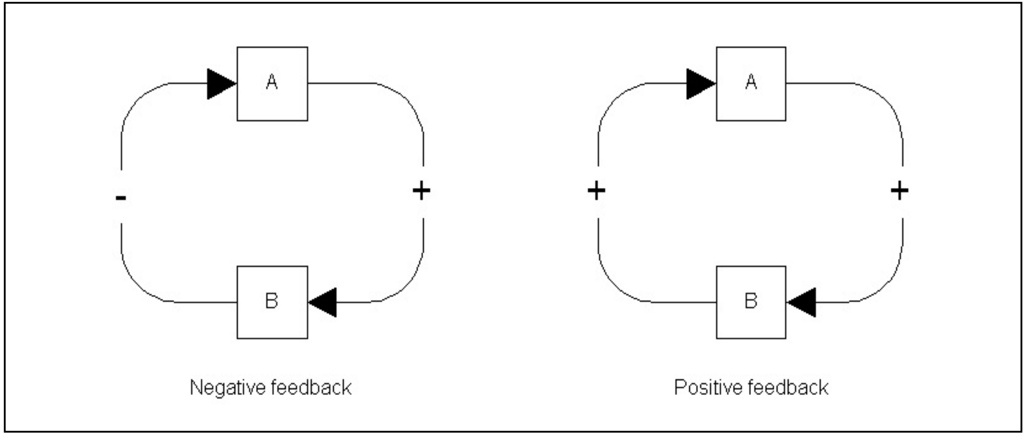

Figure 2.1. Feedback relationships. When the output of process A amplifies the reaction of process B, and the output of process B in turn amplifies the reaction of process A, then the relationship between them is known as a *positive* feedback relationship; when the output of process A augments the reaction of process B, but the output of B diminishes the reaction of process A, the relationship is known as a *negative* feedback relationship.

Closely connected to cybernetics is Shannon and Weaver's "information theory" (Shannon and Weaver, 1949). In information theory, information is viewed as a measure of uncertainty or entropy; the greater the amount of information, the lower the uncertainty. Shannon and Weaver's model deals specifically with how information is transmitted. They postulated that for information to be transmitted, it has to undergo several stages. Firstly information originating at a source is converted into a *message.* A *transmitter* then translates this message into signals that can be transmitted along lines or channels to the *receiver*. This receiver then converts the signals into a message again that is decoded and interpreted. This model of information transmission was originally targeted at engineering communication, but in subsequent years it has been applied in many different domains, from telecommunications to biology, social sciences and human dialogue.

Henri Atlan has made connections between information theory and biology, specifically in terms of the immune system (see Atlan and Cohen 1998). In animals, elements known as antigens and antibodies are key components involved in an immune response. An antigen is any molecule that triggers an immune response; an antigen might be a molecule on the outside of a pollen spore, or a cold virus for example. An anti*body* is a molecule produced by the immune system that attaches to and neutralises antigens. The relationship between antigen and antibody is highly specific, often with a single type of antibody being produced to target a specific antigen molecule. In their (1998) paper titled "Immune information, self-organization and meaning", Atlan and Cohen explain that the relationships between antigens and their associated antibodies could be viewed as a means of transmitting *information*, where the antigen is treated as a transmitter and the antibody as the receiver.

Although Atlan bases his model on Shannon and Weaver's information theory, he does make some important distinctions. Significantly, Atlan argues that the way in which extraneous information or "background noise" applies to a biological context is quite different from that of the engineering context in which Shannon and Weaver originally applied their model. In an engineering context, noise is seen as a factor that reduces the quality of the information and which should be cut out for the quality of the information to be maintained. Atlan however, argues that in a biological environment, noise is vital to the system as a means of providing *complexity* from which genetic mutations might occur, enabling the system to change and adapt. As Atlan points out, this ability for information to be adapted or to be added to is something that is not accounted for in Shannon and Weaver's original theory.

