The Place of Complexity

Nigel Thrift

> Thoughts survive if they work, if they propagate, if they find an appropriate milieu, a welcoming territory. Thoughts are the genius of the spirit. They will only maintain their appeal if they can form some kind of alliance with what we do.
>
> Thoughts are in competition for the scarce resources of our attention. To gain affective value, each thought has to make use of its intellectual milieu. There are thoughts that pass and fade. There are thoughts that conjugate with an experience that lends them validity. There are thoughts which repeat themselves over and over again, positioning themselves as unquestionable obstacles. There are thoughts that attempt to ground themselves in other, successful thoughts and share a little of their glory. There are rebellious thoughts that bring an affective reward. There are thoughts that organize human life so successfully that they manifest their own truth in their performance. (Goodchild, 1996: 211)

> Ecology, in the widest sense, turns out to be the study of the interaction and survival of ideas and programs (i.e. differences, complexes of differences, etc.) in circuits. (Bateson, 1973: 483)

> All these terms like emergence, life, anticipation, complexity – these are the things we are still trying to figure out. (Langton, cited in Waldrop, 1993: 359)

Introduction: Thoughts in Space

GEOGRAPHERS HAVE ALWAYS had a problem in coping with complexity; space complicates to the point where it can easily obscure. Thus, the early regional historians of the 16th and 17th centuries often found themselves exhausted by the sheer magnitude of the task of attempting to record every aspect of a place. Some were discouraged, others never completed their task, one or two were even driven out of their wits (Parry, 1995). Nowadays, with the advent of computing, this same

■ *Theory, Culture & Society* 1999 (SAGE, London, Thousand Oaks and New Delhi), Vol. 16(3): 31–69
[0263-2764(199906)16:3;31–69;008575]

documentary impulse persists, but translated, in the work of 'geocomputationalists', into a manic inductionism. Rather like the top-hatted neo-Victorian engineers from a steampunk science fiction novel, they want to set up an informational dominance over the world.[1]

What we can say is that space complicates because it immediately injects a notion of *distribution*; for all the Derridean notion that we live in an infinite web of meaning, the fact is that this web is differentially distributed. Its elements do not crop up everywhere equally, however often deferred. Spatial distribution, by itself, can therefore begin to account for much of what happens in the world: from the start, the geographical world is a messy one, it does not cohere. On the whole geographers therefore tend to be wary of theories that ride roughshod over ambiguity and polarize complexities. Yet they find it difficult to convey this sense of distribution – too often it ends up sounding like a simple-minded empiricism.

You might have thought, then, that geographers would take to complexity theory like a duck to water. Here, after all, is a body of theory that sees that:

> ... logic and philosophy are messy, that language is messy, that chemical kinetics is messy, that physics is messy and finally that the economy is naturally messy. And it's not that this is a mess created by the dirt that's on the microscope glass. It's that this mess is inherent in the systems themselves. You can't capture any of them and confine them to a neat box of logic. (Arthur, cited in Waldrop, 1993: 329)

Here, furthermore, is a body of theory that is preternaturally spatial: it is possible to argue that complexity theory is about, precisely, the spatial ordering that arises from injections of energy. Whereas previous bodies of scientific theory were chiefly concerned with temporal progression, complexity theory is equally concerned with space. Its whole structure depends upon emergent properties arising out of excitable spatial orders over time. And here, most of all, is a body of theory which asks questions about 'instability, crisis, differentiation, catastrophes and impasses' (Stengers, 1997: 4) in ways which suggest that there is an obvious affinity between the 'natural' and 'human' sciences, a constant dream of geography.

Yet geographers have stayed on the land, for reasons which are chiefly conjunctural. The links between complexity theory and geography *were* made in the 1970s, but by a group of quantitative geographers, led by major figures in the discipline like Alan Wilson (originally a nuclear physicist), as well as workers from cognate disciplines like Peter Allen (who was, for a time, a part of the Prigogine group in Brussels). These geographers and near-geographers used the forerunners of complexity theory for often technical reasons, for example to add non-linearities to the parameters of location-allocation models, to apply simple catastrophe theory techniques to urban models, or to summarize the form of cities using fractal-based methods (see Wilson, 1994; Batty and Longley, 1995).

In turn, given the sceptical reaction to quantitative geography in the subject as a whole at this time – the subject was going through a series of rapid changes which emphasized Marxian and other mainstream sociological approaches – complexity theory was subsumed as simply a part of the old ways, to be taken with a pinch of salt.[2] Then, adding to this reaction, quantitative geographers interested in complexity theory took most of their energy from what was happening in mathematics, physics and chemistry, rather than from the developments in biology with which the subject has had a long history of intimate relations and from which dissemination might have proved easier (Livingstone, 1992).

In this article, I want to produce an account of the dissemination of complexity theory which reinstates the links between geography and complexity theory in three ways. First, I want to take the body of work known as complexity theory seriously. It *does* have interesting and even important things to say. But, second, and at the same time, I want to recognize that, in an increasingly mediatized world, complexity theory is, to an extent, just another business opportunity. It is up for sale and it is being sold. So, third, my account of the long march of complexity theory is tinged with irony and is more than a little ambivalent. In other words, I want to capture a sense of theoretical commitment which is balanced by a sense of the way of the world.

Let me, start, then, by setting out some of the main ideas of complexity theory before moving on to an outline of the article. Complexity theory is, it must be stated from the outset, a scientific amalgam. It is an accretion of ideas, a rhetorical hybrid. In this article, I assume that the chief impulse behind complexity theory is an anti-reductionist one, representing a shift towards understanding the properties of interaction of systems as more than the sum of their parts. This is, then, the idea of a science of holistic *emergent*[3] order; a science of qualities as much as of quantities, a science of 'the potential for emergent order in complex and unpredictable phenomena' (Goodwin, 1997: 112), a more open science which asserts 'the primacy of processes over events, of relationships over entities and of development over structure' (Ingold, 1990: 209). Put another way, complexity theory concerns:

> ... the study of the behaviour of macroscopic collections of [interacting] units that are endowed with the potential to evolve in time. Their interactions lead to coherent collective phenomena, so-called emergent properties that can be classified only at higher levels than those of individual units. (Coveney and Highfield, 1995: 7)

Or as one of the key proponents of complexity theory, Chris Langton (quoted in Lewin, 1993: 12–13) puts it:

> From the interaction of the individual components [of a system] ... emerges some kind of property ... something you couldn't have predicted from what

> you know of the component parts.... And the global property, this emergent behaviour, feeds back to influence the behaviour ... of the individuals that produced it.

Complexity theory is an economy of concepts based around this emergent or self-organizing impulse, usually involving a series of what might be thought of as 'question marks' (Stengers, 1997) like non-linearity, self-organization, emergent order and complex adaptive systems (Jencks, 1996). Most of the many writers on complexity theory will then usually lay claim to a whole series of fields of study which they assert are a part of this impulse, including chaos theory, fractal modelling, artificial life, cellular automata, neural nets and the like, and to a companion vocabulary which has become both technical and metaphorical – chaos, attractors, fractals, emergent orders, self-organization, implicate order, autopoiesis, life at the edge of chaos, and so on.[4]

In this article, I want to look at the recent history of complexity theory as an account of how it has travelled and what that travel might mean. The first part of the article therefore offers an account of the geography of complexity theory, looking at how the metaphors of complexity theory have circulated around the world through the three different but related networks of science, business and New Age. This geography has not, as I will show, been a simple diffusion outward from a point. Rather, the propagators of complexity theory have been present in more than one of these networks, and these networks have therefore imported these concepts, processed them, and re-exported them – sometimes even back from whence they came – showing, once again, the difficulty of controlling interpretation since the act of communication is always at one and the same an act of dissemination. Then, in the second part of the article, I will consider how complexity theory might be seen as one of the harbingers of something more, the emergence of a structure of feeling in Euro-American societies which frames the world as complex, irreducible, anti-closural and, in doing so, is producing a much greater sense of openness and possibility about the future.[5] The conclusion to the paper then provides a cautionary gloss on this interpretation.

The Spaces of Complexity: Some Metaphorical Geographies of Complexity Theory

> ... my rap on this is that we are moving from a point where a lot of talk about molecular biology and genetics is ideology or culture.... So we are moving out of that to what I am calling biosociality where a whole form of identity, both individual and group identity, and a vast army of cultural, political, social, theoretical institutions, practices of all sorts, are emerging very rapidly around truths. So I am interested in that Foucaldian sense of seeing truths have emerged, been produced, and then circulated. (Rabinow, 1995: 449)

> Complexity is a multi-headed monster that can wreak havoc on investors who have assets to protect, preserve and enhance. Our International Fund Services people know how to handle complexity – no matter how great it is. (CITCO Group Advertisment, *The Economist*, 26 July 1997)

This section of the article tells us a story of three networks, singing a song to themselves and to each other. The networks I want to tell of are global science, global business and global New Age. And the song I want to follow is called 'complexity'.

Why have I chosen these particular three networks? First, because they are important determinants of our everyday lives. Science, business and New Age all matter to people: their discourses are touchstones of many practices. Second, because one of the processes that allows them to sing is a common one – mediatization. These are networks which are increasingly playing to publics created and driven by the media. Third, because these networks trade with each other. And why have I chosen this song? First, because it is current. The chief ideas of complexity are presently active across a vast terrain of practice – from the photographs of Eliot Porter (Gleick and Porter, 1990) to the thoughts of archbishops (Richardson and Wildman, 1997), from redefining business strategy (Beinhocker, 1997) to redefining Marxism (Owen, 1996). Second, because at the moment there are concentrated attempts to trade complexity theory into other networks. This is a process which it is possible to follow, if not in real time, then at least not so far behind.

Let me begin, though, with some reflections on how we might construct a geography of complexity theory. Though I am well aware that theory consists of more than metaphor, I will treat complexity theory as a set of metaphors concerning holistic emergent order, since this reduction at least has the merit of making it possible to produce a manageable account.[6] And what I am primarily interested in, as a result of this discussion, is the means by which metaphors of complexity theory are able to travel and gradually become a *commonplace* structure of intelligibility. I will prime my account by undertaking some definitional work.

First of all, I assume that scientific metaphors, like other metaphors, are generally indefinite. This is not a disadvantage. To the contrary, it is why they are so powerful because they can be *performed* in and to many different situations. As Game and Metcalfe (1996: 50–1) put it:

> Whereas literal knowledge aspires to the inert status of information, metaphor works with indeterminacy to keep meaning safe from the final clarification that is its obituary. Meaning's play is not a game watched from the outside but one in which we live and throughout which we understand. We may fantasise about mastering literal knowledge, fixing it in our memories or reference books or filing cabinets, but metaphors in knowledges cannot be processed, always maintaining reserves of wisdom beyond our present understanding. When someone criticised the lack of likeness in Picasso's portrait of Gertrude Stein, Picasso advised the person to wait. In the same way, the

> meaning of rich metaphors keeps blooming; people think further by growing into them, awakening to their implications. Traditions of thought grow stale with the declining productivity of their key metaphors....
>
> Metaphoric activity is not the same as the culture's reality, but we are sceptical of the literal claim to re-present reality. Reality cannot really be seen, because we cannot see the world from the outside. Our knowledges are ours, mediated through us and projecting us into the world. We cannot fix or imitate the world as it really is. As Benjamin noted, 'Perhaps there is none of [man's] higher functions in which his mimetic faculty does not play a decisive role' (1978: 333). By letting us live (in) the world, metaphors enliven our understandings. Weber was too modest when claiming that the faculty for compassion or empathy lets us understand other people: it underlies all metaphoric truth.
>
> We do not come empty-handed to our performances and metaphors. When metaphor engages us, we respond through the emotions and memories that reverberate with the role.

In particular, I would argue that metaphors are often at their most powerful when they are at their most diffuse: then their very breadth of meaning allows many meanings to be enlivened by them.

