Chapter 1 – Introduction

1.1 An intellectual journey

This thesis is a written account of an intellectual journey that I have made. In the autumn of 1999, as a recent biology graduate, I began formally researching links between biological systems and human organizations. Over the subsequent years I have explored many paths. These paths have led me to a wide variety of different topics and ideas. Some of the routes I took were hard to navigate, while others were well-trodden paths. Like the conduits within a natural network, my routes were not fixed. Indeed some of paths I chose turned out to be blind alleys, some took unexpected turns; others went only a certain distance before fading away, meaning I was faced with a choice: to turn back, or create a path of my own.

The experiences we have in our early years can have a formative effect on the directions that we take in later life. The research I have presented in this thesis could be viewed as a phase in a lifetime's intellectual journey. It would therefore be helpful to start this thesis with some account of my personal background, which explains how and why I became interested in my research topic in the first instance, and what motivated me to pursue it to its conclusion.

1.2 My origins in biology

I initially chose to study biology because, having grown up in the countryside, I loved the natural world. As a child I spent a great deal of time in the woods and fields that surrounded my parents' home, and developed a huge affinity for them. Home was a smallholding of about 20 acres, which was surrounded by a mixture of oak woodlands, grass meadows and heathland, so there was a huge variety of wildlife to see. I loved learning to identify and name the plants, insects and other animals that I encountered. I often collected and sketched the treasures that I found outside, and made journals containing notes about the animals and birds I had seen.

Later, as a teenager, when at school I began to make the choices in subject matter that would lead me to specialise in biology, I did so not so much because I loved science, but because I loved nature. Aged thirteen/fourteen, I wanted to be a garden designer, or a herbalist, or preferably both! I was fascinated with the idea of growing and using the things found in the natural world. I was avid in my quest to learn more; I think it was about that time that I began to collect books on studying nature. In terms of formal education, the obvious route was science. But while scientific study interested me, I saw it as a means to an end – at that time I enjoyed science lessons because they were the most direct way I could get to work with plants and animals at school.

Doing biology “A” level brought about a subtle shift in my thinking. For the first time I was required to design experiments, and to do this, I had to connect theoretical “book learning” with practical hands-on science. I began to really enjoy the *order* that scientific study could bring to natural things. I learned about classification, biochemistry, anatomy, genetics and so on. For “A” level, these topics were neatly broken down into simple “rules”, such as “all insects have six legs”, “respiration is the process of breaking down sugar using oxygen to produce energy and carbon dioxide”, and “plant cells have rigid cell walls, while animals cells do not”. I learned the names of the “six essential amino acids”, that the structure of DNA is a double helix, and what a gene is. It amazed me that when it came to practical experiments these simple rules seemed to work. For example, in one lesson I collected gases produced by plants as they photosynthesised, and sure enough – they produced oxygen as the rules predicted; in another I dissected an ox-heart, and indeed it contained valves, just as we’d been taught, and on the day that I looked under a microscope at an onion cell, I saw its rigid cell wall, looking just like the photo in my text book. It all seemed so simple and logical, I loved it, and I wanted to know more.

So, to me, choosing to study biology at university was the obvious next step. I gained a place at Bath University, and in September 1996 I enrolled on a course in Biological Science there. Initially, degree-level biology was everything I’d hoped it would be. I learned more about the insides of cells and how they worked, about animal anatomy and physiology, genetics, plant physiology and disease resistance, and ecology and population biology, and much more. Although it was mentally challenging (especially the biochemistry and cell biology, which I’ve never taken to very intuitively), I found it hugely exciting. The laboratory practical sessions were quite different from those at “A” level. We were amongst the first students to use the newly built biology labs at Bath, which were pristine and very modern compared with the labs I’d used before. It did take me a while to get used to the rigorous method and routine required in the more detailed practical sessions for degree level, and for a while it seemed to me that practicals were all about following instructions, sterilising things and wearing white coats. As a result, I often found it difficult to associate the lab work with the "natural biology" that I'd seen in the outside world. Nevertheless, once I'd got beyond the basics, I found much of the practical work incredibly interesting. Plant cell culture, for example, was fascinating. I found it amazing that I could cut a tiny square from a plant leaf, put it on agar jelly in a dish and treat it with the appropriate chemicals, and by the next week's session it was covered with tiny clones of the parent plant, which could be picked off and planted out like any seedling. This felt like very high tech science, and I felt privileged to be learning how to do it.