Systems theory, cybernetics and information theory therefore represented radical moves away from the classical mechanistic models of the natural world that had held sway until then. In contrast to the Cartesian/Newtonian preference for studying objects in isolation from one another, these new models considered the *processes* and *relationships* between objects in a system to be as significant, if not more so, than the objects themselves. The systems view only made sense if one looked at the system as a whole. The classical reductionist methodologies were of little use in a systems theory paradigm, and so these new models required the development of a whole new set of tools.

Some of these tools appeared in the form of the new domain of *non-linear mathematics*. Non-linear techniques provided a new way of dealing with the mathematics of complex natural systems; systems that didn't fit neatly into the classical Newtonian paradigm. Rather than normalising data so that it would fit into a traditional linear mathematical model, non-linear techniques allowed iterations and feedback loops to be accounted for. Iterative and *self-similar* [1]patterns are very commonly encountered in the natural world, so the new non-linear mathematics had direct relevance to real-life natural systems. The study of non-linear mathematics soon gave rise to two new fields of science: "chaos theory" and "complexity theory".

2.3.2 Chaos theory, complexity theory and emergence

Chaos theory came to prominence during the 1980s and deals with systems that apparently follow the normal rules and laws of physical systems, but do so in a highly unpredictable fashion (Gleick, 1987; Kauffman, 1995; Cambel, 1993). Chaotic systems can be found in many different domains; examples that have been studied include the turbulent flow of fluids, irregularities of the heartbeat, growth of certain insect populations, the dripping of a tap and the collisions of atoms in a gas (Stewart, 1990). Chaotic systems are extremely sensitive to initial conditions, and even the smallest event can trigger large consequences. A frequently quoted demonstration of this is the "butterfly effect" in weather systems, where a butterfly that flutters its wings say in Tokyo, could set off a chain of chaotic events in a weather system that result ultimately in a hurricane in Brazil a month later (Cohen and Stewart, 1995).

Kauffman explains, however, that the only reason that the behaviour of a chaotic system is unpredictable is that its extreme sensitivity to initial conditions means that one could never identify all of the factors that will play a role in its behaviour (Kauffman, 1995). To use the example I have just quoted, if one were able to precisely identify, to the minutest detail, every aspect of the butterfly's movement, then one *would* be able to predict how the chaotic system would react. The problem however, is that a chaotic system is sensitive to an *infinite* degree, and empirical science does not, nor ever will, allow us to measure in sufficient detail or with enough precision to meet this sensitivity.

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[1] Self-similar patterns are patterns that have structural similarity at different levels of magnification

Complexity theory developed from chaos theory and represents the body of research concerning systems that have *complex* characteristics. Complexity theory concerns systems that exhibit complex global behaviour as a result of the local interaction of components, or “agents”, where the behaviour of the components is determined by relatively simple rules (Cohen and Stewart, 1995). Like chaotic systems however, the outcomes of these local interactions may not be linearly related to the initial conditions of the system (Miliata, 1997), and so the global action of a complex system cannot necessarily be predicted from an understanding of the behaviour of the lower-level components alone. Complex behaviour may be found in many different kinds of system, from traffic flows, to cell differentiation, to population dynamics, and turbulence. Complexity science is relatively young, and although many are studying complex systems, a definition of complexity hasn’t really been settled upon yet. The consensus seems to be that the one thing that complex systems have in common is the fact that they are complex! (Cambel, 1993).

Some complex systems exhibit features that are referred to as “self organization” or “emergence”. These systems, which are fundamentally chaotic, or complex, have the capacity to produce patterns that are seemingly non-chaotic and predictable in behaviour. To return to an example that I used earlier, the weather is a chaotic system with emergent properties. Although the precise initial conditions that trigger individual weather patterns cannot be identified, or used to predict the detail of an outcome, the global weather system does produce some *emergent* patterns. These patterns, which include cold and warm fronts, recognisable cloud formations and so on, can be used to predict the overall behaviour of the system (Holland, 1998). Another example of an emergent feature in an otherwise chaotic system is the Great Red Spot on the surface of the planet Jupiter (Ball, 1999; Kauffman, 1995). Jupiter’s atmosphere is a chaotic system of turbulent gases, yet amongst its apparent disorder, the red spot remains constant and has done so for at least several centuries. The red spot is actually a vortex of swirling gases; basically it is a persistent storm system – it is a self-organized zone of constancy amid an otherwise chaotic system.