Second, I assume that complexity theory is deeply metaphorical; certainly, some of its more subtle proponents see it precisely as an attempt to replace one set of metaphors with another:

> ... the point of this exercise is not to conclude that there is something wrong with Darwin's theory because it is already linked to some very powerful cultural myths and metaphors. All theories have metaphorical dimensions which I regard as not only inevitable but also as extremely important. For it is these dimensions that give depth and meaning to scientific ideas, that add to their persuasiveness and colour the way we see reality. The point of recovering this and the influences that act within current Darwinian theory is simply to help us to stand back, to take stock, to contemplate alternative ways of describing biological reality. (Goodwin, 1994: 32)

To connect with the previous point, I do not therefore assume that because metaphors of complexity theory come from science they are necessarily 'clearer'. This is to ignore one of the main functions of scientific metaphors in their early stages, which is to act to clear a semantic space within what may well be an obdurate scientific tradition. The case of Darwin's development of the metaphors of evolution is instructive. Campbell (1990: 66) argues that Darwin was not able to 'explain the precise mechanism by which the earth and organism interact. However as a "place-holding illusion" – a means to identify and reserve a place within convention where a scientifically detailed explanation could be developed – it is a significant advance'. Gross (1996: xxiii) glosses this statement thus: 'This seems exactly right. Darwin's form of argument is by nature not well-specified and its just this lack of precision that accounts for its usefulness at this point in the process of discovery.'

Third, I would want to point to the importance of considering scientific metaphors as functioning in a number of registers, as ably demonstrated in the work of Barbara Maria Stafford (1992, 1994, 1996). In this article, I will chiefly consider the metaphors of complexity theory as verbal constructs, but what is equally important to remember is that science nearly always works with 'visual intuitions' as well (Lyne, 1996). This is a particularly germane observation in the case of complexity theory whose metaphors nearly all strongly depend upon the visual register (Hayles, 1991, 1996). It is difficult to think of complexity theory without its accompanying visual rhetoric: the obligatory fractal images of the Mandelbrot set, the spirals in the Beloussov-Zhabotisky reaction, the life cycle of the cellular slime mould, and the like. The 'new scientific perception is exercised metaphorically and literally through visualisation' (Wright, 1996: 234), the result of the interaction of advances in computing power with traditions of mathematical and biological representation that hark back to the invention of topology.

I want to relate how the new(ish) metaphors of complexity have been able to travel. To do this, I will take certain themes from actor-network theory as important. In particular, I will implicitly appeal to notions like translation (with its four stages of problematization, *interessement*, enrolment and mobilization), to the role of intermediaries and to the agency of inscription devices. It may be thought that actor-network theory is an ideal vehicle for considering travelling metaphors. After all, this is a 'theory' that tells stories of quasi-objects which circulate, a 'queer sociology that is emerging from the careful study of instruments, lieutenants, representatives, objects, angels and characters – to name but a few of the delegates with whom we build our daily life' (Latour, 1988a: 34). Again, actor-network theory tells stories of continuous attempts to make networks longer, of the constant extension of material-semiotic feelers, so that, in a sense, and in line with actor-network theory's 'ethnographic' principle of following the actors, the networks end where the actors say they end. Actor-network theory also points to the fact that metaphors do not come empty-handed to a situation. They are always part and parcel of wider networks of practice, involving all manner of intermediaries and inscription devices, which co-produce them as 'objects which are both plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites' (Star, 1989: 46). The semiotic and the material are two sides of the same coin (Shapin, 1998). And, consequently actor-network theory argues that metaphors do not lie still. They are always transmuting, pushed this way and that by the work of redefinition of one local knowledge by another that results from a host of different, rhizomatically multiplying agendas. For example, in the case of science:

> ... theory building is deeply heterogenous: different viewpoints are constantly being addressed and reconciled.... Each actor, site, or node of a scientific community has a viewpoint, a potential truth consisting of local

> beliefs, local practices, local constraints, and resources, none of which are fully verifiable across all sites. The aggregation of all viewpoints is the source of the robustness of science. (Star, 1989: 46)

In other words, semiosis is constant, unremitting and always entangled, and the story is in what is linked, not what something is.

But the case of complexity theory also points to some of the weaknesses of actor-network theory as practised, if not in theory (see Grint and Woolgar, 1997).[7] In particular, many applications of actor-network theory in effect frame actor-networks as discrete entities, pulling various bits of the world into them as and when it suits their purposes. The result is that a crucial dimension of actor-network theory – crossings, movement, travel – is under-emphasized; many of the wranglings and the tanglings of representational practices are thereby missed. I want to make up some of this weight in two ways. One is to take a leaf out of the growing body of work on cross-cultural consumption and interaction more generally, which stresses how greater interconnectedness can actually produce very diverse 'habitats of meaning' (Hannerz, 1996). Creolization produces all manner of creative responses out of what might appear to be quite similar materials. Another is to take a leaf from literary approaches to science, typified by the work of Gillian Beer and others (Beer, 1996; Gross, 1996; Spufford and Uglow, 1996) which also emphasize how crossings, traffic, 'lateral encounters' can all produce fresh perceptions.

> Terms move across from one zone to another, for ideas cannot survive long lodged within a single domain. They need the traffic of the apparently *in*appropriate audience, as well as the tight group of co-workers, if they are to thrive and generate further thinking. An engrossing question is what happens when *unforeseen* readers appropriate terms and texts ...
>
> Encounter, whether between peoples, between disciplines, or answering a ring at the bell, braces attention. It does not guarantee understanding; it may emphasise first (or only) what's incommensurate. But it brings into active play unexamined assumptions and so may allow interpreters, if not the principals, to tap into unexpressed incentives. Exchange, dialogue, misprision, fugitive understanding, are all crucial within disciplinary encounters as well as between peoples. Understanding askance, with your attention fixed elsewhere, or your expectations focused on a different outcome, is also a common enough event in such encounters and can produce effects as powerful, if not stronger, than fixed attention. (Beer, 1996: 1–2)

In science, the concepts of complexity have a complex genealogy: they did not come naked into the world; they are already tangled and braided. Most proponents of complexity theory claim a set of ancestors in what is, in itself, an interesting rhetorical exercise. In mathematics, there is Henri Poincaré. In computing, there is Alan Turing and John von Neumann. In biology, there is D'Arcy Thompson, Jacob Von Uexkull, J.B.S. Haldane and, latterly, by adoption, Gregory Bateson. And so on. Yet what is clear is that

by the late 1970s, as a result of manifold additions to the theory of non-linear dynamical systems and exponential advances in computing power, nearly all of the key components of complexity theory were already in place. For example, the late Conrad Waddington's (1977) *Tools for Thought* already regales the reader with most of the main themes of complexity theory, save for 'artificial life', a creation of the late 1980s, and 'life at the edge of chaos', a term first used in print by Langton in 1990 (Lewin, 1993). In the 20 years since Waddington's book, many of the elements of complexity theory have, in their various guises, become an important part of scientific discourse. But equally, it is crucially important to note that the success of complexity theory has only been partial and its future as a new scientific paradigm – as opposed to the success of some of its individual elements – is by no means assured. For example, in biology a reductionist molecular approach (typified by the human genome project) still holds sway.

Yet, ironically, perhaps, the key moments of complexity theory – chaos, attractors, non-linearity, emergent orders, self-organization, implicate order, autopoiesis, life at the edge of chaos – have moved very rapidly into other parts of Western society than science, and they seem to be producing a refiguring of the world far more rapidly than Darwin's plots ever did. Indeed, it might be possible to argue that it is outside science that complexity theory is being most successfully propagated.

Thus, complexity theory has reached into academic subjects like economics (Arthur, 1994; Barnett et al., 1996; Mirowski, 1994), town planning, regional science (Isard, 1996), architecture (Benjamin, 1995; Jencks, 1996), literary theory (Hayles, 1990, 1991; Argyros, 1991; Livingston, 1997), history (de Landa, 1997; Ferguson, 1997), sociology (Byrne, 1996; Elliott and Keil, 1997; Khalil and Boulding, 1996; Eve et al., 1997) and anthropology (Benitez-Rojo, 1996; Martin, 1994). It has become the stuff of art, film, drama, and imaginative fiction (de Lillo, 1990; Jones, 1994; Winterson, 1996). It has become inscribed in consumer objects (such as Donna Karan's new scent, Chaos). It has become a New Age selling feature (as in Chaos Magic in Neal's Yard in London). It has even become a focus of garden design (as in Charles Jencks's garden in Dumfriesshire).

But, why is it that these metaphors have been able to travel so fast? A cynic might argue that it is because as these metaphors have travelled, so they have become almost completely meaningless. Flexibility produces lack of friction which produces fatuousness. But I think there are three more deep-rooted reasons.

One is that science has become common cultural currency in a way that it never was in Darwin's time (see Beck, 1992; Thrift, 1996):

> ... the general culture incorporates scientific and quasi-scientific language, authority and modes of explanation into its talk about matters of common interest, including human behaviour, psychology, gender relations, the environment, and the nature of the cosmos, to name but a few. Thus science

> is a resource for the invention and performance of rhetoric in a variety of social contexts. (Lyne, 1996: 128)

Another reason is that, since the 1960s what Gibbons et al. (1994) call a 'Mode 2' knowledge regime has grown up based on a much greater diversity of knowledge producers, distributors and audiences. The Mode 2 knowledge regime produces knowledge which is closer to applications, which is transdisciplinary, heterogeneous, heterarchical, organizationally diverse and reflexive.[8]

At the core of this new Mode 2 knowledge regime is an expansion in the number of knowledge producers, coupled with a corresponding expansion in the number of specialist knowledges that are able to be produced. Or, put another way, a number of new, and in time autopoietic, knowledge-producing actor-networks have come into existence, with consequences for both the conditions of knowledge production and what is thought of as knowledge. These actor-networks, whose purpose is to generate and transmit knowledge, have translated the metaphors of complexity to their purposes and then circulated them in these mutated forms.

Then, last, these metaphors can travel faster because they circulate in heavily mediatized networks. In part, these networks exist to circulate information, often in heavily processed forms, which can attract audiences, and so profit.

I want to concentrate on the actions and interactions of three of these networks, one of which is a relatively old global actor but has taken on a new mediatized lease of life, the other two of which are relatively new.

The first of these networks is science.[9] Science has changed over the last 20 years. It was always an international endeavour, but now it has become cosmopolitan on an entirely different scale. Thus, Rabinow (1996: 24) writes of modern molecular biology as an entirely different kind of scientific animal from those of the past.

> Molecular biology, for example, has taken up the current conjuncture through an increased use of electronic means of communication, of data storage, of internationally coordinated projects like the human (and other organisms) genome mapping projects. The circulation and coordination of knowledge has never been more rapid or more international. Articulating and sustaining these goals is extremely expensive. Heads of major laboratories may well spend the majority of their time raising money, making contacts and forging alliances. The appearance in the last two decades of 'start up' biotechnology companies funded by venture capital and stock offerings, first in the United States and increasingly in Asia, India and Europe, has reshaped both the financing of research and (probably) its directions. Capital is international. While the principle of the international status of science has been in place for a long time, the form that it is taking in the biomedical sciences today is quite distinct. What kind of scientific life is it that is constantly travelling, constantly negotiating over resources, constantly engaged in competitive claims of priority, expanding in multiple arenas?

A vital part of this new, even more cosmopolitan science (see also Shapin, 1998) is clearly mediatization. Books, television programmes and the like, sell science. And in turn, science sells books, television and the like. Indeed, to a greater and greater degree, science is dependent upon media exposure, so that science and the media have become more and more closely intertwined.

Complexity theory is now one of the major scientific media exports. Numerous books have appeared over the last five years extolling its virtues, some by journalists but many by some of the founders of complexity theory (e.g. Gell-Mann, 1994; Goodwin, 1994; Kauffmann, 1995). Indeed, especially through the auspices of the Santa Fe Institute (SFI), set up in 1984, these founders, and other scientists, have clearly attempted to produce a site which would not only do research on complexity theory but also act as a centre for its dissemination. Thus, the Institute has acted to circulate complexity theory workers through its doors so as to produce a global 'family'.

> The word family is appropriate because SFI is a rather loose organization. The president, Edward Knapp is assisted by two vice presidents and an office staff of about a dozen remarkably dedicated workers. There are only three professors, of whom I am one, all with five year opportunities. Everyone else is a visitor, staying for periods ranging from a day to a year. The visitors come from all over the world, and a number of them pay frequent visits. The Institute holds numerous workshops, lasting a few days or sometimes a week or two. In addition, several research networks have been organized on a variety of interdisciplinary topics. The far-flung members of each network communicate with one another by telephone, electronic mail, fax, and the occasional letter, and they meet from time to time in Santa Fe or sometimes elsewhere. They are experts in dozens of specialities, and they are all interested in collaborating across disciplinary boundaries. Each one has a home institution ... but each one also prizes the Santa Fe affiliation, which permits making connections that are somehow not so easy to make at home. These home institutions may be great industrial research laboratories, universities, or national laboratories (especially the nearby one at Los Alamos ...). (Gell-Mann, 1994: xiii)

The Institute, as part of its 'family' strategy, has moved into numerous fields outside the natural sciences, including archaeology, linguistics, political science, economics, history and now management. Thus, the family strategy is a means of disseminating complexity theory both within and without science. Indeed, in certain senses, it might be seen as a strategy to make complexity theory so well known outside the networks of science that it will become better respected in science.