One topic that I really took to was ecology. Here, unlike in many other areas of biological science, I could see real direct connections between what we learned in lectures, and the natural world with which I was familiar. Rather than focussing on what happens when "chemical X attaches to a cell membrane", the ecology lectures were about such things as the species richness of an oak woodland, or why a male pheasant is brightly coloured while the female is brown. Ecology practicals were a joy, on a number of occasions I remember the whole class tramping off into a nearby woodland or field, to count ants' nests, or see fungi in their natural environment, which seemed like much more "applied" biology than the lab work.

Fairly early in my undergraduate studies however, I began to get my first major misgivings about the scientific logic that had appealed so much to me during my pre-university studies. As a biology student, I struggled to accept the reasoning behind "reductionist" methodology that sought to reduce the complexity of ecological systems by isolating parts of them, or delineating artificial boundaries within them. Reductionism, I learned, is the predominant approach in conventional biological science and refers to any approach where to understand a system, it is broken down into smaller more manageable parts; these parts may then be studied in a controlled environment where external influences are kept to a minimum. The reductionist view asserts that having learned about the parts of a system in this fashion, it is possible to put everything that has been learned about it back together in order to understand the whole.

To me, a reductionist approach always seemed to leave something missing. The problem is that many biological systems cease to function when they are taken apart, and although we may learn about their component parts when they are isolated from one another and from their environments, putting the knowledge we have gained in this way back together does not necessarily provide a realistic understanding of the whole system. Knowing everything about the individual parts of a frog, for example, does not mean that we know everything about a living frog. Sadly, however, many biological researchers assure us that we *should* learn all about natural systems in this way. Actually, some go further than this, asserting that not only is it possible to learn about a living frog from its component pieces, but that if the answers are not clear from the disassembled parts, they need to be broken down even further, to molecular and biochemical levels.

I am not suggesting that biologists using a reductionist approach have forgotten that they are dealing with parts of a larger system. Rather, my chief argument against this approach is that it makes it all too easy to entirely *decontextualise* the part of the system one is studying, which might have a considerable effect on how it behaves. This could, I believe, create difficulties when it comes to relating the findings made about decontextualised parts to how they behave as part of a system in a natural context.

In my view, the limitations of a reductionist approach are most starkly highlighted in the field of ecology. In natural ecosystems the living world can seem breathtakingly complex. A single oak tree, for example, may host hundreds of species of insects, birds, mammals and invertebrates, all living in interrelated co-dependency (as prey, competitors, parasites, symbionts and so on). Throughout my biological studies, it seemed anathema to me to try to break such a system down into isolated parts, or to delineate artificial boundaries within it to understand it, as by breaking it down one would lose the interrelatedness that seemed, to me, to be so vital in the system. I felt that reductionist ecological tools, many of which seek to simplify a system so that its study is more manageable, seemed to fit natural ecosystems very poorly; indeed in many situations they need to be considerably adapted to be of any use at all.

For example, in field ecology, “quadrats” are often used to define and isolate blocks of habitat to study. In practice, using a quadrat usually involves physically demarcating one or more small squares. Having done this, it is then possible to count, measure and observe anything within the square as if it were an independently existing environment. According to the methodology, provided the quadrat was randomly and independently placed, one can deduce that any pattern in the results obtained in this way is representative of an overall pattern for the whole environment.

Superficially, a quadrat square makes things simple. It separates an area for study that is small and easier to manage than the whole location. If more than one is used, we can make comparisons within a location, such as ”what are the differences between *here* and *over there*?”. Tools such as quadrats allow us to reduce the complexity of a natural environment to fit a scientific paradigm.

I have had to use quadrats often enough, but each time I used them, I felt that they simplified things too much. A number of other ecological tools gave me similar misgivings. Yes, I managed to reduce the complexity of the system so I got results, but often I felt that the “essence” of the natural system was being missed in this methodology. I was left with a sneaking suspicion that by eliminating the complexity, I might have been throwing the baby out with the bath water!