In the non-linear sciences, *boundaries* are treated quite differently from those in the classical Cartesian/Newtonian model. In the classical model, boundaries are often either ignored, or considered merely to be locations of entry and exit to the system. By contrast, in systems, chaos and complexity theories boundaries are viewed as *fixed* locations where important phenomena occur. It is known that emergent phenomena are more likely to occur at the boundary between a chaotic system and one that is ordered than elsewhere in the systems (Kauffman, 1995), giving rise to the term “edge of chaos”, which refers to these boundaries.

Central to all of these non-linear theories (chaos, complexity, and to a certain extent to systems theory also), are the concepts of non-linearity itself, and of non-locality. Actions or events in a chaotic or complex system may have consequences that are apparently not directly connected; and local events in a system may have global consequences. This contrasts with the classical Cartesian/Newtonian model where cause and effect are always directly and closely linked. It has also meant that, at least for non-linear systems, researchers have had to review the way that they emphasized prediction and control in a system. Chaos and complexity theories suggest that it will never be possible to control some kinds of system, as their behaviour is so unpredictable that it will never be possible to be certain how they will respond.

Despite the differences between the classical analytical model and the new whole systems models of systems theory, chaos and complexity theories, they do still have elements in common with the mechanistic view. For example, the systems theory search for general systems concepts and processes clearly reflects the classical search for cause and effect relationships, and for definable stepwise processes that lead from and to particular events or phenomena in a system. In essence, in searching for “processes”, the researcher is still seeking to identify linear relationships that are pre-eminent in classical approaches to systems.

Associated with this is a misunderstanding of what prediction and control imply for a chaotic or complex system. In chaos theory it is accepted that the system is highly sensitive to initial conditions, and it is for this reason that a chaotic system is unpredictable. However underlying this is an implicit assumption that if it *were* possible to account for and control all of the variables in the starting conditions then it would theoretically be possible to predict how the system would react. This assumption again harks back to the classical dependence on cause and effect relationships; only here in the case of chaos theory it is assumed that one will never be able to pinpoint the cause.

Finally, the novel theories (systems, chaos and complexity) all retain an analytical aim to *define* elements or parts of a system, or to define the system itself, with such questions as: "is it chaotic or is it complex?", "does the phenomenon occur at the boundary, or outside of it?". Indeed the desire to define the boundary itself points to the lack of separation between these new approaches and traditional analytical approaches.

Therefore, one must note that while systems, chaos and complexity theories all offer a new way of looking at systems, they do not provide a paradigm that is entirely free from the limitations of classical Cartesian/Newtonian analysis. As a result, these theories still involve to an extent putting on "positivist glasses" that restrict one's vision to that which is rational, definable and analysable.

However, the development of these "systems" views in science, mathematics and physics has had significant impact. They have brought about a subtle but significant change in the way many think about systems in conventional science, and legitimised the "whole systems" viewpoint. They have also prompted many scientists in other domains to think otherwise about their own subjects. For example in the biological sciences, where systems views are often refuted in favour of highly reductionist Darwinian approaches, "whole systems" approaches based on the complexity viewpoint are now becoming accepted. Brian Goodwin is one such proponent of the application of complexity sciences (Goodwin, 1997). Goodwin, a theoretical biologist, takes the view that the Darwinian evolutionary model *alone* cannot explain all natural phenomena, and that complexity and emergent processes are sometimes the reason that a higher level of organization arises in natural systems.

2.4 Holism

In the latter half of the twentieth century the view that we now call *Holism* was significantly expanded. System, chaos and complexity theories suggest that many natural systems cannot be entirely understood through reductive analysis alone, and that certain properties only emerge when the system functions as a whole. By contrast, holism maintains that natural systems can *only* be understood by looking at them in their entirety. In this way then, the holistic approach differs significantly from the non-linear models of chaos and complexity theories, it also presents a view that is in direct opposition to the classical Cartesian/Newtonian approach.