But it is not a strategy without its critics in the networks of science. The Santa Fe Institute is often seen as publicity-seeking to a fault.[10]

> I ... came across some downright negative assessments of the Santa Fe Institute's venture. For instance, Oxford University ecologist Robert May told me that what the institute does is 'interesting but biologically trivial'. The computer models are too far from real biology for his taste and are irretrievably simplistic. 'Well Bob *would* say that, wouldn't he' was one rebuttal I heard in Santa Fe. Bob has a reputation for arrogance as well as brilliance. 'I don't think Bob really knows what's going on here', Stu [Kauffman] told me. 'If he did, I think he'd see things differently.'
>
> Bob did concede that the Institute is crammed with talent, and then said that one of the things it seems most talented at was generating hyperbole. Jack Cowan, the University of Chicago mathematician who gave Stu Kauffman his first faculty position back in 1969, agreed. 'Don't get me wrong, he said, there's a lot of good work at the Institute, but I often come away wondering where some of it is leading.' Jack, a member of the Institute's science board, has long experience in research on complex dynamical systems. 'There have been examples of tremendous progress in understanding complex systems, but there have also been episodes of unbounded hype', he told me. 'Remember Catastrophe theory?' (Lewin, 1993: 184–5)

The second of these networks has come into existence since the 1960s (Figure 1). This network, which I have called elsewhere (Thrift, 1997a, 1997b) the 'cultural circuit of capitalism', is now self-organizing and is responsible for the production and distribution of managerial knowledge to managers. As it has grown, so have its appetites. It now has a constant and voracious need for new knowledges. Thus, in the second box of Figure 1 are the producers of the managerial discourse which this circuit disseminates. Chief among these are three institutions: business schools, management consultants and management gurus.

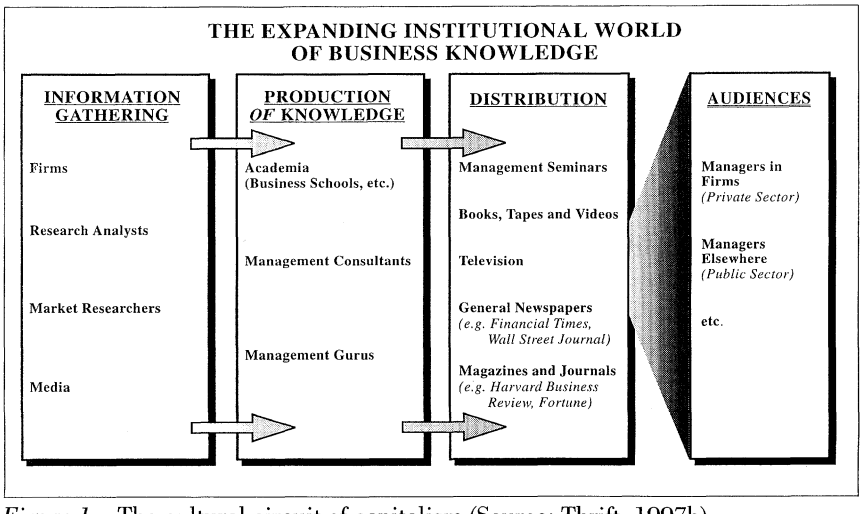

Figure 1 The cultural circuit of capitalism (Source: Thrift, 1997b)

Through the 1960s, 1970s and 1980s formal business education, and especially the MBA course, has produced a large number of academics and students who act both to generate and transmit the new knowledge (Alvarez, 1996). In the United States, admittedly the most extreme example, almost one in four students in colleges and Universities now majors in business while the number of business schools has grown fivefold since 1957 (Kogut and Bowman, 1996: 14). In the top business schools, academics compete with one another to teach students *and* to produce new ideas.

Another generator and distributor of new knowledge has been management consultancy. Management consultancy is, without doubt, a growth industry:

> Between 1970 and 1980, the revenue of management consultants registered with the Management Consultants Association doubled; from 1980 to 1987 it increased fivefold. In the UK, over the eleven years 1980-1991 the number of consultants registered with the MCA more than quadrupled to 6963 and their fees increased almost seventeenfold. By the early 1990s there were reported to be 100,000 consultants world-wide. (Ramsay, 1996: 166)

Management consultancies act as a vital part of the cultural circuit of capital. To begin with they provide ideas. For example, Arthur Andersen:

> ... has three research centres and a massive international database, to which all 40,000 consultants are supposed to contribute. The company spent nearly 7% of its budget, or $290 million, on training in 1995, more than any rival. To have a chance of becoming a partner, an Andersenite needs to have put in over 1000 hours of training – some of it at the company's 150-acre campus outside Chicago. (*The Economist*, 4 May 1996: 90)

Then, they are responsible for much of the packaging of management knowledge, usually producing formulas which can be applied over and over again in different situations (Clark, 1995). It is no surprise that the use of consultants is now so widespread. For example, Ramsay (1996) cites reports that, in an 18-month period stretching over 1994 and 1995, 94 of the top 100 British companies had used management consultants.

Then, there is one other major generator and distributor of new knowledge, the management guru. Gurus come in many shapes and sizes. Huczynski (1993) distinguishes between academic gurus like Michael Porter, Rosabeth Moss Karter, Theodore Levitt, John Kay, Gareth Morgan and Peter Senge, consultant gurus like James Champy, Peter Drucker, Tom Peters, John Naisbitt and Kenich Ohmae, and hero-managers like Mark McCormack, Akio Morita, John Harvey-Jones, Donald Trump and Lee Iacocca. These gurus often only run small business operations. But, equally, their operations may be more substantial.

There is no strong dividing line between business schools, management consultancies and management gurus. For example, Thomas Gerrity, the Dean of Wharton, was formerly a member of CSC Index, the consultancy

which produced the idea of 'business process re-engineering' and which is now retailing notions of 'organizational agility'. Whatever is the case, it is clear that it is these three institutions are responsible for producing the bulk of management knowledge.

In turn, this knowledge has to be distributed and inscribed in practice. The channels and means of distribution are multiple. First of all, of course, there are the business schools, which teach students the new ideas, the management consultants, constantly presenting clients with new ideas and ways of doing things and the management gurus, taking fees and retainers to distribute their insights. Then, second, there is a rapidly growing business media industry which packages and distributes this knowledge. Management knowledge sells, most particularly since the establishment of the non-academic management book in the early 1980s. For example, Stephen Covey's *Seven Habits of Highly Effective People* has sold more than 5 million copies world wide since its publication in 1989 (*The Economist* 24 February 1996: 106) and is currently available in 28 languages in 35 countries (it is doing particularly well in China and South Korea). Hammer and Champy's *Re-engineering the Corporation*, published in 1993, had sold 2 million copies worldwide by September 1996, and had been translated into 17 languages. Of course, management knowledge is not just diffused via books (and, increasingly tapes and videos). Journals like *Fortune*, *Business Week*, the *Harvard Business Review* and others also dispense such knowledge, as do myriad trade journals. Most broadsheet newspapers also have management pages. There are also now a number of specific television programmes which communicate management knowledge.

Finally, there is one more means of dissemination which is particularly important in the case of management knowledge. This is the management seminar, an inscription device which is a mixture of drill and, increasingly, religious revivalism. Such seminars are big business across the world. For example, in 1990 Borks and Swet estimated that corporations in the United States spent $30 billion on business training in general (*Financial Times*, 28 Jan. 1990: xiii). There are many kinds of seminar, of course. There are the modest seminars which impart skills, usually offered by training companies or management consultants. But there are also high-profile seminars featuring well-known management gurus, stretching over two or three days. Often, seminars will include books or videos in the price, so that a seamless web of production and reinforcement of ideas is produced.

Then, finally, there are management 'audiences'. It is fair to say that we know remarkably little about this aspect of the capitalist circuit of cultural capital: there are only very small amounts of 'audience research' (but see Engwall, 1992). Instead, we have to infer the character and motivations of audiences from general trends, and the few studies there are. Six conclusions can then be drawn. First, we know that managers are becoming better educated almost everywhere. For example, 'as more managers complete MBA-type programmes, they become more sophisticated,

and are able to understand and apply more complicated management ideas' (Huczynski, 1993: 48). Second, it is clear that managers do read more books (and listen to tapes and watch videos) than previously. Third, at the same time, through the increased 'packaging' of ideas in seminars and books, management ideas have become more accessible. Fourth, managers clearly want and need new ideas. They need them to make their way in organizations, to solve a particular company problem, to act as an internal motivational device, to guard against their competitors' adoption of new ideas, and simply to provide a career enhancer. In the latter case, the new idea demonstrates to others that the manager is creative, up-to-the minute and actively seeking improvements, thereby increasing that individual's visibility in the organization. Equally, the new idea can act as a defence, can provide a quick-fix solution in a difficult period, or can even simply reduce boredom (Huczynski, 1993). Fourth, the management book or seminar can act to raise or boost levels of belief. Thus, attendees at seminars by management gurus may have already read all the ideas in books beforehand but this is beside the point:

> Managers may attend Tom Peters' seminars to become immersed in his personality. In fact, if he was not to say what they have already read, they would come away disappointed. Lorenz (1986) wrote that 'managers may still pay repeated visits in their thousand to sit at [the guru's] feet, or buy his latest book. One executive at a leading multinational talks of the need for his "Drucker fix" every two years'. (Huczynski, 1993: 201)

Again, seminars may retail experiences of such intensity that they change the terms of what it means to be a person, as can happen in some experiential seminars. For example, Martin (1994) documents how the initial cynicism of some participants in these kinds of seminar is gradually overtaken by the experience of the seminar. Sixth, and finally, more managers are now women. Some commentators have argued that much of the change in the metaphorical framing of modern capitalism is a result of the feminization of management knowledge which, at least in part, results from the greater presence of women in management and the workforce (Clegg and Palmer, 1996; Collinson and Hearn, 1996).

Why have metaphors of complexity circulated in this burgeoning network? There are at least five reasons. The first of these is receptivity. From very early days, management thinking expounded systems theory approaches which directly link to complexity theory (see, for example, Emery, 1969). The intellectual ground was therefore, so to speak, prepared. The second reason is technological. As business has turned to information technology, so it has come into contact with an environment which is common between it and much of the science of complexity theory, allowing for much easier transfer of ideas. So the technological ground was also prepared. Third, the cultural circuit of capitalism needs a constant flow of ideas/metaphors: indeed this flow is a condition of its existence. These

ideas, often called 'business fads', roll by year after year. For example, between 1950 and 1988 Pascale (1991) noted 26 major fads and they have continued apace ever since. In this milieu, ideas of complexity theory are likely to receive a warm welcome. Fourth, a part of the work of the cultural circuit of capitalism is to inscribe metaphors in the conduct of business organizations and business bodies. In particular, the management seminar has proved a fertile means of introducing ideas of complexity into embodied corporate practices. At their most effective, they can produce strong shifts in what it means to be a person (Martin, 1994). Here, then, the circuit of cultural capitalism interacts with the new 'psy disciplines' (Rose, 1996) and a part of that interaction is metaphors like complexity. Then, fifth, the production of complexity theory is bound up with business, in the way that so much modern science is. For example, the Santa Fe Institute, perhaps the chief 'propagandist' for complexity theory, has had a long connection with Citicorp, is interested in the application of certain ideas in complexity theory to financial markets, and has spawned companies such as Prediction (again, chiefly involved in predicting the movement of financial markets) (Waldrop, 1993; Lewin, 1993). Now it is making a determined push into management by retailing ideas of complexity and life at the edge of chaos (Beinhocker, 1997). In 1997, for example, the Santa Fe Group and Knowledge-Based Development ran a series of seminars for business people in Phoenix and London on 'Complexity and technology: organizing for innovation' featuring the founders of complexity theory like Brian Arthur, Murray Gell-Mann, John Holland and Stuart Kauffman, and also management gurus like John Seely Brown from Xerox PARC (see Seely Brown, 1997) and David Whyte (a poet and corporate consultant). Later in 1997, seminars were organized in Dallas, Sante Fe and Chicago by the Santa Fe Center for Emergent Strategies on 'Complexity in business: organizing for emergent strategies'. The blurb for this latter series of seminars argued that:

> It is increasingly recognised that the rapidly changing business environment makes extended strategic planning less and less useful. Strategy is becoming more an ongoing process and less a set of annually produced distant targets. Instead of fighting volatility, some companies are starting to respond with greater agility and with less bias towards new ideas. These new ideas, which form the basis for new company models and behaviours, can rarely be anticipated far in advance or in useful detail. Rather, they will emerge from the interactions between the company and all the environments in which it operates.
>
> Strategy should be emergent and subject to continuing reassessments and alterations. In this way a company can keep pace with its market place, its competition and the new technologies that will change it. (Santa Fe Center for Emergent Strategies, 1997)

Goodwin (1997: 117) summarizes the particular economy of concepts that are on offer to businesses (which have the advantage that they already fit well into many current ideas of management thinking):

> Business corporations have been among the first to see the potential relevance of these ideas to management structure and creative organisational change. Since their everyday experience is 'living on the edge', any insights into dynamic structures that facilitate adaptive response are welcomed. The suggestions of complexity theory for business practice are a flattening of the management hierarchy, distribution of control through the system with fluid networks of interaction between the parts, and the necessity of periods of chaos for the emergence of appropriate new order. The move towards a more anarchic, spontaneous dynamic is clearly threatening to the controlling managers, but it appears to be the path to creativity and diversification. This in no way guarantees survival just as there is no long-term survival guaranteed to adopted, adapting spaces in evolution. What it allows for is innovative expression, which has intrinsic value for the members of the enterprise, as well as providing the best chance of the organisation's persisting in a constantly changing corporate world. All the participants in this sector of social organisation can then experience a higher quality of life, since they have greater freedom, more opportunities for creative play, and richer interactions – good for them and good for the organisation. The primary goal would not then be to survive through maximisation of profits, but to make possible a fuller and more creative life for all members of the company and thus to maximise the chances of appropriate collective responses to perpetually changing circumstances.

In turn, this economy of concepts can become a new management 'paradigm' of emergence and self-organization, which can be marketed as a set of simple principles that change 'how we design, lead, manage and view organizations' (Wheatley, 1994, publisher's blurb) (see Table 1). In other words:

> Like Newtonian science before it, twentieth-century science has grown out of a deep shift in general culture, a move away from absolute truth and absolute perspective toward contextualism; a move away from certainty, toward an appreciation for pluralism and diversity, toward an acceptance of ambiguity and paradox, of complexity rather than simplicity. Also like Newtonian science, this new science focuses the associated cultural shift and helps us to articulate the new paradigm. It provides us with the new concepts, new language, and new images that new paradigm thinking requires. Quantum

Table 1 Old and New Management Paradigms

Old paradigm	**New paradigm**
Reductive	Emergent
Isolated and controlled	Contextual and self-organizing
The parts completely define the whole	The whole is greater than the sum of its parts
Top-down management	Bottom-up leadership
Reactive	Imaginative and experimental

Source: Zohar (1997: 53).

> thinking is new paradigm thinking. Both can help us rethink the structure and leadership of organizations, and initiate change processes that will allow business to thrive in the new paradigm. (Zohar, 1997: 9)

The third network that I want to describe consists of New Age practices. New Age consists of a set of organizations which are much less coherent than the cultural circuit of capitalism but which, since the 1960s, have also become a functioning international circuit (Figure 2). Like the capitalist circuit of cultural capital, the New Age circuit depends upon a constant throughflow of new ideas, even though these are often painted as rediscoveries of older knowledge: 'New Agers are averse to traditions ... yet New Agers continually draw on traditions' (Heelas, 1996: 27). The producers of these ideas are diverse. There are, first of all, various new religious movements and communities (such as Erhard Seminars Training [est] and Findhorn). Then there are networks (such as the Wrekin Trust). Then, there are centres of spirituality and healing, camps and gatherings, and businesses. The ideas are distributed through a whole series of means. The chief of these is almost certainly the seminar or workshop. Introduced in the early 1970s, the seminar or workshop has become a pivot of New Age practices. Other forms of distribution like books, tapes, videos, managers and journalists are also becoming more important (as any glance at the New Age Section of bookshops will show: 'in the space of half a decade, Americans have doubled their consumption of New Age books to 10 million a year' [*The Economist* 5 April 1997: 58]). Not to be forgotten, either, are other more

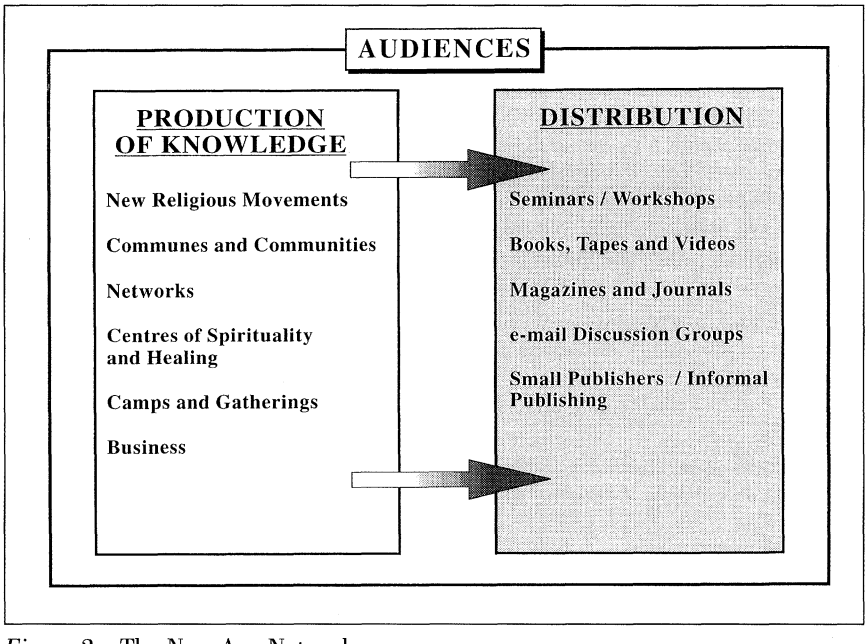

Figure 2 The New Age Network

informal means of interaction: e-mail discussion groups, small publishers and informal publications, and the general interaction in camps, gatherings and cafes. What is distinctive about the New Age circuit, compared with the cultural circuit of capitalism, is the much greater active participation by audiences; in other words, audiences are, to a much greater extent, a part of the process of idea formation.[11] Given the emphasis on self-spirituality and on syncretism in New Age this is, perhaps, no surprise.

Complexity theory seems to provide a ready-made vocabulary with which to talk self-spirituality and to battle against certain self-limiting images and beliefs and it is no surprise that metaphors of complexity have become steadily more popular in New Age since the 1980s. There are four main reasons for their popularity. First, they can very easily be interpreted as a language of the self and self-making – there are emergent properties, there is self-organization, and so on (Capra, 1996). Second, they have provided a new vehicle for dissemination of older and more general New Age and New Age-y ideas, such as Lovelock's Gaia (Capra, 1996; see also Lewin, 1993; Goodwin, 1994 for the way in which these ideas have made their way in to complexity theory). Third, they have provided symbolic authority: for a relatively small and insecure network, the use of 'scientific' metaphors adds a touch of legitimacy, and it is not far from here to *Blackfoot Physics* (Peat, 1994). Fourth, some scientists themselves seem to lean, in their more popular writings, towards connecting complexity theory with elements of New Age thinking. Most of these popular writings at some point wax a little mystical, for example by making reference to Eastern religions. According to Waldrop (1993: 23), complexity theory makes it 'entirely too easy to come off sounding New Age and flaky' but Stuart Kauffman (1995: 307), one of the doyens of the Santa Fe Institute seems less than concerned;[12] here is how he finishes his popular book:

> We have only just began to invent the science that will account for the evolving emergent order I see out of my window, from spider weaving her web, to coyote crafty on the ridge top, and we at the Santa Fe Institute and elsewhere proudly hope that we are unlocking some kinds of secrets, to all of you making your ways by your own best efforts and best lights.
>
> We are all part of this process, created by it, creating it. In the beginning was the Word – the Law. The rest follows, and we participate. Some months ago, I climbed to the first mountain top I have been able to reach since my wife and I were badly injured in a car accident. I climbed to Lake Peck with Phil Anderson, Nobel Laureate in physics and good friend at the Institute. Phil is a dowser. I once was astonished to see him pull a forked twig off a tree and march across a hilltop holding it. I pulled off a forked twig and followed him. Sure enough, whenever his twig dropped toward the ground, so too did mine. But then I could see him ahead of me. 'Does it work?', I asked him. 'Oh, sure. Half of all people can dowse.' 'Ever dig where your stick pointed?' 'Oh no. Well, once.' We reached the peak. The Rio Grande Valley spread below us to the west; the Pecos wilderness stretched out to the east; the Truchas Peaks erupted to the north.

> 'Phil', I said, 'if one cannot find spirituality, awe, and reverence in the unfolding, one is nuts.' 'I don't think so', responded my dowsing, but now sceptical friend. He glanced at the sky, and offered a prayer: 'To the great non-linear map in the sky.'

To summarize, what I have tried to show, so far, is how the practices of three diverse actor-networks, whose main purpose is the production of new knowledges, has produced a rapid diffusion of metaphors of complexity which, in turn, have been changed by the new networks in which they can circulate. But the trade in metaphors of complexity is not just between the network of science (which itself is now a more heterogeneous set of networks than in the past, which includes significant commercial interests) and the other two networks, it is also between the two newer networks as well. Thus, both business and New Age are united in their commitment to technologies of the self, from the cultural circuit's vision of an entrepreneurial self who makes the corporation healthy, wealthy and wise to the New Age network's cultivation of self-spirituality. It is no surprise then, given these imperatives, that New Age technologies have migrated into business, or that business has migrated into New Age. In both cases, metaphors of complexity have travelled with them, from different directions from the networks of science, often in mutated forms. And there is one more twist. It can, I think, be argued that the increasing visibility of complexity theory outside science promoted by institutions like the Santa Fe Institute is part of a strategy to disseminate ideas of complexity back into a science which has sometimes been resistant to them. If complexity theory becomes a part of the general culture atmosphere then it must be breathed in by science as much as by other cultural producers.[13]

There are certainly interesting examples of linkage of which I will mention just three. First, there is the travelling from science into the borderlands of New Age. For example the biologist Brian Goodwin is now Director of Studies at the Schumacher Centre at Dartington, near Totnes, a generator of alternative concepts with a heavy emphasis on environmentalist values. In 1997 he toured Britain in dialogue with a number of artists concerning 'the creative "edge" between order, chaos and complexity in the natural world' (Arnolfini, 1997).

Second, there is the travelling from New Age into business. For example, a number of New Age training consultants (not that they would call themselves that) now retail complexity ideas as part of wider set of New Age and New Age-y ideas that can be injected into businesses (Heelas, 1996; Brown, 1997).

> As freelance technicians of the sacred, working channels face the challenges of a volatile market that offers clients a constantly expanding array of therapeutic and spiritual options. To survive and prosper in such an environment, professional channels must learn to broaden their practice, to deal successfully with fickle clients, and to protect their intellectual property

> within the constraints of New Age values that are hostile to modernity. (Brown, 1997: 144)

Complexity theory offers 'channels' a means of presenting New Age assertions as neutral laws of the universe, legitimated by science. After all, 'even in the 1990s, insurance companies and HMOS are not ready to endorse the use of energy from the Pleiades, for healing or anything else. They are even less inclined to pay for it' (Brown, 1997: 170). But science is a different matter.

Third, there is the travelling from science into business. We have seen the example of Goodwin's writings, but there are others. For example, Danah Zohar, a consultant who also teaches at Templeton College, Oxford University, has published books replete with complexity ideas (e.g. Zohar, 1997) as means of broadening out the business of business so that it 'no longer restricts itself to manipulating things and nature and people for profit. Rather business becomes a spiritual vocation in the largest sense of that word' (Zohar, 1997: 154). In turn, these ideas can be inscribed by consultants at management seminars. For example, Peter Isaacs, Director of Training at Peter Chadwick Ltd, a fast-growing UK-based consultancy company describes an approach based on the 'New Science'.