Reductionist approaches are, however, very popular in conventional research practice. This is so not only in biology, but also in all other areas of science, and indeed in the social and cultural sciences, and beyond. It is easy to see why. By creating clearly demarcated boundaries within a system that allow us to quantify and simplify otherwise complex systems, we can gain a level of certainty, security and apparent predictability, and, perhaps the ultimate goal of any reductionist investigation, the knowledge of how to *control* a system.

The reductionist approach is actually a reflection of a deeper commitment in much of the Western world to *classical* philosophy and analysis. Aspects of Western thought are pivoted around classical analytical tools of enquiry and thought that exhort us to use logic and rationality to understand the world around us. Over centuries, the classical worldview, which is rooted in the philosophies of the Ancient Greeks, and was developed during the scientific and industrial revolutions, became dominant in the Western world, to the practical exclusion of all other views. I shall discuss the influence and implications of this classical worldview on modern-day science in greater detail in Chapter 2 of this thesis.

My doubts about the strong “neo-Darwinian” view, which is promoted by authors such as Richard Dawkins (Dawkins, 1976; 1986) presented another major issue that had a significant influence on the development of my thinking about biology. Dawkins advocates a view of evolution where every aspect of all natural life is considered to be the result of the activity of “selfish genes”, whose only goals are to survive and to replicate. During my undergraduate studies it seemed to me that the neo-Darwinian view of evolution is very widely applied in conventional biological science, to all manner of natural systems. I, however, had major problems with accepting this point of view, which, to me, seemed to rationalise all that is *vital* in living systems in terms that are excessively minimal. As an undergraduate, I had particular issues with how the model was often applied to the social behaviour of animals, where behaviours such as altruism, cooperation, herd dynamics, mate choice and life-long partnerships were all explained purely in terms of “selfish gene” behaviour.

I also strongly disagreed with the way that a rigid neo-Darwinian view is applied by many biologists to explain all kinds of *ecological* systems and patterns, from population biology to the distribution of plants in a natural environment. I felt that what I referred to as the “Dawkins” view was applied in a very rigid and inflexible manner by some ecologists, to explain patterns in nature that might actually have far more complex origins. I felt that there were particular problems when the neo-Darwinian view was applied to ecological systems using reductionist methodologies (of the sort I have described above), as when neo-Darwinism is combined with a reductionist approach it has the capacity to exclude *contexts* in a highly compelling, yet (in my view) dangerously simplistic manner. This seemed to me to be a rigidly positivist approach that failed to appreciate that physical and behavioural patterns in natural systems are often the outcome of highly complex and irreducible factors; yet it is an approach that is very common in current-day ecological research.

As an undergraduate, while I could appreciate that the Darwinian model of evolution had its place, I found it very hard to accept that the rules of natural selection or of selfish gene behaviour were as pervasive or as fixed in the natural world as they were often portrayed to be. Appealing as it might be to assume that nature works on a small number of very simple rules, I remained unconvinced that this was so. It seemed, however, that I was amongst a minority of biologists who thought this way, and often my arguments against the strong Darwinian theme were taken instead to be an indication that I had misunderstood what I was being taught.

One or two of my undergraduate lecturers did however recognise my point of view. One of them, Alan Rayner, was later to become one of my PhD supervisors. Alan's own view of natural systems is quite different from the predominant neo-Darwinian approach in biology, and this came through very clearly in his lecture courses on fungal ecology, which I found thoroughly inspiring. Through these courses I learned to see ecosystems as *dynamic systems* of relationships. I learned that it is possible to conduct valid science without having to treat species and individual organisms simply as abstract entities in an equation, or as merely the ecological embodiment of purely selfish genes. Rather we were encouraged to think about the organisms from *their* point of view: What might they be facing in their environment that made them grow a particular way? What might an organism need to do to retain its own identity, rather than get taken over or consumed by another? And significantly, how might human presence in an ecosystem affect the relationships within?