In recent years, holism has become explicitly connected with ecology, and particularly with what is now known as “deep ecology” (Capra, 1996). In contrast to “shallow ecology”, which considers humans as separate from nature, deep ecology treats humans as part of their environment, like all other species. It sees the world not as a series of isolated objects, but as a complex network of interrelated systems.

Some proponents of the holistic view consider all natural systems (including human systems) to be organic and indeed to be organisms in their own right. The first to do this was James Lovelock, an atmospheric chemist who developed a model of the world that he called Gaia (Lovelock, 1979). Gaia theory treats earth as a living organism, with self-regulating internal processes that make it a self-sustaining system. Apart from using heat from the sun, according to Gaia theory, the earth manages itself entirely from within. Lovelock named the model Gaia after the Greek goddess of the Earth. A key aspect of Gaia theory is that it considers the earth’s atmosphere to be maintained and actively regulated by the sum of all living organisms on the planet (Lovelock and Margulis, 1997). Effectively, Lovelock’s model is a view that unites the earth’s surface, life and atmosphere together a single *cybernetic* system (Sagan and Margulis, 1997).

Initially, many orthodox scientists rejected Gaia theory. The concept of Gaia struck at the heart of their classical modes of enquiry as it implied that the earth could not be understood merely through investigating its internal mechanisms and processes, rather, it was necessary to consider it as single unified system. One scientist who criticised Gaia theory particularly strongly in the early days was the evolutionary biologist, Richard Dawkins. Dawkins, whose book titled "The Selfish Gene" had been published in 1976, three years prior to Lovelock's "Gaia", was a fierce advocate for the powers of Darwinian natural selection. Dawkins believed that all life on Earth was the result of evolutionary selection processes, which determine that only the most successful individuals of a species survive to reproduce. According to Dawkins, Gaia theory, with its implication that the Earth was a living organism, was contrary to the laws of natural selection. For Gaia theory to work, said Dawkins, there would have had to be a number of competing Gaias, so that natural selection could determine which of them was most fit and would survive. Dawkins referred to this as a form of "interplanetary" selection, and laughed the whole of Gaia theory off as being highly improbable (Dawkins, 1982).

To counter these arguments, Lovelock developed a computer model of Gaia to convince sceptic scientists (Lovelock and Margulis, 1997); he called it "Daisyworld". Daisyworld was a "virtual" planet that was warmed by a sun. Only two species, black daisies and white daisies inhabited it. The whole of this virtual planet was moist and fertile enough to support these daisy plants, but the temperature across the planet was allowed to vary, and the plants could only grow within a certain temperature range. The daisy plants were able to regulate the temperature locally, black daisies warmed the environment (because being black they absorb heat), and the white daisies cooled it (as they reflected the sun's rays). Overall this computerised model showed that the daisies enabled the planet to self-regulate its temperature. In this very simple model, the self-regulation only worked for a limited time, and eventually the planet became too hot to sustain life. However, Lovelock later developed more complex models with greater numbers of species that were able to self-regulate the temperature for longer periods. As a result of these studies, Gaia theory began to gain recognition within the scientific community, and subsequently a number of scientific research teams worked with Gaia as their theoretical start point (Capra, 1996).

Another proponent of the deep ecological view is Ervin Laszlo (Laszlo, 1996). Laszlo's model takes an integrated view of nature, stating that natural systems connect different levels of order in the natural world. Like Lovelock, Laszlo considers natural systems to be self-organizing, and self-sustaining.

Laszlo also says that groups of objects or organisms may form “supraorganic” entities that have properties that are “more than the sum of their parts”. For example, the neurons that collectively form the human brain are not independently conscious, yet when functioning together in the brain, consciousness emerges. Another of Laszlo’s examples is that of a football team, independently the team members have their own identities and skills, but what makes the team “work” is their ability to co-relate during a game, coalescing to form a functional whole that we see as a “team”. The supraorganic group, says Laszlo, has characters that are not just the features of the members that make it up, but also of the relations between the members.