> ... the challenge laid before us during those days we worked with Danah and her colleague led us to undertake a journey to 'rewire our corporate brain'.
>
> Adopting some of the leading-edge thinking, we restructured ourselves into a collection of self-organizing networks. Each network in turn focused on key issues, whether these were market, sector, or lateral learning opportunities, that could benefit both ourselves and our clients. At the same time, we repositioned ourselves in the market place. It became our trademark to promote what at first seemed a very anti-consultant message: 'For change to be sustainable, it must ultimately come from within'. The new science was a crucial element in changing our company thinking. (Zohar, 1997: 155)

Mapping all of these metaphorical travellings and encounters would require a research project I cannot undertake here. But one thing is clear: the importance of space. Actor-networks construct spaces and times and they do this work of construction in many registers at once (Latour, 1997). There are four main ways in which the space-time geographies of these networks have helped to shape their function as shifters of metaphors.

First, they provide a map of *where counts*. In the case of science, there are the main sites where complexity theory is produced (Figure 3) which are, in turn, a part of a quite specific international geography of where science as a whole is produced which is, perhaps, best summarized by studies of citation counts. In the case of the cultural circuit of capitalism, the map is of the main poles of managerial innovation like Boston, and the sites of managerial seminars. In the case of the New Age network, the map is (or has been) chiefly one of margins (Hetherington, 1996). In Britain, for example:

> Travelling [outside the North West] one often encounters more on offer. Activities are most numerous in the capital city, Islington, London and – more specifically – Neal's Yard.... Then there are the more rural heartlands of the movement: Glastonbury, the Totnes region, the Welsh borders, Central Wales, and places along the 'Celtic' littoral including the Isle of Arran. East Grinstead is also worthy of note, being home, for instance, to the British headquarters of the National Pagan Association, the Rosicrucians and Scientology. (Heelas, 1996: 108)

In North America a similar kind of map could no doubt be drawn, taking in especially California, Arizona and New Mexico.

Second, the cultural valuation of the landscapes inscribed on these maps provides a *force of identity*. Thus science gains extra validation from certain stock landscapes such as the two Cambridges. Business also has its stock of familiar landscapes on both sides of the Atlantic. New Age sites in Britain are often woven together into a mystical geography centred on, for example, notions like Avalon. In North America, more attention is usually given to Native American cultural sites, closeness to nature and wilderness with, for example, desert and canyon landscapes providing a particular resonance. Third, these are geographies of *interaction*. In the networks of science and business, conferences, symposia, seminars, workshops and other forms of face-to-face interaction are supplemented by mediated communications. These are both worlds of 'frequent fliers and frequent faxers' (Hannerz, 1996: 29). In the New Age networks, face-to-face interaction, in seminars and workshops, at festivals and gatherings, and in cafés tends to be

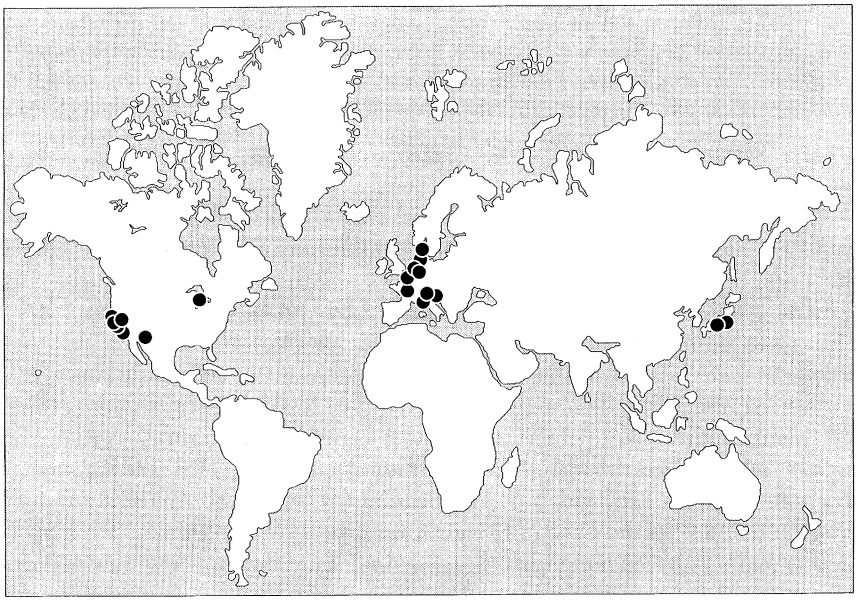

Figure 3 Where complexity theory is produced (Source: Gell-Mann, 1994)

more important. And, fourth, space provides a *vocabulary* of journeys, travels, maps, shifts and transformations which give the metaphors of complexity a semiotic force which is, at the same time, intended to imply transformation and diffusion.

At certain sites, networks can physically coincide and these sites can provide particularly important points for the transmission of metaphors since they allow direct interaction and negotiation to (quite literally) take place. For example, as I have pointed out above, one of the major scientific centres of complexity theory has been the Santa Fe Institute. The Institute, has, from the start, attempted to reach across disciplines – into economics, for example (Arthur, 1994). But what is also interesting is in just how much work emanating from the Institute, the landscape surrounding the Institute is regarded as an illustration of the importance of complexity metaphors: the New Mexico desert landscape provides a kind of ground. Then, even more interesting, Santa Fe is one of the key centres of New Age in the United States. We can see, here, how networks both interweave in spaces, and interweave spaces. Thus in Lewin's book *Complexity*, Chaco Canyon in New Mexico is figured as a landscape of complexity, as a site of a sophisticated Native American society which seems to have suffered a catastrophic collapse (and thus provides a conundrum for complexity theory to solve) and as a place which 'is also important to today's New Agers, who flock to the canyon for their own ceremonies, complete with borrowed Buddhist chants, meditation techniques, and crystals' (1993: 5).

The Times of Complexity: Complexity Theory as an Aspect of Seeing Complexity

> That life is complicated may seem a banal expression of the obvious, but it is nonetheless a profound theoretical statement – perhaps the most important theoretical statement of our time. (Gordon, 1997: 3)

I hope to have shown that metaphors of complexity have been able to travel rapidly through the burgeoning 'Type 2' knowledge actor-networks, constituting their own object as they go. So far, the tone of the article has been, if not sceptical, then certainly uncommitted. This is not, after all, a naive realist tract. But now I want to suggest that metaphors of complexity may be a sign of something of wider cultural interest and most especially a greater sense of openness and possibility concerning the future, based upon new cultural senses of time that acknowledge that things are complex and cannot be easily apprehended, models of time that are not foundational but still allow grip. In other words, I want to suggest that a new structure of feeling is emerging, a new 'cultural hypothesis' (Williams, 1973) concerning how we anticipate and frame the future which operates at 'the edge of semantic availability' (Williams, 1973: 23) to which the metaphors of complexity theory are both a call and response.

By way of preamble, I need to make it clear that I am not against the use of scientific metaphors outside science. On the one hand, there is

certainly room to exaggerate their powers. For example, in many of the books on complexity written by practising scientists there seems to be an obligatory final chapter which suggests the ways in which the metaphors of complexity will refigure science and will then go on to provide an explanation of the whole world by providing a new worldview. Then, it's off into every domain of current intellectual effort imaginable with every kind of false or tawdry analogy possible, as if to prove that these inheritors of systems theory can forget all about equifinality.

On the other hand, however, metaphors of complexity can focus cultural debate. For example, French social theory has undoubtedly been informed in productive ways by ideas drawn from science. Ideas from systems theory, topology and the like, have been used in French social theory since their invention. Again, there is a long tradition of what might be called 'philosophical biology', 'an area of enquiry which although neglected in the English-speaking reception of continental philosophy, was of decisive importance for modern thinkers such as Kant, Hegel and Nietzsche and which has enjoyed a high profile in twentieth-century French thought (Bergson, de Chardin, etc.)' (Ansell-Pearson, 1997: 17). More recently, the use of scientific metaphor has been extensive in French social theory as a means of getting at what Guattari (1996: 260) once called 'a processual calling, a processual passion'. Thus, Jacques Derrida is often noted as a writer who has drawn on precursors of complexity theory like systems theory, the writings of Gregory Bateson, and the work of Jacques Monod and François Jacob, in interesting ways. In particular, his insistence on the primacy of the 'écart' within the 'trace' (of survival over life, of translation over text) bears a strong resemblance to some current biological thinking; 'whereas biologists have traditionally taken reproduction to be the defining feature of living systems, the category of fluctuation is now considered to be logically prior to that of reproduction' (Johnson, 1993: 196). In other words:

> ... the continuous chain that extends from writing (technology) to the biological to evolution is a subset of the more general category of the trace. The enveloping context or condition of possibility is therefore something much wider than the bio-social or the bio-anthropological, the essentializing alliance of 'life' and (at the apex of evolutionary ascent) 'man' being a central tenet of logocentric thinking. Similarly, systems theory, though indebted to modern neo-Darwinian biology, with its use of concepts such as teleonomy and equifinnality, goes on to formulate a theory of self-organizing and self-regulating systems of which 'life' is but a special case, a regional instance. One arrives therefore at a non-biological theory of evolution in which the testamentary structure of survival (in the delegation and translation of the trace), the supplementary *über-leben* over and above (before and after) the economy of life, is the organizing principle. It is striking to record Bateson practising what is basically the same metaphorical inversion as Derrida ... the terminology differs, but the basic idea, that symbolic systems, or more precisely the translations between symbolic systems, are the considerations

> of the possibility of life, rather than the reverse, remains the same. (Johnson, 1993: 193–4)

Similarly, Michel Serres draws on notions from biology, systems theory and thermodynamics to fashion an early statement which echos down through his later work (e.g. Serres, 1995a, 1995b) and which refers to biology, information theory and the work of Jacques Monod (whom he knew as a friend).[14]

> It is no longer necessary to maintain the distinction between interpretative knowledge, or 'deep' knowledge, and objective knowledge. There is only one type of knowledge and it is always linked to an observer, an observer submerged in a system or in its proximity. And this observer is structured exactly like what he observes. His position changes only the relationship between noise and information, but he himself never effaces these two stable presences. There is no more separation between the subject, on the one hand, and the object, on the other (an instance of clarity and an instance of shadow). Thus separation makes everything inexplicable and unreal. Instead, each term of the traditional subject–object dichotomy is itself split by something like a geographical divide (in the same way as am I, who speak and write today): noise, disorder, and chaos on one side; complexity, arrangement and distribution on the other. Nothing distinguishes me ontologically from a crystal, a plant, an animal, or the order of the world; we are drifting together toward the noise and the black depths of the universe, and our diverse systemic complexions are flowing up the eutopic stream, toward the solar origin, itself adrift. Knowledge is at most the reversal of drifting, that strange conversion of times, always paid for by additional drift, but this is complexity itself, which was once called being. Virtually stable turbulence within the flow. To be or to know from now on will be translated by: see the islands, rare or fortunate, the work of chance or of necessity. (Serres, 1982: 83)[15]

I could go on to, for example, the work of Deleuze and Guattari, and especially to Deleuze's middle period 'biophilosophy' (see Ansell-Pearson, 1997) and Guattari's (1996) later work which, with its emphasis on 'chaosmosis', owes a clear debt of honour to the work of scientists like Prigogine and Stengers.[16]

But hopefully the point is made. In this more positive spirit, I want to suggest some of the ways in which the metaphors of complexity theory are being used in cultural debate as a means of clearing old ground and creating new. Four of these ways strike me as particularly important. First, the example of complexity theory shows how quickly scientific metaphors can now be co-opted by society as a whole, especially when forced by some of the networks I have identified. In the case of metaphors of complexity, I think it would be possible to argue that these metaphors have found and will find particularly fertile ground in contemporary Western society because they can be bent to the *reflexive* turn, which, for all the exaggerations of Beck and Giddens (Alexander, 1996), still seems to be important. Certainly,

writers as different as Capra (1996) and Maturana and Varela (1992) make these kind of links to the self, and often make them quite explicitly.