For my final year's dissertation, I chose a project on the ecology of mosses. I had a somewhat ulterior motive for choosing this, as it meant I could spend my practical study periods in the beautiful woodlands belonging to the farm where I had lodgings. But it also meant that I could truly *immerse* myself in an ecological study. I spent many happy hours identifying and measuring the distribution of the mosses I was studying, and in trying to work out *why* they grew in the patterns that they did. I discovered that the ecology of the mosses growing on scattered logs in the woodland was quite similar to the ecology of many island-dwelling species of plant, and therefore was able to draw parallels between bryophyte (moss) ecology and an ecological domain known as "island biogeography". Having identified this connection, I then spent many hours in frustration while I tried to manipulate mathematical representations of the mosses to statistically validate what I'd seen. The project taught me several salient lessons, one of which was that getting empirical (and numerical) data to demonstrate what one has observed or experienced can be very difficult, but also that if it is ultimately achieved it can be very satisfying. Eventually I did manage to show with my statistics that the mosses were living on "islands", although admittedly, not as conclusively as I would have liked. This outcome, along with other successful biological investigations that I had conducted, has led me to prefer a quantitative approach, despite the challenges encountered when one tries to implement it in a "real life" environment. Aspects of this might be recognised later in this thesis, in my empirical study of a human organizational network.

1.3 Starting postgraduate research – beginning an association with psychology

After graduating, I felt that I definitely wasn't finished with biology yet. There was still much that I wanted to know about, and I was also fired up with enthusiasm to explore the notion of systems of relationships, which I had encountered in my studies of ecology. I was particularly enthused with a seedling idea that I'd had about connecting themes I had encountered in ecology with problems in human systems, especially in human business organizations.

I approached my erstwhile lecturer, Alan Rayner, with a view to doing some further work with him. I put forward the tentative ideas that I'd had about drawing parallels between ecological systems and human business organizations. Alan immediately took to the idea, and suggested that I consider pursuing the research formally as a doctoral study. But, having encountered resistance within his own department to his unconventional approach to biological science, he warned me that I was unlikely to gain support for my idea from the biology department. Financial support didn't concern me greatly, as I intended to finance my research by working part time, but academic support was clearly going to be necessary, and if I were going to start a PhD study it would have to be registered somewhere other than in biology. Alan suggested that my idea of transferring concepts from biology to human systems was one that might appeal to a colleague of his in the Psychology department. It was from this start point therefore, that I met Helen Haste who was at that time head of the psychology department at Bath. One of Helen's research interests was "metaphor", and at our very first meeting she explained to me that the research topic I was considering was an obvious example of a metaphor. I'd not seen it in that way before, but the idea intrigued me. Prior to that point, I had never had any contact with psychology and I had very little knowledge of what the subject entailed, and I was somewhat wary of starting work in a domain about which I knew so little.

Nevertheless, I was very keen to work with Alan, and to pursue my research questions in the way that I wanted to, and both Helen and Alan seemed to be offering me opportunities that I wouldn't find elsewhere. So I registered my research topic as a doctoral study in the department of psychology, with Helen Haste and Alan Rayner as co-supervisors.

I started my postdoctoral studies with a series of short lecture courses, seminars and associated reading which rapidly acquainted me with the areas of psychology and social science that were relevant to my research. These included theories of human communication, systems theory and dialogue, public understanding of science, technology-mediated communication, and others. Under Helen Haste's guidance (whose own speciality was critical psychology), my studies emphasised critical approaches to psychology and communication theory, and highlighted the work of other researchers who had challenged positivistic thinking as I wished to do.

These formal courses and the reading associated with them had a considerable influence on my thinking. The majority of the material was very new to me, and at times I found the unfamiliarity of it all somewhat unsettling. On the whole, however, I found these different ways of thinking about the world, and the cultures within it to be intriguing. One seminar course in particular, on the "public understanding of science" (PUS) gave me a great deal to think about. Before the seminars, I had not really considered science from an "outsiders" point of view, as I had primarily been concerned with presenting scientific findings to other scientists. The PUS seminars however caused me to consider how science might be perceived by and presented to non-scientists, including how it is portrayed in the media and in fiction. I learned how science might be used as a tool to support or refute an ethical argument, to advertise a product, glamorise a story or to give weight to a political point of view, to name but a few examples. I began to think about the cultural impact of communicating science, which was not something I'd really considered before. One topic that had a surprisingly strong influence on my thinking was the portrayal of science and technology in science fiction. Prior to this I had never really been interested in science fiction films or stories, yet after a number of seminars on the topic I was hooked. I learned to look for subtexts within the stories that alluded to cultural or philosophical issues, and in particular I learned how scientific devices and concepts might be used as *metaphors* to communicate ideas without making them explicit in the story. I watched films such as *The Matrix* many times, finding new examples of metaphor and allusion with every viewing. I began to view science fiction films and texts with a new regard for the depth that might be hidden within them. In overall terms, science fiction itself has little direct relevance to the thesis I have finally developed, but I feel my study of the topic is worth mentioning because of the significant impact it has had on my thinking.