Fritjof Capra is another influential scientist who has developed a non-mechanistic post-Cartesian worldview, basing his theory of systems on “deep ecology” (Capra, 1996). Capra, originally a theoretical physicist, believes that living systems theory must be a synthesis of three approaches:

1) A study of pattern (relationships)
2) A study of structure (physical embodiments)
3) A study of processes (activities within the system)

Capra’s now famous first book, The Tao of Physics, drew parallels between modern physics and Eastern spiritual worldviews such as Buddhism and Hinduism (Capra, 1976). In doing so, he triggered the beginnings of an acceptance in the physical and mathematical sciences of a holistic perspective. Subsequently, Capra published work expressing similar theoretical shifts in the sociological sciences (Capra, 1982) and in the life sciences (Capra, 1996). Although initially regarded with suspicion by many scientists, Capra is now recognised as one of the leading advocates for the holistic worldview.

2.4.1 Problems with the holistic view

Although holism avoids the problems associated with the classical reductionist approach, it is not without its own limitations. The classical worldview seeks to understand systems by taking them apart, while the holistic view seeks to understand systems by looking at them as functional wholes. One challenge presented by this holistic approach is that *all* systems are considered as wholes, and are irreducible. This means that there is little scope for the development of methodologies that determine what lies *within* a system.

As Rayner argues (2003), holism can encourage a view where, since all things are considered to be related to one another, their boundaries are effectively assumed to be completely permeable, or indeed absent. Conceptually therefore, this absence of boundaries dissolves any distinction between inner and outer spatial contexts, all contents of the system become mixed together in a space-including, but undifferentiated “pea soup”. In such a view, *context* actually becomes the sum of all *contents* and there is no enveloping “outside”. Paradoxically, in such a holistic view, which is apparently deeply connected with ecology, there is no “environment”, no external surrounding: the system is *completely* self-contained as a “whole”.

It might be suggested that this issue arises because holism redefines what a boundary actually *is*. For example Bateson, who was an early advocate of a holistic view (his particular viewpoint was framed in cybernetic terms), questioned the idea that boundaries are defined by their physical surfaces (Bateson, 1972). According to Bateson, one could seek to understand a system in terms of information flow, rather than of relationships between physically distinct parts. This he illustrates with an example of a blind man using a cane to navigate his way down a street. According to Bateson, if one only considers the flow of information in the system, the physical distinction between the blind man and his cane becomes irrelevant. Instead, the information flow between street, cane and man become the source of *identity*, and effectively they become one continuous system. Bateson further argues that boundaries could be defined by the *behaviour* one is trying to explain. So, if one is trying to explain how the blind man walks, one needs to consider the street, the man, the cane, and so on. When the man sits down to eat his lunch however, the cane and the street become irrelevant, as they play no part in explaining how he eats.

Bateson's approach does, however, begin to distance us from the kind of holism put forward by those such as Lovelock and Capra. Other authors have tackled the issue of boundaries in holistic systems in a way that allies more closely with models such as Gaia theory. Primavesi for example, sees boundaries as regions of "structural coupling", where systems define and distinguish parts from one another, but also as the means by which they relate themselves to the whole in a process of continuous dynamic transformation (Primavesi, 2001). Similarly, Volk (1995) describes boundaries in living systems as "expressions of both separation and connection", that may exist physically (as skin, cell membranes and so on), or as functional features of an entity that relate insides to outsides (the human immune system for example).

This kind of holistic approach does, I believe share some similarities with a newly-emerging perspective, known as "Inclusionality theory", which has been developed by Rayner and others (Rayner, 1997; 2002). Inclusionality contrasts with, whilst including elements of both the classical analytical and holistic approaches, yet it overcomes many of their inherent problems by looking at systems from an entirely novel perspective. The "Inclusional" view is one with which I strongly empathise, and much of my own research has been framed terms of Inclusionality theory.