Second, and at the same time, the metaphors of complexity theory tell us something about how the *rhetoric* of contemporary science is being mediatized. The persuasive metaphors of complexity are bolstered by the persuasive techniques of a media industry which is hungry for material. The rise of popular scientific publishing is little remarked upon, yet it is clearly important,[17] especially now it has been linked to other networks like the capitalist cultural circuit and New Age. Complexity theory, in other words, becomes another means of systematizing and then commodifying ideas.

Third, the metaphors of complexity theory are also useful as a means of clearing a semantic space which might allow us to think again about the world in more explicitly *spatial* terms. There is the refiguring of 'internal' and 'external' processes which the metaphors of complexity theory lend themselves to, in the same manner as Deleuze's notion of the fold. Or, there is the way in which the metaphors of complexity theory seem to link to notions of spaces of flows, as in the work of Lash and Urry, or Serres' emphasis on message-bearing systems.

But, I want to turn to, and end with, one more clearing, upon which I will concentrate most of my remaining attention. I want to argue that the metaphors of complexity theory make it easier to think about *time* in new ways (Turner, 1997), and especially the structure of the future as open, as full of possibility and potentiality, even as pliant. They allow this sense of time to be constructed in a number of registers, of which I will point to just three.

The first of these is a shift in Western notions of *personhood* (see Strathern, 1996). As the number of possibilities of personhood has multiplied – through the division of labour, the sexual revolution, postcolonial imaginings, and so on – so the notions of persons as consisting of a set of complex, multivalent and more open subject positions, has taken hold; 'fractal' persons who are irreducible to a single dynamic (Strathern, 1996).

> Complex personhood means that all people (albeit in specific forms whose specificity is sometimes everything) remember and forget, are beset by contradiction, and recognise and misrecognise themselves and others. Complex personhood means that people suffer graciously and selfishly too, get stuck in the symptoms of their troubles, and also transform themselves. Complex personhood means even that those called 'other' are never never that. Complex personhood means that the stories people tell about themselves, about their troubles, about their social worlds, and about their society's problems are entangled and weave between what is immediately available as a story and what their imaginations are weaving towards. Complex personhood means that people get tired and some people are just plain lazy. Complex personhood means that groups of people will act together, that they will vehemently disagree with and sometimes harm each other, and that they will do both at the same time and expect the rest of us to figure it out for ourselves, intervening and withdrawing as the situation requires. Complex

> personhood means that even those who haunt our dominant institutions and their systems of value are haunted too by things they sometimes have names for and sometimes not. At the very least, complex personhood is about conferring the respect on others that comes from perceiving that life and people's lives are simultaneously straightforward and full of enormously subtle meaning. (Gordon, 1997: 405)

The second register is how those in the West regard *things*. It is possible to argue that our attitude to things has become more open and that things have become more open to us. To begin with, because we are surrounded by a more and more complex ecology of things (Williams, 1991; Thrift, 1996). Then, because these things increasingly have the capacity to interact with us; indeed they have increasingly become designed to do so (Latour, 1991). Again, because we are increasingly configured to interact with things; we have become more 'charitable' to them (Collins, 1990). And, finally, because many more things have become multifunctional and therefore able to be fitted to many situations (Knorr-Cetina, 1997). The way in which this openness is most often captured is through the notions of actor-network theory, an anti-essentialist attempt to weave the social and the technical together by stressing the construction of more or less durable actant networks:

> Actor-network theory stresses the contingent nature of networks and network theory. There is a constant need to establish and reproduce the network. In part, this can be achieved through material embodiment. Indeed, networks based solely on human relations tend to be very weak. Hence, an important question is not whether constituent members of a network are human or non-human but: 'which associations are stronger and which weaker?' (Latour, 1987: 40) (Grint and Woolgar, 1997: 24)

While actor-network theory is about reducing contingency, its purpose is also therefore about emphasizing the contingency of the world and the many possibilities that are open at any point. Indeed, in some of its more extreme manifestations (e.g. Law, 1997), actor-network theory has become contingency incarnate; the gaps and uncertainties having become almost as important as the networks.

> Similarities and differences. And here is a further difference. Perhaps there is no pattern, no overall pattern. Perhaps, then, it is not simply that we can't describe a single and coherent pattern.... Perhaps there is no single and coherent pattern. Perhaps there is nothing except practices. Perhaps there is nothing other than stories performing themselves and seeking to make connections, practical and local connections, specific links.
>
> In which case? In which case we are no longer in the business of epistemology. Of trying to find ways of telling about the links that exist between bits and pieces of complex objects. Instead ... we are in the business of creating links, of making them, of bringing them more or less

> successfully into being. Which means in turn that we are no longer trying to find good ways of narrating and describing something that was already there. Instead, or in addition, we are in the business of ontology. We are in the business of making our objects of study. Of making realities, and the connections between these realities of making the realities we describe. Of trying to find good ways of interacting with our objects, ways that are sustainable, ways that are making it possible to link with them. (Law, 1997: 8–9)

The third register, and the one which, given the geographic theme of this paper, I want to end by considering is a reframing of *space-time*, as a series of possible worlds, what Lewis (1973) calls 'unactualized possibilities', what Casti (1991, 1996) calls 'would-be worlds'. It is remarkable how little attention has been given to these kinds of cultural imaginings by social scientists, the multiplicity of sequences that lurk at every fork of the present.[18] These are shadow worlds about which we can never be certain.[19] But, they can still promise a kind of understanding 'which comes from locating an actual in a space of possibilities' (Hawthorn, 1991: 28). In other words, 'they raise the ghost of another possibility in order to investigate the groundwork of the real; they raise it in order to lay it again' (Spufford, 1996: 274) by attending to:

> ... the complexities that start to emerge if we abandon distinctions between possibility and impossibility. And in particular, a sharp distinction between possibility and impossibility. Between, for instance, objects out there (permissible) and object-and-subject couplets (impossible). Between object-singularity (permissible) and object-multiplicity, the decentered object (impermissible). Or between that which is real (permissible) and that which is fantastic (impermissible). (Law and Mol, 1996: 12)

Consideration of this kind of openness has perhaps been most developed in the investigations by Morson (1994) and Bernstein (1994) of the power of closed narrative models of time, in which events are 'foreshadowed', becoming posthumously 'historical' by virtue of a belief that, 'in one way or another, the future must already be there, must already exist substantially enough to send signs backward' (Morson, 1994: 7). By way of contrast, Morson and Bernstein advocate more open narrative models of time which 'recognize a middle realm of possibilities that could have happened even if they did not' (Morson, 1994: 6), a 'sideshadowed' realm of unactualized possibilities which can both restore the presentness of the past and simultaneously open up the present by demonstrating how:

> ... each counterlife is comprised of limitless counter-moments, and how each thought takes shape as only one realization amid the counter-thoughts that hover as its side shadows, multiple alternatives existing in a potential space and ready to be brought, by the quickening of imagination or desire, out of the shadows and into the light of formal expression. (Bernstein, 1994: 7)

Taking their cue from novels of the 19th and early 20th centuries, these authors also point to the current interest in postmodern narrative forms of the kind outlined by Gibson (1996), Brandt (1997) and Livingston (1997). Such narrative forms attempt to produce new narrative topologies, geo-poetics, constellations and 'chaologies' in which space and time are figured as the result of 'the connection among entities' (Latour, 1993), and so can slide in many directions. Thus we arrive at a polymorphic aesthetics of the 'multiple profilerations of spaces' (Gibson, 1996: 13), an aesthetics which:

> ... must turn away from laws and regulations to exchanges and interferences, connections and disconnections between spaces. It must choose against Kant, in opting for what Kant saw as 'denaturation', a confounding of different knowledges.... It must concentrate on perturbations and turbulences, multiple forms, uneven structures and fluctuating organizations. (Gibson, 1996: 13)

To summarize: it seems to me that complexity theory must be seen, then, as in a direct line of scientific thinking from topology through Einsteinian relativity theory, quantum theory and the like which has now become a part of a progressive recasting of popular Euro-American beliefs about time and space as dimensions *open to possibility*. Thus, the buttoned-down Newtonian/Darwinian 'time of the Victors' gives way to a new disclosive sense of time and space in which 'order is not the law of things but their exception' (Serres, 1982: xxvii), but which also allows certain kinds of emergent order to become possible and to be more easily acknowledged (Massey, 1997). Or, to quote Serres (1982: 53) again: 'we have not, nor shall we ever again fail dealing with spaces'.

Conclusions

This article is clearly only a starting point for what should be a much larger project.[20] In it, I have tried to use complexity theory as both an object of study and as a means of making some observations about the changing sense of what is possible in Euro-American cultures.[21] In particular, I have suggested that the metaphors of complexity theory are important signs of new senses of time which are more open to possibility.[22] However, I want to end the article with an important injunction. One interpretation of the latter part of the article might be that older senses of time based on linear notions of progress and discrete, synchronized spaces are being knocked on the head by newer 'postmodern' senses of time founded on cultural diversity and desychronized spaces of flows (see, for example, Adam, 1990, 1995; Nowotny 1994; Urry, 1994). This may be. But another interpretation is that this more open time is actually simply a continuation of the older time senses by other means. What we are tracking is an expansion of the older Euro-American mind-set, not its extinction, as the future becomes a space of

possibility for subjects who believe that anything is possible, given the means,[23] the result of

> ... the cultural place that is given to enablement itself. Euro-Americans imagine that they can do 'more' things than they once could crystallized in the hypostatization of technology as 'enabling'.... I suspect that above all they take for granted, quite simply, that *given the technology* they can do anything. If technology is society made durable, it is at the same time ability made effective. (Strathern, 1996: 46, 49)

Seen in this way, the changing sense of temporalization I have hinted at might be simply a continuation of imperialism by other channels, but now in time rather than space (Osborne, 1995; Frow, 1997). In which case, what we may be seeing in the guise of expanded possibility is simply business as usual.

Notes

I would like to thank a number of people for their comments on this paper and, in particular, participants in seminars at the Centre for Social Theory and Technology at Keele University (and especially Bob Cooper, John Law, Rolland Munro and Marilyn Strathern), at Warwick Business School (and especially Gibson Burrell and David Collinson), and at seminars in Geography at King's College, London (and especially Gernot Grabher and Chris Hamnett), and Oxford University (and especially Gordon Clark, Meric Gertler and Eric Swyngedouw). The criticism of the anonymous referees was also much appreciated.

1. For example, Openshaw (1996) has apparently recently declared that we know more about the spaces of whales than the spaces of the unemployed in Leeds.

2. In a sense, this ghettoizing of complexity theory in geography was a tragedy, since the potentialities for a much wider interaction were there. A few straws in the wind: Prigogine and Stengers' classic (1984) *Order out of Chaos* footnoted Don Parkes and my (1980) work on multiple times and spaces. Brian Goodwin talked at the British Regional Science Association Conference in 1978 (Goodwin, 1979). A whole raft of human geographers attended the two-week course which the ESRC co-sponsored in 1979 on the use of non-linear mathematics in the social sciences, which was addressed by luminaries like René Thom, Ian Stewart, Tim Postan and Christopher Zeeman. And, for a time at least, a number of us passed around the four distinctively yellow-covered IUBS *Towards a Theoretical Biology* volumes, and Brian Goodwin's (1963) *Temporal Organization of Cells*. But these nascent actor-networks never took off: the wider interaction spluttered and then fell back into quantitative geography.

3. Cilliers (1998: 143, n. 2) interestingly notes that: 'The concept "emergence" is often used in a way that creates the impression that something mysterious happens when "things come together". Perhaps it would be better to employ the term "relational properties" rather than "emergent properties".' Certainly this usage will have the benefit of drawing complexity theory closer to current debates in social theory.

4. Complexity theory therefore subsumes earlier concepts like chaos and gives them a second chance. For example: 'Steven Durlauf, a professor of the University of Wisconsin and current director of the [Santa Fe] Institute's economics program, found that "chaos proved to be a flop in economics. It provided no deep insights, while complexity has been much more compelling. Chaos and complexity are distinctly different concepts. Chaos refers to turbulent behaviour in a system where the behaviour is totally *determined* by nonlinear laws which amplify the smallest of errors in the initial conditions of the system, making the system unpredictable beyond the shortest of periods. Complexity refers to the phenonemon of order emerging from complex interactions among the components of a system *influenced* by one or more simple guiding principles. Structures such as the economy emerge out of what would otherwise be anarchy by a process called "self-organization". Complex systems organize themselves without some form of internal control"' (Sherden, 1997: 69).