There were some areas in the psychology seminars and readings that I studied that seemed to connect with things I already knew from biology. For example, I had already encountered systems theory (Bertalanffy, 1968), and I had touched on complexity theory in my studies of ecology, having read a little of the work by Stuart Kauffman and others (Kauffman, 1995). In some of the seminars and lectures I attended, Dawkins was also mentioned, but he was by no means presented as the exclusive voice from biology, which surprised me, given the dominance of his model that I had encountered in biological science. For example, Capra's work on holistic approaches to science was mentioned from time to time (Capra, 1996, 1982) (I had already read some of Capra's work as an undergraduate), as was Goodwin, whose view on evolutionary processes is framed in terms of complexity theory (Goodwin, 1997), and Lovelock's holistic Gaia Theory was often cited (Lovelock, 1979). These are all authors whose work I shall return to and discuss later in this thesis.

Another area in which I encountered new ideas that significantly affected my thought development was communication theory. I took a short seminar course titled "communication, interaction and task", which introduced me to some key thinkers in communication theory. It was in these seminars that I first encountered the work of Shannon and Weaver, whose transmitter-receiver model of communication (Shannon and Weaver, 1949), one of the earliest formal models of communicative processes, was to be influential when I developed my own model of communicative flow (with which it contrasts strongly). I also first heard of Grice, who in the 1970s had developed a model of communication that saw conversational meaning as something generated between speakers and hearers through dialogue, and was based on four "conversational maxims" (Grice, 1975, cited in Taylor and Cameron, 1987). In these seminars we also dealt with research that was much more contemporary, concerning technology-mediated communication. Through this I learned how different technologies can influence communication between a conversation's participants, through factors such as delays and overlap in the dialogue, lack of visual images and so on. It was becoming evident to me that meaning-generation in human dialogue can be seen to be the result of a great many dynamic factors, concerning contexts as well as the participants. I began to perceive similarities between attempts to model the emergence of meaning in conversation, and attempts to make sense of communication in biological ecosystems, both of which were dealing with highly complex situations.

1.4 Metaphor Theory

Metaphor proved to be a particularly important topic in my studies. I first looked at metaphor theory merely for interest, because in trying to find parallels between biological and human systems I recognised that I was working with a metaphor, and I thought I ought to know more about the topic. I started by looking at examples of biological metaphors themselves, for example Punctuated Equilibrium Theory (from ecology) as a metaphor for business development (Price and Evans, 1993). Soon, however, I moved on to look at metaphor theory itself, and was surprised to find that not only was it very interesting, but that its relevance to my study was far more profound and far-reaching than I had originally thought.

I found Lakoff and Johnson's cognitive model of metaphor (Lakoff and Johnson 1980) particularly thought provoking. Many of us were taught at school that metaphor is a way of *saying* one thing, but *meaning* another; it was treated as a way of beautifying language so that the reader or hearer might think more deeply about a text. Lakoff and Johnson however, developed a quite different model, which treated metaphor as a mental or *cognitive* process. As a consequence, contemporary metaphor researchers no longer view metaphor merely as a linguistic device; rather, it is considered to be a reflection of the way that we *think* about the world (Ortony, 1998). Many modern researchers suggest that the term "metaphor" refers to any occasion when we think of one thing *in terms of* another. So when, for example, we work on our computer "desktop", we are in fact using a metaphor. Moreover, if we investigate the computer desktop metaphor further, we find that it is associated with a whole collection of names and concepts that fit in with the idea of a computer being like an office desk; we use “files” and “folders”, which we may discard in a “recycle bin”; we have an “Inbox” into which new emails arrive, and when we send “mail” to our colleagues, we first put it in the “Outbox”. So, by using the metaphor of a computer as a desktop, a whole collection of desktop-related names and concepts are available for use as sub-metaphors. The desktop metaphor is therefore an example of a metaphorical *schema*, where metaphorical references become organised under an overall theme (Allbritton,1995). As I shall show later in this thesis, metaphorical schemas may be very powerful indeed, as they have the capacity not only to alter our language, but also to shape how and what we *think* about a topic.