2.5 A new approach: Inclusionality

Inclusionality theory is a radical new approach that considers an understanding of the relationships between contents and contexts to be fundamental to understanding living systems. It contrasts most strongly with the Cartesian/Newtonian model, as it takes a systemic view, but also contrasts with the holistic notion of the absence of distinguishing boundaries. Inclusionality does have some aspects in common with the views of authors such as Goodwin and Capra (Goodwin, 1997; Capra, 1996; Capra, 2002) who both recognise the systemic significance of communicative dialogue and relationships between organisms and their environments, but interpret the latter in terms of "feedback", which effectively splits space and time across a divisive boundary. Unlike many conventional views, which are based on binary, or dualistic logic, the Inclusional view is based on *ternary* logic. Instead of looking to identify *either-or* relationships, an Inclusional view permits things to be *both-and*. Not black *or* white, but *both* black, *and* white; not inside *or* outside, but *both* inside, *and* outside. This novel perspective therefore represents a significant shift from conventional dualistic thinking.

Core to Inclusionality is an understanding of the significance of *space* and its inseparability both from time and matter/energy. In other models, space is often either disregarded, eliminated, or seen merely as something that separates objects from their environments: in effect an “absence” of “presence”. In Inclusional thinking however, space is highly significant as an inductive “presence of absence”, which permeates within, around, and through every thing, living or otherwise. It implicitly *connects* us with our environments, and with other beings within these environments. To illustrate: we might think that we are physically separated and distinct from this page that we are reading. However no matter is entirely solid, so both we and the page comprise molecules that are surrounded by and contain spaces; our skin may seem like a impenetrable barrier yet it is not, we have pores that allow gases to pass through, and the cells themselves are surrounded by “intercellular spaces”. So, the space that surrounds our bodies is also connected with the space inside them, and also inside every object around us. Space connects us with everything else. It is everywhere, literally.

This shared nature of space means that we share a common medium with everything else around us. Space is this medium, in effect the ultimate *fluid* that pervades and communicates and so gives fluidity to all. When an object moves to fill a space, the space *displaces* reciprocally to accept it, and *vice versa* in a Universal application of Archimedes’ Principle. But actually the space was already there from the beginning! Hence, the Inclusional relationship between space and object is a bit like Terry Pratchett’s observation on the speed of light:

“Light thinks it travels faster than anything but it is wrong. No matter how fast light travels it finds the darkness has always got there first, and is waiting for it.”

(Pratchett, 1991)

Space therefore has a reciprocal relationship with energy-matter. It *is* the communicative “presence of absence” or super-conductor (because it has zero resistance) that *connects* the insides and the outsides of “things”, because it inhabits both *at the same time*.

Looked at from this perspective, the limitations of discretist and positivist views that seek to clearly define objects from their contexts, become clear. If space permeates through systems, connecting insides with outsides, it is simply not possible to sever that which is inside of something from that which is not. To return to an earlier metaphor, if one were to try to use imaginary scissors to separate an “object” from its context, one would have arbitrarily to divide the space along some imaginary line. And of course by doing this, one destroys one of the key features of the system – the implicit, and invisible communication between the object’s inner context and its outer context, or environment.

In Inclusional thinking, as they are in complexity theory, boundaries are key. Inclusional boundaries, like the boundaries in complexity theory are not finite linear entities. But unlike in complexity theory, where boundaries are viewed as specific locations where important phenomena occur, in Inclusionality, boundaries are primarily considered to be manifestations of information both distinguishing and coupling inner contexts (contents) with outer environments. Importantly, Inclusional boundaries are both permeable and dynamic. They are continual reflections of the reciprocity between inner and outer spaces, which in any real system is also dynamic.

Inclusionality also has implications for the way we understand communication. As far as people are concerned, an Inclusional view of communication could relate to our dialogue, and to our actions with regards to other people, beings and environments. The same principles apply here as in other areas of Inclusionality. Namely, a new view of space, an understanding of the reciprocal relationship between inner and outer contexts, and a need to recognise that permeable, dynamic boundaries are all-important. I shall examine the Inclusional view of communication later in this thesis, but first (in the next chapter), I shall discuss how the perspectives I have introduced here have influenced the development of theories and models of *communication*.