5. This article is, then, an exercise in the study of culture, society and economy all at one and the same time, an article which I hope gives the lie to the kinds of division which, in geography at least, seem to be used mainly to give succour to a number of rather cosy intellectual establishments.

6. On the other hand, as one referee pointed out, it does not stop me avoiding certain important questions about the degree to which theory becomes more or less metaphorical as it tracks from one context and usage to another. I acknowledge that this is an important lacuna in this article.

7. This is an important distinction. Originators of actor-network theory, like Latour, are well aware of these weaknesses and have attempted to counter them (see, for example, Latour, 1988a). But I think the criticism holds more generally.

8. And which is more likely to be feminized by its lack of a sense of a fundamental hierarchy. The feminist connections to complexity theory are made by Wertheim (1997: 242): 'I believe we need a world picture that is not so fixated on hierarchy. I suggest that women physicists might play a role in helping to evolve a less hierarchical world picture. Again, the point is not that women are innately less hierarchical but that having been acculturated differently than men, they have a somewhat different pool of perspectives to bring to the endeavour.' There are other gendered connections in this article. For example, the majority of New Age Channels (see below) would appear to be women.

9. I am, of course, well aware that science is a network which is particularly diverse and diffuse. For example, Traweek (1988) shows that the world of the particle physicist is unlike that of other physicists. It depends upon a geography of equipment, a set of social connections and notions of trust which are in many ways quite different from the practices of other physicists.

10. Throughout the history of complexity theory, in its various forms, the scientists connected with it have been accused of hyperbole, partly, I suspect, as a result of their close contact with the media. For example, René Thom was regarded as a judicious self-publicist. Ilya Prigogine seems to be regarded in the same way. In a sense, *complexity theory is one of the first fully mediatized scientific theories.*

11. What is the same is the movement back and forth between countries of key practitioners. For example, many British New Age practitioners were trained in the United States.

12. Cilliers (1998: 147, n. 2) notes the disjuncture between Kauffman's scientific texts and the 'flowery, quasi-religious rhetoric of *At Home in the Universe*'.

13. But such an approach is not without its risks, especially in the more rhetorical accounts of complexity theory: 'The first thing that might strike someone interested in the discourse on complexity is the revival of a kind of classical scientism. What seems to happen is that themes of world crisis, and a questioning of the presuppositions that allowed us to underestimate the crisis or to think of it as epiphenomenal, are interwoven with the themes of a "new rationality". This is an eminently classical scientism, in that the renewal of the scientific knowledge that was initially critiqued is heralded as a *solution* to ethico-political problems'. (Stengers, 1997: 4)

14. No doubt, it would be possible, therefore, to trace out the influences of a nascent complexity theory on actor-network theory, via Serres' influence on Latour (see Latour, 1988a, 1993; Serres and Latour, 1995).

15. It is worth recalling that Serres' (1982) book includes a lengthy 'post face' by Prigogine and Stengers.

16. Although, of course, writers like Deleuze and Guattari have been criticized for not understanding the terms from the natural sciences they make use of, including terms drawn from complexity theory.

17. The 'Hawking phenomenon' (*A Brief History of Time* has sold 12 million books in English) seems to be important, especially when it is translated into accessible half-way houses as in Krauss (1996).

18. Though we might argue that Latour's (1996) *Aramis* is precisely an attempt to document possible worlds. 'Let's not make a verbal separation between what exists and what does not exist' (Latour, 1996: 79). See the quotation from Law and Mol below.

19. We can think of two ways in which these possible worlds can be at least partly actualized by using Gell's (1992) distinction, following McTaggart, between A-series time, the human time subjectively grasped by conscious subjects encapsulated in what, for example, counts as past, present and future in each culture, and B-series time, 'physical' or ecological time. As Gell points out, no such distinction can easily be maintained but they are convenient fictions. The structure of possibility provided by the B-series outlook on time and space is perhaps best summarized by the work of the Swedish geographer, Torsten Hägerstand on 'time-geography'. Hägerstand's intention was (rather like complexity theory) to work from a small number of rules about the allocation of space and time up to the full complexity of societies, with structures emerging at higher levels of organization through allocation effects. As Gell (1992: 197) puts it: 'time-geographers' contributions are ... an analytical language for exploring social systems, not simply a descriptive language for representing objects and events distributed in space and time. It is a language in which it is possible to construct permutable structural models which represent both the spatio-temporal relationships in the environment which are the geographers' primary concern, and also the implicit dimension of social ideas which are embedded in these relationships'. And Gell (1992: 191, my emphasis) makes clear: 'In effect, Hägerstrand is concerned with the representation of society as a concrete, physically real process in physicist's "block universe" type time. But one should not be misled into supposing that this apparent physicalism is the methodological outgrowth of a determinist theoretical stance. Hägerstrand is not concerned to demonstrate that what is so (empirically) must be so (rationally).

On the contrary, time-geography is concerned to *discover what is "possible"* in the light of permutable structural models of the choreography of social life in real space-time.' Though complexity theory relates to B-series time and space, it seems to me that it is in its effect on a notion of A-series time and space that its impact can chiefly be found.

20. One set of networks I would want to inject into this larger project would obviously be the networks of the social sciences and humanities. Complexity is an idea whose time seems to be coming in these networks too. For example, this article was originally given in 1996 in a seminar on 'Complexity and the Social Sciences'. By November 1997 a large conference was being held in Limburg on, 'Uncertainty, Knowledge and Skill' which included presentations by Robert Cooper, John Law and – of course – Ilya Prigogine. In turn, and perhaps inevitably, contributors were being criticized for not understanding the terms they were taking from the natural sciences. Another line of thought I have considered taking up would have traced Von Uexkull's work through the biological complexity theory of writers like Goodwin (1994) to Ingold's (1990, 1995) thoughts on biology and anthropology, taking in Fraser's (1975, 1978) *unwelt* theory of time, which is also heavily influenced by Von Uexkull.

21. Strathern (1992) makes the point that such a sense of the future may in fact be possible because certain aspects of the future (she gives the example of genetics) are now more *certain* than before: it is certainty that breeds a sense of possibility, not uncertainty.

22. Such an analysis might be related to the ecological crisis, in terms of the remorseless expansion of consumption based upon time scales which do not coincide with those of the environment (see Adam, 1997).

23. In other words, there is a real tension here. It is possible to side with an optimist like Appadurai (1996: 53, my emphasis) for whom: 'the imagination has now acquired a singular new power in social life. The imagination – expressed in dreams, songs, fantasies, myths and stories – has always been part of the repertoire of every society, in some culturally organized way. But there is a peculiar new force to the imagination in social life today. More persons in more parts of the world consider *a wider set of possible lives* than they ever did before. One important source of this change is the mass media, which present a rich, ever-changing store of positive lives ...' whilst, at the same time, wanting to express some caution at this depiction.

References

Adam, B. (1990) *Time and Social Theory*. Cambridge: Polity Press.

Adam, B. (1995) *Timewatch*. Cambridge: Polity Press.

Adam, B. (1997) *Timescapes*. London: Routledge.

Alexander, C. (1996) *Fin de Siecle Social Theory*. London: Verso.

Alvarez, J.L. (1996) 'The International Popularization of Enterpreneurial Ideas', in S. Clegg and G. Palmer (eds) *The Politics of Management Knowledge*. London: Sage.

Ansell-Pearson, K. (ed.) (1997) *Deleuze and Philosophy: The Difference Engineer*. London: Routledge.

Appadurai, A. (1996) *Modernity at Large: Cultural Dimensions of Globalization*. Minneapolis: University of Minnesota Press.

Argyros, A.J. (1991) *A Blessed Rage for Order: Deconstruction, Evolution and Chaos*. Ann Arbor: University of Michigan Press.

Arnolfini (1997) *Arnolfini June/July 1997*. Bristol: Arnolfini Gallery.

Arthur, W.B. (1994) *Increasing Returns and Path Dependence in the Economy*. Ann Arbor: University of Michigan Press.

Barnett, W.A., A.P. Kirman and M. Salmon (eds) (1996) *Nonlinear Dynamics and Economics*. Cambridge: Cambridge University Press.

Bateson, G. (1973) *Steps to an Ecology of Mind*. London: Paladin.

Batty, M. and P. Longley (1995) *Fractal Cities*. London: Academic Press.

Beck, U. (1992) *Risk Society*. London: Sage.

Beer, G. (1996) *Open Fields: Science in Cultural Encounter*. Oxford: Oxford University Press.

Beinhocker, M. (1997) 'Strategy at the Edge of Chaos', *McKinsey Quarterly* 1: 18.

Benitez-Rojo, (1996) *The Repeating Island*. Durham, NC: Duke University Press.

Benjamin, A. (ed.) (1995) 'Complexity: Architecture/Art/Philosophy', *Journal of Philosophy and the Visual Arts* 6: 6–23.

Bernstein, M.A. (1994) *Foregone Conclusions: Against Apocalyptic History*. Berkeley: University of California Press.

Brandt, J. (1997) *Geopoetics: The Politics of Mimesis in Poststructuralist French Poetry and Theory*. Stanford, CA: Stanford University Press.

Brown, M.F. (1997) *The Chanelling Zone: American Spirituality in an Anxious Age*. Cambridge, MA: Harvard University Press.

Byrne, D. (1996) 'Chaotic Cities or Complex Cities', pp. 50–70 in S. Westwood and J. Williams (eds) *Imagining Cities*. London: Routledge.

Campbell, J.A. (1990) 'Scientific Discovery and Rhetorical Invention: The Path to Darwin's *Origin*', in H.W. Simon (ed.) *The Rhetorical Turn: Invention and Permission in the Conduct of Inquiry*. Chicago: University of Chicago Press.

Capra, F. (1996) *The Web of Life*. London: Harper Collins.

Casti, J. (1991) *Searching for Certainty: What Scientists Can Know About the Future*. London: Scribners.

Casti, J. (1996) *Would-be Worlds: How Simulation is Changing the Frontiers of Science*. New York: John Wiley.

Cilliers, P. (1998) *Complexity and Postmodernism: Understanding Complex Systems*. London: Routledge.

Clark, T. (1995) *Managing Consultants*. Milton Keynes: Open University Press.

Clegg, S. and G. Palmer (eds) (1996) *The Politics of Management Knowledge*. London: Sage.

Collins, H.M. (1990) *Artificial Experts: Social Knowledge and Intelligent Machines*. Cambridge, MA: MIT Press.

Collinson, D. and J. Hearn (eds) (1996) *Men as Managers, Managers as Men: Critical Perspectives on Men, Masculinities and Management*. London: Sage.

Coveney, P. and R. Highfield (1995) *Frontiers of Complexity: The Search for Order in a Chaotic World*. London: Faber and Faber.

Covey, S. (1989) *Seven Habits of Highly Effective People*. New York: Simon and Schuster.

de Landa, M. (1997) *A Thousand Years of Nonlinear History*. New York: Zone Books.

de Lillo, D. (1990) *White Noise*. New York: Picador.

Elliott, E. and L.D. Kiel (eds) (1997) *Chaos Theory in the Social Sciences: Foundation and Application*. Ann Arbor: University of Michigan Press.

Emery, F. (1969) *Systems Theory*. Harmondsworth: Penguin.

Engwall, L. (1992) *Mercury Meets Minerva*. Oxford: Pergamon Press.

Eve, R.A., S. Horsfall and M.E. Lee (eds) (1997) *Chaos, Complexity and Sociology: Myths, Models and Theories*. Beverly Hills: Sage.

Ferguson, N. (ed.) (1997) *Virtual History: Alternatives and Counterfactuals*. London: Picador.

Fraser, J.T. (1975) *Of Time, Passion and Knowledge*. New York: George Braziller.

Fraser, J.T. (1978) *Time as Conflict*. Basel: Birkhauser Verlag.

Frow, J. (1997) *Time and Commodity Culture: Essays in Cultural Theory and Postmodernity*. Oxford: Oxford University Press.

Game, A. and D. Metcalfe (1996) *Passionate Sociology*. London: Sage.

Gell, A. (1992) *The Anthropology of Time*. Oxford: Berg.

Gell-Mann, M. (1994) *The Quark and the Jaguar: Adventures in the Simple and the Complex*. London: Little Brown.