My encounter with this view of metaphor had a considerable impact on the development of my thesis. I began to shift my view of using biological metaphors simply as a means of connecting two topic domains (biology/business systems), and to consider metaphor itself as a possible underlying explanation for the parallels that I had already seen. Perhaps metaphors between biological and human systems were possible because of the way in which we construct theories and concepts in both domains? I had much to work on here, but ultimately it was metaphor theory that enabled me to see the connections between the otherwise apparently disparate parts of my study.

1.5 My involvement with and contribution to Inclusionality theory.

Throughout my doctoral studies, I have continued to work closely with Alan Rayner. Around the time that I started my study in 1999, Alan was publishing early work on an approach that he (with others) was developing; he called this approach “Inclusionality”. Inclusionality was developed primarily in reaction to the highly objective and rationalistic perspective that is predominant in modern science. As I have already mentioned, much of modern science is centred on a *reductionist* perspective, which seeks to break systems down into parts that may be studied in isolation from one another. The idea is that the knowledge that is gained about these reduced parts may be added together to produce an understanding of the whole system. As I shall explain in some depth later in this thesis, the reductionist approach necessitates the identification of discrete and finite *boundaries* of these parts within a system, so that the different parts may be identified and separated from one another.

By contrast, in an Inclusional approach, boundaries are not treated as discrete outlines that separate one part of a system from another; rather they are considered to be areas that identify a shift between so-called inner and outer *contexts*. In Inclusionality, it is recognised that boundaries play a key role in *mediating* the relationships between inner and outer contexts, and an appreciation of this is considered to be fundamental to our understanding of system dynamics.

Core to Inclusionality is the concept that *space* is a fluid medium that permeates, connects, relates and communicates. In other models, space is often disregarded, eliminated, or seen merely as something that separates objects from their environments. In Inclusional thinking, however, space is highly significant as the omnipresent medium that implicitly *connects* us with our environments, and with other beings within these environments.

One of the key things about Inclusionality theory is that it does not entirely reject scientific methodologies and approaches, rather it seeks to question the *assumptions* behind these approaches. In this sense it does perhaps have similarities with critical analysis in psychology, and elsewhere. Inclusionality is a view with which I have much affinity, and to an extent, this has coloured and directed the way I have conducted my research. Consequently I shall discuss Inclusionality in considerable detail later in this thesis, including how it contrasts with conventional approaches.

My own research has contributed to the development of Inclusionality theory, as well as helping to communicate an Inclusional perspective to a wider academic community. From the outset of my research, I was keen to introduce Inclusionality to academics outside of the domain of biology (Alan had already published on Inclusionality within biology). I was also keen to explore and write about Inclusional ideas of *communication* and of systems *relationships*, which in practice took me through a variety of subject domains, including (but not restricted to) both biology and psychology.

1.6 The Teamwork study

From the outset of my study I was keen to conduct some empirical research in a non-academic environment. Since I initially intended to make connections between biological science and human business systems, I kept my eyes open for an opportunity to conduct a research project in a human business environment.

The opportunity to do this actually arose fairly early in my doctoral study, when I became involved (though my non-academic work) in a construction-industry project called "Teamwork", in 2001. My association with the Teamwork project came about through my ongoing work for ATA, my father's IT systems company, where I was working part time. ATA's principal client at the time was Bourne Steel, a constructional steelwork fabrication company employing nearly 200 people. ATA designed, implemented and supported all of Bourne Steel's IT facillities. ATA and Bourne Steel were jointly involved in Teamwork, and both supported my proposal to use the event as a research opportunity.

Teamwork was a DTI funded team-working project, which was organized by a group of companies associated with the British construction industry. The aim of the Teamwork project was to bring together various companies involved in large-scale building design and fabrication, to work together collaboratively on a single "virtual" project. Teamwork was intended to focus on using collaborative work methods to tackle problems in the design and supply chain, and to improve integration and cooperation between the various parties involved in the design process.

I recognised that this event might provide me with an opportunity to study communication between people at work in a commercial environment. Also because the event was novel and "experimental", and the participants were relatively free to conduct their projects as they wished, I suspected I would have the opportunity to see how the participants organised themselves to get their projects done.

Since my Teamwork study occurred at a relatively early stage in my research, I set out with some fairly loose ideas of what I wanted to find out. My research questions were centred around looking for patterns of interaction between the participants, and of communicative flow (such as one might find in a biological ecosystem), as well as on how the participants dealt with conflict, and the effect that communicative tools such as computers affected how they conducted themselves and worked with one another. In practice I approached the Teamwork event much in the way that I would have conducted an ecological study – through observation of behaviour, collection of some specific data, and looking to interpret the data through analysis after the event.

My actual research at Teamwork took the form of an observational study on the development of communication patterns within the Teamwork environment, with particular focus on their week-long "Liveweek" event held in June 2001. Liveweek was intended to serve as an experimental "trial run" of some of the collaborative working practices. I investigated the development of interaction networks between people at Liveweek, the communicative behaviour of the teams, and their use of supportive "artefacts", which included computer models, paper-based design sketches, and other documentation.

Although this empirical research appears towards the end of my thesis, this actually does not reflect the chronological sequence of events in my research process. The "Liveweek" event took place in 2001, but the bulk of the *theoretical* work (philosophy development) took place after this. The Liveweek data, and research experience, acted as catalysts for my subsequent theory development, and it was through consideration of the Liveweek data that I developed the flow-form network model of communication that was the major theoretical outcome of my research. The Liveweek project therefore serves in this thesis as a set of findings which can be used to *exemplify* the power of the flow-form network metaphor that I subsequently developed.

1.7 The Teamwork study as a catalyst for further research on communicative networks

It was my examination of the Teamwork data that set me on the trail of network analysis. I had returned from the Liveweek event with a series of video recordings of conversations, along with a collection of basic observations that showed which participants had interacted with one another and when. I had an idea that I wanted to create a diagrammatic representation of these interactions, so I set about looking for the tools to do so. It was this research that led me ultimately to Social Network Analysis, and the associated computer tools for data analysis.

Catalysed by the Teamwork research, therefore, I began to investigate how others had studied communicative networks, and I found that there is a comprehensive literature on the subject. I looked in particular at social network analysis (Scott, 2003; Borgatti, Everett and Freeman, 2002), and also at "small world" network theories (Barabasi, 2003; Buchanan 2003; Watts, 2004), which are becoming increasingly popular in the contemporary study of networks. In Chapter 5 of this thesis I present a detailed discussion of these theories.

I soon discovered however, that I wasn't particularly comfortable with the "small world" network model, or with other similar models of communication networks. Many of these models seemed to be focussed on what happens when one joins otherwise unconnected "nodes" to form a network. But to me they didn't seem to realistically represent the flows of communication within a network, nor to effectively represent the network's contexts and environments. In my studies of biology, I had encountered natural communicative networks, such as those of fungal "root" systems (known as mycelial networks), which were quite different from these node-based networks, and which seemed to me to *embody* communicative processes far more effectively. I set about trying to work out what were the key differences between "small world" networks and natural communicative networks such as those of the fungi, and the implications of those differences. It was during one of my discussions on this subject with Alan Rayner that the concept of "flow-form networks" first emerged.

1.8 Flow-form: an Inclusional interpretation of communicative networks

The "flow form" model of network communication that I have developed, and presented in this thesis (Chapter 6 onwards) has made a significant contribution to Inclusionality Theory. As I mentioned above, the idea of "flow-form" communication was inspired by certain kinds of living network found in the natural world, such as blood circulatory systems, and fungal mycelial networks. These systems, which consist of interconnected networks of communicative tubules, not only serve to communicate *fluids* within a system, but also, due to the properties of their living boundaries, are highly responsive to their environmental contexts.

The flow-form model contrasts at a profound level with conventional models of communicative networks, which are often presented as systems of interconnected *nodes*, and it offers a radically different way of conceptualising how a networked structure could behave. The flow-form model therefore represents a shift away from the node-centred thinking of conventional network theory, towards an understanding of networks as representations of communicative *flow*.