Gibbons, M., C. Limöges, H. Novotny, S. Schwartzman, P. Scott and M. Trow (1994) *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*. London: Sage.

Gibson, A. (1996) *Towards a Postmodern Theory of Narrative*. Edinburgh: Edinburgh University Press.

Gleick, J. and E. Porter (1990) *Nature's Chaos*. London: Abacus.

Goodchild, P. (1996) *Deleuze and Guattari: An Introduction to the Politics of Desire*. London: Sage.

Goodwin, B.C. (1983) *The Temporal Organization of Cells*. London: Academic Press.

Goodwin, B.C. (1979) 'Generative and Cognitive Models of Biological Pattern Formation', pp. 20–5 in I.G. Cullen (ed.) *Analysis and Decision in Regional Policy*, London Papers in Regional Science 9. London: Pion.

Goodwin, B.C. (1994) *How the Leopard Changed its Spots*. London: Weidenfeld and Nicholson.

Goodwin, B.C. (1997) 'Community, Creativity and Society', *Soundings* 5: 111–23.

Gordon, A.F. (1997) *Ghostly Matters: Haunting and the Sociological Imagination*. Minneapolis: University of Minnesota Press.

Grint, K. and S. Woolgar (1997) *The Machine at Work: Technology, Work and Organisation*. Cambridge: Polity Press.

Gross, A.G. (1996) *The Rhetoric of Science*, 2nd edn. Cambridge, MA: Harvard University Press.

Guattari, F. (1996) *Chaosmosis: An Ethico-Aesthetic Paradigm*. Sydney: Power Press.

Hammer, M. and J. Champy (1993) *Re-engineering the Corporation*. London: Brealey.

Hannerz, U. (1996) *Transnational Connections: Culture, People, Places*. London: Routledge.

Hawthorn, G. (1991) *Plausible Worlds*. Cambridge: Cambridge University Press.

Hayles, N.K. (1990) *Chaos Unbound: Orderly Disorder in Contemporary Literature and Science*. Ithaca, NY: Cornell University Press.

Hayles, N.K. (ed.) (1991) *Chaos and Order*. Chicago: University of Chicago Press.

Hayles, N.K. (1996) 'Narratives of Artificial Life', pp. 146–64 in G. Robertson et al. (eds) *Future Natural: Nature, Science, Culture*. London: Routledge.

Heelas, P. (1996) *The New Age*. Oxford: Blackwell.

Hetherington, K. (1996) 'Identity Formation, Space and Social Centrality', *Theory, Culture & Society* 13: 33–52.

Huczynski, T. (1993) *Management Gurus: What Makes Them and How to Become One*. London: Routledge.

Ingold, T. (1990) 'An Anthropologist Looks at Biology', *Man* (NS) 25: 208–29.

Ingold, T. (1995) 'Building, Dwelling, Living: How Animals and People Make Themselves at Home in the World', pp. 57–80 in M. Strathern (ed.) *Shifting Contexts: Transformations in Anthropological Knowledge*. London: Routledge.

Isard, W. (1996) *Commonalities in Art, Science and Religion*. London: Avebury.

Jencks, C. (1996) *The Architecture of the Jumping Universe, A Polemic: How Complexity Science is Changing Architecture and Culture*, revised edn. London: Academy Editions.

Johnson, C. (1993) *System and Writing in the Philosophy of Jacques Derrida*. Cambridge: Cambridge University Press.

Jones, S. (1994) 'Demonology: Some Thoughts towards a Science of Chaos in Recent British Theatre', *Contemporary Theatre Review* 11: 49–59.

Kauffman, S. (1995) *At Home in the Universe: The Search for Laws of Complexity*. Oxford: Oxford University Press.

Khalil, E.L. and K.E. Boulding (eds) (1996) *Evolution, Complexity and Order*. London: Routledge.

Knorr-Cetina, K. (1997) 'Sociality with Objects: Social Relations in Postsocial Knowledge Societies', *Theory, Culture & Society* 14: 1–30.

Kogut, B. and E. Bowman (1996) 'Redesigning for the 21st Century', *Final Times* 22 (March): 13–14.

Krauss, A. (1996) *The Reader's Guide to a Brief History of Time*. London: Collins.

Latour, B. (1988) 'Opening One Eye while Closing the Other: A Note on Some Religious Paintings', pp. 15–38 in G. Fyfe and T. Law (eds) *Picturing Power: Visual Depiction and Social Relations*. London: Routledge.

Latour, B. (1991) 'Technology is Society made Durable', pp. 103–32 in J. Law (ed.) *A Sociology of Monsters*. London: Routledge.

Latour, B. (1993) *We Have Never Been Modern*. Hassocks: Harvester.

Latour, B. (1996) *Aramis, or the Love of Technology*. Cambridge, MA: Harvard University Press.

Latour, B. (1997) 'Trains of Thought: Piaget, Formalism and the Fifth Dimension', *Common Knowledge* 6: 170–91.

Law, J. (1997) 'Traduction/trahison', *Sociology* 56: 1–20.

Law, J. and A. Mol (1996) 'Decisions' paper presented to the Centre for Social Theory and Technology Seminar, November 1996.

Lewin, R. (1993) *Complexity: Life on the Edge of Chaos*. London: Dent.

Livingston, I. (1997) *Arrow of Chaos: Romanticism and Postmodernity*. Minneapolis: University of Minnesota Press.

Livingstone, D. (1992) *The Geographical Tradition*. Oxford: Blackwell.

Lyne, J. (1996) 'Quantum Mechanics, Consistency and the Art of Rhetoric: A Response to Krips', *Cultural Studies* 10: 115–32.

Martin, E. (1994) *Flexible Bodies*. Boston, MA: Beacon Press.

Massey, D. (1997) 'Spatial Disruptions', in S. Golding (ed.) *Eight Technologies of Otherness*. London: Routledge.

Maturana, H. and F. Varela (1992) *The Tree of Knowledge*. New York: Shambhala.

Mirowski, P. (1994) *Natural Images in Economic Thought*. Cambridge: Cambridge University Press.

Morson, G.S. (1994) *Narrative and Freedom: The Shadows of Time*. New Haven, CT: Yale University Press.

Nowotny, H. (1994) *Time: The Modern and Postmodern Experience*. Cambridge: Polity Press.

Osborne, P. (1995) *The Politics of Time*. London: Verso.

Openshaw, S. (1996) cited in 'Byte', *Yorkshire Post*.

Owen, J.J. (1996) 'Chaos Theory, Marxism and Literature', *New Formations* 29: 84–112.

Parkes, D. and N.J. Thrift (1980) *Times, Spaces, Places: A Chronogeographic Perspective*. Chichester: John Wiley.

Parry, G. (1995) *The Trophies of Time*. Oxford: Oxford University Press.

Pascale, T. (1991) *Managing on the Edge*. Harmondsworth: Penguin.

Peat, D. (1994) *Blackfoot Physics*. London: Fourth Estate.

Prigogine, I. and I. Stengers (1994) *Order out of Chaos*. New York: Bantam Books.

Rabinow, P. (1995) *Making PCR: A Story of Biotechnology*. Chicago: University of Chicago Press.

Rabinow, P. (1996) *Essays on the Anthropology of Reason*. Princeton, NJ: Princeton University Press.

Ramsay, H. (1996) 'Managing Sceptically: A Critique of Organizational Fashion', in S. Clegg and G. Palmer (eds) *The Politics of Management Knowledge*. London: Sage.

Richardson, M. and W.J. Wildman (eds) (1997) *Religion and Science: History, Method and Dialogue*. London: Routledge.

Rose, N. (1996) *Inventing Ourselves: Psychology, Powerful Personhood*. Cambridge: Cambridge University Press.

Santa Fe Centre for Emergent Strategies (1997) Seminar Announcement. http://www.santa-strategy.com

Seely Brown, J. (ed.) (1997) *Seeing Differently: Insights on Innovation*. New York: Harvard Business School Press.

Serres, M. (1982) *Hermes: Art, Literature, Science*. Baltimore, MD: John Hopkins University Press.

Serres, M. (1995) *Genesis*. Ann Arbor: University of Michigan Press.

Serres, M. and B. Latour (1995) *Conversations on Science and Technology*. Ann Arbor: University of Michigan Press.

Shapin, S. (1998) *Science Incarnate*. Chicago: University of Chicago Press.

Sherden, W.A. (1997) *The Fortune Sellers: The Big Business of Buying and Selling Predictions*. New York: John Wiley.

Spufford, F. (1996) 'The Difference Engine and the Difference Engine', pp. 266–90 in F. Spufford and J. Uglow (eds) *Cultural Babbage: Technology, Time and Invention*. London: Faber and Faber.

Spufford, F. and J. Uglow (eds) (1996) *Cultural Babbage: Technology, Time and Invention*. London: Faber and Faber.

Stafford, B.M. (1992) *Body Criticism: Imagining the Unseen in Enlightenment Art and Medicine*. Cambridge, MA: MIT Press.

Stafford, B.M. (1994) *Artful Science: Enlightenment Entertainment and the Eclipse of Visual Education*. Cambridge, MA: MIT Press.

Stafford, B.M. (1996) *Good Looking: Essays on the Virtue of Images*. Cambridge, MA: MIT Press.

Star, S.L. (1989) 'The Structure of Ill-Structured Solutions: Boundary Objects and Heterogeneous Distributed Problem Solving', pp. 37–54 in L. Gasser and N. Huhn (eds) *Distributed Artificial Intelligence*. New York: Morgan Kauffman.

Stengers, I. (1997) *Power and Invention: Situating Science*. Minneapolis: University of Minnesota Press.

Strathern, M. (1992) 'Reproducing Anthropology', pp. 172–89 in S. Wallman (ed.) *Contemporary Futures: Perspectives on Social Anthropology*. London: Routledge.

Strathern, M. (1996) 'Cutting the Network', *Journal of the Royal Anthropological Institute* (NS) 2: 517–35.

Thrift, N.J. (1996) *Spatial Formations*. London: Sage.

Thrift, N.J. (1997a) 'The Rise of Soft Capitalism', *Cultural Values* 1: 21–57.

Thrift, N.J. (1997b) 'The Rise of Soft Capitalism', pp. 25–71 in A. Herod, G. Tuathail and S. Roberts (eds) *Unruly World: Globalization, Governance and Geography*. London: Routledge.

Traweek, S. (1988) *Beamtimes and Lifetimes: The World of High Energy Physicists*. Cambridge, MA: Harvard University Press.

Turner, F. (1997) 'Chaos and Social Science', pp. xi–xxxii in R.A. Eve, S. Horsfall and M.E. Lee (eds) *Chaos Complexity and Sociology: Myths, Models and Theories*. Thousand Oaks, CA: Sage.

Urry, J. (1994) 'Time, Leisure and Social Identity' *Time and Society* 3: 131–50.

Waddington, C.H. (1977) *Tools for Thought*. London: Allen Lane.

Waldrop, M.M. (1993) *Complexity*. New York: Viking.

Wertheim, M. (1997) *Pythagoras' Trousers: God, Physics and the Gender Wars*. London: Fourth Estate.

Wheatley, M.J. (1994) *Leadership and the New Science: Learning about Organization from an Ordinary Universe*. San Francisco: Berrett-Koehler.

Williams R. (1978) *Marxism and Literature*. Oxford: Oxford University Press.

Williams, R.H. (1991) *Notes on the Underground*. Cambridge, MA: MIT Press.

Wilson, A.G. (1994) *Modelling the City*. London: Routledge.

Winterson, J. (1996) *Gut Symmetries*. London: Granta Books.

Wright, R. (1996) 'Art and Science in Chaos: Contested Readings of Scientific Visualisation', pp. 218–36 in G. Robertson et al. (eds) *Future Natural. Nature, Science, Culture*. London: Routledge.

Zohar, D. (1997) *Rewiring the Corporate Brain: Using the New Science to Rethink How We Structure and Lead Organizations*. San Francisco: Berret-Koehler.

Nigel Thrift is a Professor in the School of Geographical Sciences, University of Bristol. His chief interests are in the spaces of technology, the growth of soft capitalism, and theories of weak subjectivity. He is currently writing a social history of time consciousness with Paul Glennie. His most recent books include *Spatial Formations, Money/Space* (with Andrew Leyshon) and *City A–Z* (co-edited with Steve Pile). He was a founder and is a member of the Editorial Board of *Society and Space*.