1.9 Flow-form – model, metaphor or advocacy?

One further point that is worth mentioning here that there is a distinction between a *metaphor* and a *model*, and that this issue is of concern with regards to my own studies. It has been said that a metaphor is being used when one thinks of "one thing *as if it were* another" (Lakoff and Johnson, 1980). A model, however, can be grouped with charts, maps, graphs, diagrams and photographs, as a device for showing "how things are" (Black, 1977 (reprinted in Ortony, 1998).

In the latter parts of my thesis, I have presented "flow-form network" sometimes as a metaphor, and sometimes as a model. The reason for this is that, at this stage, I have chosen not to resolve whether it is either model or metaphor. Indeed, I have found it useful to explore the flow-form network concept *both* as metaphor and as model. As metaphor, flow-form networks can link biological phenomena with other domains (psychology, management, systems theory and so on), while as model, it has the potential to *explain* patterns phenomena that were previously unexplained by conventional models.

It has also been suggested that there is a third means by which the flow-form network might be presented: framed in terms of *advocacy*. This means presenting the flow-form idea not just as "if it were" (metaphor) something else, nor "as things are" (model), but as "a suggestion for practice". The advocacy approach is also represented in my thesis, particularly in the concluding chapters where I discuss possible future applications of the idea.

It might be suggested that the lack of resolution between these three approaches has led to some ambiguity in the thesis, and that it might have been clearer had I chosen just one approach (i.e. model, metaphor or advocacy). However, doing that would have precluded the possibility of exploring the other ideas as freely as I wanted to, and the route that I have taken has, I feel, resulted in a thesis that is a more honest representation of my own intellectual journey.

1.10 Navigating this thesis

To help the reader of this thesis, I have presented a brief description of each chapter topic below.

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

This is a partial account of the history and development of scientific enquiry in the Western world, highlighting in particular the ideas and concepts that have influenced my own research paths. It includes a discussion of the rationalistic Cartesian/Newtonian model, followed by a review of non-linear approaches that include Systems theory, Chaos theory and complexity theory, holism, and finally I discuss a recently developed approach known as Inclusionality.

Chapter 3 – Communication theory

A survey of literature concerning theories of communication. In this chapter I explain how communication theory has paralleled the development of Western philosophies, and discuss some of the contrasting models that have been developed to understand communicative systems.

Chapter 4 – Metaphor

A survey of the literature on metaphor. In this chapter I introduce the notion of metaphor as more than merely a linguistic device, and the modern idea of metaphor as a *cognitive* phenomenon. I also discuss the idea of a metaphorical *schema* as the means by which we can understand and work within a system, and finally consider how some of the existing metaphorical schemas have affected how we understand human organizations.

Chapter 5 – Conventional network theory

In this chapter I introduce the literature on network theory. I cover the development of conventional models of networks, including “small-worlds” models, and other node-based structures. The chapter concludes with a critique of modern network theory that explains how these node-based models can influence and limit our understanding of systems.

Chapter 6 – Natural networks: towards a new metaphor of networks formed through *flow*

Presents literature on naturally existing networks, demonstrating how they are manifestations of *flow-form*, rather than of interactions between *nodes* in a networked structure. In this chapter I introduce my own novel model of networks, which is based on these natural *flow-form* structures, and suggest how it may be applied as a *mental model*.

Chapter 7 – The study of flow-form networks: an introduction to the methodological issues and challenges

In this chapter I discuss some of the methodological issues and challenges associated with applying the *flow-form* network model.

Chapter 8 – Teamwork study: aims, context and rationale

This is the first in a series of four chapters that deal with my practical research in a business context. The study concerns a construction industry event titled "Teamwork". In this chapter I introduce the aims and rationale of this study.

Chapter 9 – Teamwork study: procedures

This chapter deals with the procedures I employed to collect and analyse data at Teamwork

Chapter 10 – Teamwork study: results and analysis

This chapter presents the empirical results of the Teamwork study

Chapter 11 – Teamwork study: discussion

In this chapter I discuss the results and other aspects of the Teamwork study, in relation to my flow-form network model.

Chapter 12 – Concluding discussion

This chapter includes a discussion of the challenges of transdisciplinary research, the manner in which conventional analytical methodologies can affect data collection and analysis from flow-form networks, the potential use of the flow-form network model as a model for human organizations, and possibilities for further research and development of the model. I discuss in particular the implications and potential applications of this research in the domain of psychology.